The science behind the report:

Small and medium-sized businesses can reduce software licensing and other OPEX costs by choosing latest-generation 16G Dell PowerEdge servers powered by 4th Gen AMD EPYC 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 Small and medium-sized businesses can reduce software licensing and other OPEX costs by choosing latest-generation 16G Dell PowerEdge servers powered by 4th Gen AMD EPYC processors.

We concluded our hands-on testing on June 23, 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 May 20, 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.

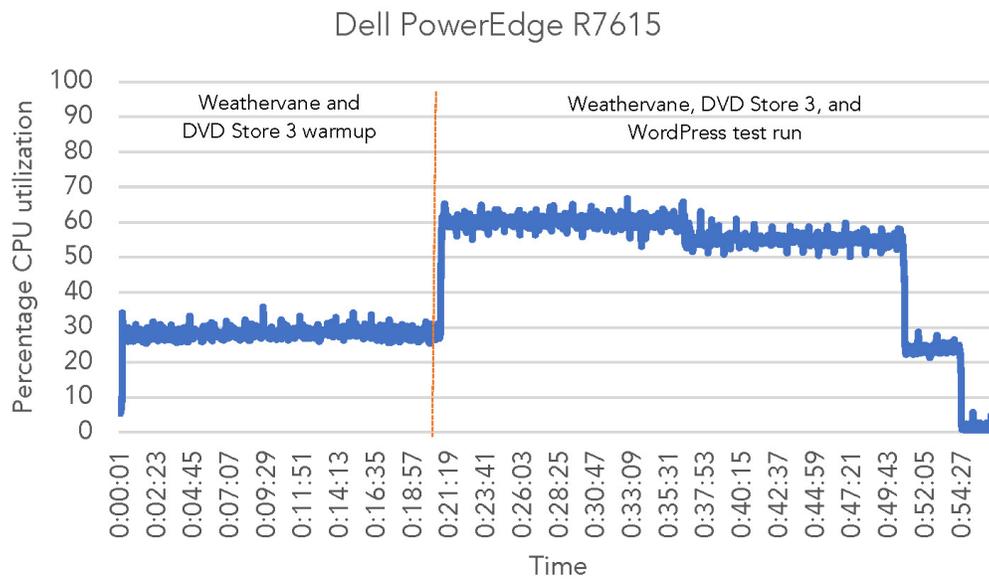| Workload/application	Benchmarking tool	Metric	Highest-performing 16G Dell™ PowerEdge™ R7615 server	Highest-performing 15G Dell PowerEdge R7515 server	Percentage advantage for 16G Dell PowerEdge R7615 server
Web application/ WordPress 6.2	Siege HTTP load tester and benchmarking utility	Transactions per second (higher is better)	1,584.81	1,243.53	27.4%
		Response time in seconds (lower is better)	0.03	0.04	25.0%
Kubernetes/ Tanzu Community Edition v0.12.1	Weathervane 2.1	Operations per second (higher is better)	1,094.10	1,096.33	-0.2%
		Response time in seconds (lower is better)	0.02	0.04	50.0%
OLTP database/ SQL Server 2019	DVD Store 3	Orders per minute (higher is better)	29,436	23,604	24.7%

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CPU utilization

Dell PowerEdge R7615

Weathervane and DVD Store 3 warmup

Weathervane, DVD Store 3, and WordPress test run

Figure 5: CPU utilization for the 16G Dell PowerEdge R7615 during testing. Source: Principled Technologies.

Dell PowerEdge R7515
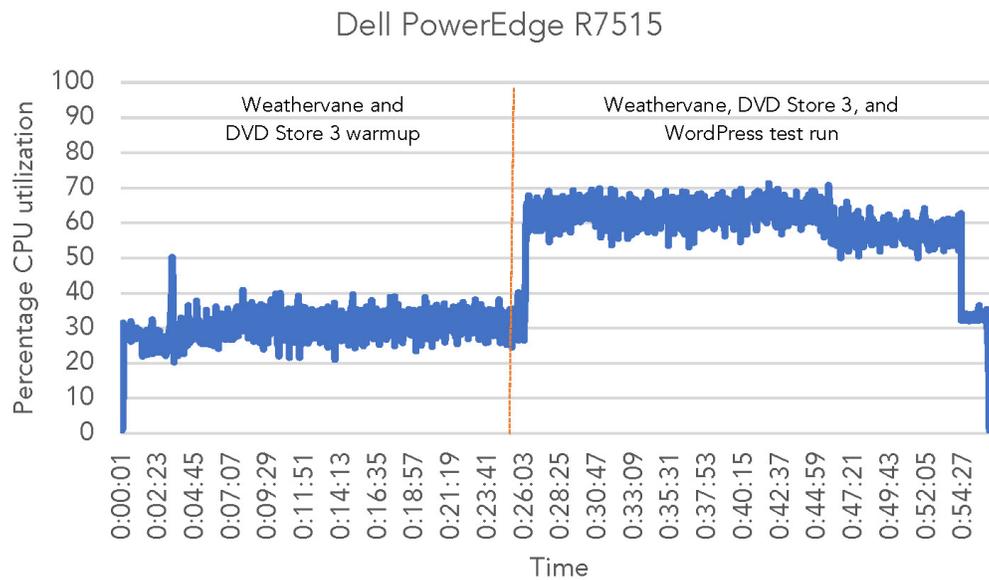
Weathervane and DVD Store 3 warmup

Weathervane, DVD Store 3, and WordPress test run

Figure 6: CPU utilization for the 16G Dell PowerEdge R7515 during testing. Source: Principled Technologies.

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System configuration information

Table 2: Detailed information on the systems we tested.

Server configuration information	3x 16G Dell PowerEdge R7615	3x 15G Dell PowerEdge R7515
BIOS name and version	0.5.2	2.11.4
Operating system name and version/ build number	Microsoft Windows Server 2022 Datacenter Version 10.0.20348 Build 20348	Microsoft Windows Server 2022 Datacenter Version 10.0.20348 Build 20348
Date of last OS updates/patches applied	1/10/2023	5/22/2023
Power management policy	Performance	Performance
Processor		
Number of processors	1	1
Vendor and model	AMD EPYC™ 9354	AMD EPYC 7543P
Core count (per processor)	32	32
Core frequency (GHz)	3.25	2.80
Stepping	1	1
Memory module(s)		
Total memory in system (GB)	192	128
Number of memory modules	12	8
Vendor and model	Hynix® Semiconductor HMCG78AEBRA107N	Samsung® M393A2K43DB3 CWE
Size (GB)	16	16
Type	DDR5	DDR4
Speed (MHz)	4,800	3,200
Speed running in the server (MHz)	4,800	3,200
Storage controller		
Vendor and model	PERC H755 Front (Embedded)	PERC H740P Mini (Embedded)
Cache size (GB)	8,192	8,192
Firmware version	52.21.0-4606	51.16.0-4076
Driver version	7.721.03.00	7.716.02.00
Local storage (OS)		
Number of drives	2	2
Drive vendor and model	KIOXIA® KPM6XRUG960G	KIOXIA KPM6XRUG960G
Drive size (GB)	960	960
Drive information	24 Gbps, SAS SSD	12 Gbps SAS SSD
Local storage (capacity)		
Number of drives	8	8
Drive vendor and model	KIOXIA KPM6XRUG960G	KIOXIA KPM6XRUG960G
Drive size (GB)	960	960
Drive information	24 Gbps, SAS SSD	12 Gbps SAS SSD

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Server configuration information	3x 16G Dell PowerEdge R7615	3x 15G Dell PowerEdge R7515
Network adapter 1		
Vendor and model	Broadcom® Gigabit Ethernet BCM5720	Broadcom Gigabit Ethernet BCM5720
Number and type of ports	2x 1Gb Ethernet	2x 1Gb Ethernet
Firmware version	22.20.8	22.31.6
Network adapter 2		
Vendor and model	Broadcom Adv. Dual 25Gb Ethernet	Broadcom Adv. Dual 25Gb Ethernet
Number and type of ports	2x 25Gbps	2x 25Gbps
Firmware version	22.21.06.80	22.31.13.70
Cooling fans		
Vendor and model	Dell	Dell
Number of cooling fans	12	6
Power supplies		
Vendor and model	Dell 06C11WA02	Dell 0W8R3CA02
Number of power supplies	2	1
Wattage of each (W)	1,400	750

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How we tested

Overview

For our testing, we deployed two remote Windows Server 2022 with Hyper-V using Storage Spaces Direct (S2D) clusters comprising three nodes and one supporting infrastructure server for each environment. Our 16G environment used three single-socket Dell PowerEdge R7615 servers while our 15G environment used three single-socket Dell PowerEdge R7515 servers. Both environments used Windows Server 2022 with Hyper-V and S2D. For each environment, we deployed an infrastructure server to support our infrastructure VMs: domain controller and workload clients. The infrastructure server for the 16G cluster was a PowerEdge R540 and the infrastructure server for the 15G cluster was a PowerEdge R6515. We ran the following on both clusters concurrently:

- An OLTP workload driven by DVD Store 3 (DS3). For more information about DVD Store 3, visit https://github.com/dvdstore/ds3.
- WordPress workload using Siege on Ubuntu
- A multi-tier web application supported by Hyper-V with Tanzu Kubernetes using VMware Weathervane 2.1. For more information about Weathervane 2.1, view the development blog at https://blogs.vmware.com/performance/2020/02/weathervane2-kubernetes.html and GitHub repository at https://github.com/vmware/weathervane.

Due to the differences in the R7515 and R7615 system design, we could not match the system memory capacities while also populating the DIMMs in each system in an optimized configuration. As a result, the R7615 servers contained a high RAM capacity. Because we aimed to keep the VM counts the same in each environment, we configured the 16G VMs with more RAM to take advantage of the addition RAM resources. For more information on our VM configurations, see the table below.

Table 3: Specifications for the VMs we used in our testing.

Workload VM number and type on each node	Number of vCPUs per VM	Memory per VM (MB)	Virtual hard disk number and size per VM
16G Dell PowerEdge R7615			
2x SQL Server	10	28,672	1x 140 GB OS 1x 140 GB DB 1x 40 GB log
1x Weathervane	16	61,440	1x 256 GB
2x WordPress	10	28,672	1x 48 GB
15G Dell PowerEdge R7515			
2x SQL Server	10	16,384	1x 140 GB OS 1x 140 GB DB 1x 40 GB log
1x Weathervane	16	40,960	2x 256 GB
2x WordPress	10	16,384	1x 48 GB

Setting up the infrastructure and the Windows test clusters

Installing the Active Directory Server VM

We installed and configured a VM with two vCPUs, 8 GB of RAM, and a 90GB VMDK on the private network to host Active Directory, DNS, DHCP, and NTP and to be a certificate authority. In addition, we configured a Microsoft Windows Server 2022 VM, installed updates, and created a template for use throughout the configuration process to quickly deploy the required infrastructure.

1. Log into the vSphere client as administrator@vsphere.local.
2. On the infra server, deploy a Windows Server VM from the template using the appropriate specs from Table 3, and log in as an administrator.
3. Launch Server Manager.
4. Click Manage→Add Roles and Features.
5. At the Before you begin screen, click Next.
6. At the Select installation type screen, leave Role-based or feature-based installation selected, and click Next.
7. At the Server Selection screen, select the server from the pool, and click Next.
8. At the Select Server Roles screen, select Active Directory Domain Services.

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9. When prompted, click Add Features, and click Next.
10. At the Select Features screen, click Next.
11. At the Active Directory Domain Services screen, click Next.
12. At the Confirm installation selections screen, check Restart the destination server automatically if required, and click Install.

Configuring Active Directory and DNS services on the Active Directory server

1. After the installation completes, a screen should pop up with configuration options. If a screen does not appear, in the upper-right section of Server Manager, click the Tasks flag.
2. Click Promote this server to a Domain Controller.
3. At the Deployment Configuration screen, select Add a new forest.
4. In the Root domain name field, type `test.local` and click Next.
5. At the Domain Controller Options screen, leave the default values, and enter a password twice.
6. Click Next four times to accept default settings for DNS, NetBIOS, and directory paths.
7. At the Review Options screen, click Next.
8. At the Prerequisites Check dialog, allow the check to complete.
9. If there are no relevant errors, check Restart the destination server automatically if required, and click Install.
10. When the server restarts, log on using test\Administrator and the password you chose in step 5.

Configuring the Windows time service on Active Directory server

1. To ensure reliable time, point your Active Directory server to a physical NTP server.
2. Open a command prompt.
3. Type the following:

```
w32tm /config /syncfromflags:manual /manualpeerlist:"<ip address of a NTP server>"
w32tm /config /reliable:yes
w32tm /config /update
w32tm /resync
net stop w32time
net start w32time
```

Setting up DHCP services on the Active Directory server

1. Open Server Manager.
2. Select Manage, and click Add Roles and Features.
3. Click Next twice.
4. At the Select server roles screen, select DHCP Server.
5. When prompted, click Add Features, and click Next.
6. At the Select Features screen, click Next.
7. Click Next.
8. Review your installation selections, and click Install.
9. Once the installation completes, click Complete DHCP configuration.
10. On the Description page, click Next.
11. On the Authorization page, use the Domain Controller credentials you set up previously (TEST\Administrator).
12. Click Commit.
13. On the Summary page, click Close, and click Close on the Add Roles and Features Wizard.
14. In Server Manager, click Tools→DHCP.
15. In the left pane, double-click your server, and click IPv4.
16. In the right pane, under IPv4, click More Actions, and select New Scope.
17. Click Next.
18. Enter a name and description for the scope, and click Next.
19. Enter the following values for the IP Address Range, then click Next.

    a. Start IP address: 172.16.10.1

    b. End IP address: 172.16.100.254

    c. Length: 24

    d. Subnet mask: 255.255.0.0

20. At the Add Exclusions and Delay page, leave defaults, and click Next.

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21. Set the Lease Duration, and click Next. We used 30 days.
22. At the Configure DHCP Options page, leave Yes selected, and click Next.
23. At the Router (Default Gateway) page, leave the fields blank, and click Next.
24. At the Specify IPv4 DNS Settings screen, type `test.local` for the parent domain.
25. Type the preferred DNS server IPv4 address, and click Next.
26. At the WINS Server page, leave the fields empty, and click Next.
27. At the Activate Scope page, leave Yes checked, and click Next.
28. Click Finish.

Installing and configuring SSL Certificate in Microsoft Active Directory on the Active Directory server

1. Log into the Active Directory server as administrator@test.local.
2. Open Server Manager.
3. Select Manage, and click Add Roles and Features.
4. When the Add Roles and Features Wizard begins, click Next.
5. Select Role-based or feature-based installation, and click Next.
6. Select the Active Directory FDQN, and click Next.
7. At the server roles menu, select Active Directory Certificate Services.
8. When prompted, click Add Features, and click Next.
9. Leave Select features as is, click Next.
10. At the Active Directory Certificate Services introduction page, click Next.
11. Select Certification Authority and Certification Authority Web Enrollment.
12. When prompted, click Add Features, and click Next.
13. Click Next two more times, click Install, and click Close.
14. In Server Manager, click the yellow triangle icon for Post-deployment configuration.
15. On the destination server, click Configure Active Directory Certificate Services.
16. Leave credentials as test\administrator, and click Next.
17. Select Certificate Authority and Certificate Authority Web Enrollment, and click Next.
18. Select Enterprise CA, and click Next.
19. Select Root CA, and click Next.
20. Select Create a new private key, and click Next.
21. Select SHA256 with a 2048 Key length, and click Next.
22. Leave the names fields and defaults, and click Next.
23. Change expiration to 10 years, and click Next.
24. Leave Certificate database locations as default. Click Next.
25. Click Configure.
26. When the configuration finishes, click Close.
27. Open a command prompt, and type `ldp`
28. Click Connection, connect.
29. Type the Active Directory FDQN for server.
30. Change the port to 636
31. Check SSL, and click OK.

Configuring secure LDAP on the Active Directory Server

1. Open administrative tools→Certification Authority.
2. Under the Active Directory server FQDN, right-click Certificate Templates, and select Manage. Right-click Kerberos Authentication, and select Duplicate Template.
3. Click Request Handling.
4. Check the box for Allow private key to be exported, and click OK.
5. Right-click the new template, and rename it LDAPoverSSL.
6. Return to the Certificates console. In the right pane, right-click New→Certificate Template to issue.
7. Select LDAPoverSSL, and click OK.

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Installing SQL 2019 Enterprise and Microsoft SQL Server Management Studio

1. On the infra server, deploy a Windows Server VM from the template using the appropriate specs from Table 7 for composer, and log in as an administrator.
2. Download en_sql_server_2019_enterprise_x64_dvd_5e1ecc6b, and open Setup.exe.
3. Select installation, and click New SQL Server stand-alone installation or add features to an existing installation.
4. In the SQL Server 2019 Setup, select Use Microsoft Update to check for updates, and click Next.
5. Enter a product key, and click Next.
6. Accept the License terms, and click Next.
7. For Feature Selection, select Database Engine Services, Full-Text and Semantic Extractions for key phrases, Client Tools Connectivity. Click the link to Download Reporting Services.
8. Click download for Microsoft SQL Server Reporting Services 2019.
9. Click SQLServerREportingServices.exe.
10. Click Install Reporting Services.
11. Leave the default free edition, and click Next.
12. Accept the license terms, and click Next.
13. Select Install Reporting Services only, and click Next.
14. Leave the defaults for Install location, and click Install.
15. Once the process completes, click Close.
16. Return to the SQL Server 2019 Setup wizard, and click Next.
17. On the Instance Configuration screen, leave the default instance, and click Next.
18. On the Server Configuration screen, change the Startup Types to Automatic. Click Next.
19. On the Server Configuration screen, select Mixed Mode, add the current user, and enter a password for the sa account. Click Data Directories.
20. Change the Data root directory to the additional drive. Click Next.
21. Click Install. Once complete, click Close.

Configuring RDMA and Storage Spaces Direct

Configuring the OS9 Dell Network Switch for DCB (Data Center Bridging) and RoCE (RDMA over Converged Ethernet)

1. Enter the following commands on your SAN network switch:

```
#enable DCBX
switch# conf
switch(conf)#dcbx enable

#Turn on ETS
switch(config)#system qos
switch(config-sys-qos)# ets mode on

#Configure the qos-map to match the queues to the CoS values, 0(LAN), 4(iSCSI), and 5(RDMA)
switch(config)#qos-map traffic-class qmap
switch(config-qos-map)#queue 0 qos-group 0-3,6-7
switch(config-qos-map)#queue 5 qos-group 5
switch(config-qos-map)#queue 4 qos-group 4

# Start configuring the class maps to be used with all respective policy maps
switch(config)#class-map type queueing q0
switch(config-cmap-queuing)#match queue 0
switch(config-cmap-queuing)#exit
switch(config)#class-map type queuing q4
switch(config-cmap-queuing)#match queue 4
switch(config-cmap-queuing)#exit
switch(config)#class-map type queuing q5
switch(confg-cmap-queuing)#match queue 5
switch(config-cmap-queuing)#exit
switch(config)#class-map type network-qos iSCSI
switch(config-cmap-nqos)#match qos-group 4
switch(config-cmap-nqos)#exit
switch(config-cmap)#class-map type network-qos RoCEv1
switch(config-cmpa-nqos)#match qos-group 5
```

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```
#Start configuring the relevant policy maps which will use the class-maps defined in steps 3-4 and
self-generated class "class-trust".
switch(config)#policy-map type qos trust_dot1p
switch(config-pmap-qos)#class class-trust
switch(config-pmap-c-qos)#trust dot1p

#ETS policy map assign bandwidth percentage to each queue.
switch(config)#policy-map type queuing q1
switch(config-pmap-queuing)#class q0
switch(config-pmap-c-que)#bandwidth percent 10
switch(config-pmap-c-que)#exit
switch(config-pmap-queuing)#class q4
switch(config-pmap-c-que)#bandwidth percent 40
switch(config-pmap-c-que)#exit
switch(config-pmap-queuing)#class q5
switch(config-pmap-c-que)#bandwidth percent 50

#PFC policy turning pfc "ON" on CoS 4 and 5 or iSCSI and RDMA flows respectively.
switch(config)#policy-map type network-qos PFC_ON
switch(config-pmap-network-qos)#class iSCSI
switch(config-pmap-c-nqos)#pause
switch(config-pmap-c-nqos)#pfc-cos 4
switch(config-pmap-c-nqos)#exit
switch(config-pmap-network-qos)#class RoCEv1
switch(config-pmap-c-nqos)#pause
switch(config-pmap-c-nqos)#pfc-cos 5

#Apply policy maps to interfaces
switch(config-if-eth1/1/5)#switchport mode trunk
switch(config-if-eth1/1/5)#switchport trunk allowed vlan 100,200,300
switch(config-if-eth1/1/5)#service-policy input type network-qos PFC
switch(config-if-eth1/1/5)#service-policy input type qos trust_dot1p
switch(config-if-eth1/1/5)#service-policy output type queuing q1

#Applying ETS on output queues
switch(config-if-eth1/1/5)#ets mode on Turns "ON" ETS
switch(config-if-eth1/1/5)#qos-map traffic-class qmap
switch(config-if-eth1/1/5)#priority-flow-control mode on
```

2. Use the following configuration for each network port used for SAN:

```
interface ethernet1/1/1:1
no shutdown
switchport mode trunk
switchport access vlan 1
switchport trunk allowed vlan 101-102
flowcontrol receive off
priority-flow-control mode on
service-policy input type network-qos policy_RoCE
service-policy output type queuing policy_q1
ets mode on
qos-map traffic-class Q1
trust-map dot1p default
```

3. Enter the final command:

```
copy-running-config startup-config
```

Installing the required roles and features for Storage Spaces Direct

1. Make sure RDMA is enabled on all NIC ports through the BIOS settings.
2. As the domain administrator, open a PowerShell window on each cluster node.
3. Run the following command:

```
Install-WindowsFeature –Name "Data-Center-Bridging","Failover-Clustering","Hyper-V","RSAT-
Clustering-PowerShell","Hyper-V-Powershell","File-Services" -IncludeManagementTools
```

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4. Rename the pNIC to "NIC1" in each host. This optional step makes it possible to reuse the PowerShell cmdlets below as shown.

```
PS> Rename-NetAdapter 'SLOT 3 Port 1' NIC1
```

5. Check that the name change took effect:

```
PS> Get-NetAdapter
Name InterfaceDescription     ifIndex Status MacAddress          LinkSpeed
---- --------------------     ------- ------ ----------          ---------
NIC1 Chelsio Network Adapter        3 Up     00-07-43-2D-D6-D8   40 Gbps
```

Configuring the cluster nodes for RoCE

1. As the domain administrator, on each cluster node open a PowerShell ISE window as Administrator.
2. Beside Script, click the down arrowhead "v" to expand the script pane.
3. Edit the following script, and replace "NIC1" with the adapter name for port 1 of your RoCE Network adapter.
4. Paste in the following script:

```
Remove-NetQosPolicy -Confirm:$False
New-NetQosPolicy "Cluster" -Cluster -PriorityValue8021Action 7
New-NetQosTrafficClass "Cluster" -Priority 7 -BandwidthPercentage 1 -Algorithm ETS
Set-NetQosDcbxSetting -InterfaceAlias "NIC2" -Willing $false
New-NetQosPolicy "SMB" -NetDirectPortMatchCondition 445 -PriorityValue8021Action 5
Enable-NetQosFlowControl -Priority 5
New-NetQosTrafficClass "SMB" -priority 5 -bandwidthpercentage 95 -algorithm ETS
Enable-NetAdapterQos -InterfaceAlias "NIC2"
New-NetQosPolicy "DEFAULT" -Default -PriorityValue8021Action 0
Disable-NetQosFlowControl 0,1,2,3,4,6,7
```

5. To run the script, click the green play button.
6. At the Confirmation window, click Yes. The script will configure DCB to match the DCB configuration on your switch.
7. After any reboot, always re-run this script to make sure the adapters are set up for properly for RoCE.

Configuring the VM switch and adapters

1. As the domain administrator, on each cluster node, open a PowerShell ISE window as Administrator.
2. Edit the following script to make the following replacements:
   a. Replace "NIC1" with the adapter name for port 1 of your RoCE Network adapter.
   b. Replace the IP addresses with the appropriate IP addresses for your system.

```
New-VMSwitch -Name SetSwitch -NetAdapterName "NIC1" -AllowManagementOS $true
-EnableEmbeddedTeaming $true
Rename-VMNetworkAdapter -ManagementOS -NewName Mgmt
Add-VMNetworkAdapter -ManagementOS -VMNetworkAdapterName SMB_1
remove-netipaddress -InterfaceAlias "vEthernet (Mgmt)" -IPAddress <insert IP address>
-PrefixLength 24
New-NetIPAddress -InterfaceAlias "vEthernet (Mgmt)" -IPAddress 192.168.1.20 -PrefixLength 24
New-NetIPAddress -InterfaceAlias "vEthernet (SMB_1)" -IPAddress 192.168.1.10 -PrefixLength 24
set-vmnetworkadaptervlan -ManagementOS -Access -VlanID 101 -VMNetworkAdapterName SMB_1
set-vmNetworkAdapter -ManagementOS -Name "SMB_1" -IeeePriorityTag on
Get-NetAdapterRdma "vEthernet (SMB_1)"
Enable-NetAdapterRdma "vEthernet (SMB_1)"
Set-VMNetworkAdapterTeamMapping -ManagementOS -VMNetworkAdapterName SMB_1
-PhysicalNetAdapterName "NIC1"
```

3. At the Confirmation window, click Yes. The script configures the SETswitch for use by Storage Spaces Direct.
4. Set up a third vSwitch to use your non-RoCE adapter that has access to the main network. Configure the adapter for DHCP on VLAN 0.
5. In the blue PowerShell pane, type the following command, replacing "NIC1" with the name of your network connected NIC (not your RDMA) NIC:

```
New-VMSwitch -Name Internet -NetAdapterName Embedded NIC1 -AllowManagementOS $true
```

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Using one node to create the Storage Spaces Direct cluster storage

1. Prepare the data drives for Storage Spaces Direct (ensure the drives contain no important data before running this script):

```
# Fill in these variables with your values
$ServerList = "Server01", "Server02", "Server03", "Server04"

Invoke-Command ($ServerList) {
    Update-StorageProviderCache
    Get-StoragePool | ? IsPrimordial -eq $false | Set-StoragePool -IsReadOnly:$false -ErrorAction
SilentlyContinue
    Get-StoragePool | ? IsPrimordial -eq $false | Get-VirtualDisk | Remove-VirtualDisk
-Confirm:$false -ErrorAction SilentlyContinue
    Get-StoragePool | ? IsPrimordial -eq $false | Remove-StoragePool -Confirm:$false -ErrorAction
SilentlyContinue
    Get-PhysicalDisk | Reset-PhysicalDisk -ErrorAction SilentlyContinue
    Get-Disk | ? Number -ne $null | ? IsBoot -ne $true | ? IsSystem -ne $true | ?
PartitionStyle -ne RAW | % {
        $_ | Set-Disk -isoffline:$false
        $_ | Set-Disk -isreadonly:$false
        $_ | Clear-Disk -RemoveData -RemoveOEM -Confirm:$false
        $_ | Set-Disk -isreadonly:$true
        $_ | Set-Disk -isoffline:$true
    }
    Get-Disk | Where Number -Ne $Null | Where IsBoot -Ne $True | Where IsSystem -Ne $True | Where
PartitionStyle -Eq RAW | Group -NoElement -Property FriendlyName
} | Sort -Property PsComputerName, Count
```

2. Choose one node on each cluster, and run the cluster validation tool on it.
3. As the domain administrator, open a PowerShell window.
4. Run the following command:

```
Test-Cluster –Node S2D-Node01, S2D-Node02, S2D-Node03 –Include 'Storage Spaces Direct', 'Inventory',
'Network', System Configuration'
```

5. The PowerShell window displays the location of the generated cluster validation report. Open the cluster validation report, and ensure no failures have taken place.
6. Verify that any warnings in the report are negligible, or correct the warnings before deployment.
7. Deploy the failover cluster, replacing the IP address, cluster name, and node names with the appropriate values for your network:

```
New-Cluster -Name "S2DCluster" –Node "S2D-Node1","S2D-Node2","S2D-Node3" -NoStorage -StaticAddress
<Cluster IP Address>
```

8. To enable Storage Spaces Direct on the failover cluster, enter the command below for your cluster hardware:

```
Enable-ClusterStorageSpacesDirect
```

9. To create three volumes on the failover cluster, enter the commands below for your cluster hardware:

```
New-Volume -StoragePoolFriendlyName "S2D on S2DCluster" -FriendlyName Volume1 -Size 2000GB
New-Volume -StoragePoolFriendlyName "S2D on S2DCluster" -FriendlyName Volume2 -Size 2000GB
New-Volume -StoragePoolFriendlyName "S2D on S2DCluster" -FriendlyName Volume3 -Size 2000GB
```

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Testing transactional database performance with DVD Store 3

We used the following steps to configure the test VMs for DVD Store 3. We deployed six VMs in each environment with the following settings:

- 10 vCPUs
- 28,672 MB of RAM for 16G cluster and 16,384 MB of RAM for 15G cluster
- 1 x 140GB VHD for the OS
- 1 x 140GB VHD for SQL Data on a separate SCSI controller
- 1 x 40GB VHD for SQL Logs on a separate SCSI controller
- 1 virtual adapter on the private network

Installing Microsoft Windows Server 2022 Datacenter Edition

1. Boot the VM to a Microsoft Windows Server 2022 installation ISO.
2. Click Install.
3. When prompted to Activate Windows, indicate that you don't have a product key.
4. Select Windows Server Datacenter (Desktop Experience), and click Next.
5. Click the box to accept the license terms, and click Next.
6. Select Custom: Install Windows only (advanced), and click Next.
7. After the server reboots, enter a password for the Administrator account, and click Finish.
8. Log into the Administrator account.
9. For the networks question, click Yes.
10. In the Server Manager application, click Local Server.
11. Click Computer Name, and change it to the desired name.
12. When Server Manager starts, on the toolbar, select Manage, and select Server Manager Properties.
13. Check the box to not start Server Manager automatically at logon, and click OK.
14. On the Server Manager application, click Local Server.
15. On the Windows Defender Firewall line, click Public: Off, and turn off the Domain, Private, and Public firewalls.
16. On the Remote Desktop line, click Disabled, and on the pop-up, click Allow remote connections. Click OK.
17. On the Feedback & Diagnostics line, click Settings, set the Feedback drop-down to Never, set the View Diagnostic data to On, and close the Settings window.
18. On the IE Enhanced Security Configuration line, click On, turn it off for both Administrators and Users, and click OK.
19. Select your desired time zone.
20. On the Windows Defender line, click Real-Time Protection: On, turn all options off, and close the Settings window.
21. Close the Server Manager application.
22. Open the Settings window, and select Update & Security.
23. Click Check for updates. The VM downloads and applies patches. This is usually a long process.
24. Restart if necessary, and continue applying patches until no more are available.
25. Navigate to the Services application, set the Windows Update service to Disabled, and turn it off.

Installing SQL Server 2019

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 check box, 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.

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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 Install SQL Server Management Tools.
19. Click Download SQL Server Management Studio.
20. Click Run.
21. When the Microsoft SQL Server Management Studio screen appears, click Install.
22. When the installation completes, click Close.

Configuring and running DVD Store 3

We generated the data using the Install.pl script included with DS3, providing the parameters for our 40GB database size and the database platform we used. We ran the Install.pl script on a utility system running Windows Server 2016 to generate the database schema. After processing the data generation, we built the 40GB database in Microsoft SQL Server and performed a full backup, storing the backup file locally on each test VM. We used that backup file to restore the database when necessary. The only modifications 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. Generate the data and create the database and file structure using database creation scripts in the DS3 download. Make size modifications specific to our 40GB database, and make the appropriate changes to drive letters.

1. Create database tables, stored procedures, and objects using the provided DVD Store scripts.
2. Set the database recovery model to bulk-logged to prevent excess logging.
3. Load the data we 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.
4. Create indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
5. Update statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
6. On the SQL Server instance, create a ds3user SQL Server login using the following Transact SQL (TSQL) script (other than this file size modification, we created and loaded the database in accordance with DVD Store documentation):

```
USE [master]
GO
CREATE LOGIN [ds3user] WITH PASSWORD=N'',
DEFAULT_DATABASE=[master],
DEFAULT_LANGUAGE=[us_english],
CHECK_EXPIRATION=OFF,
CHECK_POLICY=OFF
GO
EXEC master..sp_addsrvrolemember @loginame = N'ds3user',
@rolename = N'sysadmin'
USE [DS3]
CREATE USER [ds3DS3user] FOR LOGIN [ds3user]
EXEC sp_addrolemember N'db_owner', N'ds3DS3user'
USE [master]
CREATE USER [ds3masteruser] FOR LOGIN [ds3user]
EXEC sp_addrolemember N'db_owner', N'ds3masteruser'
```

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

Running the DVD Store 3 tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle from a controller Windows Server VM on our infrastructure server. Additionally, we used six Windows Server VMs on our infrastructure sever as clients to run the DVD Store 3 driver remotely. DVD Store outputs an orders-per-minute (OPM) metric, which is a running average calculated through the test. In this report, we report the last OPM that each target reported.

Each complete test cycle consisted of these general steps:

1. Clean up prior outputs from the target system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Reboot the target.

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5. Wait for a ping response from the server under test and the client system.
6. Let the test server idle for 10 minutes.
7. 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=0.00 --detailed_view=Y --warmup_time=24 --report_rate=1 --pct_newcustomers=20
--csv_output=<drivepath>
```

Testing Kubernetes performance with Weathervane 2.1

We created a Tanzu Community Edition (TCE) cluster in an Ubuntu VM. The cluster used Docker containers as cluster nodes. We deployed the Weathervane containers on the TCE cluster and ran the Weathervane workload with fixed number of simulated users (WvUsers). We captured operations per seconds (OPS) and response time (RT) for each run.

Installing Ubuntu 22.04

1. Create a new Hyper-V VM with the following attributes:

   - 16 vCPU
   - 61,440 MB of memory for 16G cluster, 40,960 of memory for 15G cluster
   - 256GB VHD

2. Attach the Ubuntu 22.04 installation ISO to the VM.
3. Connect to the VM console, and power on the VM.
4. Select Install Ubuntu 22.04, and press Enter.
5. Select the desired language, and press Enter.
6. Select the desired keyboard layout, and press Enter.
7. At the Network Connections screen, give the network adapter a private IP address, and press Enter.
8. At the Configure Proxy screen, leave the defaults, and press Enter.
9. At the Mirror Address screen, leave the defaults, and press Enter.
10. At the Installer Update screen, select Update to the new installer, and allow the update to complete.
11. At the Guided Storage Configuration screen, select Use the entire disk, and press Enter.
12. Enter a hostname, username, password, and press Enter.
13. Select Install OpenSSH server, and press Enter.
14. At the package selection screen, leave the defaults, and press Enter.
15. Allow the operating system to install and reboot the VM.

Installing Docker on Ubuntu 22.04

1. Update the apt package and install packages to allow apt to use a repository over HTTPS:

```
sudo apt-get update
sudo apt-get install ca-certificates curl gnupg lsb-release
```

2. Add Docker's official GPG key:

```
sudo mkdir -m 0755 -p /etc/apt/keyrings
curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /etc/apt/
keyrings/docker.gpg
```

3. Set up Docker repository:

```
echo   "deb [arch=$(dpkg --print-architecture) signed-by=/etc/apt/keyrings/docker.gpg] https://
download.docker.com/linux/ubuntu $(lsb_release -cs) stable" | sudo tee /etc/apt/sources.list.d/
docker.list > /dev/null
```

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4. Install Docker engine:

```
sudo apt-get update
sudo apt-get install docker-ce docker-ce-cli containerd.io docker-buildx-plugin
docker-compose-plugin
```

5. Verify Docker is running:

```
sudo systemctl status docker
```

6. Assign current user to docker group

```
sudo usermod -a -G docker pt
```

Installing Tanzu Community Edition (TCE) and kubectl on Ubuntu 22.04

1. Install kubectl:

```
sudo snap install kubectl --classic
```

2. Download Tanzu Community Edition for Linux from https://github.com/vmware-tanzu/community-edition/releases/tag/v0.12.1
3. Unzip the tar file:

```
tar -xvf tce-linux-amd64-v0.12.1.tar
```

4. Install TCE:

```
cd tce-linux-amd64-v0.12.1/
./install.sh
```

Creating a workload cluster on Tanzu

1. Create a workload cluster with 4 worker nodes:

```
tanzu uc create tce --worker-node-count 4
```

2. Verify all nodes and pods are ready and running:

```
kubectl get nodes
kubectl get pods -all-namesapces
```

Installing and running a Weathervane test

1. Download Weathervane from GitHub:

```
git clone https://github.com/vmware/weathervane
```

2. Build Docker images for the Weathervane components and upload them to Docker Hub

```
./buildDockerImages.pl --username <Docker Hub username>
```

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3. Create a weathervane config file with the following content:

```
{
  "description" : "xsmall",
  "configurationSize": "xsmall",
      "runStrategy" : "fixed",
      "numQosPeriods" : "6",
      "users" : "2500",
      "dockerNamespace" : "<Docker Hub Username>",
  "kubernetesClusters" : [
    {
      "name" : "appCluster",
      "kubeconfigFile" : "/home/pt/.config/tanzu/tkg/unmanaged/tce/kube.conf",
      "kubeconfigContext" : "kind-tce",
    },
    {
      "name" : "driverCluster",
      "kubeconfigFile" : "/home/pt/.config/tanzu/tkg/unmanaged/tce/kube.conf",
      "kubeconfigContext" : "kind-tce",
    },
  ],

  "driverCluster" : "driverCluster",
      "appInstanceCluster" : "appCluster",
  "appIngressMethod" : "nodeport-internal",

      "cassandraDataStorageClass" : "standard",
  "postgresqlStorageClass" : "standard",
  "nginxCacheStorageClass" : "standard",
}
```

4. Run a Weathervane test:

```
./runWeathervane.pl --configFile=weathervane.config.k8s.my --skipPvTest
```

Installing and configuring WordPress

Installing Ubuntu 22.04

1. Create a new Hyper-V VM with the following attributes:

    - 10 vCPU
    - 28,672 MB of memory for 16G cluster and 16,384 MB of memory for 15G cluster
    - 48 GB VHD

2. Attach the Ubuntu 22.04 installation ISO to the VM.
3. Connect to the VM console, and power on the VM.
4. Select Install Ubuntu 22.04, and press Enter.
5. Select the desired language, and press Enter.
6. Select the desired keyboard layout, and press Enter.
7. At the Network Connections screen, give the network adapter a private IP address, and press Enter.
8. At the Configure Proxy screen, leave the defaults and press Enter.
9. At the Mirror Address screen, leave the defaults and press Enter.
10. At the Installer Update screen, select Update to the new installer, and allow the update to complete.
11. At the Guided Storage Configuration screen, select Use the entire disk, and press Enter.
12. Enter a hostname, username, password, and press Enter.
13. Select Install OpenSSH server, and press Enter.
14. At the package selection screen, leave the defaults, and press Enter.
15. Allow the operating system to install, and reboot the VM.

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Installing WordPress

1. SSH to the Ubuntu 22.04 VM.
2. Update the system:

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

3. Disable the firewall:

```
sudo ufw disable
```

4. Install the prerequisite packages:

```
sudo apt install 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
```

5. Install WordPress:

```
sudo mkdir -p /srv/www
sudo chown www-data: /srv/www
curl https://wordpress.org/latest.tar.gz | sudo -u www-data tar zx -C /srv/www
```

6. Create /etc/apache2/sites-available/wordpress.conf with the following contents:

```
<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>
```

7. Enable the site, enable URL rewriting, and disable the default site:

```
sudo a2ensite wordpress
sudo a2enmod rewrite
sudo a2dissite 000-default
```

8. Reload Apache2:

```
sudo service apache2 reload
```

9. Configure the database:

```
sudo mysql -u root
mysql> CREATE DATABASE wordpress;
mysql> CREATE USER wordpress@localhost IDENTIFIED BY '<password>';
mysql> GRANT ALL ON wordpress.* TO wordpress@localhost;
mysql> FLUSH PRIVILEGES;
mysql> quit
```

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10. Start MySQL:

```
sudo service mysql start
```

11. Copy the sample configuration file:

```
sudo -u www-data cp /srv/www/wordpress/wp-config-sample.php /srv/www/wordpress/wp-config.php
```

12. Set the database credentials in the configuration file:

```
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/<your-password>/' /srv/www/wordpress/wp-config.php
```

13. Use https://api.wordpress.org/secret-key/1.1/salt/ to replace the keys in the configuration file:

```
sudo -u www-data nano /srv/www/wordpress/wp-config.php
```

14. Shut down the VM, and copy the VHD to create additional VMs.
15. After cloning the VHD, update the local IP address in the WordPress database as follows:

```
sudo mysql -u root
mysql> USE wordpress;
mysql> UPDATE wp_options SET option_value='http://<new IP address>' \
WHERE option_name='siteurl';
mysql> UPDATE wp_options SET option_value='http://<new IP address>' WHERE option_name='home';
mysql> quit
```

Creating the client VM

1. Create a new Hyper-V VM on the client host with the following attributes:

   - 4 vCPU
   - 4,192 MB RAM
   - 48 GB VHD

2. Attach the Ubuntu 22.04 installation ISO to the VM.
3. Connect to the VM console, and power on the VM.
4. Select Install Ubuntu 22.04, and press Enter.
5. Select the desired language, and press Enter.
6. Select the desired keyboard layout, and press Enter.
7. At the Network Connections screen, give the network adapter a private IP address, and press Enter.
8. At the Configure Proxy screen, leave the defaults, and press Enter.
9. At the Mirror Address screen, leave the defaults, and press Enter.
10. At the Installer Update screen, select Update to the new installer, and allow the update to complete.
11. At the Guided Storage Configuration screen, select Use the entire disk, and press Enter.
12. Enter a hostname, username, password, and press Enter.
13. Select Install OpenSSH server, and press Enter.
14. At the package selection screen, leave the defaults and press Enter.
15. Allow the operating system to install and reboot the VM.

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Installing and running Siege

1. Log into the VM via SSH.
2. Update the system:

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

3. Disable the firewall:

```
sudo ufw disable
```

4. Install Siege:

```
sudo apt-get install siege
```

5. To run the workload, specify the target IP address and total run time:

```
siege -t 30M <target_ip_address>
```

Read the report at https://facts.pt/n5JdSGR ▶

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