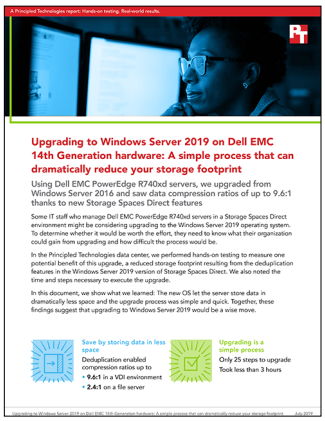


The science behind the report:

Upgrading to Windows Server 2019 on Dell EMC PowerEdge servers: A simple process that can dramatically reduce your storage footprint

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 Upgrading to Windows Server 2019 on Dell EMC PowerEdge servers: A simple process that can dramatically reduce your storage footprint.

We concluded our hands-on testing on July 9, 2019. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on July 7, 2019 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Our results

Deduplication testing

	Vdbench generation settings		Space used before deduplication (GB)	Space used after deduplication (GB)	Compression ratio
	Compression/ deduplication ratio	Block size			
File server 1 (ISO files)	N/A	N/A	764	312	2.4:1
File server 2 (Microsoft Office files)	N/A	N/A	304	158	1.9:1
VDI 1	2:1	8	1,044	273	3.8:1
VDI 2	4:1	16	1,044	121	8.6:1
Virtualized backup 1	4:1	4	1,044	119	8.8:1
Virtualized backup 2	2:1	4	1,044	300	3.5:1
Virtualized backup 3	4:1	64	1,044	106	9.8:1
Virtualized backup 4	2:1	64	1,044	279	3.7:1

Upgrade and live migration processes

	Number of steps	Time to complete
Upgrading from Microsoft® Windows Server® 2016 to Windows Server 2019	25	2 hours 46 minutes
Live migrating a VM to the newly created volume	7	1 hour 34 minutes

System configuration information

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

Server configuration information	Dell EMC™ PowerEdge™ R740xd
BIOS name and version	Dell 2.1.7
Operating system 1	
Operating system name and version/build number	Windows Server 2016
Date of last OS updates/patches applied	6/29/2019
Power management policy	Custom
Operating system 2	
Operating system name and version/build number	Windows Server 2019
Date of last OS updates/patches applied	7/5/2019
Power management policy	Custom
Processor	
Number of processors	2
Vendor and model	Intel® Xeon® Gold 6130
Core count (per processor)	16
Core frequency (GHz)	2.10
Stepping	4
Memory module(s)	
Total memory in system (GB)	192
Number of memory modules	12
Vendor and model	Hynix® HMA82GR7AFR8N-VK
Size (GB)	16
Type	PC4-2666
Speed (MHz)	2,666
Speed running in the server (MHz)	2,666
Storage controller	
Vendor and model	Dell HBA 330 Mini
Cache size (GB)	0 MB
Firmware version	16.17.00.03
Local storage 1	
Number of drives	2
Drive vendor and model	Intel SSDSCKJB240G7R
Drive size (GB)	240
Drive information	m.2 SSD

Server configuration information	Dell EMC™ PowerEdge™ R740xd
Local storage 2	
Number of drives	4
Drive vendor and model	Toshiba® THNSF8800CCSE
Drive size (GB)	800
Drive information (speed, interface, type)	6 Gb/s, SATA, SSD
Local storage 3	
Number of drives	8
Drive vendor and model	Toshiba MG04ACA4
Drive size (GB)	4,096
Drive information (speed, interface, type)	6 Gb/s, 7.2K SATA, HDD
Network adapter	
Vendor and model	Mellanox ConnectX-4 LX 25GbE SFP
Number and type of ports	2 x 25GbE
Driver version	14.24.80.00
Cooling fans	
Vendor and model	Delta PFR0612DHE-C
Number of cooling fans	6
Power supplies	
Vendor and model	Dell 05RHVVA00
Number of power supplies	2
Wattage of each (W)	750

How we tested

Setting up the Microsoft Windows Server 2016 Storage Spaces Direct (S2D) cluster

Configuring the out-of-band management switch

We used a Dell S3048 1GbE switch for our out-of-band management of the S2D cluster. We configured four ports with the appropriate VLAN for our S2D iDRAC connections. We also configured one port for our Microsoft Active Directory (AD) and S2D management VMs, and another port to connect our OOB switch to the TOR switch. See our switch configuration in the Vdbench configuration files section.

Configuring the top-of-rack switch

We used a Dell S5048 25GbE switch for our cluster networking traffic. We placed all cluster-facing ports into hybrid mode, enabled Data-Center-Bridging, and enabled Priority Flow Control on all ports. See our switch configuration in the Vdbench configuration files section.

Configuring the infrastructure VM

We used Windows Server 2016 VM as our Active Directory and DNS server. On this VM, we added the Active Directory Domain Service and the DNS Server roles, and created a new domain for our test cluster.

Configuring the S2D cluster nodes

We used four Dell EMC PowerEdge R740xd servers for our test cluster. We configured the iDRAC and BIOS on each server to match the pre-deployment checklist provided by Dell EMC in the Ready Node deployment guide. We first installed Windows Server 2016 Datacenter Edition onto a 240GB virtual disk, consisting of two m.2 SSDs in a RAID 1 pair, separate from the drives designated for cluster storage. We then created a SET switch, configured the network adapters with IP addresses, and joined each server to the domain. Finally, we ran the network and storage commands to enable RDMA and Storage Spaces Direct. We chose the manual deployment method, and performed the following steps for each server:

Installing Windows Server 2016

1. Boot the server to the Windows Server 2016 installation media. We used the BMC console virtual media to mount the ISO image and install remotely.
2. At the prompt, press any key to boot from the CD/DVD location.
3. Click Next.
4. Click Install Now.
5. Select Windows Server 2016 Datacenter Edition (Desktop Experience), and click Next.
6. Check I accept the license terms, and click Next.
7. Select the 240GB OS drive, and click Next.
8. After installation, enter a password for Administrator, and click Finish.

Installing server roles and features

1. Open a PowerShell window as the domain administrator and run the following command to install the required roles and features for Storage Spaces Direct:

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

Changing the host name

1. In the open PowerShell window, run the following command to change the hostname and restart the server.

```
Rename-Computer -NewName S2D-Node01 -Restart
```

Configuring the VM switch and adapters

1. Open a PowerShell window as the domain administrator and run the following commands to create and configure the VM switch and adapters:

```
New-VMSwitch -Name S2DSwitch -AllowManagementOS $true -NetAdapterName 'SLOT 4 PORT 1','SLOT 4 PORT 2' -MinimumBandwidthMode Weight -Verbose

Add-VMNetworkAdapter -ManagementOS -Name 'Management' -SwitchName S2DSwitch -Passthru | Set-VMNetworkAdapterVLan -Access -VlanID 100 -Verbose

Add-VMNetworkAdapter -ManagementOS -Name 'Storage1' -SwitchName S2DSwitch -Passthru | Set-VMNetworkAdapterVLan -Access -VlanID 101 -Verbose
```

```
Add-VMNetworkAdapter -ManagementOS -Name 'Storage2' -SwitchName S2DSwitch -Passthru | Set-
VMNetworkAdapterVLan -Access -VlanID 102 -Verbose

Rename-NetAdapter "*Management*" Management

Rename-NetAdapter "*Storage1*" Storage1

Rename-NetAdapter "*Storage2*" Storage2

New-NetIPAddress -InterfaceAlias Management -IPAddress 192.168.100.1 -PrefixLength 24 -AddressFamily
IPv4 -Verbose

Set-DNsClientServerAddress -InterfaceAlias Management -ServerAddresses 192.168.100.10

New-NetIPAddress -InterfaceAlias Storage1 -IPAddress 192.168.101.1 -PrefixLength 24 -AddressFamily
IPv4 -Verbose

New-NetIPAddress -InterfaceAlias Storage2 -IPAddress 192.168.102.1 -PrefixLength 24 -AddressFamily
IPv4 -Verbose
```

Joining the Active Directory domain

1. Open a PowerShell window as the domain administrator and run the following command to join the Active Directory domain:

```
$credential = Get-Credential
Add-Computer -DomainName test.local -Credential $credential -Restart
```

Configuring the network adapters for RDMA

1. Open a PowerShell window as the domain administrator.
2. To enable RDMA on the virtual adapters, run the following command:

```
Enable-NetAdapterRDMA -Name Storage1, Storage2
```

3. To map the virtual adapters to the physical ports, run the following commands:

```
Set-VMNetworkAdapterTeamMapping -VMNetworkAdapterName "Storage1" -ManagementOS
-PhysicalNetAdapterName "SLOT 4 PORT 1"
Set-VMNetworkAdapterTeamMapping -VMNetworkAdapterName "Storage2" -ManagementOS
-PhysicalNetAdapterName "SLOT 4 PORT 2"
```

4. To enable RDMA for Live Migration Traffic, run the following command:

```
Set-VMHost -VirtualMachineMigrationPerformanceOption SMB
```

5. To set a network QoS policy, run the following commands:

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

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

New-NetQosPolicy -Name 'SMB' -NetDirectPortMatchCondition 445 -PriorityValue8021Action 3

New-NetQosTrafficClass -Name 'SMB' -Priority 3 -BandwidthPercentage 50 -Algorithm ETS

New-NetQosPolicy -Name "Default" -Default -PriorityValue8021Action 0

Enable-NetQosFlowControl -Priority 3

Disable-NetQosFlowControl -Priority 0,1,2,4,5,6,7

Enable-NetAdapterQos -InterfaceAlias 'SLOT 4 PORT 1','SLOT 4 PORT 2'

Set-NetQosDcbxSetting -Willing $false
```

Running the cluster validation tool

1. Open a PowerShell window as the domain administrator.
2. To validate the cluster configuration, run the following command:

```
Test-Cluster -Node S2D-Node01, S2D-Node02, S2D-Node03, S2D-Node04 -Include 'Storage Spaces Direct',
'Inventory', 'Network', 'System Configuration'
```

3. Open the cluster validation report, and ensure there are no failures. If there are warnings in the report, verify that they are negligible, or correct the warnings before deployment.

Deploying the S2D cluster

1. Open a PowerShell window as the domain administrator.
2. Run the following command to create a new Storage Spaces Direct cluster without storage (we will add storage later):

```
New-Cluster -Name S2DSystem -Node S2D-Node01, S2D-Node02, S2D-Node03, S2D-Node04 -StaticAddress
192.168.100.6/24 -NoStorage -IgnoreNetwork 192.168.101.0/24, 192.168.102.0/24 -Verbose
```

Enabling the S2D cluster

1. Open a PowerShell window as the domain administrator and run the following command:

```
Enable-ClusterStorageSpacesDirect
```

Removing the host management network from Live Migration

1. Open a PowerShell window as the domain administrator and run the following commands:

```
$clusterResourceType = Get-ClusterResourceType -Name 'Virtual Machine'

$hostNetworkID = Get-ClusterNetwork | Where-Object { $_.Address -eq '192.168.100.0' } | Select
-ExpandProperty ID

Set-ClusterParameter -InputObject $clusterResourceType -Name MigrationExcludeNetworks -Value
$hostNetworkID
```

Updating Hardware timeout for Spaces port

1. Open a PowerShell window as the domain administrator and run the following commands:

```
Set-ItemProperty -Path HKLM:\SYSTEM\CURRENTCONTROLSET\SERVICES\spaceport\Parameters -Name HwTimeout
-Value 0x00002710 -Verbose
```

Updating the firmware, driver, and OS

1. Open a PowerShell window as the domain administrator and run the following commands to see what driver and firmware versions you have:

```
Get-PnpDevice | Select-Object Name, @{l='DriverVersion' ;e={(Get-PnpDeviceProperty -InstanceID
$_.InstanceID -KeyName 'DEVPKEY_Device_DriverVersion').Data}} -Unique
```

2. Go to support.dell.com and download the latest drivers and firmware, making sure that it's at least the minimum supported in the matrix.
3. Open a PowerShell window as the domain administrator and run the following command on the first node:

```
Suspend-Node -Drain
```

4. Run the following command to check and make sure the node is paused:

```
Get-ClusterNode
```

5. Update the node and restart.
6. Repeat steps 3 through 5 on the remaining three nodes.

Testing procedure

After the initial cluster setup, we started by creating eight CSVS_ReFS Mirror-Accelerated Parity (MAP) volumes on our Windows Server 2016 Storage Spaces Direct cluster. We then created eight VMs for our testing, and put one VM on each S2D MAP volume.

For our VMs, we created six with CentOS 7 and used Vdbench to generate datasets that the system could compress and deduplicate. For each of the six VMs we used a different block size, compression ratio, and deduplication ratio to generate these data sets. We also created two VMs with Windows Server 2016 to represent general purpose fileservers. We copied ~744 GB of ISO files onto the first fileserver, and ~284GB of Microsoft Office files, PDF files, executables, and other common files to the second fileserver.

Windows Server 2016 does not have the deduplication feature available for Storage Spaces Direct, so that formed our baseline storage usage. After we upgraded the Storage Spaces Direct cluster to Windows Server 2019, we recreated the same eight CSVS_ReFS volumes and migrated each VM over to the newly created volumes. We then enabled deduplication on each volume and let the background deduplication process run.

Creating the MAP volumes

1. Open a PowerShell window on any of the nodes and run the following command:

   ```
   New-Volume -FriendlyName "Volume" -FileSystem CSVFS_ReFS -StorageTierFriendlyNames Performance,
   Capacity -StorageTierSizes 1TB, 4TB
   ```

2. Repeat step 1 for each VM. We used eight MAP volumes in our testing, one for each VM.

Creating the Vdbench and fileserver VMs

1. Run the following command in PowerShell to create a new VM:

   ```
   New-VM -Name <vmname> -Path <Path-to-folder> -NoVHD -Generation 2 -MemoryStartupBytes 32GB
   -SwitchName S2DSwitch
   ```

2. Open the Hyper-V Manager GUI.
3. On the newly created VM, right-click, and select Settings…
4. We configured our VM with the following settings:
   a. 8 vCPUs
   b. 32GB RAM
   c. New Hard Disk: 50GB Fixed VHDX (OS)
   d. New Hard Disk: 1TB Fixed VHDX (Data)
   e. DVD Drive
5. In the DVD Drive tab, click Image file, and navigate to the location of the CentOS 7 ISO for Vdbench VMs, or Windows Server 2016 ISO for fileserver VMs.
6. Change the boot order to boot from the newly added ISO.
7. Click Apply.
8. Click OK.

Installing CentOS 7 on the Vdbench VMs

1. Boot the VM from the CentOS 7 ISO.
2. Select English, and click Next.
3. Select automatic partitioning for the disk.
4. Choose Minimal Install.
5. Disable kdump.
6. Enable the first active network port and configure it. For example, assign static IP address of 192.168.100.1/16 with gateway of 192.168.0.1, and DNS server of 192.168.0.10.
7. Set the hostname.
8. Set the time zone to Eastern/US; enable NTP to sync from your time server if applicable.
9. Click Install.
10. Set the root password.
11. Reboot when the install has finished.

Installing Windows Server 2016 on the fileserver VMs

1. Power on the VM.
2. At the prompt, press any key to boot from the CD/DVD location.
3. Click Next.
4. Click Install Now.

5. Select Windows Server 2016 Datacenter Edition, and click Next.
6. Check I accept the license terms, and click Next.
7. Select the OS VHD, and click Next.
8. After installation, enter a password for Administrator, and click Finish.
9. Run Windows Updates, and reboot when prompted.

Producing the Vdbench dataset

1. Log on to the CentOS VM as root.
2. Set SELINUX to disabled in the following config file:

   ```
   vi /etc/selinux/config
   ```

3. Disable the firewall:

   ```
   systemctl disable firewalld
   systemctl stop firewalld
   ```

4. Install Java:

   ```
   yum install java
   ```

5. Download and copy vdbench 5.04.07 zip to the home folder.
6. Unzip vdbench.
7. Update the OS:

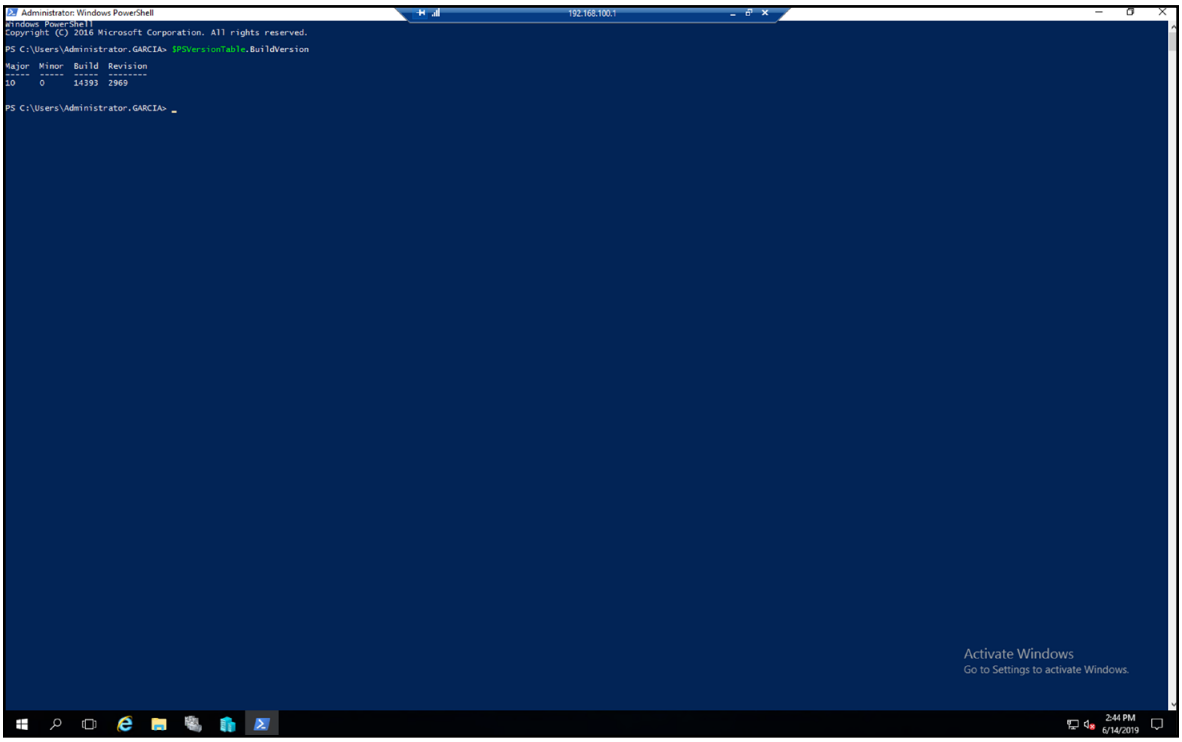
   ```
   yum update -y
   ```

8. Reboot.
9. Log on as root.
10. Navigate to the vdbench folder you unzipped in step 6.
11. Run the Vdbench job to create the dataset:

    ```
    ./vdbench -f <config_filename>.cfg -o <config_filename>_out
    ```

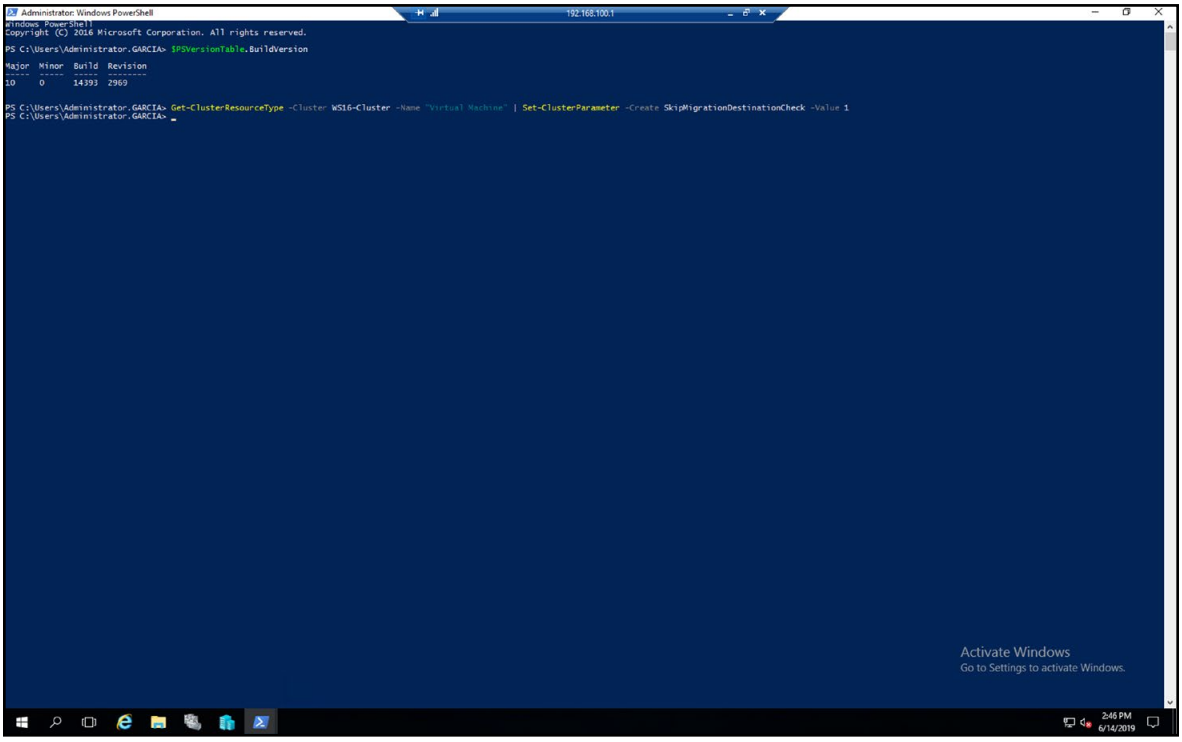
Upgrading from Windows Server 2016 to Windows Server 2019

1. Check that the servers are running version 14393.2828 or newer of Windows Server 2016.



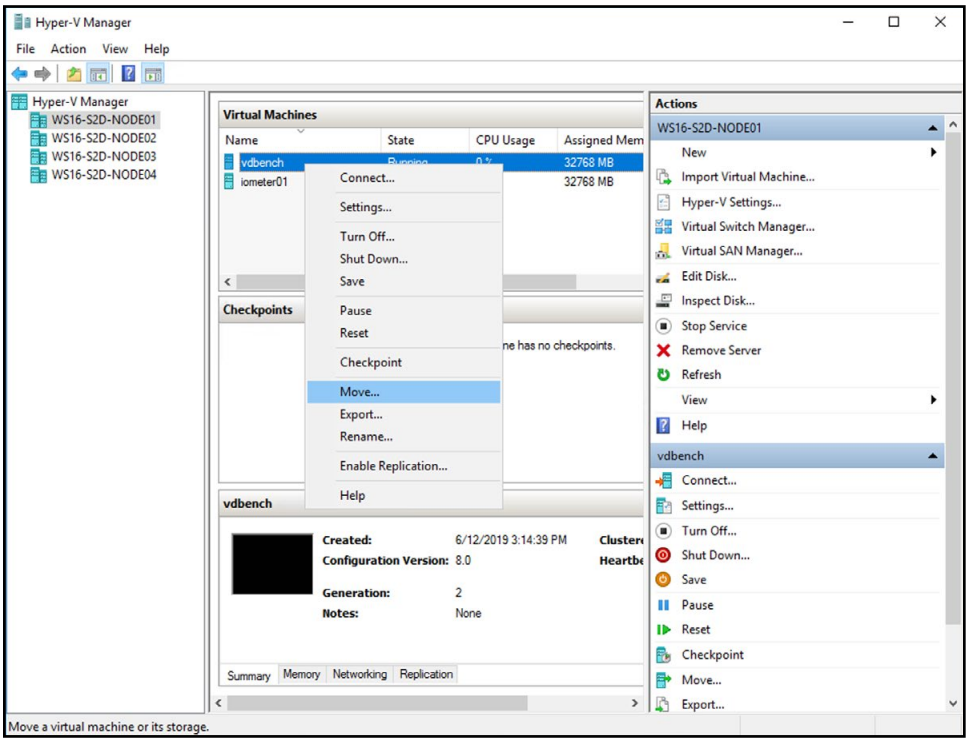
2. If you're using a software-defined networking switch with SET, run the following command in an elevated PowerShell session:

```
Get-ClusterResourceType -Cluster {clusterName} -Name "Virtual Machine" |
Set-ClusterParameter -Create SkipMigrationDestinationCheck -Value 1
```



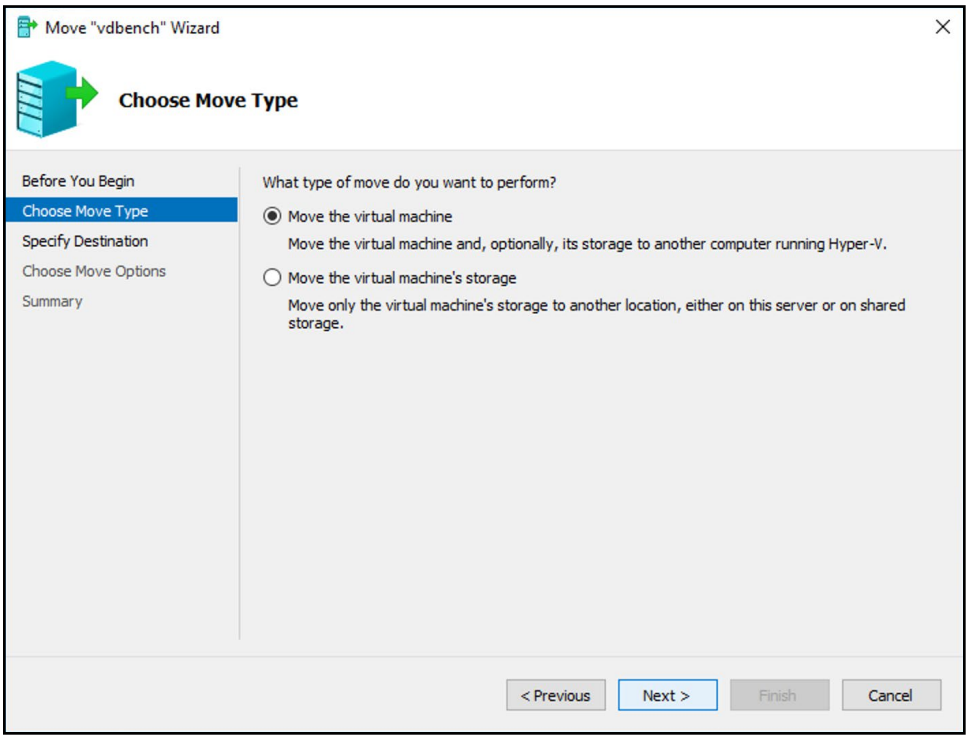
3. Use Hyper-V VM live migration to move the running VM from the server:

a. Right-click the VM you wish to migrate, and select Move.

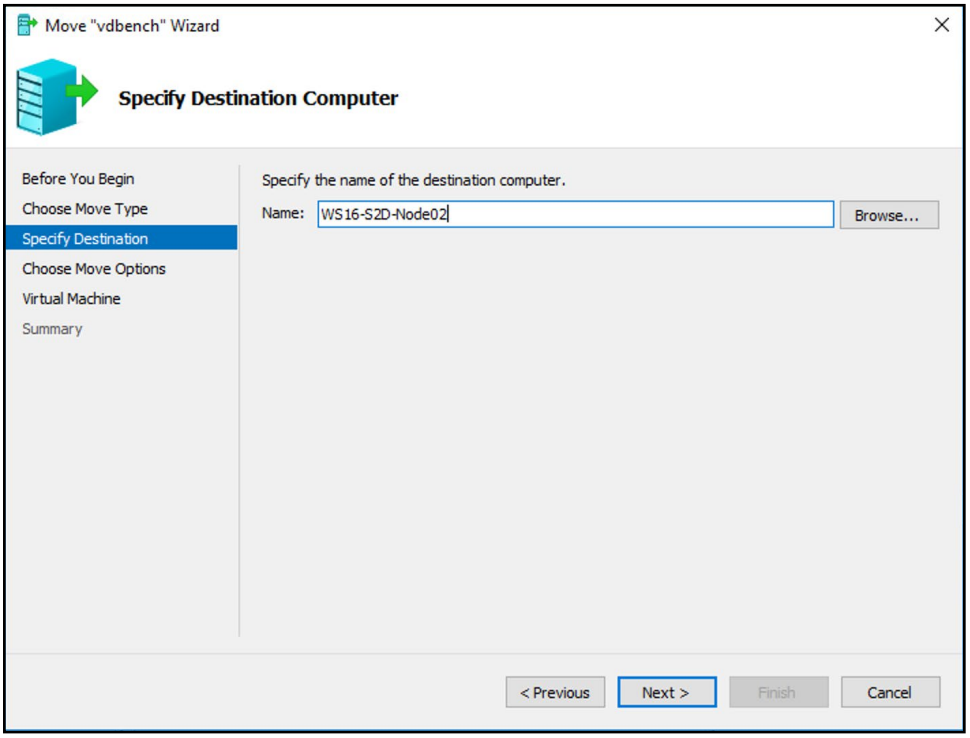


b. At the splash screen, click Next.

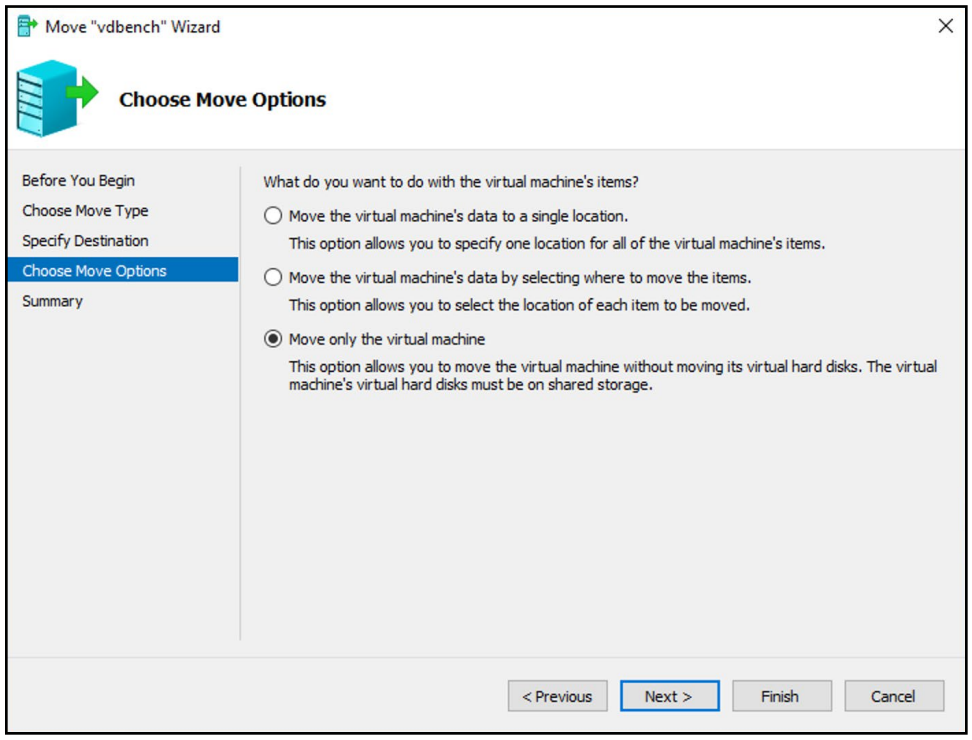
c. Select Move the virtual machine, and click Next.



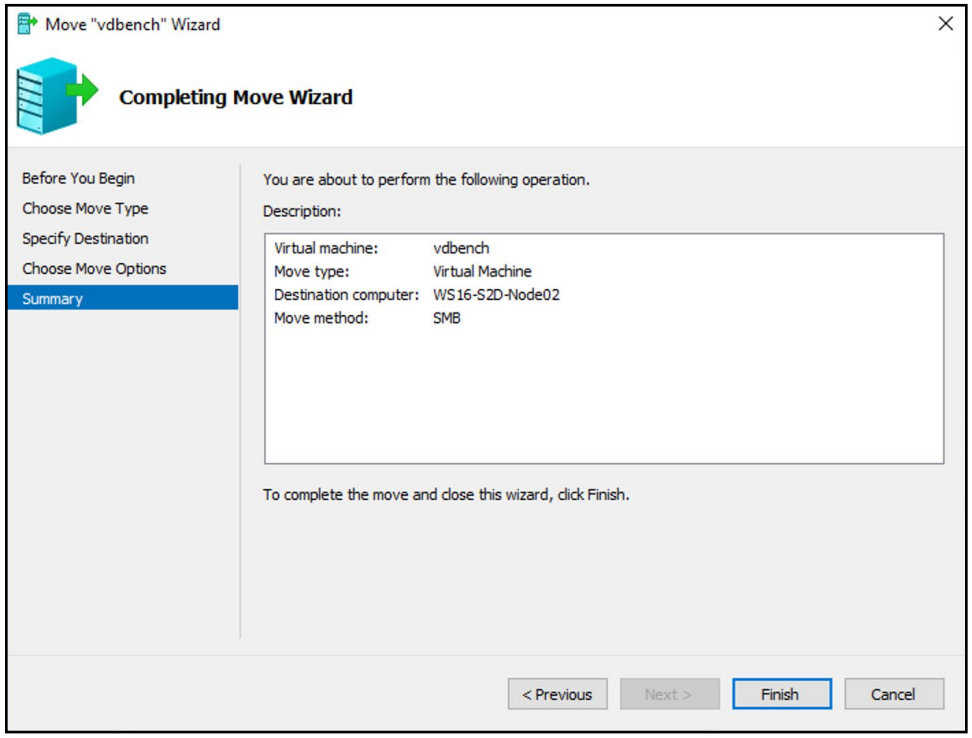
d. Specify a name for the destination server, and click Next.



e. Select Move only the virtual machine, and click Next.

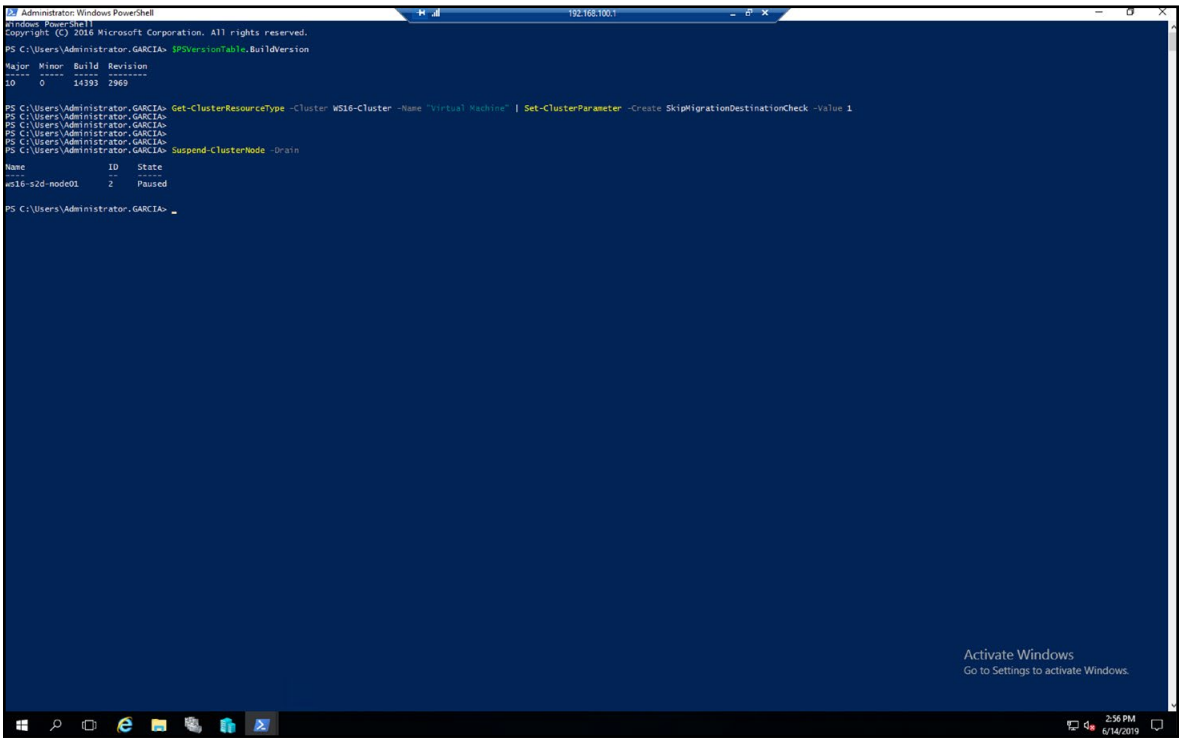


f. Review the move details, and click Finish.



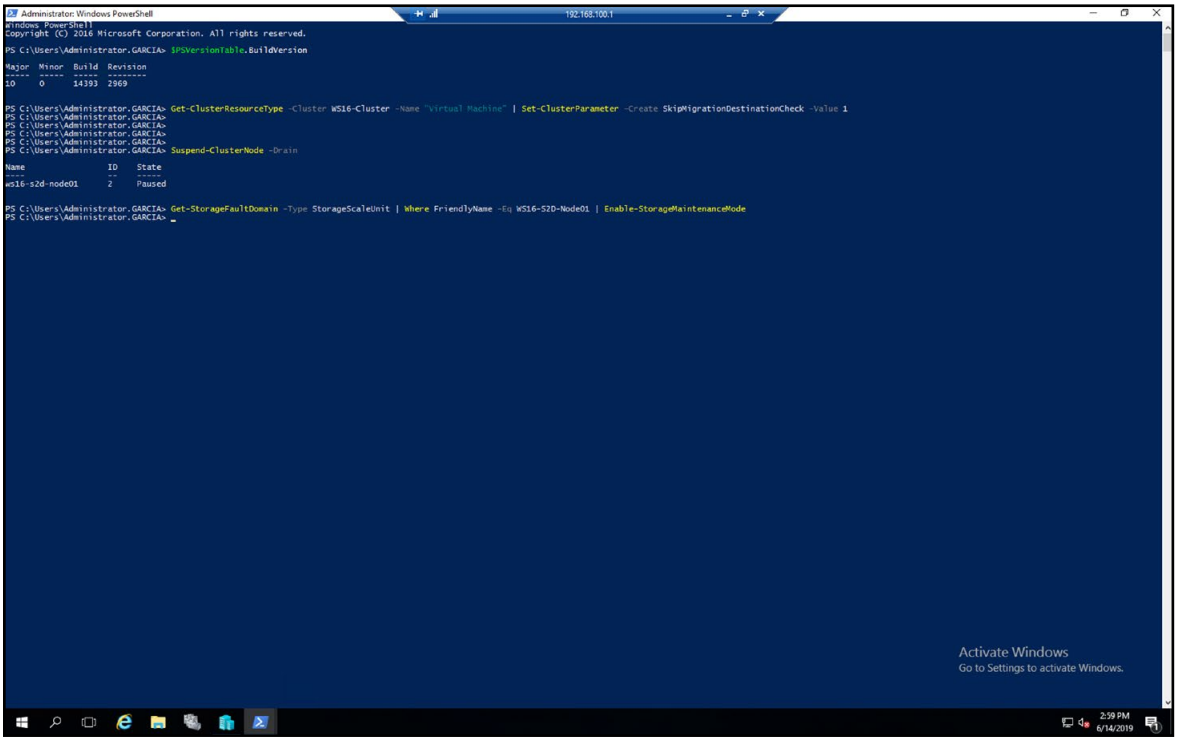
4. Pause the cluster service by running the following PowerShell command:

```
Suspend-ClusterNode -Drain
```



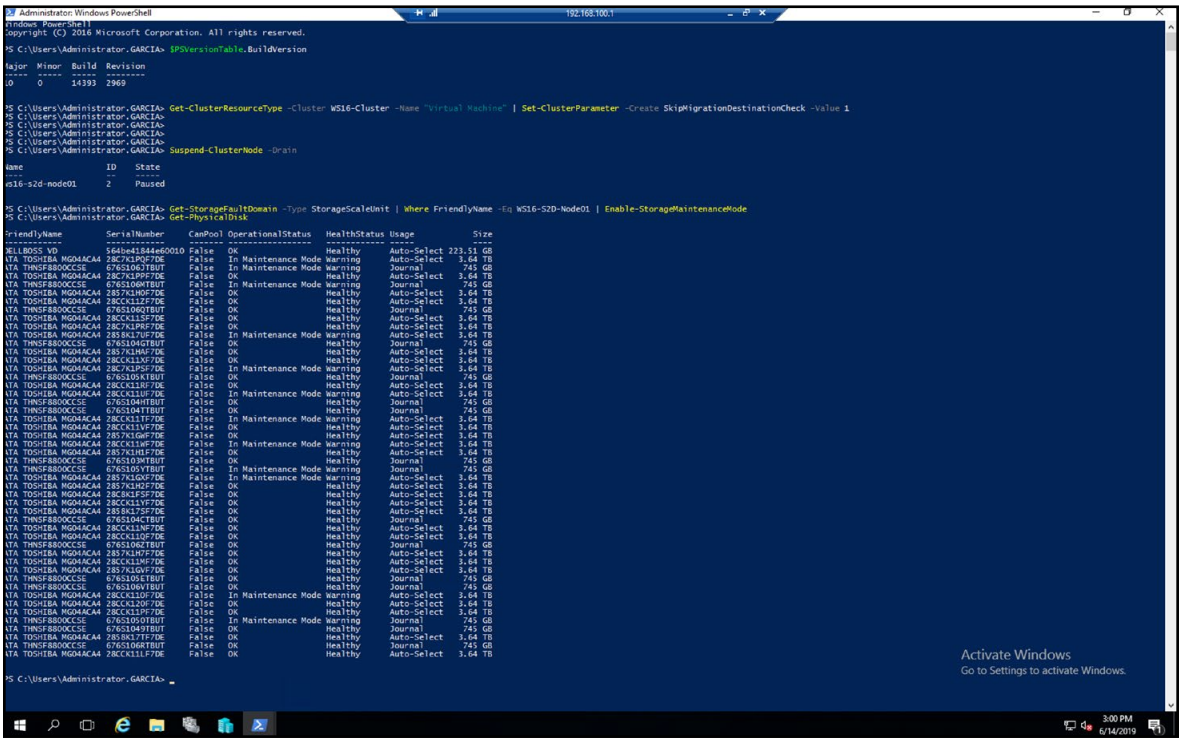
5. Place the server in storage maintenance mode by running the following PowerShell command:

```
Get-StorageFaultDomain -type StorageScaleUnit | Where FriendlyName -Eq <ServerName> | Enable-StorageMaintenanceMode
```

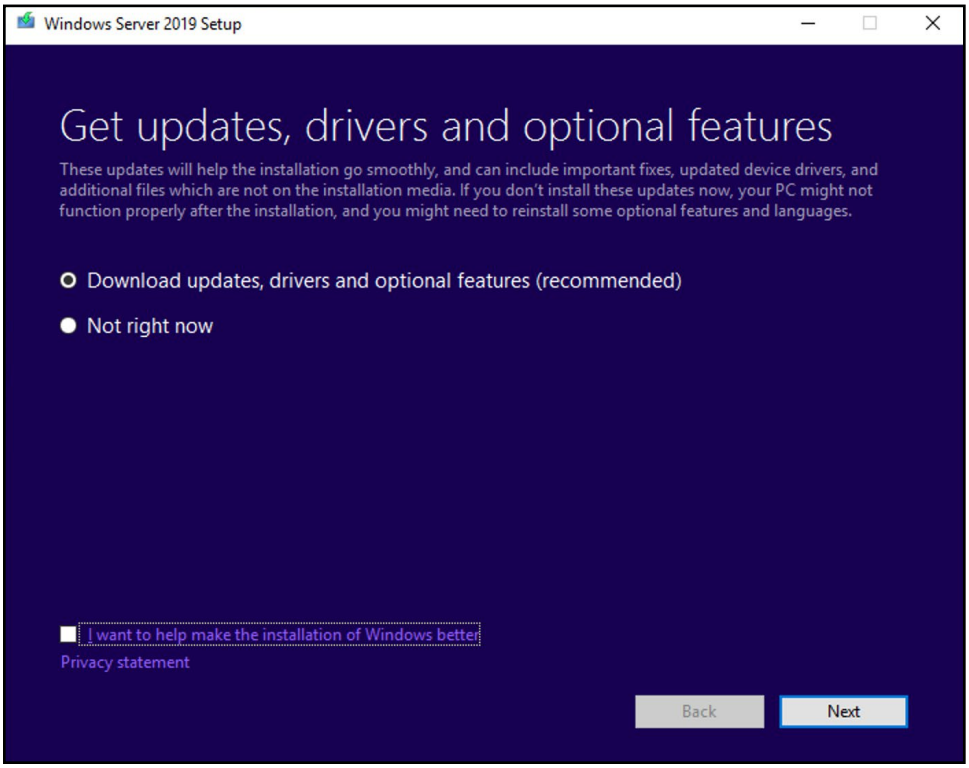


6. To make sure all of the disks are in maintenance mode, run the following command:

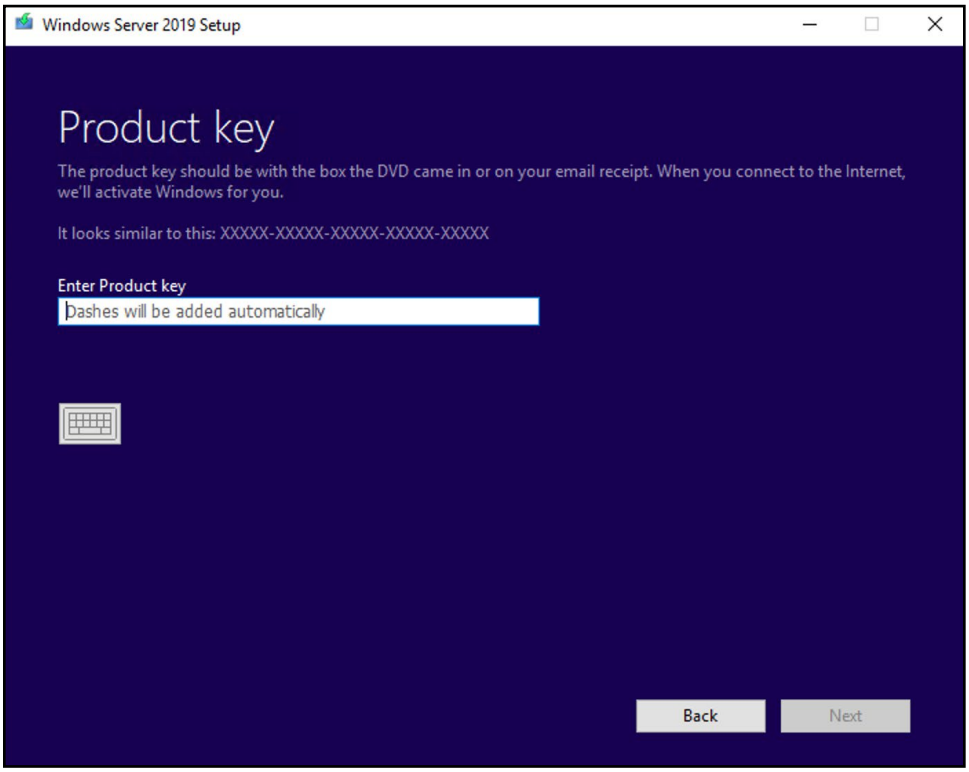
```
Get-PhysicalDisk
```



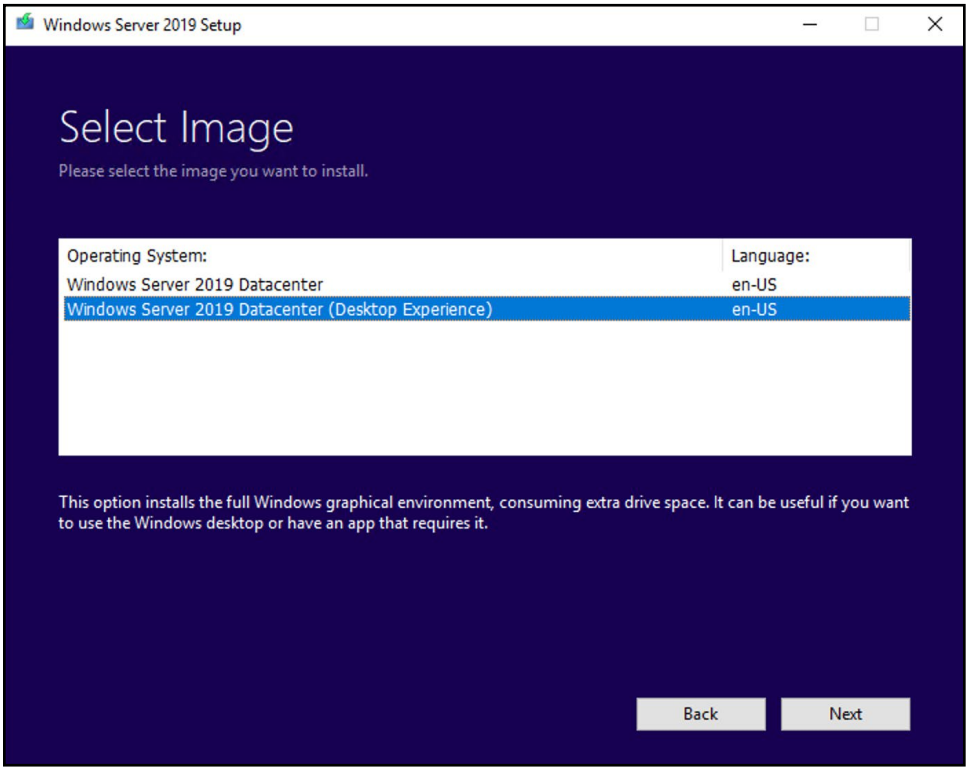
7. Double-click a Windows Server 2019 ISO to mount the image.
8. Change directories to the Windows Server 2019 mounted volume.
9. Run setup.exe.
10. On the Windows Server 2019 Setup screen, select Download updates, drivers and optional features (recommended), and click Next.



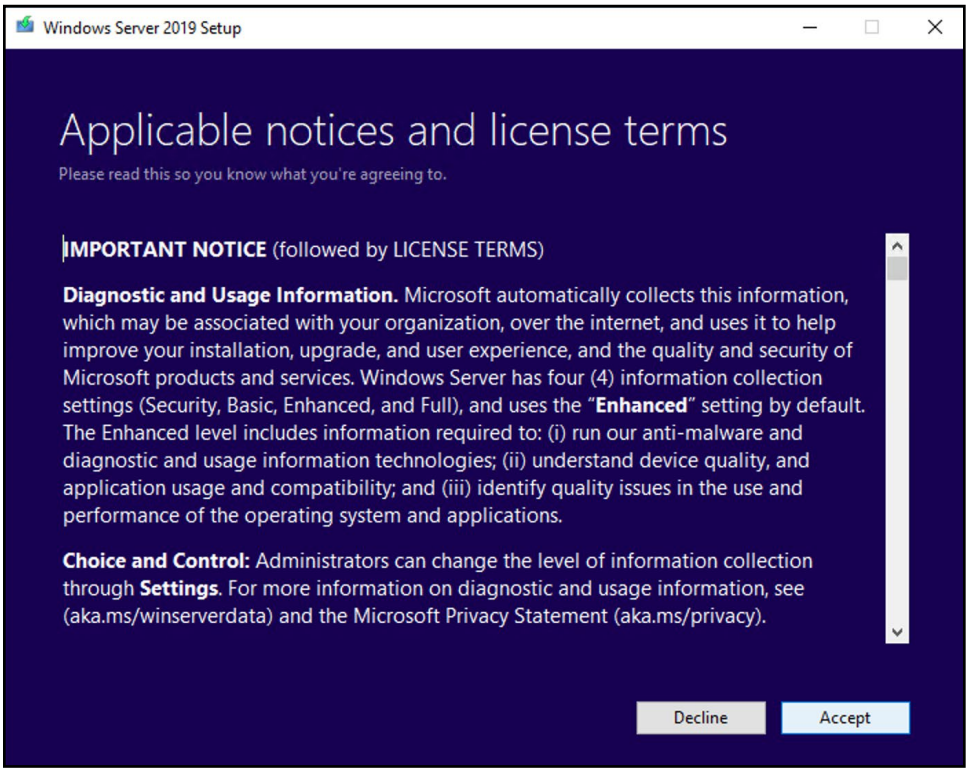
11. Enter the product key, and click Next.



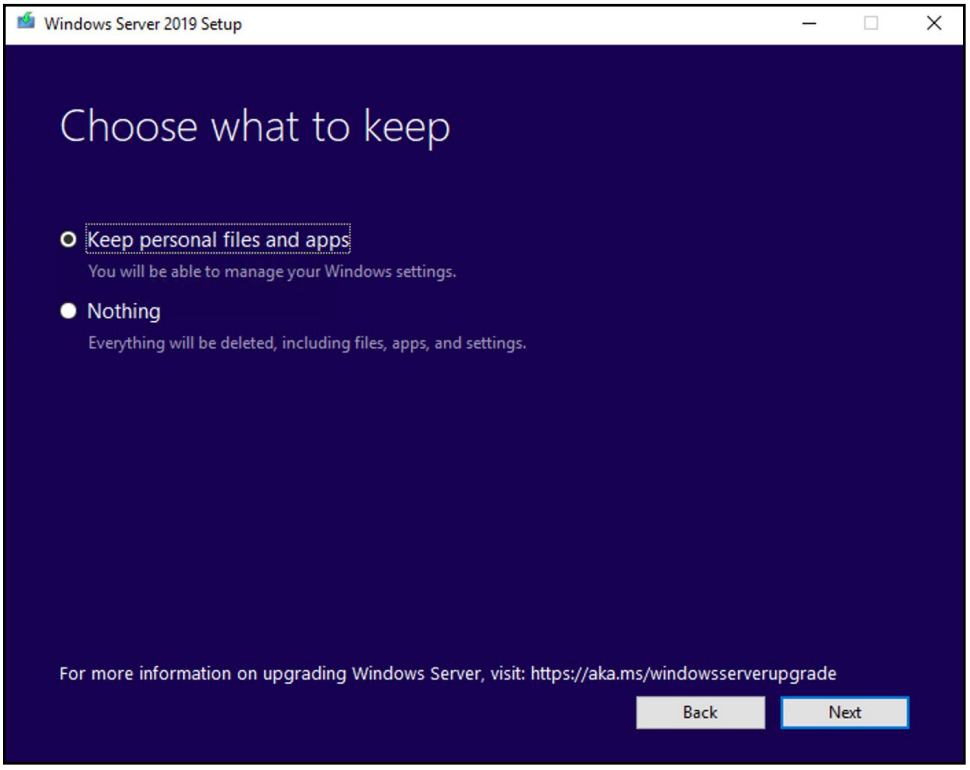
12. Select Windows Server 2019 Datacenter (Desktop Experience), and click Next.



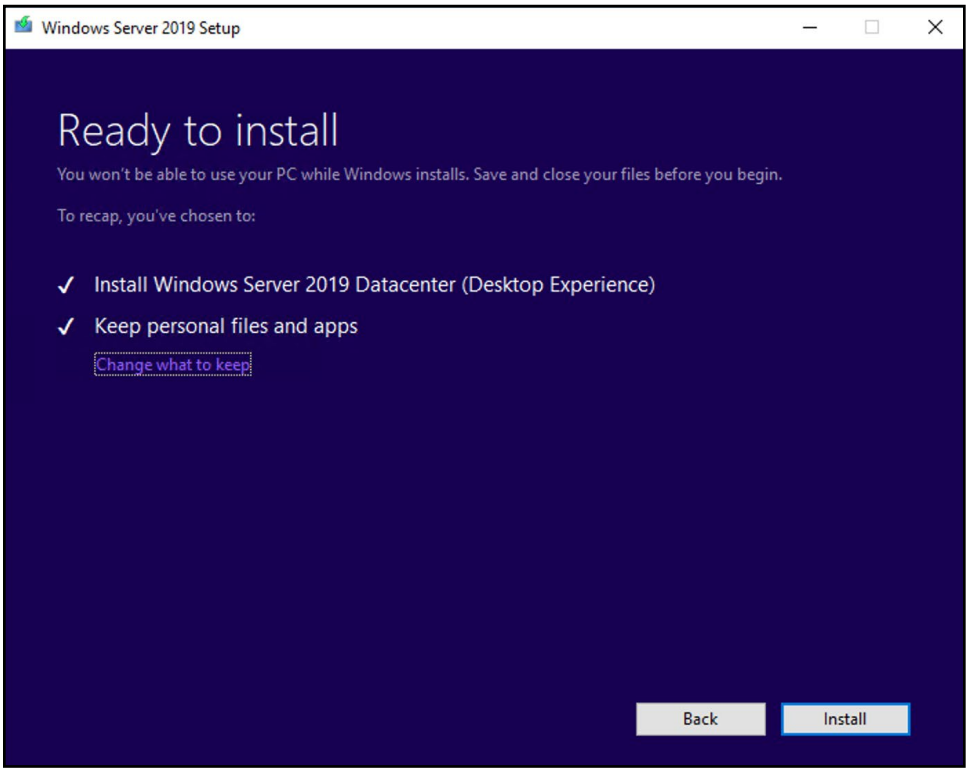
13. On the EULA screen, click Accept.



14. Select Keep personal files and apps, and click Next.

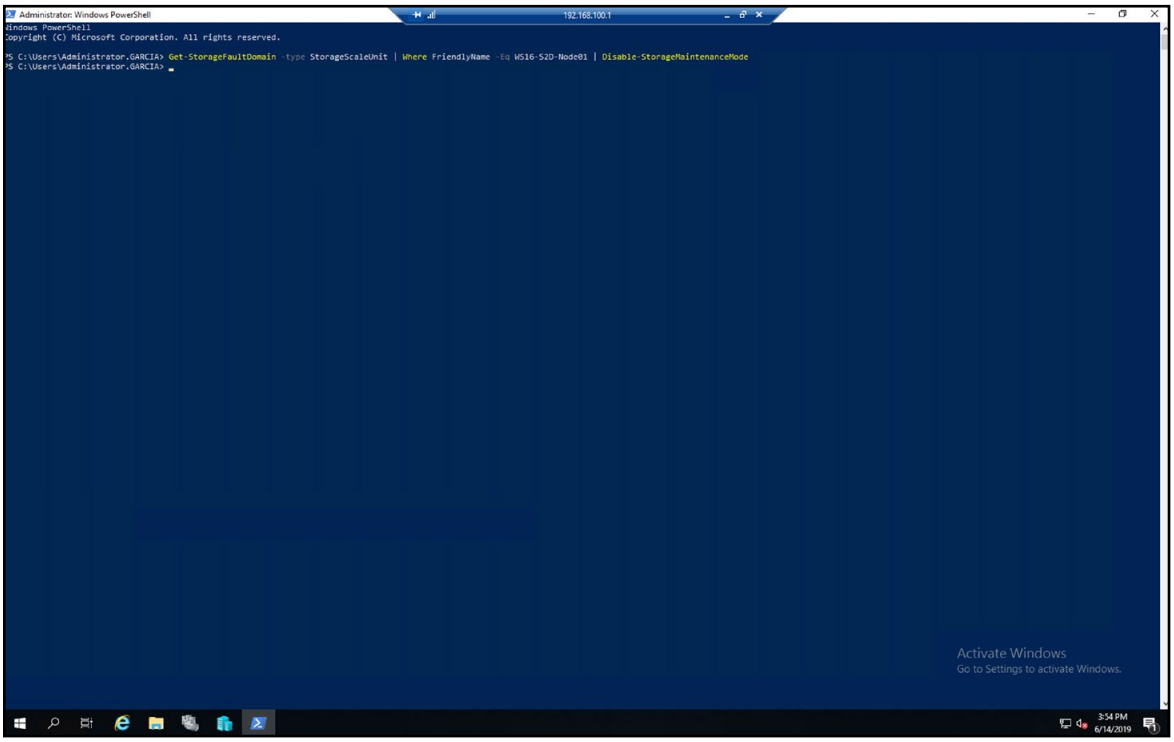


15. Click Install.



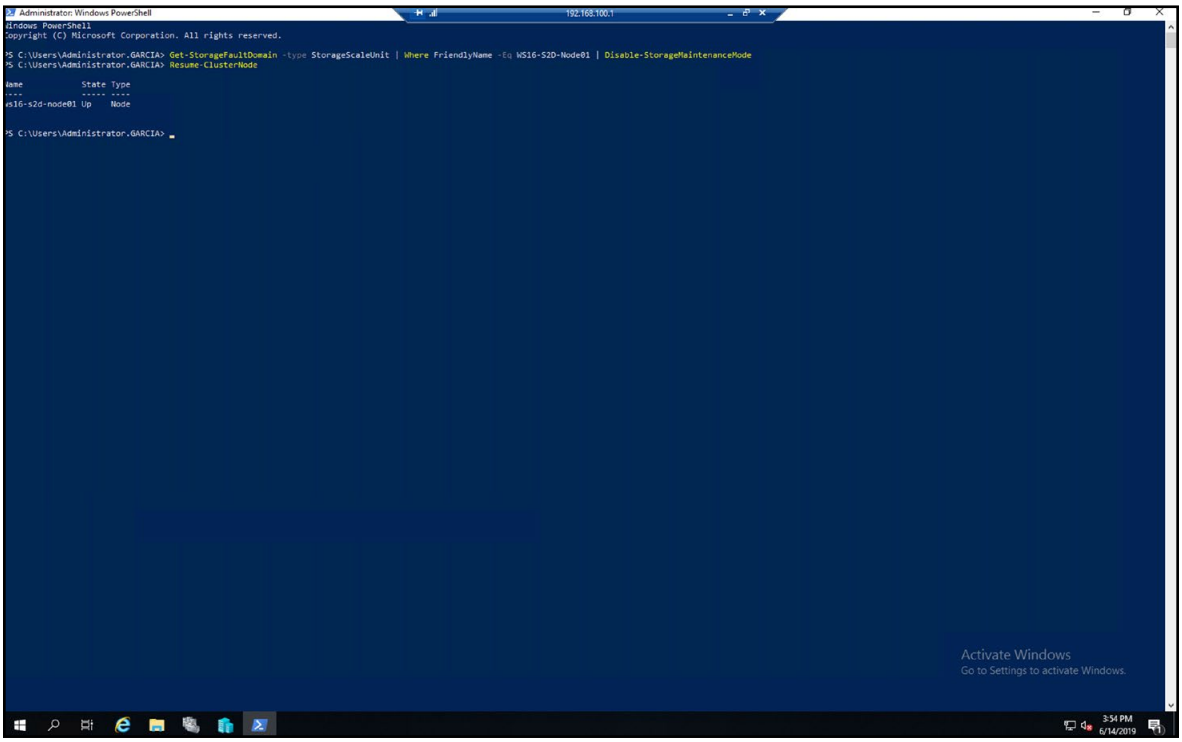
16. After the install has finished, log into the host.
17. Open an elevated PowerShell session.
18. To remove the node from storage maintenance mode, run the following command:

```
Get-StorageFaultDomain -type StorageScaleUnit | Where FriendlyName -Eq <ServerName> | Disable-StorageMaintenanceMode
```



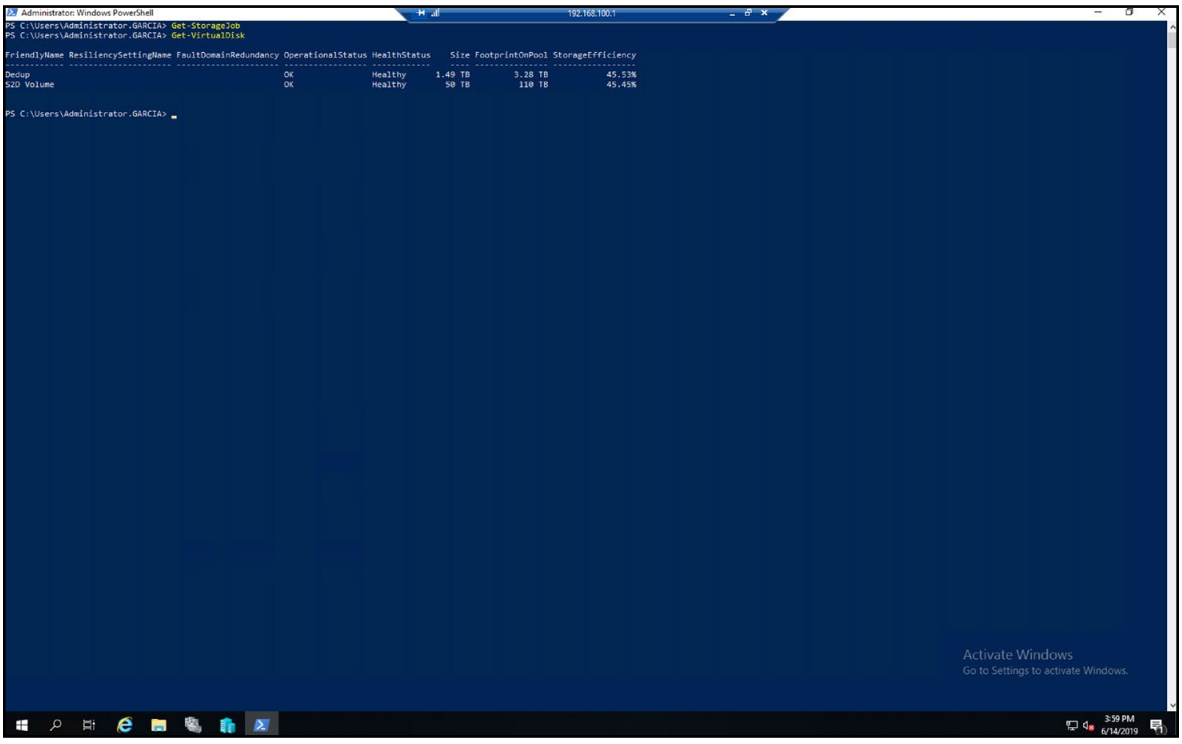
19. To resume the cluster service, run the following PowerShell command:

```
Resume-ClusterNode
```



20. Wait for the storage jobs to finish before moving to the next server in the cluster.
21. To check the state of the storage repair, run the following commands:

```
Get-StorageJob
Get-VirtualDisk
```



22. Once the storage job is complete and all virtual disks are returned to a healthy state, repeat steps 3 through 21 on the remaining nodes in the cluster.
23. To update the cluster functional level, run the following PowerShell command:

    ```
    Update-ClusterFunctionalLevel
    ```

24. To update the storage pool, run the following PowerShell command:

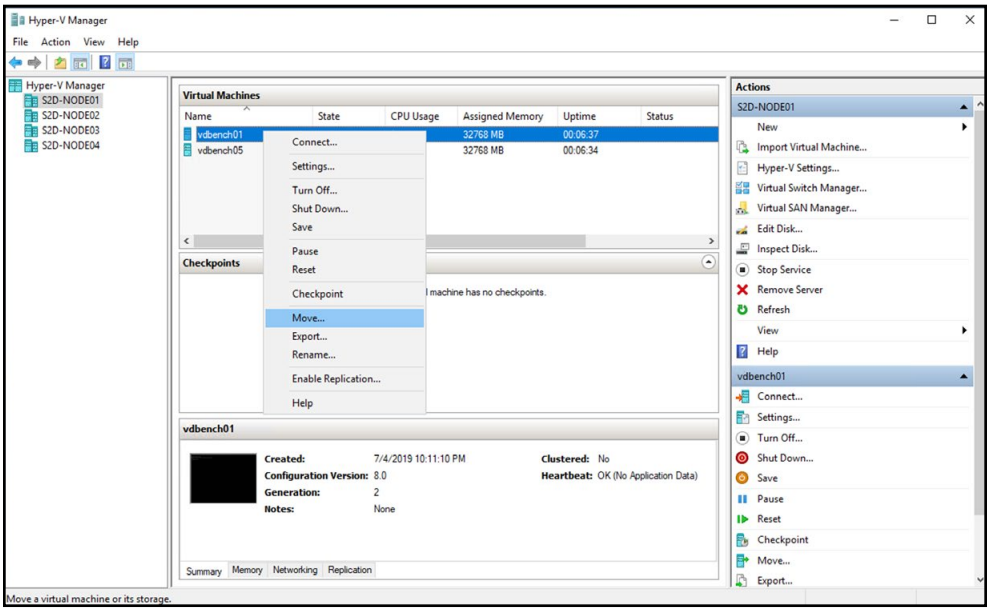
    ```
    Get-StoragePool -FriendlyName S2D* | Update-StoragePool
    ```

25. To set the live migration check back, run the following PowerShell command:

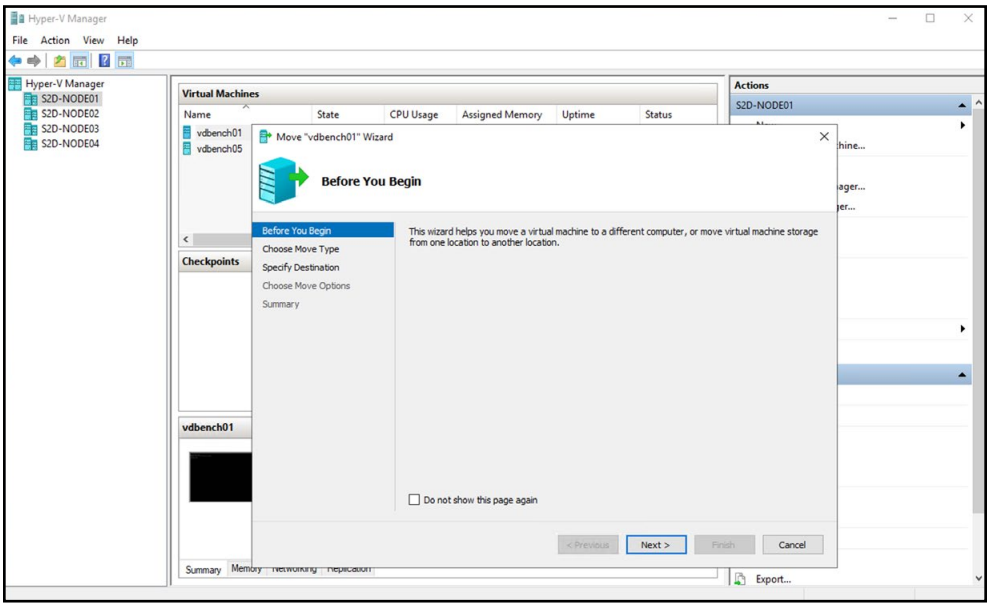
    ```
    Get-ClusterResourceType -Cluster {clusterName} -Name "Virtual Machine" |
    Set-ClusterParameter SkipMigrationDestinationCheck -Value 0
    ```

Live migrating a VM to the newly created volume

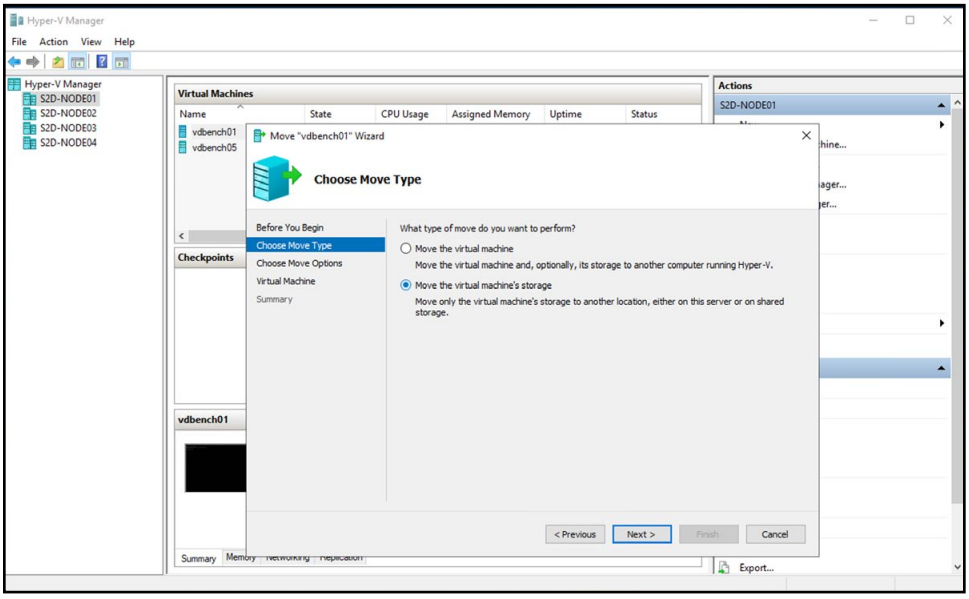
1. Open the Hyper-V Manager GUI.
2. Right-click the VM, and select Move.



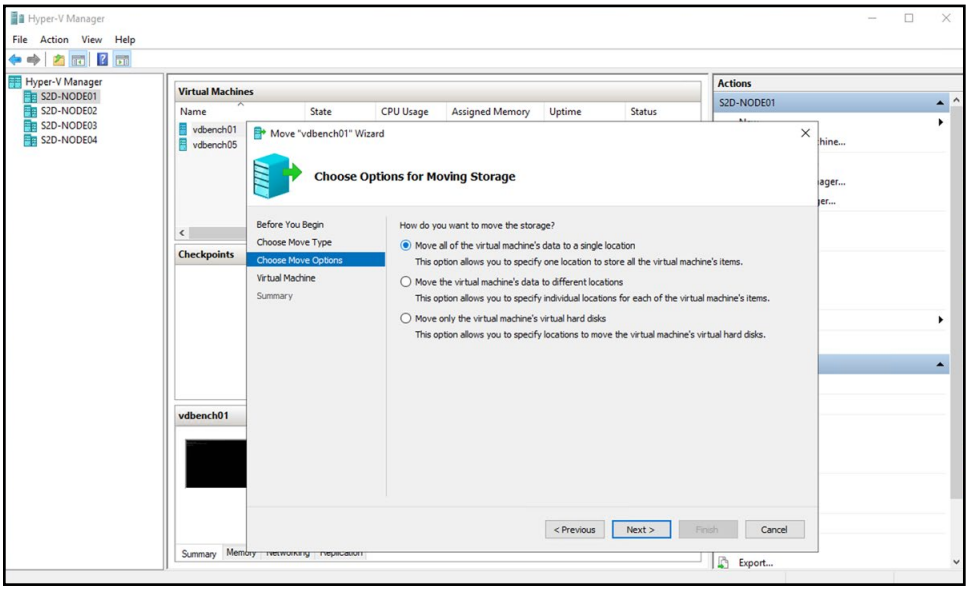
3. Click Next.



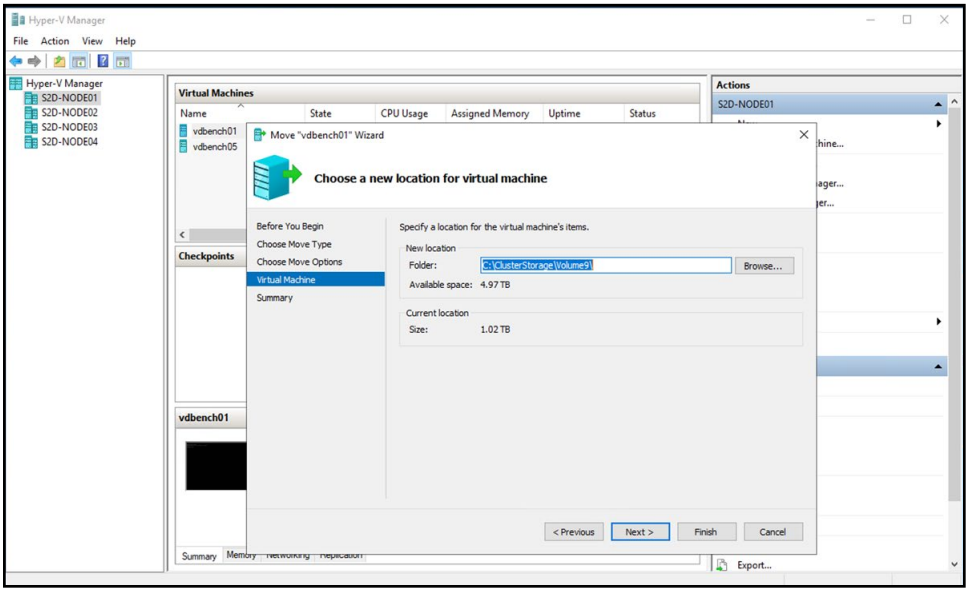
4. Select Move the virtual machine's storage, and click Next.



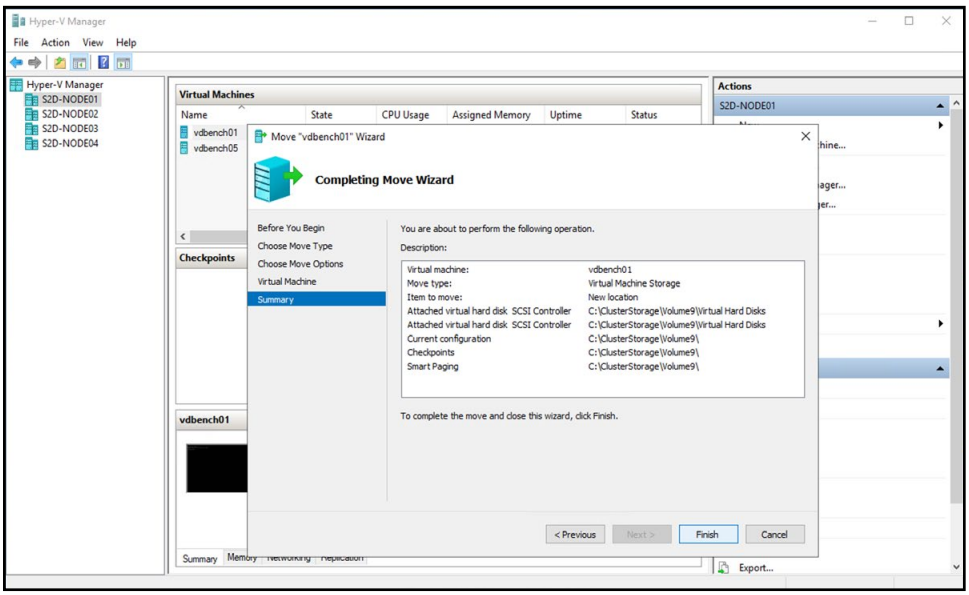
5. Select Move all of the virtual machine's data to a single location, and click Next.



6. Browse to the location of the newly created volume, and click Next.



7. Review the move summary, and click Finish.



Vdbench configuration files

```
vdbench01_build.cfg
messagescan=no
compratio=4
dedupratio=4
dedupunit=4k

sd=sd1,lun=/dev/sdb,openflags=o_direct,thread=1
wd=Prefill,sd=(sd1),xfersize=256k,rdpct=0,seekpct=EOF
rd=Prefill,wd=Prefill,iorate=max,elapsed=100h

vdbench02_build.cfg
messagescan=no
compratio=2
dedupratio=2
dedupunit=4k

sd=sd1,lun=/dev/sdb,openflags=o_direct,thread=1
wd=Prefill,sd=(sd1),xfersize=256k,rdpct=0,seekpct=EOF
rd=Prefill,wd=Prefill,iorate=max,elapsed=100h

vdbench03_build.cfg
messagescan=no
compratio=4
dedupratio=4
dedupunit=64k

sd=sd1,lun=/dev/sdb,openflags=o_direct,thread=1
wd=Prefill,sd=(sd1),xfersize=256k,rdpct=0,seekpct=EOF
rd=Prefill,wd=Prefill,iorate=max,elapsed=100h

vdbench04_build.cfg
messagescan=no
compratio=2
dedupratio=2
dedupunit=64k

sd=sd1,lun=/dev/sdb,openflags=o_direct,thread=1
wd=Prefill,sd=(sd1),xfersize=256k,rdpct=0,seekpct=EOF
rd=Prefill,wd=Prefill,iorate=max,elapsed=100h

vdbench05_build.cfg
messagescan=no
compratio=2
dedupratio=2
dedupunit=8k

sd=sd1,lun=/dev/sdb,openflags=o_direct,thread=1
wd=Prefill,sd=(sd1),xfersize=256k,rdpct=0,seekpct=EOF
rd=Prefill,wd=Prefill,iorate=max,elapsed=100h


vdbench06_build.cfg
messagescan=no
compratio=4
dedupratio=4
dedupunit=16k

sd=sd1,lun=/dev/sdb,openflags=o_direct,thread=1
wd=Prefill,sd=(sd1),xfersize=256k,rdpct=0,seekpct=EOF
rd=Prefill,wd=Prefill,iorate=max,elapsed=100h
```

Read the report at http://facts.pt/syujn3d ▶

This project was commissioned by Dell Technologies.

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