Dell PowerStore: Microsoft Hyper-V Best Practices

May 2024

H18069.8

White Paper

Abstract

Follow the best practice guidance in this document to configure Microsoft Windows Server Hyper-V to perform optimally with Dell PowerStore storage.

Copyright

Contents

Executive summary

Overview

Follow the best-practice guidance in this document to deploy and optimize the Windows Server Hyper-V hypervisor role with Dell PowerStore storage. This paper focuses on the block (SAN) capabilities of single-appliance or multi-appliance PowerStore cluster configurations in support of Windows Server Hyper-V.

Hyper-V and PowerStore storage are feature-rich solutions. Hyper-V and PowerStore integrate to offer a diverse range of configuration options that solve key business objectives such as storage capacity, performance, and resiliency.

Audience

This document is intended for individuals who evaluate, manage, operate, or design a Dell networked storage environment using PowerStore systems, including IT administrators, storage architects, partners, and Dell Technologies employees. Readers should have functional knowledge of Dell PowerStore storage and Hyper-V.

Revisions

Date	Part number/ revision	Description
April 2020	H18069	Initial release PowerStoreOS 1.0
July 2020	H18069.1	Minor updates
October 2020	H18069.2	Minor updates
April 2021	H18069.3	Update for PowerStoreOS 2.0
October 2021	H18069.4	Minor updates
October 2021	H18069.4	Template update
July 2022	H18069.5	Update for PowerStoreOS 3.0
February 2023	H18069.6	Update guidance for TRIM/UNMAP
May 2023	H18069.7	Update for PowerStoreOS 3.5
May 2024	H18069.8	Update for PowerStoreOS 4.0 • Metro Volume support extended to Windows Server Failover Clustering and Hyper-V • Remove references to PowerStore X

To learn more about Metro Volume support for Windows Server Failover Clustering (WSFC) and Hyper-V with PowerStoreOS 4.0, see the white paper Dell PowerStore: Metro Volume on the Dell PowerStore Info Hub.

Note: If you did not obtain this document from the Dell PowerStore Info Hub, your version might be outdated.

We value your feedback

Dell Technologies and the author of this document welcome your feedback on this document. Contact the Dell Technologies team by email.

Author: Marty Glaser

Note: For links to other documentation for this topic, see the Dell PowerStore Info Hub and Dell Technologies Support.

Introduction

PowerStore overview

Dell PowerStore is a feature-rich, next-generation, enterprise storage appliance. PowerStore provides an ideal block-based storage platform for Windows Server and the Hyper-V role. PowerStore provides powerful storage integrations, optimizations, and management tools that are well suited to support Microsoft environments.

PowerStore achieves new levels of operational simplicity and agility. It uses a container-based microservices architecture, advanced storage technologies, and integrated machine learning to unlock the power of your data. PowerStore is a versatile platform with a performance-centric design that delivers multidimensional scale, always-on data reduction, and support for next-generation media.

PowerStore brings the simplicity of public cloud to on-premises infrastructure, streamlining operations with an integrated machine-learning engine and seamless automation. It also offers predictive analytics to easily monitor, analyze, and troubleshoot the environment. PowerStore is highly adaptable, providing the flexibility to host specialized workloads directly on the appliance and modernize infrastructure without disruption. It also offers investment protection through flexible payment solutions and data-in-place upgrades.

Figure 1. Dell PowerStore 2U storage appliance (shown with and without the front bezel)

PowerStore management tools

PowerStore Manager is an intuitive, all-inclusive HTML5-based management UI. PowerStore Manager is integrated on each PowerStore appliance.

- No client installation is required.
- Java is not required.
- The UI is supported with most popular web browsers.

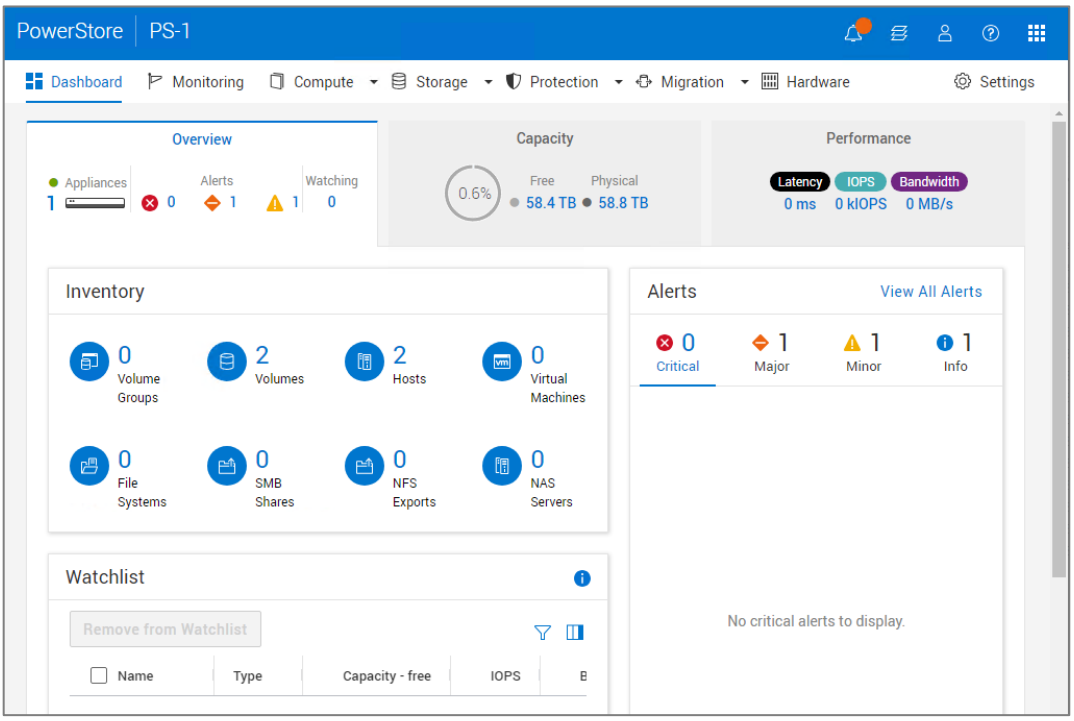


Figure 2. PowerStore Manager UI dashboard

Each PowerStore cluster provides an easy-to-use, web-based REST API interface for cluster management and automation tasks. To access the REST API interface, open a supported web browser, and add **/swaggerui** to the management IP of the cluster.

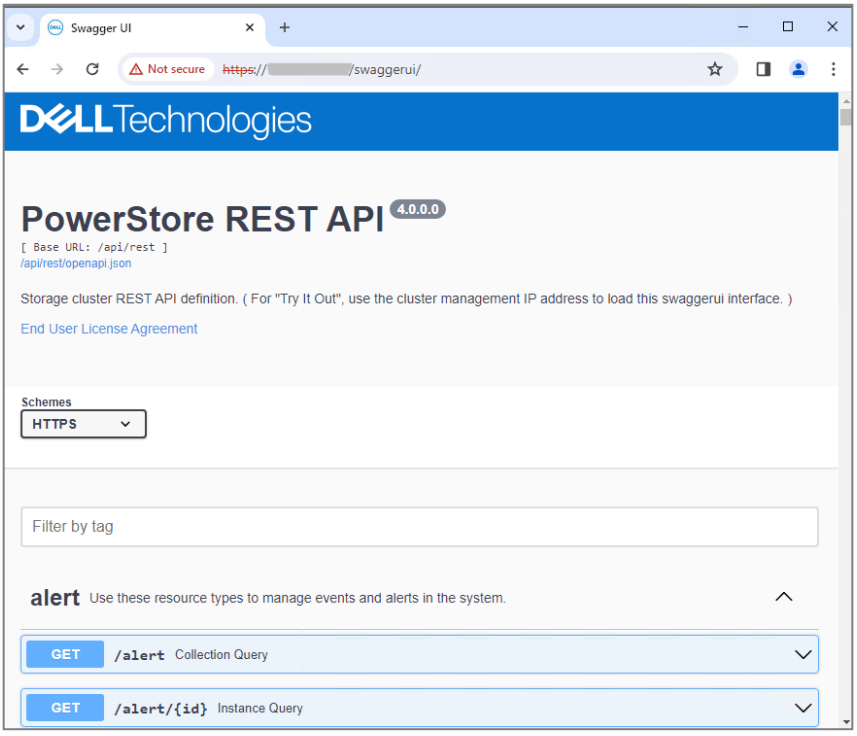


Figure 3. PowerStore REST API

The PowerStore command-line interface (CLI) tool is an optional interface. Download the latest version from Dell Support for your PowerStore model.

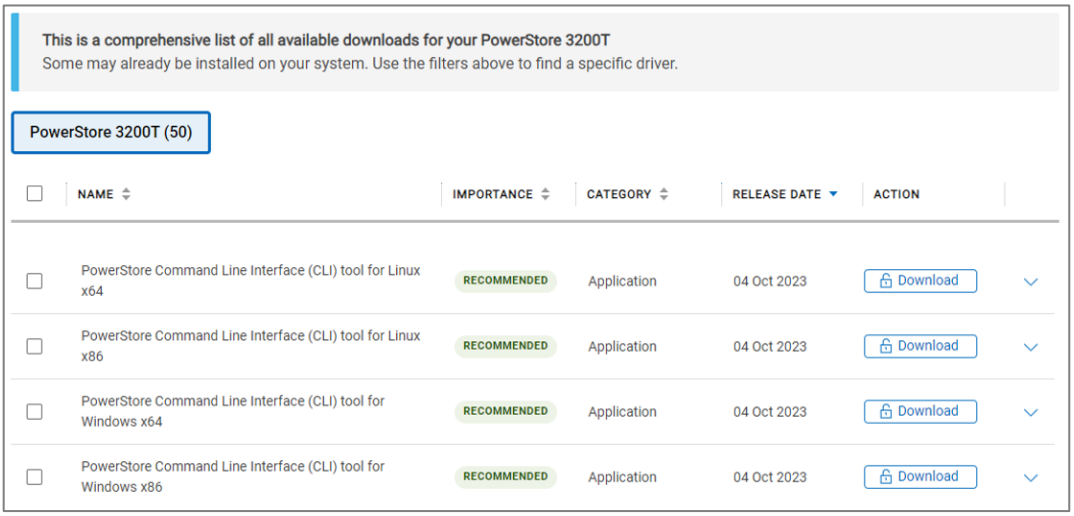


Figure 4. PowerStore CLI download

Documentation and support

To learn more about specific PowerStore models and features, see the Dell Data Storage Portfolio.

PowerStore documentation is on the Dell PowerStore Info Hub and Dell Support.

PowerStore product documentation and support are also available in PowerStore Manager. Click **Online Help** or **General Support** in the UI.

This white paper provides guidance that is supplemental to these resources.

Note: Most PowerStore storage features work in the background, regardless of the platform or workload. Usually, the default storage settings for PowerStore are optimal for Hyper-V environments. This document provides configuration strategies and configuration options for PowerStore and Hyper-V that might enhance usability, performance, and resiliency in your environment.

Microsoft Hyper-V overview

Hyper-V is a mature, robust, proven virtualization platform. Hyper-V is a software layer that abstracts physical host server hardware resources. It presents these resources in an optimized and virtualized manner to guest virtual machines (VMs) and their workloads. Hyper-V optimizes the use of physical resources in a host server such as CPUs, memory, NICs, and power. Hyper-V virtualization allows multiple VMs to share physical host resources concurrently.

The Hyper-V role enables virtualization technology on Windows Server. Hyper-V is an optional role. Install the Hyper-V role if you want to host VMs or create Hyper-V clusters.

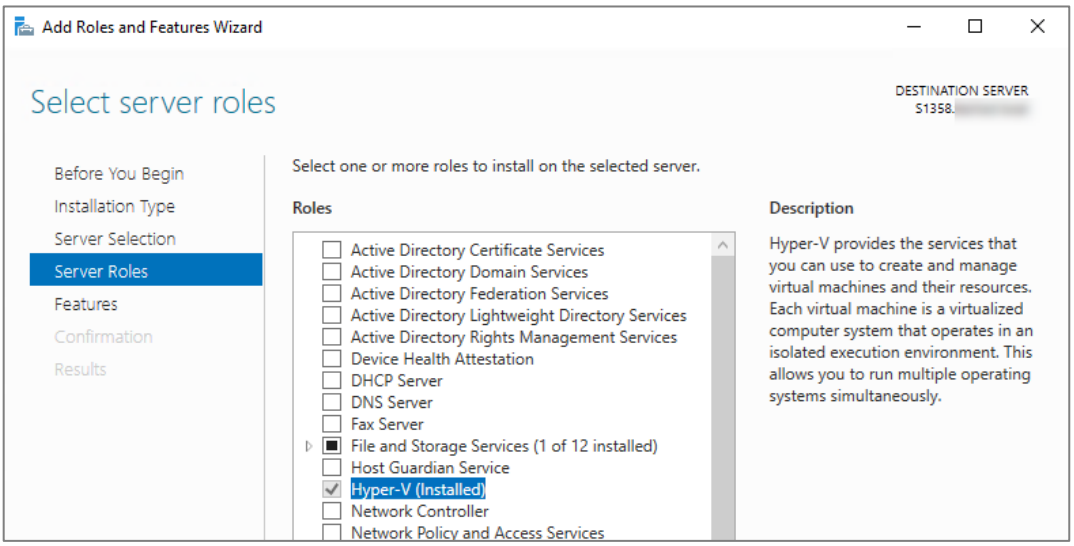


Figure 5. Server Manager > Add Roles and Features Wizard

The Hyper-V role, the Multipath I/O feature, and the Failover Clustering feature are not installed by default. Install Multipath I/O if your environment supports MPIO. Install Failover Clustering if you plan to create failover clusters or Hyper-V clusters.

To learn more about Hyper-V features, see the Microsoft Virtualization Documentation library.

Hyper-V management tools

Use these methods to install and manage the Hyper-V role and other roles and features on a Windows Server:

- Windows Admin Center
- Windows Server Manager
- PowerShell

Windows Admin Center

Windows Admin Center is a free, centralized server-management tool from Microsoft. Windows Admin Center consolidates common in-box tools to simplify the management of server environments and server clusters from one interface.

Windows Admin Center is a locally installed client that is HTML5-based and browser-accessible. Windows Admin Center is also an extensible platform. Third parties can develop integrations for their own products or solutions.

PowerStore supports integration with Windows Admin Center. For more information about Windows Admin Center integration with PowerStore, see the *Dell PowerStore Manager for Windows Admin Center User Guide* at Dell Support.

Windows Admin Center is the recommended tool for managing Windows Server environments. However, it might not have full feature parity with the traditional management tools it replaces. Continue to use Hyper-V Manager, Failover Cluster Manager, Microsoft System Center Virtual Machine Manager (SCVMM), and Microsoft PowerShell if the functionality you want is not in Windows Admin Center.

This document includes configuration examples that use a combination of traditional tools and Windows Admin Center.

To learn more, see the Microsoft Windows Admin Center website.

For more information about Hyper-V features that are not specific to storage, see the Microsoft Virtualization Documentation library.

Supported versions

PowerStore support for different versions of Windows Server and the Hyper-V role might change over time. To verify Windows Server operating system and Hyper-V version compatibility with PowerStore for your environment, see the latest documentation and release notes for your version of PowerStoreOS, including the PowerStore Simple Support Matrix at Dell Support.

PowerStore supports the long-term servicing channel (LTSC) releases of Windows Server. Limit the use of other releases such as semiannual channel (SAC) (legacy) or annual channel (AC) with PowerStore to nonproduction, test, or development use. See this Microsoft article to learn more about the LTSC and AC servicing channels.

See References for a list of other resources.

Best practices overview

Developers and end users derive best practices over time from their collective experience. Dell Technologies builds best practices into the design of next-generation products. With mature technologies such as Hyper-V and Dell Technologies storage appliances, default settings and configurations typically incorporate the latest best practices.

As a result, tuning is often unnecessary and discouraged unless a specific design, situation, or workload will benefit from a different configuration. This document highlights situations where the default settings or configurations might not be optimal for Hyper-V.

Best practice design objectives commonly incorporate the following principles:

- Minimize complexity and administrative overhead.
- Optimize performance.
- Maximize security.
- Ensure resiliency and recoverability.
- Ensure a scalable design that can grow with the business.
- Maximize the return on investment over the life of the hardware.

Best practices are baselines that might not be ideal for every environment, including the following examples:

- Legacy systems that perform well and have not reached their life expectancy might not adhere to current best practice standards.
- A test or development environment that is not business critical might use a less-resilient design or lower-tier hardware to reduce cost and complexity.

Note: We recommend that you follow the best practices described in this document. However, best practice recommendations might not apply to all environments. If questions arise, contact your Dell Technologies representative.

Terminology

See Table 1 for a list of common terms used with PowerStore.

Table 1. Terminology

Term	Definition
Appliance	A PowerStore base enclosure, or a base enclosure and attached expansion enclosures.
Base enclosure	A 2U rackmount chassis with two active/active processing nodes (node A and node B) in the back, and 25 NVMe drive slots in the front.
Cluster	A PowerStore appliance is a cluster. A cluster supports one to four appliances.
Expansion enclosure	A 2U rackmount chassis that is cabled to a base enclosure to provide an additional 25 drive slots for storage expansion. All PowerStore models support expansion except the PowerStore 500.
Metro Volume	A PowerStore volume configured for synchronous replication between two PowerStore clusters. Metro Volume guarantees transactional consistency between PowerStore clusters for disaster avoidance and load-balancing options within metro distance.
Node	The component within a base enclosure that contains processors and memory. Each appliance consists of two hot-swappable nodes. Each node has an embedded module that provides management access, front-end connectivity, and ports for storage expansion.
PowerStoreOS	The PowerStore operating system.
PowerStore Manager	An HTML5-based UI client for PowerStore configuration, management, and monitoring.

To learn more about Metro Volume support for Windows Server and Hyper-V with PowerStoreOS 4.0, see the white paper Dell PowerStore: Metro Volume on the Dell PowerStore Info Hub.

Storage and transport best practices

Essential documentation

Administrators should review and follow the guidance in these documents to ensure a successful deployment of Windows Server and Hyper-V on PowerStore. These documents provide essential guidance as you plan, configure, and deploy PowerStore.

- Dell PowerStore Release Notes
- Dell PowerStore Drive and OS Support Matrix
- Dell PowerStore Host Connectivity Guide

- Dell PowerStore Best Practices Guide
- Dell PowerStore Installation and Service Guide
- Dell PowerStore Hardware Information Guide
- Dell PowerStore Planning Guide
- Dell PowerStore Networking Guide

PowerStore documentation is on Dell Support and the Dell PowerStore Info hub.

Use the PowerStore Manager UI to access online help and support documentation after deploying PowerStore.

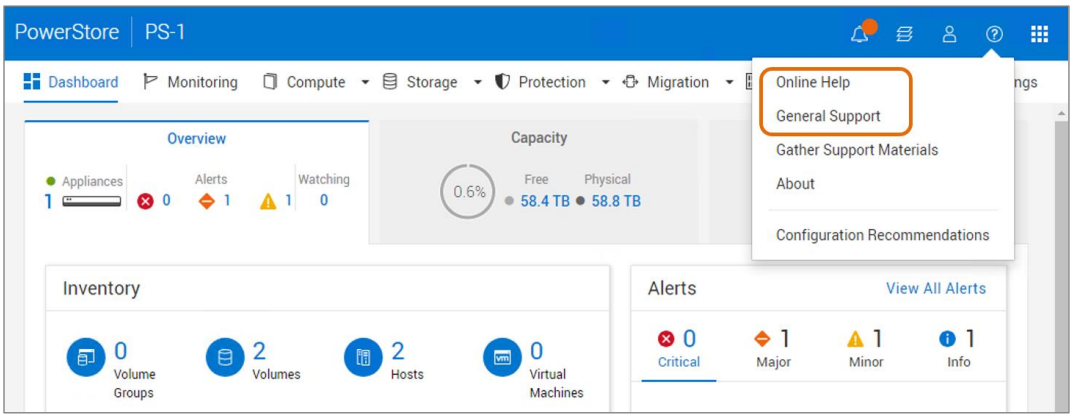


Figure 6. Help and support options in PowerStore Manager

This white paper provides supplemental guidance and best practices.

Correctly size the PowerStore storage appliance

Consider the environmental design factors that impact storage capacity and performance before you deploy PowerStore. Careful planning ensures that new or expanded storage is sized correctly for the Hyper-V environment. When you deploy PowerStore to support an existing Hyper-V workload, you might already understand the required performance metrics such as storage capacity, bandwidth, and IOPS. If the environment is new, determine the performance requirements so you can correctly size the storage, the storage fabric, and the workload hosts.

You can avoid many short-term and long-term problems when the storage part of the solution provides the right capacity and performance now and in the future. Scalability is a key design consideration.

Work with your Dell Technologies representative to complete a performance evaluation if you have questions about how to correctly size a PowerStore storage solution for your environment and workload.

Disk capacity and performance

Total disk storage capacity does not guarantee adequate disk performance. If you install a few large-capacity disks in a storage appliance, capacity needs might be satisfied, but the configuration might not support a high-IOPS workload.

Administrators must plan for IOPS, bandwidth, and capacity to properly size PowerStore for Hyper-V or any other workload.

Avoid bottlenecks

To optimize performance, administrators identify and mitigate design limitations that cause bottlenecks. A bottleneck negatively impacts performance or functionality under load when a capacity threshold is exceeded with the overall design. Design a balanced configuration end-to-end to optimize a workload so it performs at or near peak efficiency. The following design elements are potential bottlenecks:

- Storage performance (bandwidth; read and write I/O).
- Storage capacity.
- Storage CPU and memory capacity.
- Host server compute, memory, and bandwidth capacity.
- Network and fabric bandwidth, throughput, and latency.

Initial storage configuration

PowerStore supports a unified configuration (file storage and block storage). Choose **block optimized** during the initial configuration of PowerStore if file services are not needed. NAS services reserve some compute and storage resources with a unified PowerStore appliance, even if NAS is unused.

Note: If file services (NAS) will be needed later, select **Unified** when you complete the initial configuration. An appliance configured as unified must be reinitialized to change the configuration.

All PowerStore models support multipath I/O (MPIO) front-end connectivity to hosts. See MPIO best practices for more information.

For more information about PowerStore host connectivity for Windows Server and Hyper-V, see the Dell PowerStore Host Configuration Guide at Dell Technologies Support.

Transport and front-end connectivity

PowerStore provides block storage to host servers configured to use a storage area network (SAN).

PowerStore supports 16/32 Gb FC, and 10/25 GbE iSCSI. NVMe over Fibre Channel (NVMe/FC) and NVMe over TCP (NVMe/TCP) are two additional transports offered with PowerStore. NVMe/FC and NVMe/TCP are unsupported by Microsoft.

Note: Administrators must have a good understanding of the Hyper-V workload to size the storage fabric correctly. PowerStore will not perform optimally if the storage fabric is inadequate for the workload.

Consider the following best practice recommendations for Hyper-V:

- Regardless of the transport used, configure at least two paths for each host to provide redundancy in production environments.
- Configure MPIO on each host in the environment.
- Hosts that use single path (no MPIO) might be acceptable in test or development environments that are not business critical.

Administrators can use their current transport to maximize the return on their hardware investment or switch to a different transport. The choice of transport is based on factors such as personal preference, complexity, economics, or familiarity.

For more information, see the *Dell PowerStore Host Configuration Guide* at Dell Technologies Support.

Hyper-V best practices

Introduction

PowerStore is an excellent choice as external storage for stand-alone or clustered Windows Servers. PowerStore supports failover clustering and the Hyper-V role. Core PowerStore features such as thin provisioning, data reduction, snapshots, and replication work in the background regardless of the platform or operating system. Usually, the default PowerStore settings are optimal for Windows Server environments. This section provides best practice guidance for Hyper-V on PowerStore.

General best practices for Hyper-V

See Microsoft documentation for general Hyper-V settings and best practices that are not specific to PowerStore.

Go to docs.microsoft.com and search for Hyper-V to view a list of technical documentation, which includes:

- Performance Tuning Hyper-V Servers
- Hyper-V Storage I/O Performance
- Hyper-V Network I/O Performance
- Detecting bottlenecks in a virtualized environment

For more information about general best practices and tuning steps for Hyper-V, see the Microsoft Windows Server Documentation library.

Follow the general configuration guidance found in Microsoft documentation to configure your Hyper-V environment. To avoid redundancy, most general configuration guidance is not duplicated here. This document assumes that administrators will deploy and tune Hyper-V in accordance with established Microsoft best practices.

General best practices that are common with any Hyper-V deployment include the following recommendations:

- Understand the I/O requirements of a Hyper-V workload before deploying the workload on PowerStore.
  - Size the solution adequately end-to-end to avoid bottlenecks.
  - Allow headroom for expansion that factors in anticipated growth.
- Keep the design simple to ease administrative overhead.
  - Adopt a standard naming convention for objects such as hosts, volumes, and initiators. Consistent and intuitive naming makes administration easier.
- Configure all production hosts to use at least two data paths (MPIO) to eliminate single points of failure.

  - Use of single-path I/O might be acceptable in test or development environments that are not business critical.
- Use Windows Server Core to minimize the attack surface of a server and reduce administrative overhead.
- Use Windows Admin Center to centrally manage hosts and clusters.
- Update all hosts and VMs regularly.
- Provide adequate malware protection.
- Protect essential data with backups that meet recovery time objectives (RTO) and recovery point objectives (RPO).
  - Snapshots and replication are integral to a data protection strategy with PowerStore.
  - To learn more about Metro Volume support for Windows Server and Hyper-V with PowerStoreOS 4.0, see the white paper Dell PowerStore: Metro Volume on the Dell PowerStore Info Hub.
- Minimize or disable unnecessary hardware devices and services to free up host resources for VMs. This action will help reduce power consumption.
- Schedule tasks such as periodic maintenance, backups, malware scans, and updates to run after hours.
  - Stagger start times if resource-intensive maintenance operations overlap.
- Follow vendor recommendations to optimize the settings for an application or workload to reduce or eliminate unnecessary processes or activity.
- Use PowerShell or other scripting tools to automate step-intensive, repeatable tasks. PowerStore CLI and REST API provide additional management and scripting functionality.
  - Ensure consistency.
  - Avoid mistakes due to human error.
  - Reduce administrative overhead.
- Enable monitoring and alerting features to identify and resolve issues quickly.
  - Configure email alerts.
  - Enable Dell SupportAssist in PowerStore to automatically contact support resources when events such as a disk failure occur.

Cluster validation

Run cluster validation before you create a Hyper-V cluster on PowerStore. Ensure that all tests related to storage and MPIO pass before you configure a Hyper-V cluster and deploy a workload.

1. Stage each Windows Server and configure the Hyper-V role based on Microsoft best practices.
2. Configure two or more data paths to PowerStore for each host (iSCSI or FC).
3. Install and configure MPIO on each host.
4. Use PowerStore Manager to create a host group on PowerStore.

5. Use PowerStore Manager to map at least one cluster volume to the host group. Use a consistent LUN ID.
6. On a host, initialize the new disk, bring it online, and format it.
7. Perform a disk rescan on each host in the host group.
8. Use Failover Cluster Manager to run cluster validation for the hosts in the host group.
9. Verify that all tests related to disk and MPIO pass.
    a. If any tests fail, the configuration might not support clustering.
    b. Troubleshoot and resolve all disk or MPIO failures and run cluster validation again until they pass.

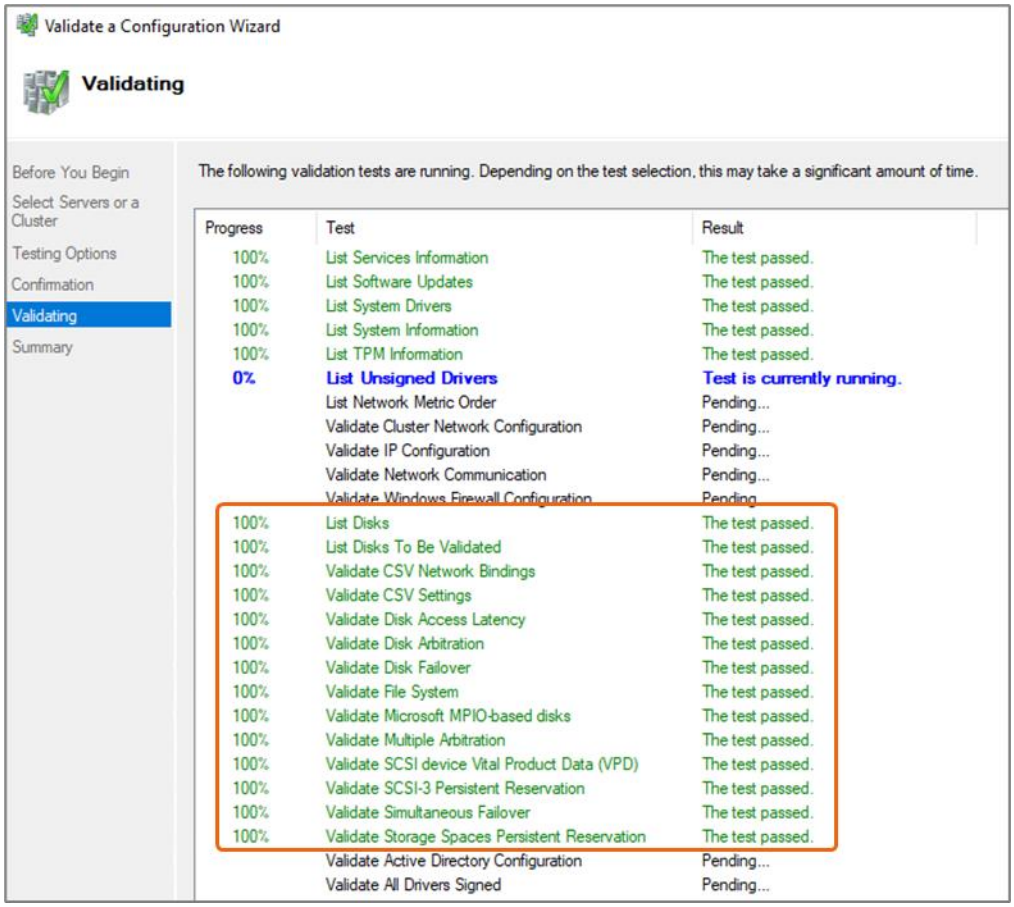


Figure 7. Failover Cluster Manager > Cluster validation wizard: Ensure that all disk and MPIO tests pass

Minor warnings will not prevent host clustering. For example, cluster validation might detect slight differences in the patch level of fully updated hosts.

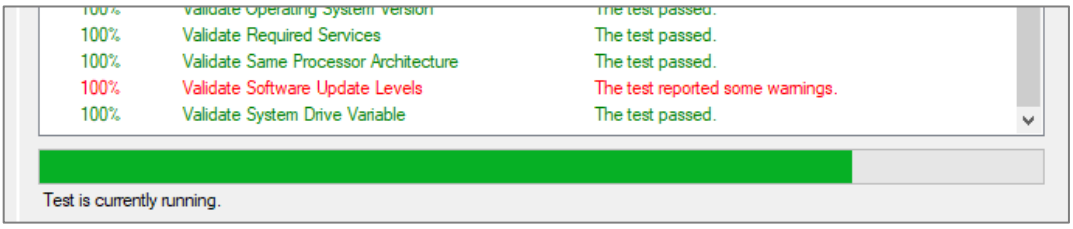


Figure 8. Cluster validation verifies software updates

You can also use Windows Admin Center, in addition to Failover Cluster Manager, to create and manage clusters.

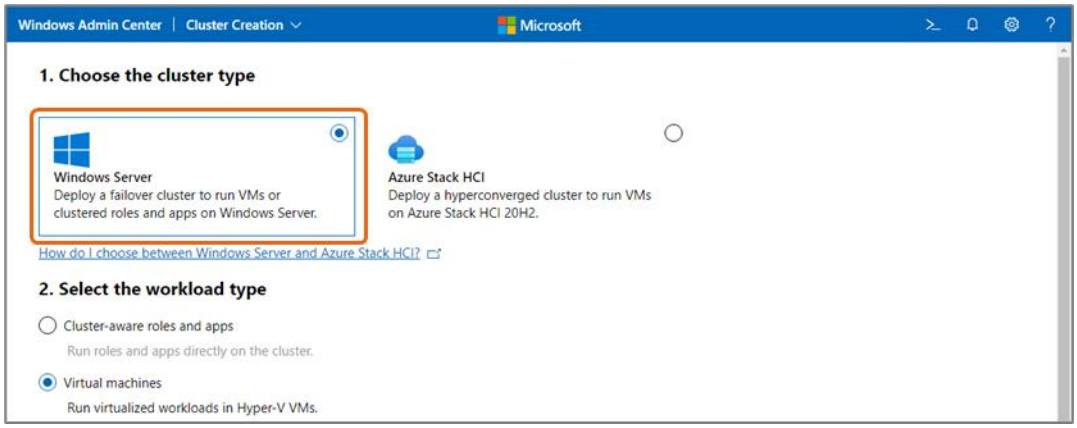


Figure 9. Windows Admin Center cluster creation tools

Guest VM integration services

Guest VM integration services are a package of virtualization-aware drivers installed on a guest VM. Integration services optimize the guest VM virtual hardware for interaction with the physical host hardware and with external storage.

Microsoft Updates installs VM integration services automatically with Windows Server 2016 Hyper-V and newer.

If you have earlier versions of Hyper-V in your environment, you must install and manually update integration services on VMs. In Hyper-V Manager, use the **Action** menu to mount the Integration Services Setup Disk (an ISO file). Follow the prompts in the guest VM console to complete the installation.

Windows Server 2016 Hyper-V and newer does not support mounting an integration-services ISO. Use Microsoft Updates to install and update integration services with Hyper-V 2016 and newer.

Verify that integration services update on the VM when you move a VM from an older version of Hyper-V to a newer version.

If a VM does not perform as expected due to CPU, disk I/O, or network performance, verify that the VM integration services are current for the VM.

The presence of unknown devices on a VM indicates a problem with integration services. Verify that integration services are current on a VM if you see unknown devices.

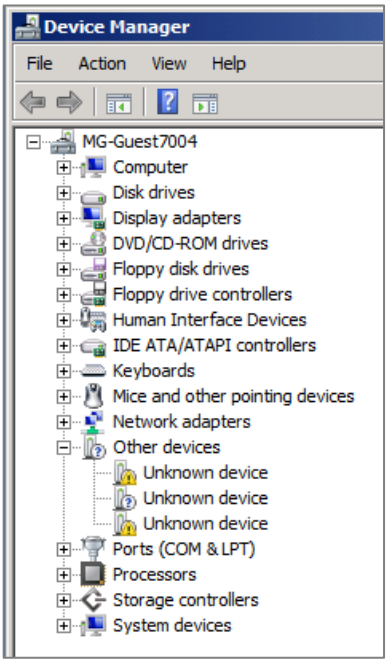


Figure 10. Unknown guest VM devices indicate missing or outdated integration services

Use tools such as Failover Cluster Manager, PowerShell, or Windows Admin Center to verify the version of integration services.

Hyper-V guest VM generations

Windows Server 2012 R2 Hyper-V introduced generation 2 VMs. Generation 1 VMs are still supported with all versions of Hyper-V.

Generation 2 VMs offer the following enhancements:

- Unified Extensible Firmware Interface (UEFI) replaces the legacy BIOS at boot-up. UEFI provides better security and better interoperability between the operating system and the hardware. UEFI offers improved virtual driver support and performance.
- Elimination of the requirement to use a virtual IDE disk for the boot disk. Generation 1 VMs require a virtual IDE disk controller for the boot disk.
  - Generation 2 guests support virtual SCSI controllers for all disks.
  - Virtual IDE is not supported with generation 2 VMs.

Generation 1 VMs are supported with all versions of Hyper-V. However, with Hyper-V 2016 and newer, the New Virtual Machine Wizard might default to generation 1. Create VMs as generation 2 as a best practice, if the guest operating system will support it.

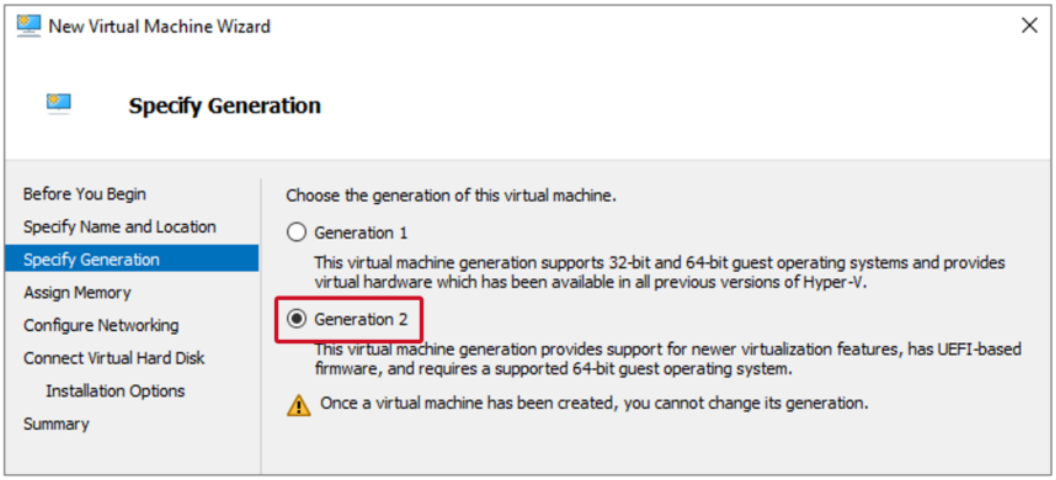


Figure 11. Guest VM generation option

For either generation of guest VM, if multiple disks require high I/O, each disk can be associated with its own virtual disk controller to maximize performance.

Convert VMs to a newer generation

Microsoft does not provide a way to convert a generation 1 VM to generation 2. However, conversion might be possible if you choose to use a third-party tool (use at your own risk). The best-practice method is to migrate a workload from a generation 1 VM to a generation 2 VM. If you attempt a conversion with a third-party tool, do so in a test environment first to validate that the process works.

Virtual hard disks

A virtual hard disk is a set of data blocks that the host operating system stores as a regular Windows file with a VHD, VHDX, or VHDS extension. PowerStore supports all virtual disk format types.

Virtual hard disk format

Generation 1 and generation 2 VMs support the following virtual hard disk formats:

- **VHD:** All Hyper-V versions support this format. VHD is a legacy format.
  - VHD supports a maximum size of 2 TB.
  - The New Virtual Hard Disk wizard might default to VHD with older versions of Hyper-V. Use VHDX for new VM deployments when supported by the guest operating system.
- **VHDX:** Windows Server 2012 Hyper-V and newer support this format.
  - The VHDX format is more resilient.
  - VHDX offers better performance.
  - VHDX scales to 64 TB.
  - Use Hyper-V Manager or PowerShell to convert a VHD to VHDX format.
- **VHDS (VHD Set):** Windows Server 2016 Hyper-V and newer support this format.
  - Two or more guest VMs can share access to a VHDS.

- Guest VMs can use VHDS disks as virtual cluster disks in a high-availability (HA) configuration.

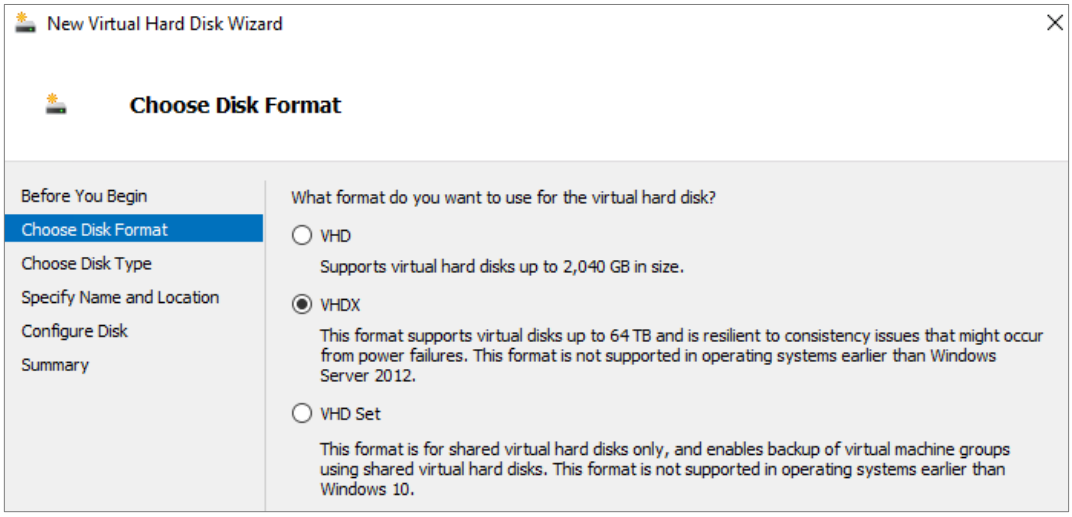


Figure 12. Virtual hard disk format options

Virtual hard disk type

In addition to the VHD, VHDX or VHDS virtual hard disk format options, you can designate a virtual hard disk as fixed, dynamically expanding, or differencing.

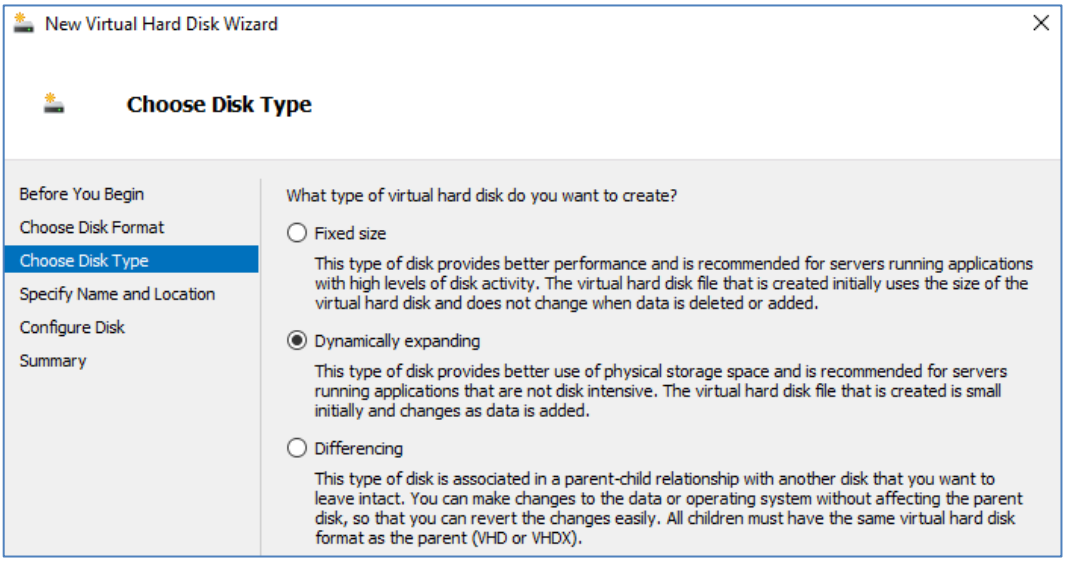


Figure 13. Options for virtual disk type

A dynamically expanding disk is the default type and will work well for most Hyper-V workloads on PowerStore storage. With PowerStore, only new data consumes storage capacity, regardless of the disk type (fixed, dynamic, or differencing). As a result, the type of workload determines the best disk type. PowerStore storage efficiency will be optimal regardless of the virtual hard disk type.

For general workloads, the performance difference between fixed and dynamic will usually be negligible. For workloads that generate high I/O, such as Microsoft SQL Server

databases, Microsoft recommends the fixed-size virtual hard disk type to optimize performance.

Fixed and dynamic virtual hard disk comparison

A fixed virtual hard disk consumes the full amount of space from the perspective of the Windows host server. A dynamic virtual hard disk consumes new space on the host only when a VM writes new data to the disk. Dynamic virtual hard disks are more space efficient from the perspective of the Windows host. From the perspective of the guest VM, fixed and dynamic virtual hard disks appear as the same size.

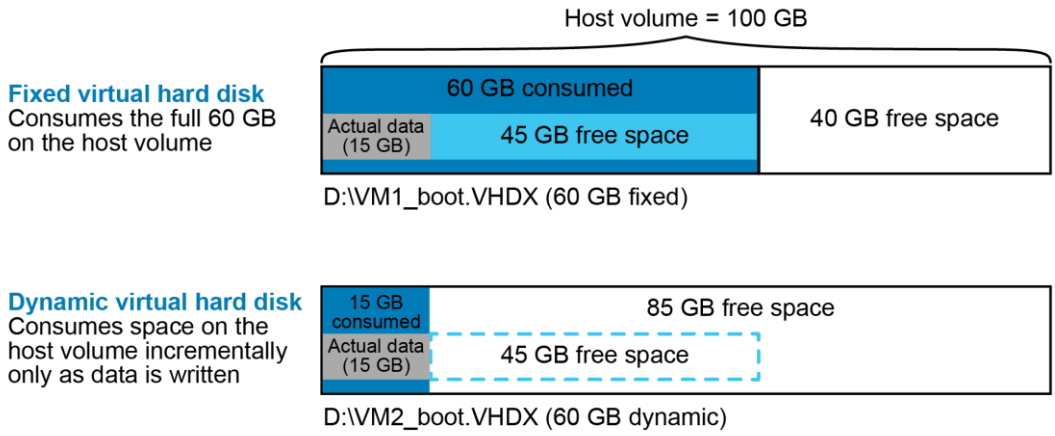


Figure 14. Fixed and dynamic virtual hard disk comparison

Consider performance and management best practices when you choose a virtual hard disk type in your PowerStore storage environment.

- **Fixed size** virtual hard disks:
  - Workloads or functions that generate high disk I/O experience better performance with fixed-size VHDs.
  - Less space efficient on the Windows host server volume. For example, a 100 GB fixed size VHD file consumes 100 GB on the host, even if the VHD contains no data.
  - Less susceptible to fragmentation.
  - Takes longer to copy to another location. The VHD file size is the same as the format size, even if the VHD contains no data.
- **Dynamically expanding** virtual hard disks:
  - Recommended for most workloads, except for high disk I/O use cases.
  - Space-efficient on the Windows Server host. The VHD file expands only as a VM writes new data.
  - More susceptible to fragmentation at the host level.
  - Require a small amount of host CPU and I/O overhead as they expand. There is no negative performance impact unless the workload I/O is high.

  - Require less time to copy over the network. For example, if a 500 GB dynamically expanding VHD contains 20 GB of data, the VHD file size is 20 GB (not 500 GB).
  - Dynamic VHDs allow disk space on the host to be overprovisioned. Monitor overprovisioned disk space closely. Configure capacity alerts on a host server if host volumes are overprovisioned.
- **Differencing** virtual hard disks:
  - Limited use cases. For example, a virtual desktop infrastructure (VDI) deployment can use differencing VHDs.
  - Increased complexity.
  - You can realize more storage efficiency with differencing VHDs. Differencing VHDs allow multiple Hyper-V guest VMs with identical operating systems to share a common virtual boot disk.
  - All VM children must use the same virtual hard disk format as the VM parent.

Virtual hard disks and thin provisioning with PowerStore

All virtual hard disk types (fixed, dynamic, or differencing) take full advantage of PowerStore storage thin provisioning to maximize storage efficiency.

The example in Figure 15 shows a 100 GB volume presented to a Hyper-V host that contains two 60 GB virtual hard disks. The example shows overprovisioning to demonstrate behavior, but not as a best practice.

- **VM1_boot.VHDX** is a fixed-size VHD.
- **VM2_boot.VHDX** is a dynamic VHD.
- Each virtual hard disk contains 15 GB of data.
- The fixed and dynamic VHDs consume 75 GB of space on the host server.
  - 60 GB fixed disk consumes 60 GB of space
  - 60 GB dynamic disk consumes 15 GB of space

Note: The host server will always report the format size as consumed for a fixed-size VHD.

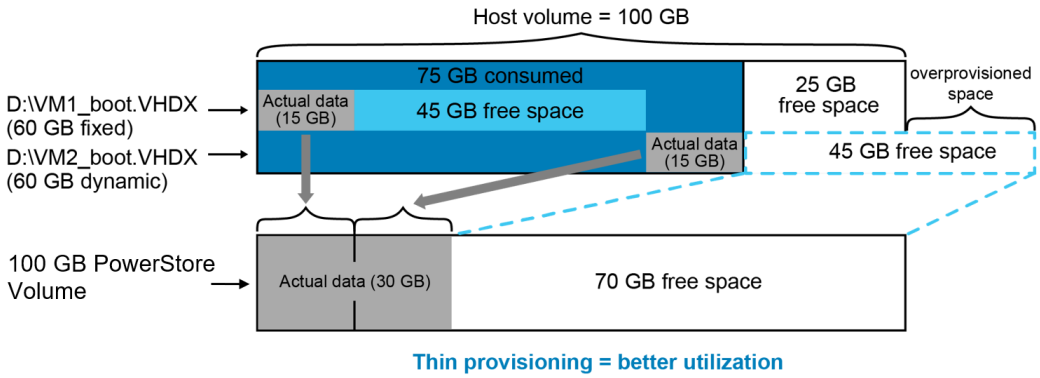


Figure 15. Thin provisioning with PowerStore

Comparatively, PowerStore reports storage utilization on this same volume as follows:

Example: 15 GB of used space on the fixed disk + 15 GB of used space on the dynamic disk = 30 GB.

Note: Either type of virtual hard disk (dynamic and fixed) will consume the same space on PowerStore because of thin provisioning. Consider other factors such as the I/O demand of workloads as primary considerations when you determine the type of virtual hard disks in your environment.

Overprovisioning with dynamic virtual hard disks

Use caution if you overprovision your storage with dynamic VHDs.

To mitigate risks, consider the following best practice recommendations:

- Create Hyper-V physical volumes that are large enough so that current and future expanding dynamic virtual hard disks will not fill the host volumes to capacity. PowerStore thin provisioning ensures space efficiency regardless of the initial size of a volume.
  - Allow adequate overhead on the physical volume if you configure native Hyper-V checkpoints (snapshots). Hyper-V checkpoints consume extra disk space.
  - Expand physical volumes as needed to allow headroom.
  - Configure a capacity alert for a physical host volume if it is overprovisioned. For example, to allow time for remediation, configure an alert if a volume exceeds 80% capacity.
- Closely monitor alerts on PowerStore. Warnings about disk group and pool capacity will allow time for remediation.

Hyper-V checkpoints

A native Hyper-V-based checkpoint creates a snapshot of a VM on the physical host volume or cluster volume.

Note: Native Hyper-V checkpoints (snapshots) and PowerStore appliance-based storage snapshots function independently.

Each extra Hyper-V checkpoint creates another snapshot. Hyper-V stores checkpoints in a hierarchical tree.

The time required to read data from a long chain of Hyper-V checkpoints injects read latency that can negatively impact workload performance.

Limit the use Hyper-V VM checkpoints to essential or temporary use cases as a best practice if checkpoints are required.

Administrators can use PowerStore snapshots to protect and replicate VM data, in addition to native Hyper-V VM replication tools.

Present PowerStore storage to Hyper-V hosts and VMs

Map the following PowerStore volume types to Windows Server and Hyper-V hosts, nodes, and guest VMs.

Boot from SAN

PowerStore supports boot-from-SAN. Windows Server stand-alone and clustered hosts support boot-from SAN when the hosts have a compatible boot-from-SAN adapter. Guest VMs support booting from a pass-through disk directly from PowerStore. Do not use a pass-through disk unless you have a specific use case that requires a pass-through disk. Use virtual hard disks (VHDs) with VMs whenever possible.

Consider the following advantages as you choose a boot configuration:

Boot-from-SAN advantages:

- PowerStore snapshots of boot-from-SAN volumes provide for quick recovery for a host server.
- Replicate boot-from-SAN volumes to another PowerStore at a remote location for enhanced DR protection when both sites use similar host server hardware.
- PowerStore supports the configuration of a base volume as a boot-from-SAN system-prepared (Sysprep) gold image. Thin clones of gold image can be used to rapidly provision new boot-from-SAN hosts.
  - See the section Use PowerStore to create a gold image to learn more about Sysprep.

Boot-from-local-disk advantages:

- Offline SAN or storage fabric maintenance does not affect a local boot disk.
- Local boot allows a host with critical roles or services to stay online if the storage or storage fabric goes offline.
  - Critical roles include Active Directory, DNS, and DHCP.
- Host groups on PowerStore support Windows Server hosts with local boot only. Boot-from SAN hosts cannot be added to a PowerStore host group.

Note: Present PowerStore boot-from-SAN volumes as **LUN 0** to Windows Server and Hyper-V hosts.

Data volumes

PowerStore supports the following types of volumes as data volumes for Windows Server hosts, Hyper-V hosts, clusters, and VMs.

- SCSI (Fibre Channel (FC) and iSCSI).
  - NTFS and ReFS disk formats.
- Cluster volumes and cluster shared volumes (CSV).
- Direct-attached in-guest iSCSI or virtual Fibre Channel (vFC) disks for guest VMs. However, PowerStore does not support direct attached disks configured as Metro Volumes.

- Pass-through disks for guest VMs (for boot or data). However, PowerStore does not support a pass-through disk configured as a Metro Volume if the pass-through disk is configured as a boot disk.

Note: Use virtual hard disks (VHD, VHDX, VHDS) for VM boot and data whenever possible. Use direct-attached or pass-through disks only if you have a use case that requires them.

PowerStore supports the native Microsoft device-specific module (DSM) for MPIO. Use the Microsoft DSM on physical hosts, nodes, and VMs for MPIO support.

Use PowerStore host groups and volume groups when VMs and data span multiple hosts or volumes.

Note: Microsoft does not support NVMe over Fibre Channel (NVMe/FC) or NVMe over TCP (NVMe/TCP). Windows Server environments will support NVMe transports if Windows drivers become available from Microsoft. Check the latest Microsoft and PowerStore documentation to verify Windows Server support for NVMe/FC or NVMe/TCP before you choose a NVMe initiator type.

See the Dell PowerStore Administrator's Guide and the Dell PowerStore Deployment Guide at Dell Support for in-depth transport and cabling guidance.

Cluster shared volumes

PowerStore supports cluster-shared volumes (CSVs).

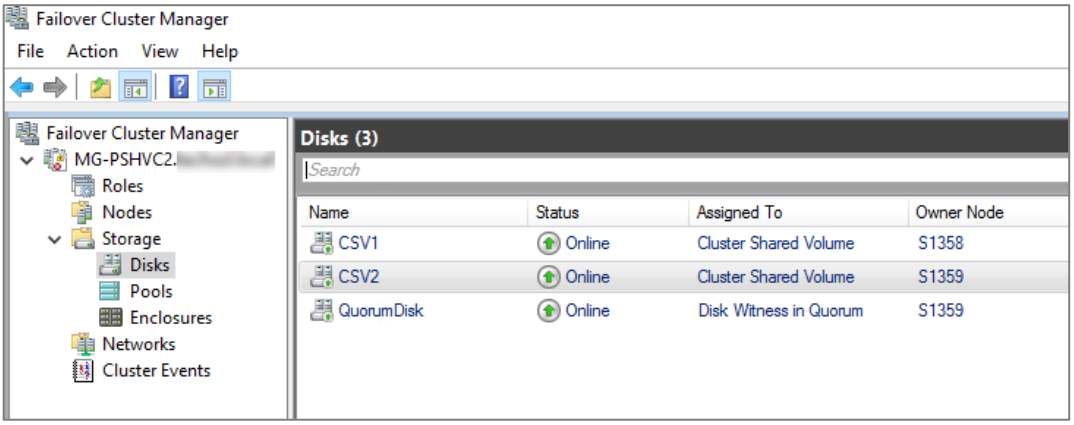


Figure 16. Cluster shared volumes

Windows Server 2008 R2 introduced cluster-shared volumes (CSV). A CSV is a cluster volume that allows all nodes in a Hyper-V cluster to have concurrent read/write access.

CSVs allow a clustered role, such as a Hyper-V VM, to fail over quickly from one Hyper-V host (node) to another without regard to CSV node ownership. A failover operation does not depend on the CSV node assignment.

CSVs are commonly used to support Hyper-V guest VM workloads. Microsoft support for additional workloads on CSV has expanded with newer releases of Windows Server.

A CSV is initially formatted as NTFS or ReFS; then it is configured as a CSV.

Note: Place virtual hard disks for a VM on CSVs as a best practice. CSVs are more resilient than regular cluster volumes. Use regular cluster volumes to host VM virtual hard disks only if you have a specific use case that requires it.

Transport options

PowerStore supports SCSI (iSCSI and Fibre Channel (FC)). PowerStore also supports NVMe/FC and NVMe/TCP. However, Microsoft does not support either NVMe transport option as of this writing.

For Microsoft environments, the choice of transport (iSCSI or FC) is based on factors such as customer preference, size of the environment, economics, and the required support expertise.

FC and iSCSI

Fibre Channel: businesses that have standardized on FC benefit from a fast, stable, and reliable data transport that ensures resilience, performance, and data isolation.

- The storage fabric is separate from the TCP network.
- FC requires dedicated hardware.
  - FC requires a separate storage area network consisting of FC switches. The additional hardware creates a larger hardware footprint and uses more power.
  - Each host server requires one or more FC host bus adapters (HBA).
- FC requires additional time and support expertise to manage.

iSCSI has grown in popularity.

- iSCSI performance has improved over time. Performance is now comparable to FC.
- Administrators can leverage their existing (or expanded) Ethernet infrastructure to implement iSCSI if their environment supports it.
- Converged Ethernet networks minimize hardware footprints.
  - A smaller footprint is especially beneficial for small office, branch office, and edge use cases.

Regardless of the transport, configure MPIO for redundant storage data paths to each host as a best practice.

A single path configuration is less complicated, easier to configure, and less expensive to implement. Use of a single data path is acceptable only when the workload is not critical. For example, nonproduction test or development environments that are not business critical might use lower tier hardware and a single path.

Choose a transport

In a Hyper-V environment on PowerStore, configure all hosts or nodes to use a single common SCSI transport as a best practice. Use FC or iSCSI, but not both.

Use cases for concurrent transports

Windows Server hosts and clusters support the use of concurrent transports (FC and iSCSI). However, limit the use of multiple transports to specific or temporary use cases.

A data or workload migration is a valid use for multiple transports. Windows Server supports FC and iSCSI adapters installed in the same host.

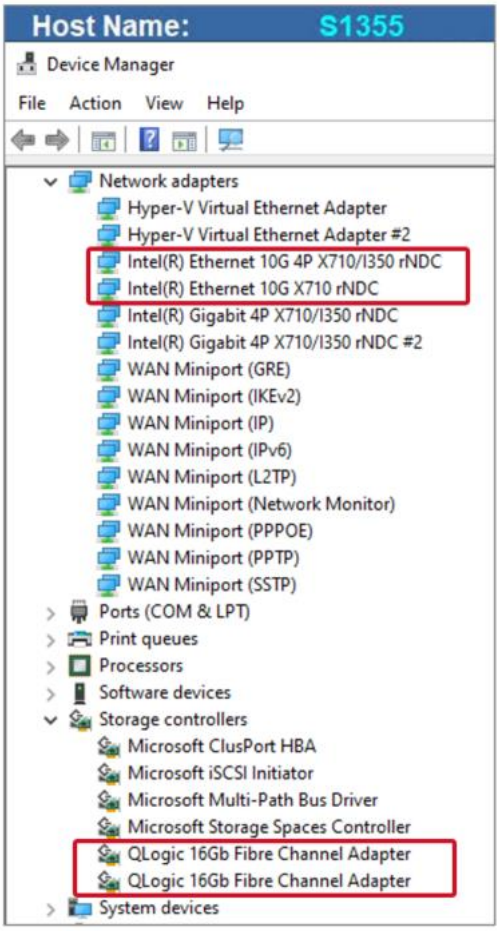


Figure 17. Host server with Intel Ethernet 10 GbE NICs (iSCSI) and Mellanox (QLogic) 16 Gb HBAs (FC)

Do not assign FC and iSCSI paths to the same volume or cluster volume. For example, configure volume 1 to use FC, and configure volume 2 to use iSCSI.

- Volume 1, mapped to Host 1, with two FC paths = OK
- Volume 2, mapped to Host 1, with two iSCSI paths = OK
- Volume 3, mapped to Host 1, with two FC paths and two iSCSI paths (four paths total) = not supported

---

Caution: A volume with concurrent FC and iSCSI paths will experience unpredictable service-affecting I/O behavior given a path failure scenario.

Consider the following data migration example:

- A host server has a local boot disk, and an FC HBA.
- The host server connects to a data volume on a legacy storage appliance with FC.
  - The legacy appliance will be retired.
- The host server has a NIC that supports iSCSI.

- An administrator wants to migrate a workload from the legacy FC data volume to a new iSCSI volume on PowerStore.

Perform the following steps:

1. Create a host object on the PowerStore appliance that uses iSCSI mappings.
2. Present a new data volume from the PowerStore appliance to the host. Configure MPIO for the new data volume.
3. Perform a disk rescan. The host server will display two volumes:
   a. Volume 1: Legacy FC volume mapped from the legacy storage appliance.
   b. Volume 2: New iSCSI volume mapped from the new PowerStore appliance.
4. Migrate the workload from the legacy FC volume to the new iSCSI volume.
5. Discontinue the legacy FC volume.

MPIO best practices

Windows Server and Hyper-V support MPIO. MPIO is not installed by default. Install the MPIO feature with your preferred tool, such as PowerShell or Server Manager.

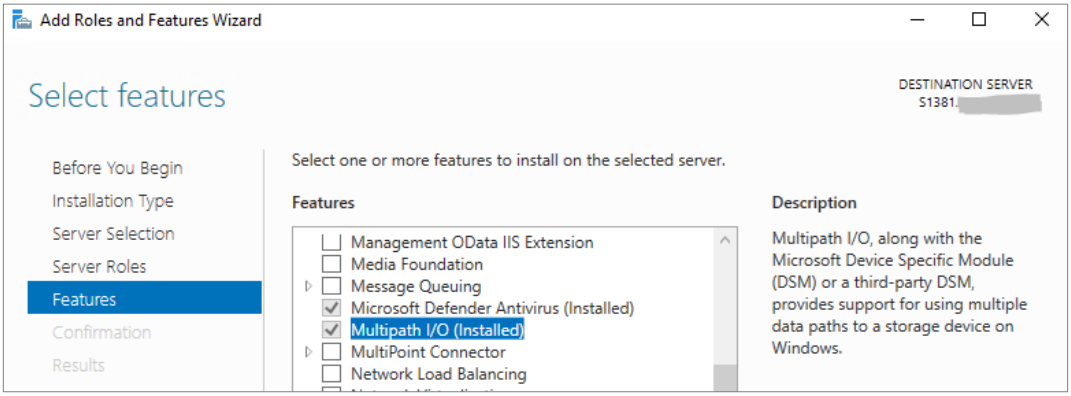


Figure 18. Install the Multipath I/O feature

After installing the Multipath I/O feature on a host, map a PowerStore volume to the host. Use your preferred Microsoft tool or utility to configure the PowerStore volume for MPIO. Repeat this step for each transport used if a host has FC and iSCSI volumes.

Note: PowerStore fully supports the native Microsoft DSM that comes with the Windows Server operating system. Use the Microsoft DSM as a best practice.

Consider using PowerPath for Windows if you need more advanced control over MPIO behavior. To learn more, see PowerPath for Windows on Dell Support.

MPIO policy

Windows Server and Hyper-V hosts default to the **Round Robin with Subset** policy with PowerStore. Round Robin with Subset will work well for most Hyper-V environments. Specify a different supported MPIO policy if wanted.

Number of paths

Configure two to four front-end (FE) storage paths from each PowerStore node to your storage fabric (four to eight paths total). Four to eight total storage paths provide optimal redundancy and performance.

- Configure four FE paths from each PowerStore node for workloads with high I/O and bandwidth demands.
- Do not configure more than four FE storage paths from a PowerStore node to the same storage fabric. Use of more than four paths (eight paths total) will degrade performance.

MPIO path behavior

On a Server host, the **Active/Optimized** paths are associated with the active PowerStore storage controller (for example, Node A) for that volume. The **Active/Unoptimized** paths are associated with the standby PowerStore storage controller for that volume (for example, Node B).

The PowerStore volume wizard will alternate the active controller in a round-robin fashion when you create volumes on PowerStore to help load balance the PowerStore nodes. Administrators can override the behavior and specify the active PowerStore node for a new volume.

Other MPIO best practices

- Do not change MPIO registry settings on the Windows or Hyper-V host (such as time-out values) unless directed by PowerStore documentation or Dell Support.
  - See the E-Lab Host Connectivity Guide for Microsoft Windows for the recommended MPIO timeout values.
- Configure dual fabrics and storage networks for switch and path level redundancy.
- Configure each host to use at least two paths with a SAN configuration (iSCSI or FC). Configure host MPIO settings to protect against a PowerStore node or data path failure.
- Verify that software versions are current for all components in the data path.
  - PowerStoreOS.
  - Data and FC switch firmware.
  - Boot code, firmware, and drivers for FC HBAs, Ethernet NICs, and converged network adapters (CNAs).
- All hardware should be supported. Review the Dell PowerStore Support Matrix at Dell Support to verify hardware compatibility.
- Monitor the performance of your storage fabric.
  - Watch for anomalies such as switch port error counts.
  - An intermittent issue with a switch port, cable, NIC, or HBA can cause significant performance degradation in MPIO environments.

Guest VMs and block storage options

Administrators should use virtual hard disks (VHD, VHDX, VHDS) with Hyper-V VMs whenever possible. However, Hyper-V does support three methods for presenting SAN block storage directly to a guest VM. Limit the use of pass-through or direct attached disks to specific or temporary use cases. The three supported methods are:

- In-guest iSCSI.
- Virtual Fiber Channel (vFC). For more information about vFC, see Virtual Fibre Channel.
- Physical pass-through disk.

If you have a use case that requires direct-attached storage, of the three options available, use in-guest iSCSI as a best practice.

Note: PowerStore does not support Metro Volumes configured as boot-from-SAN disks, in-guest iSCSI disks, or vFC disks.

In-guest iSCSI

Configure the host and VM network so the VM can access PowerStore iSCSI volumes through a Hyper-V host or cluster data network.

- Configure in-guest iSCSI on the VM the same way you configure iSCSI on a physical host.
- A guest VM supports MPIO when multiple paths are available to the VM. Install and configure the multipath I/O feature on the VM.

vFC

There is a separate section in this paper that covers vFC in more detail. See Virtual Fibre Channel.

Physical pass-through disks

A pass-through disk is a physical disk presented directly to a Hyper-V VM. The Hyper-V host or cluster assigns a LUN ID to a pass-through disk but does not have I/O access to the disk. Hyper-V keeps the disk in a reserved state. Only the guest VM has read/write I/O access.

- Hyper-V 2008 introduced pass-through disks. Pass-through disks are a legacy option that preserves backwards compatibility.
- Pass-through disks are no longer necessary because of the feature enhancements with newer releases of Hyper-V (generation 2 guest VMs, VHDX format, and shared VHDs).
- Avoid the use of pass-through disks, other than for temporary or specific use cases.
- Use of pass-through disks in not recommended in a cluster environment, other than for temporary or specific use cases.

1. Map a SAN volume to the physical Hyper-V host or cluster nodes.
2. Bring the disk online, initialize the disk, and then take the disk offline.

3. Use Hyper-V Manager or Failover Cluster Manager to attach the disk directly to a guest VM.
4. Generation 1 VMs (with virtual IDE or virtual SCSI controllers) and generation 2 VMs (with virtual SCSI controllers) support pass-through disks.

In-guest iSCSI, vFC, and pass-through disk use cases

PowerStore appliances support in-guest iSCSI, vFC, and direct-attached (pass-through) disks mapped to Hyper-V guest VMs. However, avoid these options as a best practice, unless a specific use case requires it. Typical use cases include:

- **Performance**: Direct-attached disks bypass the host server file system and so offer slightly better performance than a VHD or VHDX. There is no significant difference in performance between a direct-attached disk and a virtual hard disk for most workloads.
  - Preferred: Redesign the environment to eliminate virtual disk performance as a bottleneck rather than switching to a direct-attached disk.
- **Clustering**: VM clustering on legacy Hyper-V platforms requires the use of direct-attached disks. Use of shared VHDs is the preferred option for VM clustering (HA) with Server 2012 R2 and newer.
- **Troubleshooting**: Use of a direct-attached disk can be helpful if you must troubleshoot I/O performance on an isolated physical volume that is separate from all other servers and workloads.
- **Custom snapshot or replication policy**: When it is necessary, apply a custom PowerStore protection policy (snapshots and replication) to a specific disk (volume).
  - Preferred: Place a virtual hard disk on a dedicated cluster volume or cluster shared volume (CSV) in a one-to-one configuration. Then, apply PowerStore snapshots and replication to the cluster disk or CSV.
- **Capacity**: Legacy VHDs support a maximum size of 2 TB. VHDX supports a maximum size of 64 TB. The maximum supported size of a direct-attached disk is usually much larger than 64 TB; it is a function of the VM operating system.

In-guest iSCSI, vFC, and pass-through disk storage limitations

- **Native Hyper-V Snapshots**: You lose the ability to perform a native Hyper-V snapshot when a VM uses direct-attached storage. However, the ability to protect direct-attached volumes with PowerStore snapshots and replication is unaffected.
- **Complexity**: Use of direct-attached disks increases complexity. Of the three options, vFC is the most complicated. More complexity increases management overhead.
- **Mobility**: Direct-attached disks create a physical hardware layer dependency that reduces VM mobility.
- **Scale**: Each pass-through disk consumes a LUN ID on each host in a Hyper-V cluster. Extensive use of pass-through disks quickly becomes impractical and unmanageable at scale on a Hyper-V cluster. Use pass-through disks only if they are required for a specific use case. Management of any of the three types of direct-attached storage becomes increasingly difficult at scale.

- **Differencing Disks**: The use of a pass-through disk as a boot volume on a guest VM prevents the use of a differencing disk.
- **Metro Volume**: PowerStore does not support in-guest iSCSI, or vFC disks configured as Metro Volumes. Pass-through disks are supported as Metro Volumes when configured as data disks, but not as boot disks.

Note: Legacy Hyper-V environments that use direct-attached disks for guest VM clustering (HA) should switch to shared virtual hard disks (VHDS) as a best practice when modernizing.

Virtual Fibre Channel

vFC overview

PowerStore supports virtual Fibre Channel (vFC), but there are limitations. If you require direct-attached storage for a Hyper-V guest VM, use in-guest iSCSI (preferred).

vFC is a more complicated setup than in-guest iSCSI. vFC is more difficult to configure and troubleshoot.

PowerStoreOS versions before 3.0 offer limited support for vFC. PowerStoreOS versions before 3.0 do not support mapping standby (offline) virtual WWNs to a VM.

Note: The use of vFC adapters may require disabling a security parameter. See this Microsoft KB for more information.

vFC design

The Microsoft implementation of vFC assigns two virtual WWN address sets to each vFC adapter on a guest VM, as shown in Figure 19. Address set B is offline by default. The guest VM alternates between address set A and B when the VM fails over or live migrates. Only one set can be active at a time.

vFC with PowerStoreOS prior to 3.0

With PowerStoreOS versions before 3.0, PowerStore Manager does not provide a way to map WWNs to a guest VM if the WWNs are offline. Only half of the WWNs can be mapped (the active set but not the standby set). As a result, if the VM switches to the standby address set for any reason, the VM loses connectivity to the vFC volume. This occurrence causes a service interruption.

- We do not recommend this configuration for VMs on a Hyper-V cluster. Whenever a guest VM fails over or live-migrates to another physical node in a cluster, the active vFC WWN address set goes offline and the standby set becomes active.
- A VM with vFC configured on a stand-alone Hyper-V host will typically always use address set A. If you reboot the host or the VM, the VM should continue to use address set A. However, there is no guarantee that the guest VM will always use address set A. The risk of a service interruption is always present should vFC on the guest VM switch to address set B.

vFC with PowerStore 3.0 and newer

If you configure vFC with PowerStoreOS 3.0 and newer, make sure to map set A WWNs (active/online) and manually map set B WWNs (standby/offline). This configuration preserves vFC connectivity if a guest VM fails over or live-migrates.

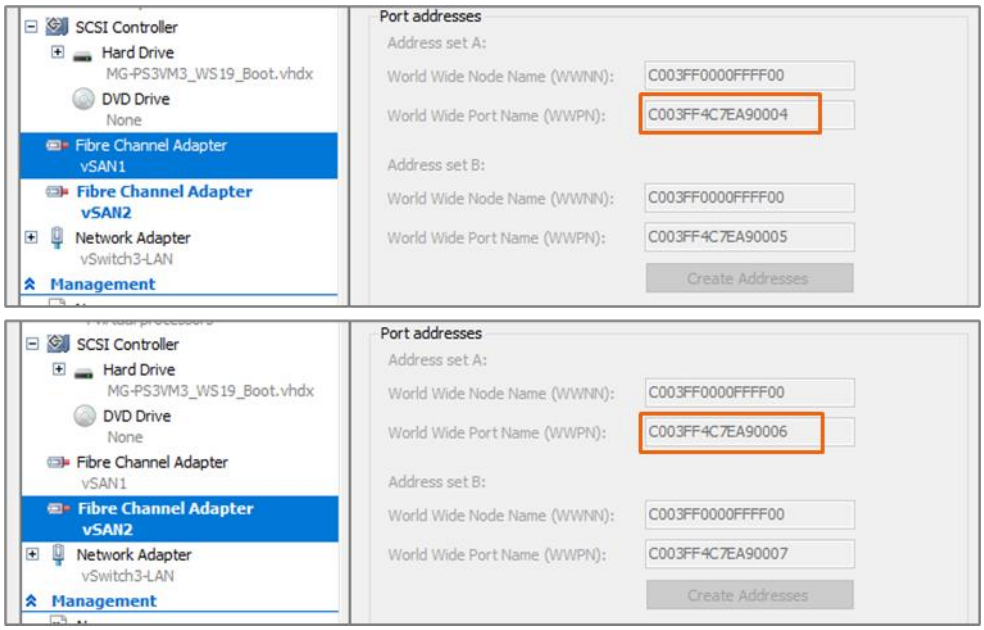


Figure 19. Hyper-V Manager vFC adapter configuration for a guest VM

In this example, the ports ending in 04 and 06 (set A) are active/online. The ports ending in 05 and 07 (set B) are standby/offline. If the guest VM live migrates or fails over to another Hyper-V node, the state of the address sets reverse. Ports 04 and 06 (set A) go offline, and ports 05 and 07 (set B) become active.

vFC use cases

There are limited use cases for vFC with PowerStore. The use cases for vFC are like the use cases for in-guest iSCSI and pass-through disks. See In-guest iSCSI, vFC, and pass-through disk use cases for more information.

vFC and MPIO

vFC supports MPIO. If MPIO is wanted, install and configure the MPIO feature on the guest VM.

PowerStore storage and Hyper-V clusters

Use a consistent LUN number when you map a shared volume to a Hyper-V cluster: quorum disks, cluster disks, and cluster shared volumes. Configure host groups in PowerStore Manager as a best practice. When you map a shared volume to a host group in PowerStore Manager, the wizard assigns the next available LUN number that is common on each Hyper-V node automatically.

Note: PowerStore host groups do not support Hyper-V hosts that use boot-from-SAN.

If you do not use PowerStore host groups, use PowerStore Manager to change LUN IDs if necessary. Ensure that LUN IDs are consistent after a shared volume is mapped to multiple Hyper-V nodes.

Volume design considerations for PowerStore storage

Each cluster shared volume (CSV) supports one or more VMs. Determine the number of VMs per CSV based on user preference, the workload, and how PowerStore storage features such as snapshots and replication will be used. Place multiple VMs on a CSV as a useful design baseline for most scenarios. Adjust this strategy for specific uses cases.

Advantages for placing multiple VMs on a CSV include:

- **Avoid volume sprawl**: Fewer PowerStore appliance volumes are easier to manage.
- **Efficiency**: It is quick and easy to deploy a VM to an existing CSV.

Advantages for placing one VM on a CSV include:

- **I/O isolation**: It is easier to isolate and monitor disk I/O patterns for a specific Hyper-V guest VM or workload.
- **Ease of recovery**: It is easy to quickly restore a guest VM. Recover the underlying CSV with a PowerStore snapshot.
- **Replication control**: Administrators can free up replication bandwidth. Replicate a specific VM to another location.
- **Move large guest VMs quickly**: You should use native Hyper-V tools to migrate VMs. However, when a VM is large, it might be quicker and easier to move a guest VM from one host or cluster to another by remapping the volume. If you use remapping to move a CSV, you avoid copying or moving a large guest VM over the network.

Another strategy is to group Hyper-V guests or VHDs with a common purpose on a CSV.

TRIM/UNMAP and disk space recovery

When you delete a file on a Windows Server, the server deletes the file pointer, and Windows shows the recovered space as free capacity. However, the old data remains on the disk. Over time, the server operating system overwrites the old data with new data.

When deleting files, the host server also passes a TRIM/UNMAP command to the external storage appliance. If the external storage supports TRIM/UNMAP, the external storage will reclaim the space in the storage pool.

Recovery of deleted disk space on PowerStore with TRIM/UNMAP is a key benefit of thinly provisioned volumes.

PowerStore supports TRIM/UNMAP with Windows Server and Hyper-V given the following conditions:

- The Windows Server operating system must be version 2012 or later.
- TRIM/UNMAP must be enabled in Windows (enabled is the default Windows setting).
- Physical volumes (includes boot-from-SAN disks, cluster shared volumes, direct-attached and pass-through disks) must be *basic* disks.
- Physical volumes must be formatted as NTFS volumes. Other formats, such as ReFS, do not support TRIM/UNMAP.
- Virtual hard disks support TRIM/UNMAP given the following conditions:

- The cluster shared volume (or other data volume) that hosts the virtual hard disk is a *basic* disk formatted as an NTFS volume.
- The guest VM operating system is Windows Server 2012 or later.
- The guest VM is a generation 2 VM.
- The guest VM operating system formats the virtual hard disk (fixed or dynamic) as a *basic* disk NTFS volume.
- TRIM/UNMAP is enabled on the guest VM.

By default, TRIM/UNMAP is enabled. Do not disable TRIM/UNMAP, unless it is necessary. It might be necessary to temporarily disable TRIM/UNMAP under these conditions:

- When troubleshooting, or when directed by Dell support.
- Avoid a long wait time when formatting a large volume.

Avoid a long format wait time

When TRIM/UNMAP is enabled, internal tests demonstrate that the format time for a 500 GB NTFS or ReFS volume on PowerStoreOS is less than one minute. Format time for a 1 TB volume is less than two minutes. Format time for a 5 TB volume is less than seven minutes.

With TRIM/UNMAP temporarily disabled, formatting a large NTFS or ReFS volume completes in a few seconds.

To avoid a long wait when formatting a large volume, temporarily disable TRIM/UNMAP in Windows with the Registry Editor, fsutil, or PowerShell. For more information, see the next two sections, Manage TRIM/UNMAP with fsutil and Manage TRIM/UNMAP with PowerShell.

Manage TRIM/UNMAP with fsutil

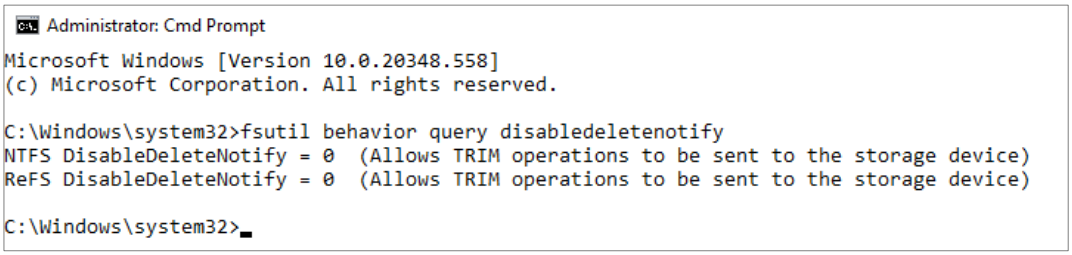
To temporarily disable TRIM/UNMAP with fsutil, follow these steps:

1. Access a command prompt on the host server with elevated (administrator) rights.
2. Run the following command:

   ```
   fsutil behavior query DisableDeleteNotify
   ```

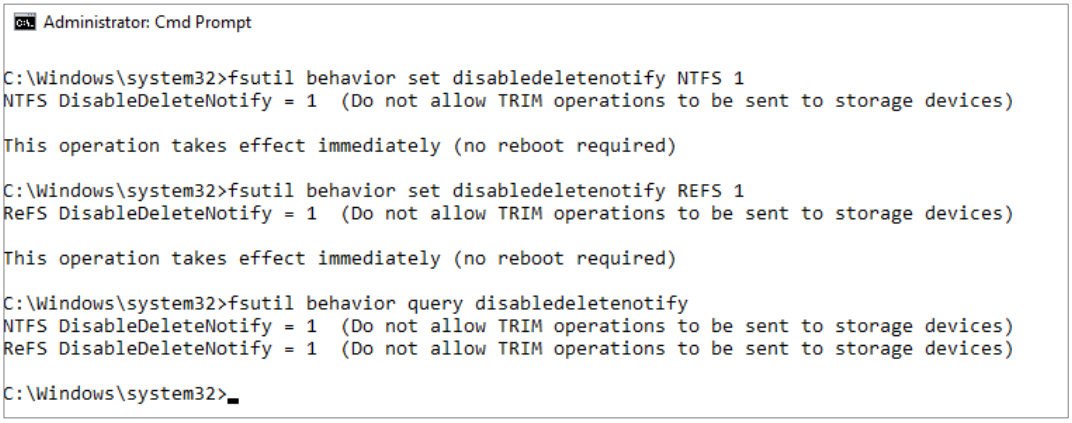
   If `DisableDeleteNotify = 0`, TRIM/UNMAP is enabled. This attribute is configurable for NTFS and ReFS volumes.

Note: For Windows Server 2012, `DisableDeleteNotify` does not differentiate between NTFS and ReFS; the attribute setting applies to both format types.



3. To disable TRIM/UNMAP for NTFS and ReFS, run the following commands to set the `DisableDeleteNotify` attribute to `1` (on Windows Server 2012, omit `NTFS` and `REFS` from the commands). Changing this attribute does not require a reboot.

```
fsutil behavior set disabledeletenotify NTFS 1
fsutil behavior set disabledeletenotify REFS 1
```



4. Complete your volume format activities.
5. When finished, enable TRIM/UNMAP (set the `DisableDeleteNotify` attribute to `0` for NTFS and ReFS volumes).

Manage TRIM/UNMAP with PowerShell

Windows Server 2012 and later supports the use of PowerShell to manage TRIM/UNMAP. To temporarily disable TRIM/UNMAP with PowerShell, follow these steps:

1. Open PowerShell with administrator rights.
2. Query the state of `DisableDeleteNotification` by running one of the following commands.

Note: on Windows Server 2012, the `DisableDeleteNotification` attribute applies to NTFS and ReFS volumes.

- For NTFS volumes on Windows Server 2012 and later (NTFS and ReFS volumes on Windows Server 2012):

```
Get-ItemProperty -Path "HKLM:\SYSTEM\CurrentControlSet\Control\FileSystem\" -Name DisableDeleteNotification
```

- For ReFS volumes (Windows Server 2016 and later):

```
Get-ItemProperty -Path "HKLM:\SYSTEM\CurrentControlSet\Control\FileSystem\" -Name
RefsDisableDeleteNotification
```

A result of `0` means TRIM/UNMAP is enabled.

```
DisableDeleteNotification : 0
RefsDisableDeleteNotification : 0
```

3. To disable TRIM/UNMAP, run one of the following commands.

   Changes do not require a reboot.

   - For NTFS on Windows Server 2012 and later (NTFS and ReFS on Windows Server 2012):

```
Set-ItemProperty -Path "HKLM:\SYSTEM\CurrentControlSet\Control\FileSystem\" -Name
DisableDeleteNotification -Value 1
```

   - For ReFS (Windows Server 2016 and later):

```
Set-ItemProperty -Path "HKLM:\SYSTEM\CurrentControlSet\Control\FileSystem\" -Name
RefsDisableDeleteNotification -Value 1
```

4. Complete your volume format activities.
5. When finished, use PowerShell to enable TRIM/UNMAP (revert `DisableDeleteNotification` and `RefsDisableDeleteNotification` from `1` to `0`).

Recovery of disk space with Windows Server 2008/R2

Microsoft provides a Sysinternals command-line tool named sDelete to recover disk space on Windows Server 2008/R2. See the Microsoft Sysinternals documentation library for more information about sDelete if you have Windows Server 2008 in your environment.

Note: PowerStore does not support Windows Server 2008/R2.

ODX

Offloaded data transfer (ODX) reduces CPU and network utilization on a Microsoft Server. ODX offloads a file-copy process from the host server to external storage. PowerStore does not support ODX.

For more information about ODX, see the Microsoft Windows Server Documentation Library.

ReFS

Windows Server 2012 introduced the resilient file system (ReFS). Microsoft recommends ReFS for large data volumes. ReFS uses a file-system design that auto-detects data corruption and performs repairs while the volume stays online. ReFS eliminates the need to run time-consuming check-disk operations on large volumes to resolve disk errors or corruption. PowerStore supports ReFS. However, ReFS does not support TRIM/UNMAP (a Microsoft limitation).

Microsoft recommends ReFS for large data volumes. Compare the features for NTFS and ReFS before you choose ReFS. If a volume requires TRIM/UNMAP support, choose NTFS.

PowerStore protection policies support NTFS and ReFS: snapshots, thin clones, data reduction, replication, and so on.

Disable automount

Automount is enabled by default on Windows Server. Automount automatically assigns drive letters to newly mapped volumes, including thin clone recovery volumes. Automount behavior is undesirable in a Hyper-V environment because it can interfere with data recovery processes.

In a Hyper-V environment on PowerStore, automount should be disabled as a best practice.

The following figure shows how to disable the automount feature.

1. Run `diskpart` from a command prompt with administrator privileges.
2. Run the command `automount disable`.
3. Confirm that the command completes: `Automatic mounting of new volumes disabled`.

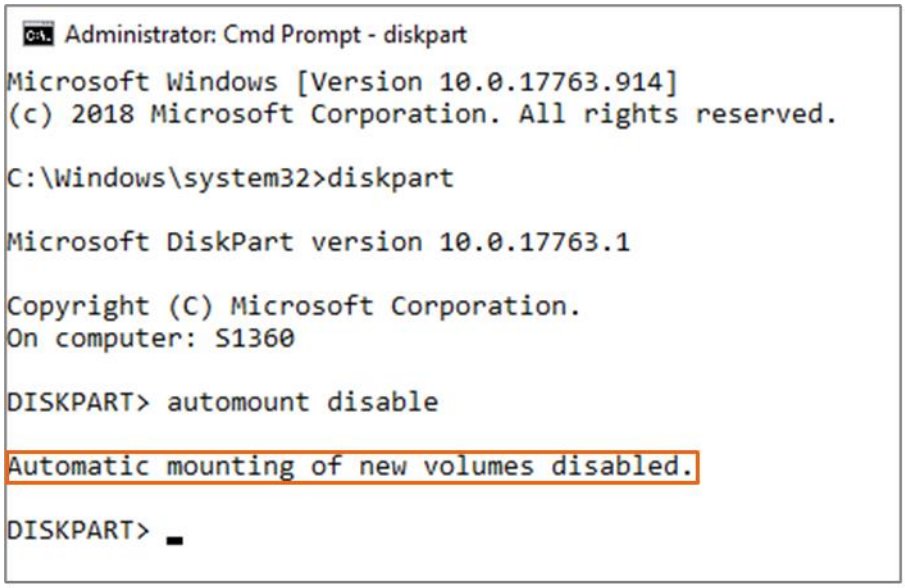


Figure 20. Disable the automount feature with diskpart

Placement of page files

Windows Servers and VMs place the page file on the boot volume by default. Windows automatically manages page file and memory settings. Users do not need to intervene to optimize memory management. Do not change the default page file settings unless required for a specific use case. For example, an application vendor might provide guidance for tuning page file and memory settings to optimize the performance of a specific workload.

If a vendor recommends page file modifications to optimize a workload, also consider the following tips as part of the overall page-file strategy.

- Move the page file to a separate dedicated volume or virtual hard disk.
  - Volumes or virtual hard disks dedicated to page files usually do not require snapshot protection or replication.
  - Reduces the snapshot overhead for boot volumes.
  - Avoids replication of unnecessary data to a remote location.
- Example: In a Hyper-V cluster environment, dedicate a CSV to virtual hard disks that contain page files. Omit the CSV from snapshot protection and replication.

Resiliency of essential services

Consider the following best practices to optimize the availability of essential services in your Hyper-V and PowerStore environment.

- Configure at least one domain controller as a physical host with local disk, or as a VM on a Hyper-V host with local disk.
- Run at least one domain controller independent of SAN storage so it will continue to provide essential services if external storage is unavailable. Essential services include AD user authentication, cluster authentication, DNS, and DHCP.
- Place a management host or VM (jump box) in the environment that remains accessible regardless of the state of the storage fabric or SAN resources. Install critical management tools on this resource to aid with administration, troubleshooting, monitoring, and recovery.

Domain controller placement

Do not place all domain controller VMs on the same Hyper-V cluster. If the cluster service depends on AD authentication to start, an outage of the Hyper-V cluster will result in an AD service interruption and a recovery conundrum for the administrator. Recovery might require the following steps:

- Manually recover a domain controller VM outside of the Hyper-V cluster and bring it online.
- With AD available, Hyper-V cluster services can now authenticate and start.
- Redesign the environment so that at least one domain controller does not depend on Hyper-V cluster services starting first.

Queue depth best practices for Hyper-V

Queue depth refers to the number of disk transactions that can be in flight from an initiator port (on a host server) to a target port (on the storage appliance). If required, you can modify the queue depth settings for a host server FC or iSCSI adapter.

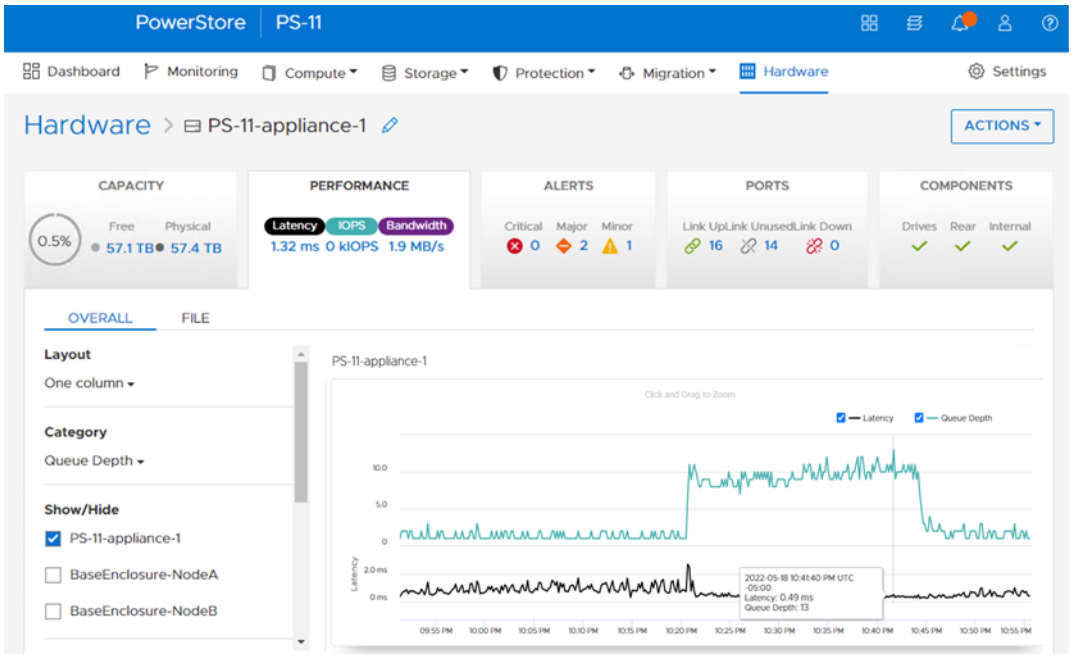


Figure 21. Monitor PowerStore queue depth with PowerStore Manager

A target port on a PowerStore appliance supports multiple host initiator ports. Multiple host initiator ports send data concurrently to a target port. Limit initiator queue depth to control the number of transactions an initiator can send to a target. Flooding occurs when a target port becomes saturated, and transactions are queued. Flooding causes higher latency and degraded performance for the affected workload.

With PowerStore SAN configurations, configure up to four front-end data (target) ports per PowerStore node per fabric. Do not configure more than four ports because this configuration might cause performance degradation. Configure two to four ports for an optimal configuration. Multiple target ports spread out I/O and reduce the risk of port saturation.

When to change queue depth

On a Windows Server host, queue depth is a function of the Microsoft storport.sys driver and the vendor-specific miniport driver for the FC or iSCSI adapter. The default queue-depth settings are adequate for most workloads.

Note: Do not modify queue-depth settings unless you have a specific reason to do so. Test queue-depth changes first in a nonproduction environment.

Consider the following example:

- A PowerStore appliance.
- A small Hyper-V cluster with two nodes.
- The workload on the Hyper-V cluster is an I/O-intensive, large-block, sequential-read application.
- Increase the queue depth settings to provide significant performance benefits for the workload on this small cluster.

However, consider the possible negative impact if you change queue depth settings.

- When the environment has many hosts (many initiator ports).
- Increased host initiator queue depth might saturate the target ports on the PowerStore appliance.
- All connected hosts might suffer negative performance impacts as a result.

Vendor-specific queue depth settings

See the documentation for your host adapter for information about queue depth settings.

For example, see the Marvell QLogic Fibre Channel Adapters Users Guide at Marvell.com.

PowerStore management and configuration best practices

PowerStore host groups

Map PowerStore volumes (quorum disk, cluster disk, or CSV) to Hyper-V nodes with a consistent LUN number.

Use host groups in PowerStore to simplify the task of mapping a new volume to more than one node simultaneously with a consistent LUN ID. This practice saves time in larger environments and reduces the risk of user error.

Use the **Add Host Group** wizard in PowerStore to create a host group. Add hosts that do not have mapped PowerStore volumes. If a host already has a mapped PowerStore volume (includes boot-from-SAN volume), the host is ineligible.

PowerStore volume groups

In a clustered environment such as Hyper-V, a workload might span multiple CSVs. Time consistency of snapshots and replication becomes vital in recovery scenarios. Use volume groups in PowerStore to ensure time consistency.

Run the **Create Volume Group** wizard in PowerStore to create a volume group. The **Apply write-order consistency to protect all volume group members** option is selected by default. Keep this default to ensure that PowerStore protection policies (snapshot rules, replication rules, and remote backup rules) apply to all volumes in the group simultaneously.

You can add new or existing volumes to a volume group. For a multi-appliance PowerStore cluster, volumes added to a volume group must all reside on a common appliance.

If a volume is not on a common appliance, migrate the volume to the same appliance as the other volumes in the cluster.

When the migration is complete, you can group the volume with the other volumes, and the wizard will finish without errors. Protection policies (snapshot rules and replication rules) assigned at the volume-group level apply automatically to all new and existing volumes in the group. If a volume-group protection policy includes a replication rule, it might require significant time for initial replication to complete if the volumes contain significant data.

Consistent LUN IDs

Use a consistent LUN number when mapping PowerStore volumes to multiple nodes in the Hyper-V cluster as a best practice. In PowerStore Manager, run the **Map Hosts** wizard and select **Provide a Logical Unit Number**.

PowerStore data reduction and Hyper-V

With PowerStore, inline data reduction (compression and deduplication) is enabled by default. Users cannot disable PowerStore data reduction.

Data reduction works in the background with PowerStore. Hyper-V environments benefit from PowerStore data reduction without any extra configuration required.

Data encryption

Data at rest encryption (D@RE) is enabled by default on PowerStore. No configuration steps are necessary to protect the drives.

Intuitive names

To ease management of a Hyper-V environment on PowerStore, use intuitive, descriptive, and consistent names where possible for all PowerStore objects. These objects include Hyper-V server host and node names, cluster names, volume names, host groups, and volume groups. Avoid generic names such as *Server1* or *Data1*.

Use intuitive names to make it easier to find and associate related objects when applying filters. This practice also simplifies the application of rules to lists of objects in PowerStore Manager, such as a volumes list. The use of consistent names becomes more important to ease administrative overhead as the number of objects on a PowerStore appliance increases.

Data protection

Introduction

All PowerStoreOS versions support asynchronous data replication and recovery options for Hyper-V environments. PowerStoreOS 4.0 introduces support for synchronous replication for block storage. Protection options include snapshots, thin clones, refreshes, restores, and replication to remote PowerStore systems for the following data types:

- Boot-from-SAN disks
- Data volumes
- Cluster volumes
- Cluster shared volumes (CSV)
- In-guest iSCSI and vFC volumes
- Physical (pass-through) disks

In addition, PowerStoreOS 4.0 extends Metro Volume support to Microsoft and Linux environments. Metro Volume supports Windows Server 2016 Hyper-V and newer.

Note: PowerStore does not support Metro Volumes configured as boot-from-SAN (BfS) disks, in-guest iSCSI disks, or virtual Fibre Channel disks (vFC). Pass-through disks are supported as Metro Volumes as data disks, but not as boot disks.

This white paper addresses data protection strategies specific to synchronous and asynchronous replication.

To learn more about Windows Server Hyper-V use cases and best practices with Metro Volume, see the Dell PowerStore: Metro Volume white paper on the Dell PowerStore Info Hub.

Snapshots and thin clones

PowerStore snapshots are space efficient. Snapshots consist of pointers to frozen data blocks. Snapshots do not consume space. When you create a thin clone from a snapshot and map it to a host, only new data written to the thin clone consumes additional storage space.

PowerStore snapshots can be taken of volumes that are mapped as LUNs to a Hyper-V environment regardless of content. Volumes, snapshots, and thin clones can be replicated to other PowerStore clusters for DR or archive purposes.

For more information about PowerStore snapshots, thin clones, refreshes, and restores, see the online help in the PowerStore Manager UI.

PowerStore snapshots allow administrators to perform the following actions in Hyper-V environments:

- Recover servers to a crash-consistent state.
  - Boot-from-SAN Hyper-V hosts and nodes.
  - Guest VMs and their workloads.
- Use thin clones to provision lab or isolated test environments that are based on a production environment.
- Create gold images to provision new servers.

Secure snapshot

PowerStoreOS 3.5 introduced secure snapshot as an optional setting for volumes and volume groups. The secure snapshot feature provides the following benefits for Microsoft environments:

- A simple, cost-effective defense against malicious or accidental deletion of snapshots, volumes, or volume groups.
- Protection against ransom attacks.
- Maximum flexibility: Enable or disable secure snapshots at any time on any volume or volume group.

Note: If you disable secure snapshot for a volume, you must wait until the expiration date before you can delete secure snapshots.

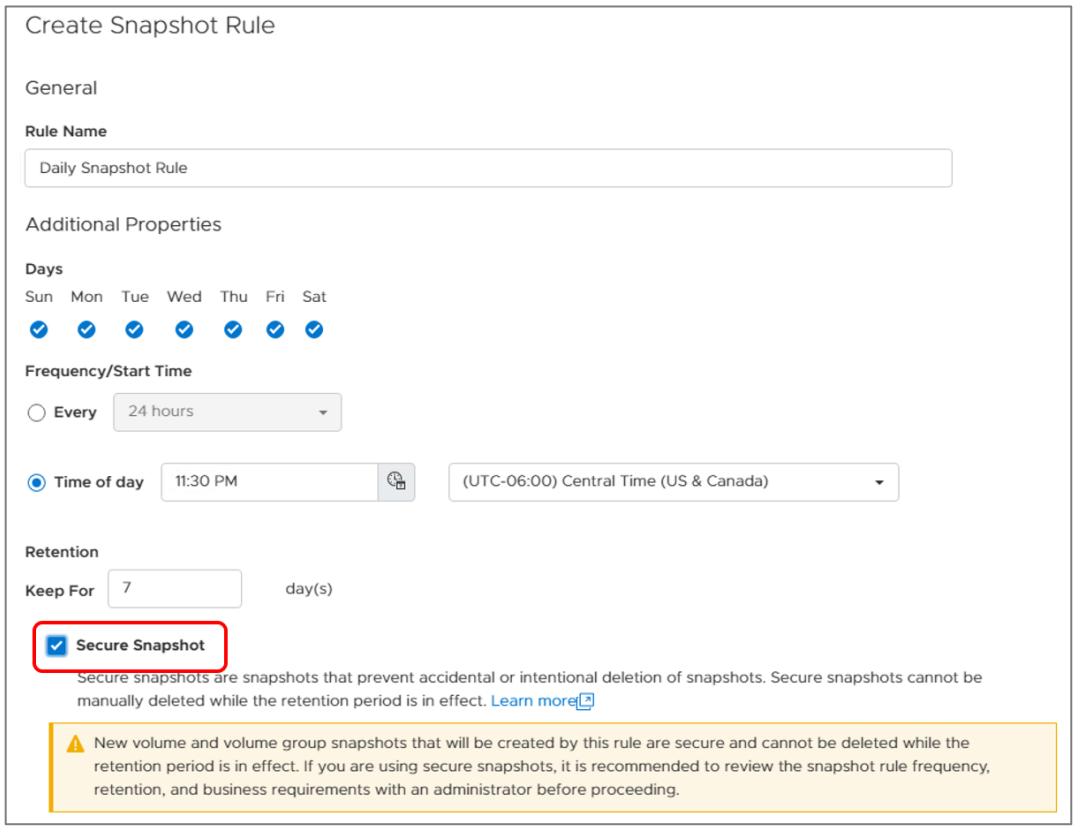


Figure 22. Secure snapshot option

Application consistency with snapshots

PowerStore snapshots taken without regard to the state of the host operating system or workload are crash consistent. PowerStore snapshots taken manually, or as part of a recurring schedule, are crash-consistent by default. Administrators must place a host or workload in a consistent (paused) state if a consistent snapshot is essential for recovery.

If you use a crash-consistent snapshot to restore a host, VM, or workload, it is like starting the resource after an unexpected event such as a power outage.

Often, host operating systems and nontransactional workloads will recover to a crash-consistent state without complications. However, there is an elevated risk of data loss or corruption if you attempt to recover a transactional workload such as Microsoft SQL Server to a crash-consistent state.

Consider these recommendations if you need host or workload consistency before taking a PowerStore snapshot.

- Use application-native tools to place a workload in a consistent state temporality (pause I/O; save active data to disk).
- Stop application services temporarily (to pause application I/O).
- Use a Microsoft volume shadow copy service (VSS) aware process such as backup software that can place a server or workload in a consistent state temporarily.
- Power off the server or VM that hosts the workload. However, this method is often disruptive and impractical in a production environment. Use this method when you create a gold image of a system prepared (Sysprep) volume for a host or VM.

After the host or workload is in a consistent state (paused), take a PowerStore snapshot. Then, return the host or workload to its active state.

If possible, use scripting and automation tools to orchestrate a workflow that performs these steps automatically.

- Reduce administrative overhead.
- Eliminate mistakes due to human error.
- An automated process can run after hours on its own without human intervention.

The following sections provide examples for how to use PowerStore snapshots and thin clones in a Hyper-V environment.

Use PowerStore snapshots to recover guest VMs

This section provides guidance and best practices for snapshot recovery options.

Use a consistent or crash-consistent PowerStore snapshot of a host volume that contains the VHD to recover a Hyper-V guest VM to a previous point in time.

You can also use a snapshot to create a copy of a VM in an isolated environment. Perform this action at the same location, or at a different location (if you have enabled PowerStore volume replication between PowerStore clusters).

Recover a guest VM on a stand-alone Hyper-V host

In this scenario, the VHD and configuration files for a VM reside on a PowerStore data volume. The volume is mapped to a Hyper-V host.

Option 1: Use a PowerStore snapshot to refresh or restore the existing data volume on the host that contains the VM configuration and VHDs. You could also replace the volume with a thin clone.

- This option is practical if the data volume contains one VM.
  - If the data volume contains multiple VMs, the option is viable if you want to recover of all the VMs to the same point in time. See option 2 and option 3 to recover a single VM from a volume with multiple VMs.
- The recovered VM can power on without any additional configuration or recovery steps required.
- If you use a thin clone to replace the original volume, document the LUN number, drive letter, or mount point information of the original volume. Perform this action before starting the recovery.

Option 2: Map a thin clone of the volume that contains the VM configuration and VHDs to the same host as a new volume, with a new drive letter or mount point. Manually recover the VM.

1. Delete, move, or rename the original VHDs.
2. Copy the VHDs from the thin clone to the original location.
3. Rename the VHDs.
4. Use Hyper-V manager to reassociate the VHDs with the guest VM. Reassociation will prevent permission errors when the guest VM starts.

This option might not be practical if the VHDs are large because of the copy time.

- To avoid a long copy time, delete the original VM and import the recovery VM (Hyper-V 2012 and later versions) from the thin clone.
- Alternatively, create the recovery VM as a new VM directly from the thin clone.
- After the recovery, unmap the original volume if it is not needed.

To recover a subset of data from a VM, mount a recovery VHD as a temporary volume on the host server. Recover the wanted data over the network. Dismount the recovery VHD when finished.

Option 3: Map the thin clone to a different Hyper-V host and recover the VM there by importing the VM configuration. Alternatively, create a new VM that points to the virtual hard disks on the recovery volume.

- Use this method when the original and recovery VMs must be online simultaneously.
  - Isolate the VMs when two instances are online simultaneously.
- Use this option when the original host server is no longer available.

Record essential details about the VM configuration, such as the number of virtual CPUs, memory, virtual networks, and IP addresses. If a VM import fails (or is not supported), use this information to create a new VM.

Options 1, 2, and 3 will also work with PowerStore volume groups. Configure a PowerStore volume group as a best practice if a VM has multiple VHDs that reside on multiple host data volumes. A volume group will ensure that snapshots have a consistent timestamp across all the volumes in the group. Consider the following example:

- VM1 has a boot VHD on Data Volume 1
- VM1 has a data VHD on Data Volume 2
- A PowerStore volume group named VG1 contains Data Volumes 1 and 2
- VG1 has a protection policy applied that includes snapshot protection.

Recover a guest VM on a cluster shared volume

Recovery of a VM on a CSV is similar to a VM recovery on a data volume on a stand-alone host. However, CSV recovery scenarios might require the administrator to change the disk signature to avoid a conflict that can be service-impacting.

Windows Server assigns each disk a unique ID (or signature). A disk ID consists of a string of characters in hexadecimal format. Here are two disk ID examples:

- GPT disk: EF4F117E-6F16-4927-B696-CFA9AE988D80
- MBR disk: 045C3E2F4

A PowerStore snapshot of a Windows Server host volume or CSV is an exact point-in-time copy (includes the disk ID). A thin clone created from a PowerStore snapshot will have the same disk ID as the source volume.

Stand-alone Windows or Hyper-V servers dynamically avoid disk ID conflicts. A stand-alone server automatically detects duplicate disk IDs and changes them without user intervention.

However, Windows is unable to dynamically change a duplicate disk ID when:

- The volume is a cluster volume or CSV, and
- You map the volume to a Windows Server failover cluster or a Hyper-V cluster consisting of two or more nodes.

In this situation, an administrator must manually change the disk ID of the thin clone before it is mapped to the cluster. A duplicate disk ID might cause a service interruption.

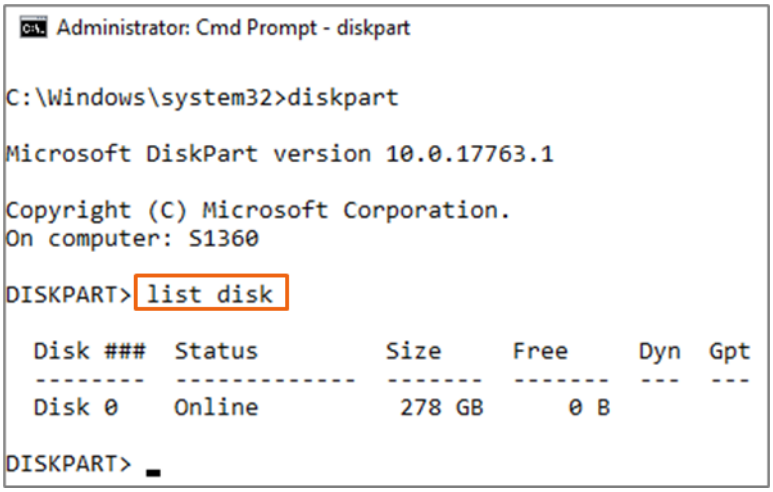
Given a duplicate disk ID situation with a cluster volume or CSV, it is easy to work around or resolve the issue.

- **Option 1:** Map the thin clone to a stand-alone Windows Server host that is not a member of the cluster. Then, copy the guest VM files over the network to recover the guest.
- **Option 2**: Map the thin clone to a stand-alone Windows Server host outside the cluster and use `diskpart` to manually change the disk ID from the command line. Change the disk ID and then map the thin clone to the cluster.

Change a disk ID with diskpart

Follow these steps to change a duplicate disk ID. You can also use PowerShell.

1. Log in to a stand-alone Windows Server (with or without the Hyper-V role installed) that is available in PowerStore. This server must not be a member of the Hyper-V cluster.
2. Open a command window with administrator rights.
3. Enter `diskpart`.
4. Enter `list disk`.
5. Note the current list of disks. In this example, Disk 0 is the only disk.



6. Use PowerStore Manager to map a thin clone of the cluster disk to this host.
7. From the `diskpart` command prompt, enter `rescan`.

8. Enter `list disk`.

   The new disk (the thin clone) is listed in an offline state.

```
Administrator: Cmd Prompt - diskpart

C:\Windows\system32>diskpart

Microsoft DiskPart version 10.0.17763.1

Copyright (C) Microsoft Corporation.
On computer: S1360

DISKPART> list disk

  Disk ###  Status         Size     Free     Dyn  Gpt
  --------  -------------  -------  -------  ---  ---
  Disk 0    Online          278 GB      0 B
  Disk 1    Offline         200 GB      0 B        *

DISKPART>
```

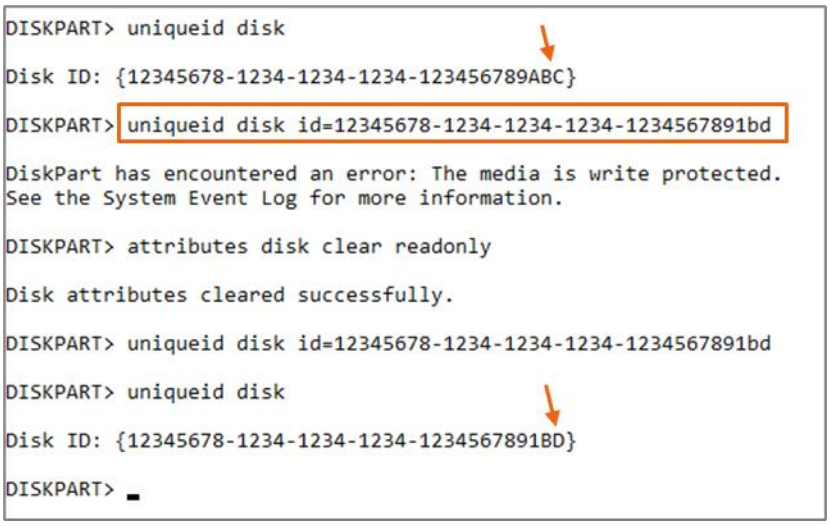
9. To select the offline disk, enter `select disk <#>`.
10. Enter `online disk` to bring it online.
11. Enter `list disk` to confirm that the disk is online.

```
DISKPART> select disk 1

Disk 1 is now the selected disk.

DISKPART> online disk

DiskPart successfully onlined the selected disk.

DISKPART> list disk

  Disk ###  Status         Size     Free     Dyn  Gpt
  --------  -------------  -------  -------  ---  ---
  Disk 0    Online          278 GB      0 B
* Disk 1    Online          200 GB      0 B        *

DISKPART>
```

12. Enter `uniqueid disk` to view the current ID for the disk.
13. To change the disk ID, enter `uniqueid disk ID=<newid>`.
    - For an MBR disk, the disk ID is an eight-character string in hexadecimal format.
    - For a GPT disk (shown in this example), the disk ID is a longer Globally Unique Identifier (GUID) that is also in hexadecimal format.
    - Change at least one character to make the ID unique.

Note: If a disk is read-only, the disk ID cannot be changed (you will receive an error message). If a disk is read-only, enter `attributes disk clear readonly` to clear the read-only attribute and repeat this step.

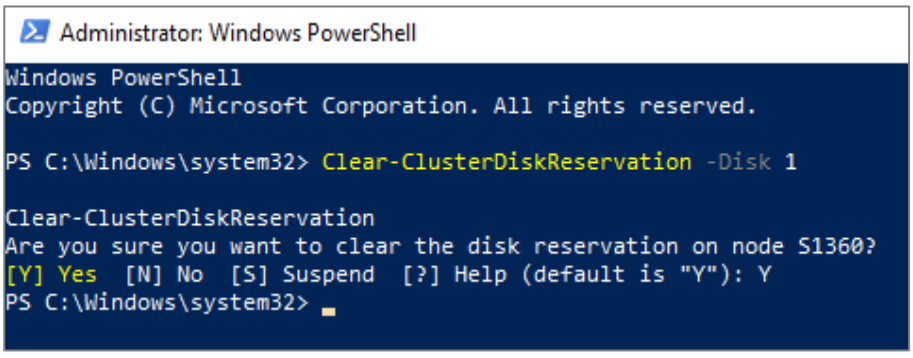
14. Enter `uniqueid disk` again to verify the new ID.



15. Now that the thin clone has a unique disk signature, exit from diskpart.
16. Use PowerStore Manager to unmap the disk from the stand-alone host server, and map the disk to the specified Hyper-V cluster.
17. Perform a rescan disk on all nodes of the Hyper-V cluster and bring the disk online. If Windows has automatically assigned a drive letter to any volumes on the disk, remove the drive letters, and return the disk to an offline state.

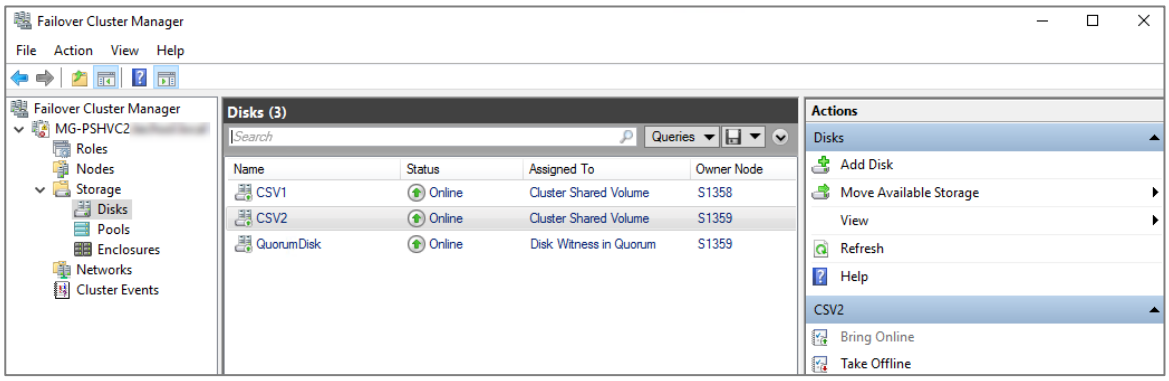
    Note: Disable automount as a best practice. Automatically assigned drive letters can interfere with Hyper-V recovery operations. See Disable automount for details.

18. Clear the cluster reservation attribute on the volume. Perform this action with PowerShell.
    a. Open a PowerShell window with administrator privileges.
    b. Clear the cluster reservation on the disk so that failover cluster manager can discover and import the disk.



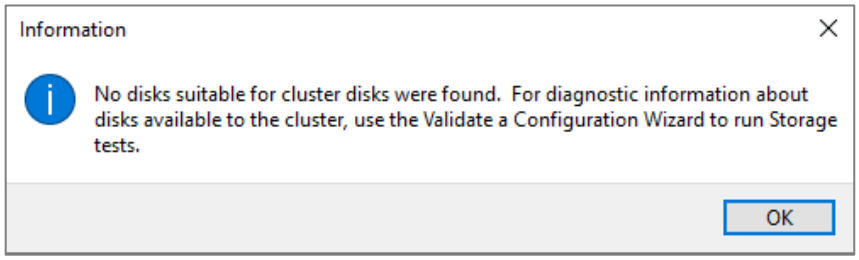
    c. Close PowerShell.

19. Place the disk in an offline state and perform a rescan disk on each node in the Hyper-V cluster. Failure to do a rescan on all Hyper-V nodes will interfere with disk discovery in the next step.



20. Add the disk to the Hyper-V cluster. Use the **Actions** menu in Failover Cluster Manager to convert the disk to a cluster shared volume if the original disk was a CSV.

Note: If the cluster is unable to discover the disk, run cluster validation and examine the report for disk errors. Resolve any errors and attempt to add the disk again.



21. After the volume is online, complete the wanted steps or VM recovery steps.

Use PowerStore snapshots to create a test environment

Use PowerStore snapshots to quickly create a test or development environment that mirrors a production environment. To complete this step, you can map thin clones to other host servers or clusters. You can perform this action at the same location, or a different location when PowerStore volume replication is configured between PowerStore clusters.

Note: To avoid IP, MAC address, or server-name conflicts, place copies of VMs recovered from a thin clone in an isolated environment if the original VMs are online.

Use PowerStore to create a gold image

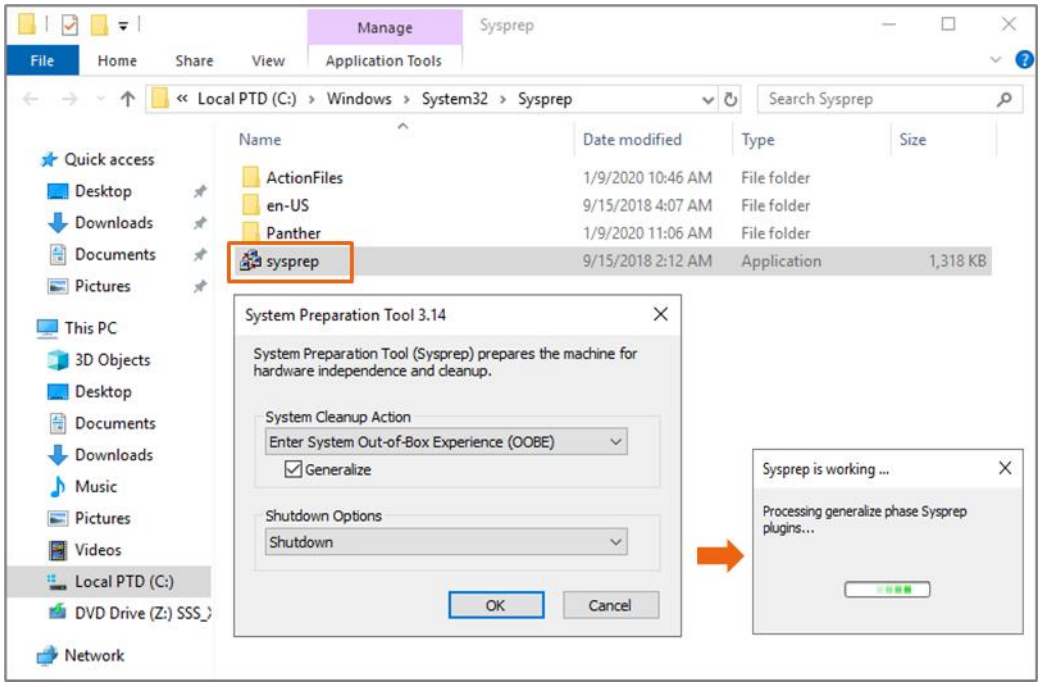
An administrator can use PowerStore snapshots and thin clones to create operating-system gold images. Use a gold image to deploy additional severs without having to stage the operating system from scratch each time.

Gold images provide the following benefits:

- Saves time: Quickly provision new servers with minimal reconfiguration required.
- Saves storage space: Only new data written to the thin clone consumes space on PowerStore. Unchanged data resides on the source volume.
- Ensures consistency: Each new server provisioned has the same initial configuration as the gold image.

Follow these steps to configure a Windows Server boot-from-SAN gold image:

1. Create and map a PowerStore volume to a Windows host server or Hyper-V server (use LUN 0) that supports boot-from SAN.
2. Install the operating system.
    a. Install the wanted roles and features such as the Hyper-V role, failover clustering, and MPIO.
    b. Configure the server, including MPIO.
    c. Patch the operating system.
3. Power off the host to place the operating system in a consistent state.
4. Take a manual PowerStore snapshot of the volume and select **No Automatic Deletion**. Use an intuitive name so it is easy to identify the purpose of this snapshot later. Use this snapshot to update the gold image with patches or other changes.
5. Power on the server and run the Microsoft tool *Sysprep*. Select the options **Generalize**, **Out-of-box Experience**, and **Shutdown**. Click **OK**.



6. Allow *Sysprep* to complete, and the host will shut down.
7. Manually create another PowerStore snapshot of the volume.
    a. As before, select **No Automatic Deletion**.

b. Add a description to make it easy to identify the purpose of this snapshot.

8. Select the snapshot. Click **More Actions > Create Thin Clone Using Snapshot**.
9. View the thin clone in the volumes list under **Storage**.
10. Map the thin clone to a new host as LUN 0.
11. Boot the host and allow the initial startup process to complete.
12. Customize the server configuration as needed.

Note: The PowerStore appliance and node that owns a volume also owns all snapshots and thin clones (children) that are associated with the volume. A PowerStore resource imbalance might occur if many thin clones are created from the same source volume.

Move or migrate a VM on PowerStore

Use native Microsoft tools to move or migrate a VM from one host or cluster to another as a best practice. Often, native tools allow VM moves and migrations to occur without downtime.

However, it might be impractical or too time-consuming to move or migrate a large VM over a network. You can use PowerStore to remap the underlying volume to avoid a long copy wait time. Unmap the PowerStore volume or volume group containing the VM, map it to a new host or cluster, and bring the VM online there.

Use a thin clone to move a VM if you want to temporarily preserve the state of the original environment.

Note: Schedule a maintenance window when moving a VM by remapping a PowerStore volume because it will require down time.

Business continuity with Hyper-V and PowerStore

Overview

A good business-continuity strategy incorporates disaster recovery (DR) and disaster avoidance planning. A DR plan ensures that a company can recover as quickly as possible from data loss or from an interruption or failure preventing access to data. It is an important part of the overall IT strategy.

DR risks are diverse and might vary by location. Disasters can be small or large. The loss of a single document that impacts one user is a disaster for that user. If not resolved quickly, a site failure might impact all users and jeopardize the future of the business.

The essential elements of DR are commonplace, dependable, cost-effective, and easy to implement. They address or prevent events that are most likely to occur. These protections might include moving key workloads to a cloud provider, making tape backups with offsite storage, online backups, or disk-to-disk backups. Safeguards can also include network and physical security measures, malware protection, and redundant hardware and internet connections. Also, DR can include SAN-based snapshots with remote replication, and battery backups or generators.

PowerStoreOS 4.0 extends Metro Volume support to include Windows Server and Hyper-V (2016 and newer). To learn more about Metro Volume support for Windows Server and

Hyper-V with PowerStoreOS 4.0, see the white paper Dell PowerStore: Metro Volume on the Dell PowerStore Info Hub.

Business continuity becomes more complicated and costly with the size and number of locations. While virtualization technologies such as Microsoft Hyper-V can help ensure continuity in a disaster, they can also add complexity to the overall design.

PowerStore provides Hyper-V administrators with options to protect, move, replicate, and recover data using snapshots, thin clones, and replications. PowerStoreOS 4.0 extends Metro Volume support to Microsoft environments. This section addresses key disaster recovery and avoidance concepts that should be integral to business continuity planning with PowerStore and Hyper-V.

Cost and risk analysis

The most robust DR solutions might also be cost prohibitive. These solutions might require weighing the costs compared to the risks and determining the level of DR protection that is necessary. Factors to consider as part of a cost and risk analysis include:

- The specific regulations that apply to your service or industry.
- The terms of the service level agreements (SLAs) for business continuity that must be honored.
- Types of applications and data that are mission-critical to the business or to customers.

Determine the recovery-time objective (RTO) for each application or service. RTO is the maximum amount of time unavailability before the business impact becomes too great. Examples include:

- Practice management system: 30 minutes
- Messaging system: four hours
- Research and development server: two days

Determine the recovery point objective (RPO). RPO is the amount of data loss that is acceptable for a subset of data.

Example: Configure a PowerStore snapshot to protect a volume (and its workload) every 24 hours. The RPO is 24 hours. This means up to 24 hours of data loss might occur if you recover the volume or workload from the last snapshot. Increase the frequency of PowerStore snapshots to shorten the RPO.

Determine the types of events that are most likely to occur in your area. For example, a coastal location might be likely to experience a hurricane or flooding.

Identify an alternate site that is sufficiently distant so that the same event does not impact both locations.

Determine the cost of the DR solution. Is the cost justified given the risk?

Disaster recovery and disaster avoidance

PowerStore provides Hyper-V administrators with many options to protect, move, archive, and recover data given a disaster recovery (DR) or disaster-avoidance scenario. In addition to the integrated redundancies with PowerStore architecture, administrators can use snapshots, thin clones, replication, and Metro Volume in creative ways to ensure business continuity.

Unplanned events

Unplanned DR events cause downtime with little or no warning. DR events can be categorized as follows:

- **Data loss**: Malware infection, corruption, accidental deletion, sabotage, storage hardware failure, and so forth.
  - PowerStore snapshots and replication to a remote site are an important part of a recovery plan in these scenarios.
  - The redundancies built into PowerStore and Hyper-V, combined with a robust storage fabric that uses MPIO, can reduce risks associated with hardware failures.
- **Access interruption**: Network failure or power failure (no data loss)
  - Redundant data paths help maintain connectivity to sites, between sites, and within the data center.
    - Redundant power sources protect against a short-term or long-term power loss.
- **Major events**: Events that result in data loss, hardware loss, and loss of site access, such as a fire or natural disaster.
  - Configure another site that can serve as a backup for critical workloads.
  - Use a cloud-based solution to host critical workloads and data if you do not have an alternate location for DR.

Planned events

Planned events cause down time but allow administrators lead time to invoke a disaster avoidance plan that avoids or limits business impact. Leverage Metro Volume to protect against downtime when you have a planned event. See the white paper Dell PowerStore: Metro Volume on the Dell PowerStore Info Hub to learn more.

- **Maintenance**: Planned power outage, hardware upgrades, software upgrades, and so forth.
  - Fail critical workloads over to another PowerStore appliance at the same site or a different site.
  - Keep noncritical workloads in place but schedule down time when it will not be service impacting.
  - Leverage native Microsoft tools, PowerStore snapshots, replications, Metro Volume with failover/failback technology to ensure business continuity.
- **Weather**: For example, when a hurricane approaches, coastal locations usually have enough lead time to invoke a predefined disaster avoidance plan.

- Schedule periodic testing to ensure that the execution of a disaster avoidance plan goes smoothly.
- A failover site should be geographically distant so it is unaffected by the same weather event.

A good business continuity plan anticipates disaster recovery and disaster avoidance scenarios, with strategies to ensure business continuity for the most likely events. These strategies should use a combination of manual and automatic processes to address the widest range of scenarios that is feasible within the budget.

Conclusion

Summary

A successful deployment of Microsoft Hyper-V on Dell PowerStore storage requires careful planning, adherence to best practices, and testing. PowerStore is well suited to host high-density, high-demand Hyper-V virtual workloads. PowerStore provides Microsoft Hyper-V administrators with an all-inclusive complement of tools, options, and features. The guidance in this white paper will help you design and deliver PowerStore and Hyper-V solutions that are resilient, dependable, and highly performant.

References

Dell Technologies documentation

The following Dell documentation provides other information related to this document. Access to these documents depends on your login credentials. If you do not have access to a document, contact your Dell Technologies representative.

- Dell Technologies Storage Info Hub
- Dell Technologies Support
- E-Lab Host Connectivity Guide for Microsoft Windows

Microsoft documentation

For Microsoft documentation, see the following resources:

- Microsoft Windows Server Documentation Library
- Microsoft Virtualization Documentation Library
- Microsoft Learn