Dell EMC SC Series Storage and Microsoft Multipath I/O

Abstract

This document provides an overview of Multipath I/O (MPIO) along with best practice guidelines for configuring MPIO on Microsoft® Windows Server® with Dell EMC™ SC Series storage.

January 2018

Revisions

Date	Description
October 2010	Initial release
October 2010	Corrected errors
November 2011	Additional content on Microsoft® Windows Server® Core
October 2012	Updated to include Windows Server 2012 content
May 2013	Updated to include Windows Server 2008 R2/2012 iSCSI initiator setup and appendix listing recommended hotfixes and registry values
October 2013	Updated to include Windows Server 2012 R2 content
January 2014	Updated hotfix information
January 2015	Updated configuration recommendations
March 2015	Updated hotfix and configuration recommendations
April 2015	Added SAS front-end content
February 2016	Removed Windows Server 2003 content and updated hotfix recommendations
October 2016	Re-ordered document for clarity, added Windows Server 2016 and Nano Server content, and updated hotfix recommendations
January 2017	Updated configuration recommendations
June 2017	Updated hotfix info and configuration recommendations
January 2018	Re-ordered document for clarity, updated hotfix and configuration recommendations, updated guidance on Nano Server

Acknowledgements

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1 Preface

This document provides an overview of Multipath I/O (MPIO) along with best practice guidelines for configuring MPIO on Microsoft® Windows Server® 2008 R2, 2012, 2012 R2, and 2016 with Dell EMC™ SC Series storage.

Nano Server was an installation option (in addition to Core and Desktop) offered for the first time with Windows Server 2016. Nano Server was originally designed to run as a base OS on physical or virtual servers. However, support for Nano Server as an OS for physical or virtual servers was discontinued by Microsoft with the September 2017 semi-annual channel (SAC) 1709 update of Windows Server 2016. Nano Server is now supported as a container OS only. For more information, view the *Dell EMC SC Series Storage and Microsoft Windows Server 2016* best practices guide and Microsoft TechNet.

Note: Mainstream support for Windows Server 2008 R2 ended in January 2015, and extended support is scheduled to end in January 2020. Customers with Windows Server 2008 R2 should plan to migrate to a newer Windows Server OS before extended support ends.

1.1 Audience

This document was written for system administrators who are responsible for the setup and maintenance of Windows servers and associated storage and who wish to learn more about MPIO configuration and best practices with SC Series storage. Readers should have working knowledge of Windows Server and SC Series storage.

1.2 Feedback

We value customer feedback as we strive to provide high quality documentation in support of Dell EMC products. Please send feedback or recommendations on how we can improve this document to StorageSolutionsFeedback@dell.com.

2 Introduction to Microsoft Multipath I/O

Microsoft MPIO is a framework that allows administrators to configure load balancing and failover processes for Fibre Channel (FC), iSCSI, and serial attached SCSI (SAS) front-end (FE) connected storage devices. Load balancing can be configured to use up to 32 independent paths for each connected storage device. Two to four paths per storage device is a common configuration with SC Series storage.

SC Series arrays provide native redundancy and failover protection with multiple controllers and RAID modes. From the perspective of the host server, path redundancy (for both load balancing and failover) is provided by MPIO.

The MPIO framework uses a device-specific module (DSM) which is software that allows the host server to recognize and intelligently manage multiple paths to the same SAN volume. Without a DSM, the host is unable to manage multiple paths and as a result, Disk Management erroneously reports multiple instances of the same disk device, one disk for each path. Microsoft provides a built-in DSM (MSDSM) for Windows Server 2008 R2 and above that is fully compatible with SC Series storage, and is the focus of this paper.

2.1 SC Series storage front-end connection options

Several MPIO-capable front-end connection cabling options are available with SC Series storage. Regardless of the type of connection used, with MPIO, the host server will see multiple paths to storage objects when multiple paths are presented to the host server.

This section provides an overview of these connection options to aid with understanding the overall SC Series MPIO architecture, but it does not provide detailed front-end connection configuration guidance. For front-end configuration guidance, including detailed cabling examples, see the storage system configuration and deployment guide or owner's manual for your SC Series array on the Dell EMC SC Series Storage product page.

2.1.1 Legacy port mode

In legacy port mode, front-end I/O ports are assigned to fault domains as either primary or reserve ports. I/O uses the primary ports only. Reserve ports stay in standby mode. If a primary port fails, I/O will fail over to the reserve port. Legacy port mode requires twice as many I/O ports as virtual port mode in order to enable multiple paths and therefore makes less efficient use of the available hardware. Legacy port mode, as the name suggests, is an older (but still supported) configuration option that is not recommended unless a specific workload or operating system requires it. For example, some non-Microsoft operating systems may require legacy port mode.

Figure 1 shows an example cable configuration using legacy port mode. Each color represents a separate fault domain.

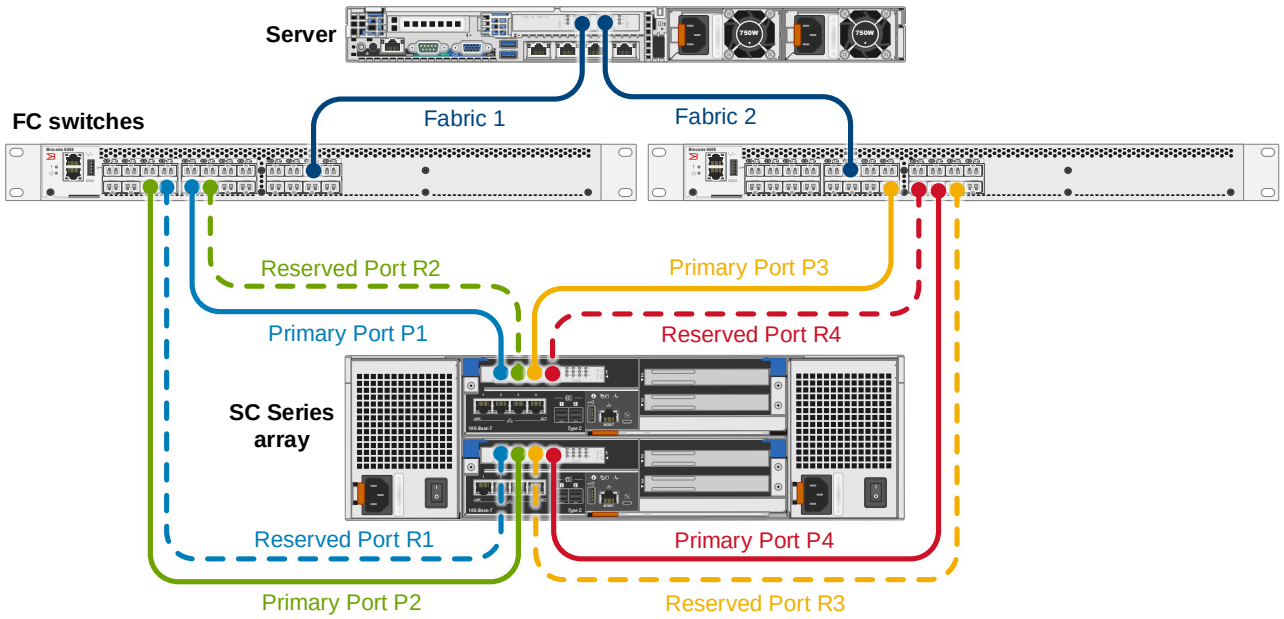


Figure 1 Legacy port mode cabling example with FC

2.1.2 Virtual port mode

Virtual port mode is the recommended configuration for Microsoft environments. In virtual port mode, all front-end I/O ports that are assigned to fault domains are configured as active ports. Because all ports are active, additional front-end bandwidth is available without sacrificing redundancy. Figure 2 shows that virtual port mode provides the same MPIO functionally with half the number ports (four instead of eight) as legacy port mode.

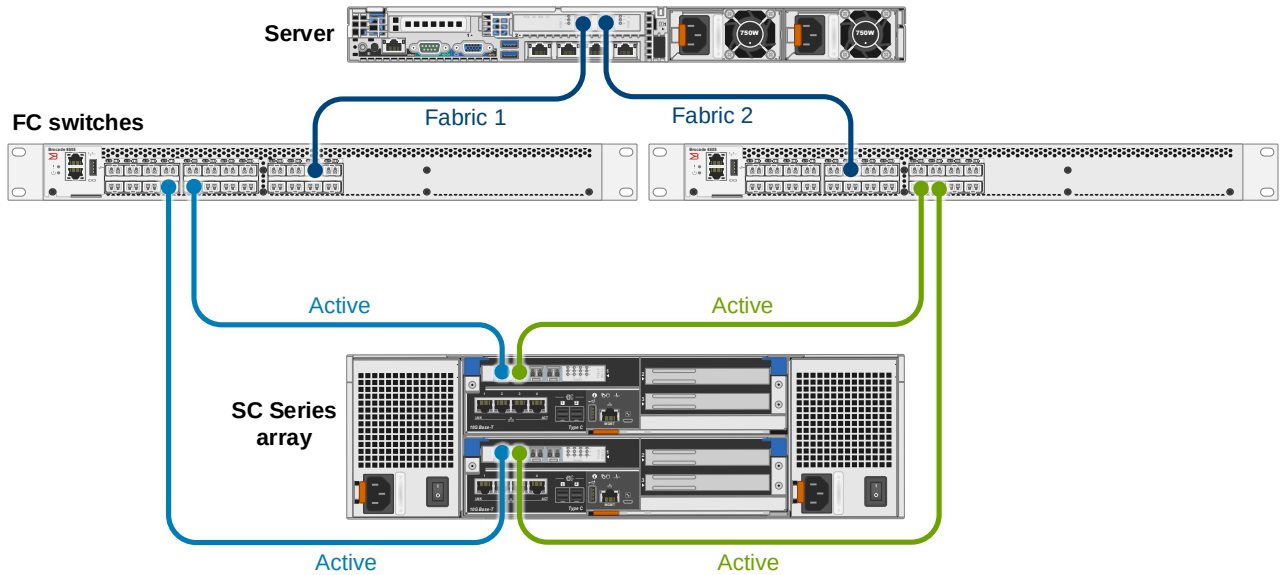


Figure 2 Virtual port mode cabling example with FC

A virtual front-end port configuration with iSCSI fault domains (FD 1 and FD 2 in this example) is similar to FC.

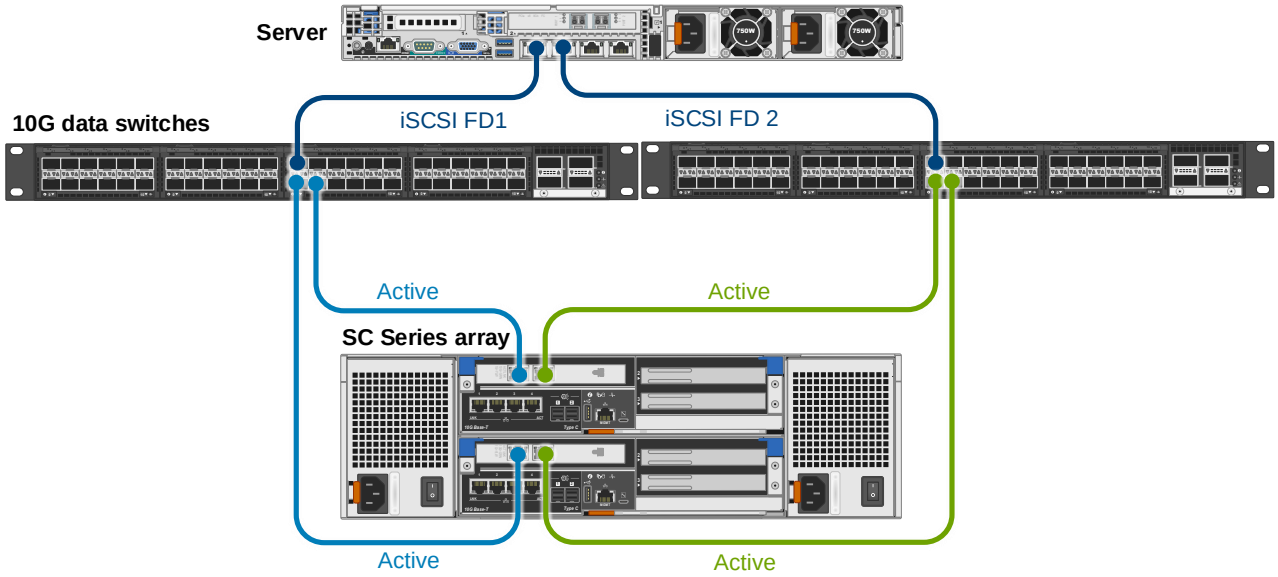


Figure 3 Virtual port mode cabling example with iSCSI

Note: To use virtual ports with FC, all FC switches and host bus adapters (HBAs) must support N_Port ID Virtualization (NPIV).

Note: In virtual port mode, iSCSI uses a control port configured for each fault domain. Servers connect to the control port, which then redirects traffic automatically to the appropriate virtual port on the SC Series.

2.1.3 SAS front-end

Select SC Series arrays support SAS FE ports for MPIO connectivity. With SAS FE, host servers are connected directly to SAS ports on the SC Series array as shown in Figure 4. Host servers require a supported SAS host bus adapter (HBA) in order to connect directly to SC Series SAS FE ports. SAS FE is a simple, cost-effective transport option that is ideal for locations such as a branch office with a limited number of host servers (up to four host servers per SC Series array).

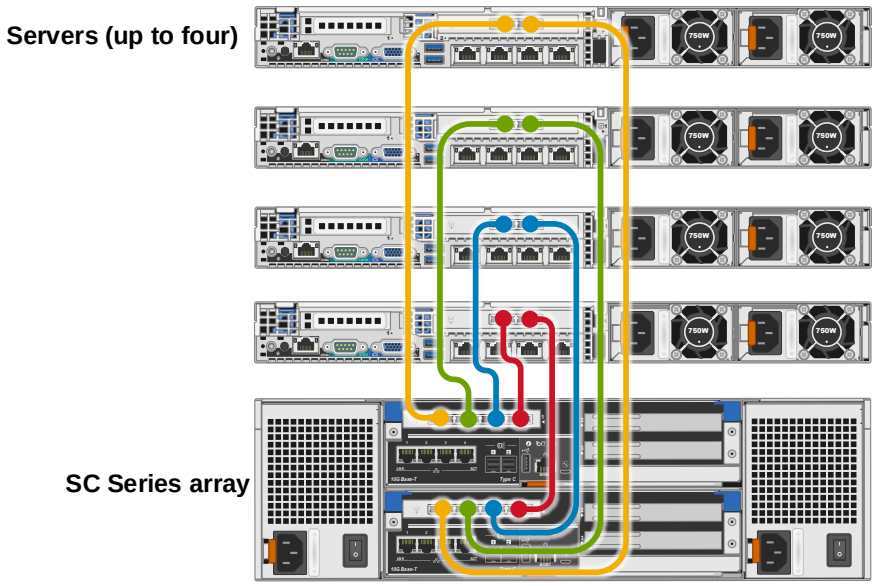


Figure 4 Cabling example with SAS FE

In addition to the general SAS FE cabling guidance found in the user configuration guide or owner's manual for your SC Series storage, see the *Dell EMC SC Series Storage with SAS Front-end Support for Microsoft Hyper-V* configuration guide for detailed cabling examples and step-by-step configuration guidance for SAS FE in Microsoft environments.

Note: SAS FE is also supported with VMware. For more information, see the *Dell EMC SC Series Storage with SAS Front-end Support for VMware vSphere* configuration guide.

3 Install the MPIO feature

Microsoft includes a built-in DSM for Windows Server 2008 and newer that manages all aspects of failover and load balancing. SC Series storage uses this DSM because it provides all of the necessary functionality. This also simplifies implementation as it eliminates the need to install and maintain another software component in the environment.

The Microsoft DSM is not functional on Windows Server until the MPIO feature is installed. The Microsoft DSM for Windows Server can manage iSCSI, FC, and SAS FE volumes.

3.1 Windows Server 2008 R2

On Windows Server 2008 R2, the MPIO feature can be installed using Server Manager. Server Manager offers two options for installing the MPIO feature: the Server Manager graphical user interface (GUI) or the **servermanagercmd** command line interface (CLI).

To access Server Manager, click **Start > Control Panel > Administrative Tools > Server Manager**, or click the Server Manager icon in the taskbar.

3.1.1 Server manager GUI

To install MPIO using the Server Manager GUI perform the following steps:

1. Open **Server Manager**.
2. In the tree view, click **Features**.
3. Under **Features Summary**, click **Add Features**.
4. Check **MPIO** and click **Next**.
5. Click **Install**.
6. Once the feature is installed, reboot the server.

3.1.2 Windows Server manager CLI

1. To install MPIO using the CLI, open a command prompt with elevated (administrator) privileges and type:

   ```
   Servermanagercmd -install "Multipath-IO"
   ```

2. Reboot the server.

3.1.3 Windows Server Core

1. For a Window Server 2008 R2 Core installation, open a command prompt and type (commands are case sensitive):

   ```
   DISM /online /enable-feature:MultipathIo
   ```

2. Reboot the server.

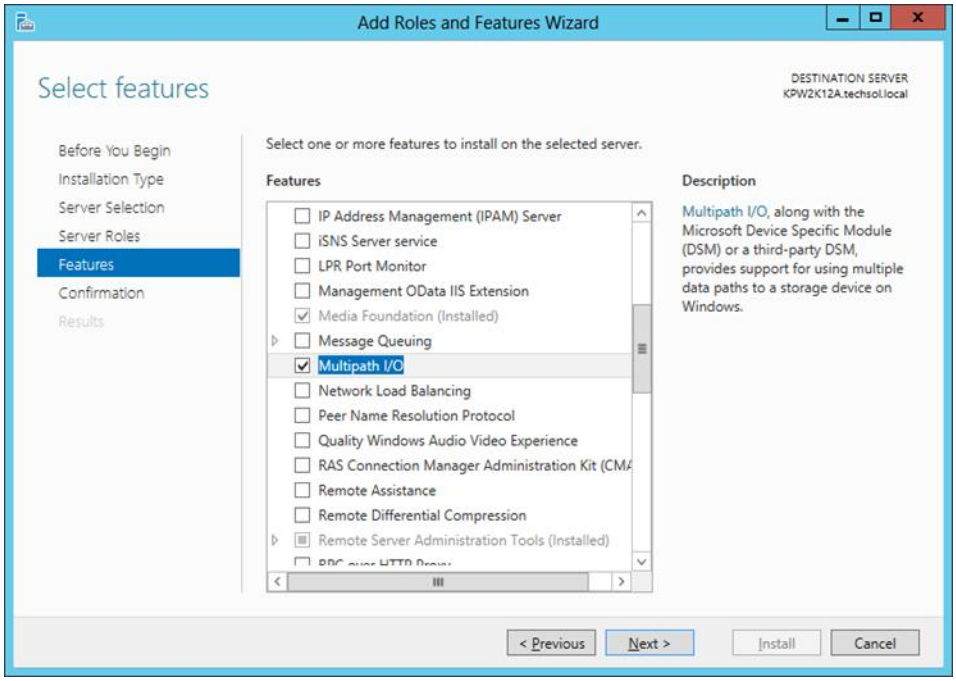
3.2 Windows Server 2012 or later

The MPIO feature can be installed on Windows Server 2012 or later using the Server Manager GUI or through the MPIO module in Microsoft PowerShell®.

On Windows Server 2012 and newer Core installations, use PowerShell to install MPIO.

3.2.1 Server Manager GUI

1. Open **Server Manager**.
2. From the Dashboard, click **Add Roles and Features**.
3. When the wizard opens, click **Next**.
4. Under **Installation Type**, select **Role-based** or **feature-based** installation and click **Next**.
5. Under **Server Selection**, choose the desired server and click **Next**.
6. Under **Server Roles**, click **Next** (do not select any roles to install).
7. Under **Features**, select **Multipath I/O** and click **Next**.



8. Click **Install**.
9. Click **Close** when finished.
10. Reboot the server.

3.2.2 PowerShell

1. Open a PowerShell window with elevated (administrator) privileges.
2. At the PowerShell prompt, enter the following command:

```
Enable-WindowsOptionalFeature –Online –FeatureName MultiPathIO
```

3. Reboot the server.

4 Configure server objects on SC Series storage

Follow the steps in this section to configure Windows Server objects on SC Series storage. These steps assume a properly configured SC Series array with front-end cabling in place for FC, iSCSI, or SAS FE, with at least two paths available to support MPIO.

- FC: Ensure that proper zoning and cabling is in place to allow the host server HBAs to see the SC Series HBAs.
- iSCSI: Ensure that proper networking, VLANs and cabling are in place to allow the host server iSCSI NICs to see the iSCSI NICs on the SC Series array.
- SAS FE: Ensure that host server SAS ports are cabled directly to SC Series SAS ports.

The examples in this guide assume that host servers are configured to boot from local disk.

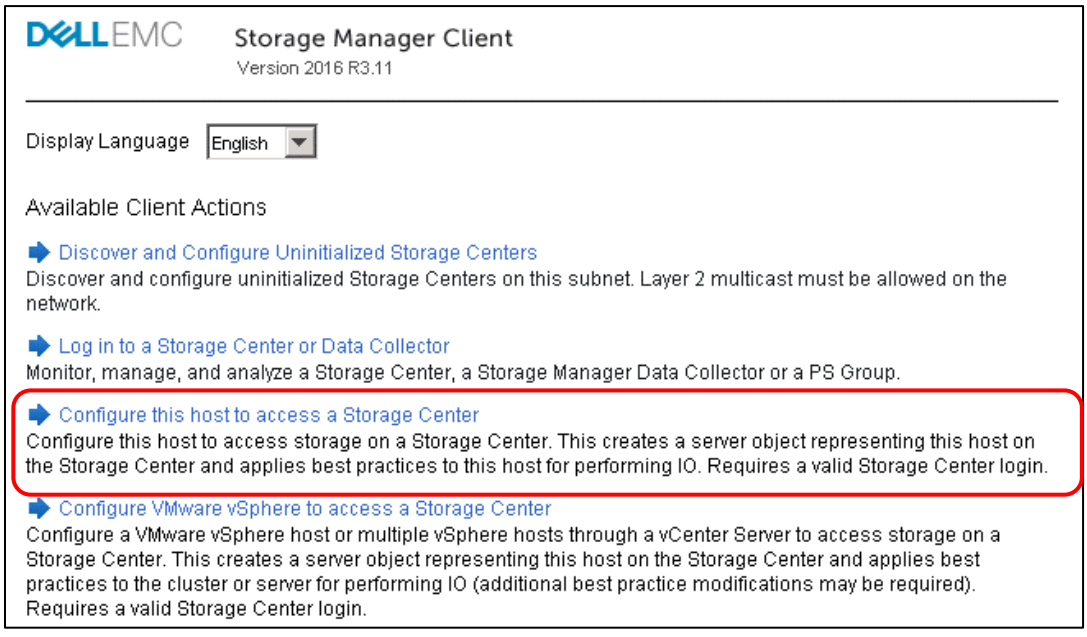
Note: SC Series storage also supports boot-from-SAN with FC or iSCSI with Windows Server 2008 R2 and newer. SAS FE does not support boot-from-SAN. To learn more about boot-from-SAN, see the *Dell EMC SC Series Storage and Microsoft Windows Server 2016* best practices guide.

4.1 Automatic configuration with the Dell Storage Manager client

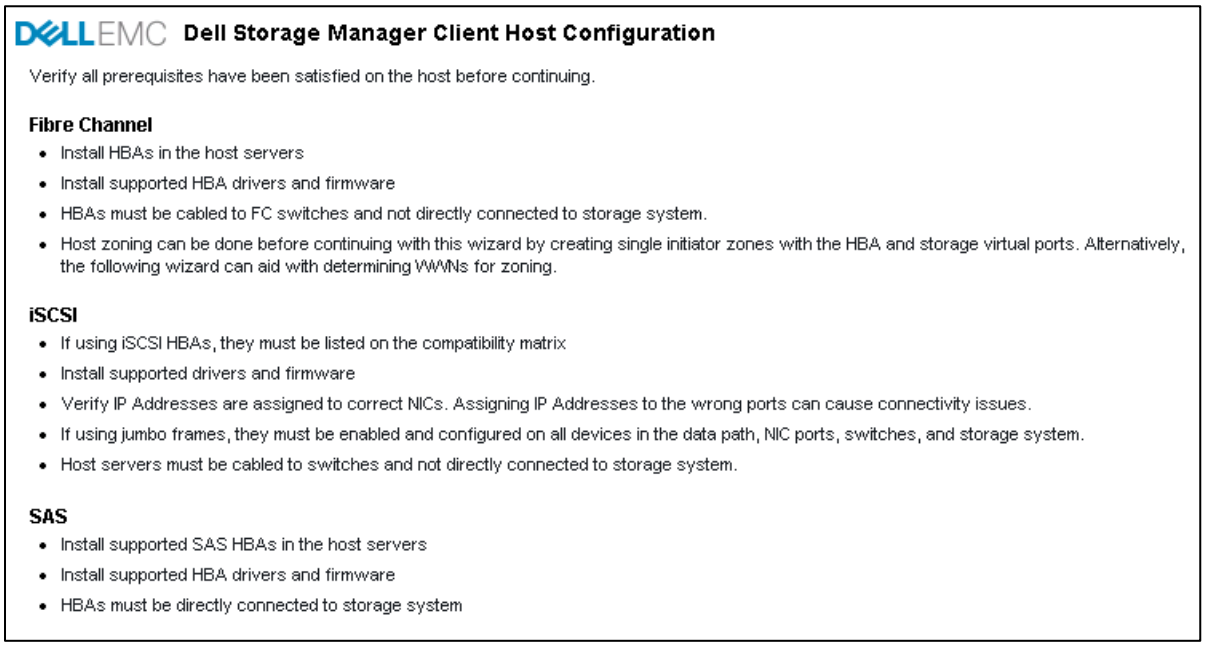
The preferred method to create a new server object on SC Series storage is to use the host configuration wizard on the launch screen of the Dell Storage Manager client. One of the main benefits of this method of server creation is the wizard will automatically adjust the host server MPIO time-out settings in the Windows registry to match the current best practices as listed in appendix A.

Because automatic host configuration is not always possible, such as when the host does not yet have an OS installed, manual configuration is also possible. To use the DSM client to automatically create a new host server object on SC Series storage, follow these steps:

1. Install the Dell Storage Manager client on the host server.
2. Start the Dell Storage Manager client, and on the launch screen, select **Configure this host to access a Storage Center**.



3. Review the prerequisites and click **Next**.

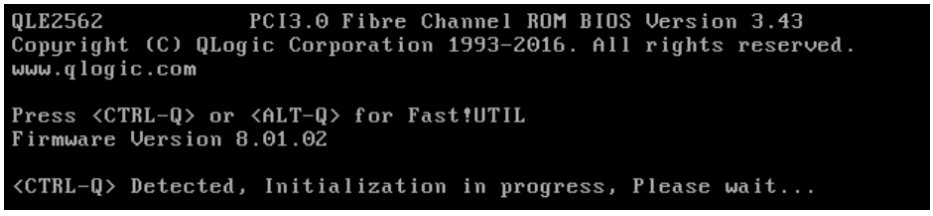


4. If more than one SC Series array is available, select the desired array and click **Next.**
5. The wizard will gather information about the host which may require a few minutes. If issues are encountered with the discovery, resolve them and repeat the process.
6. Once the server object is created, create and map at least one SC Series volume to the server.
7. Configure the MPIO settings (see section 5).

4.2 Manual server configuration with FC

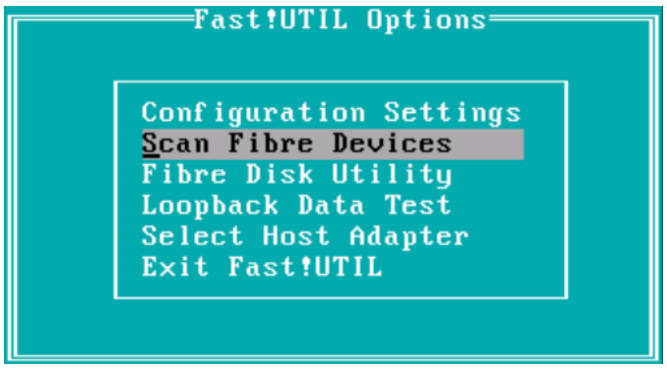
Use the **Configure this host to access a Storage Center** option in the Dell Storage Manager client to automatically configure a new FC server object on the SC Series array, as shown in section 4.1. In cases where this is not possible, create the server object manually using the following steps. The steps are the same for SC Series arrays configured for virtual port or legacy port mode.

1. Power on the Windows Server host.
2. Verify that the BIOS for each FC HBA is enabled. For QLogic HBAs, press [Control + Q] at boot to enter the **Fast!UTIL** configuration utility.

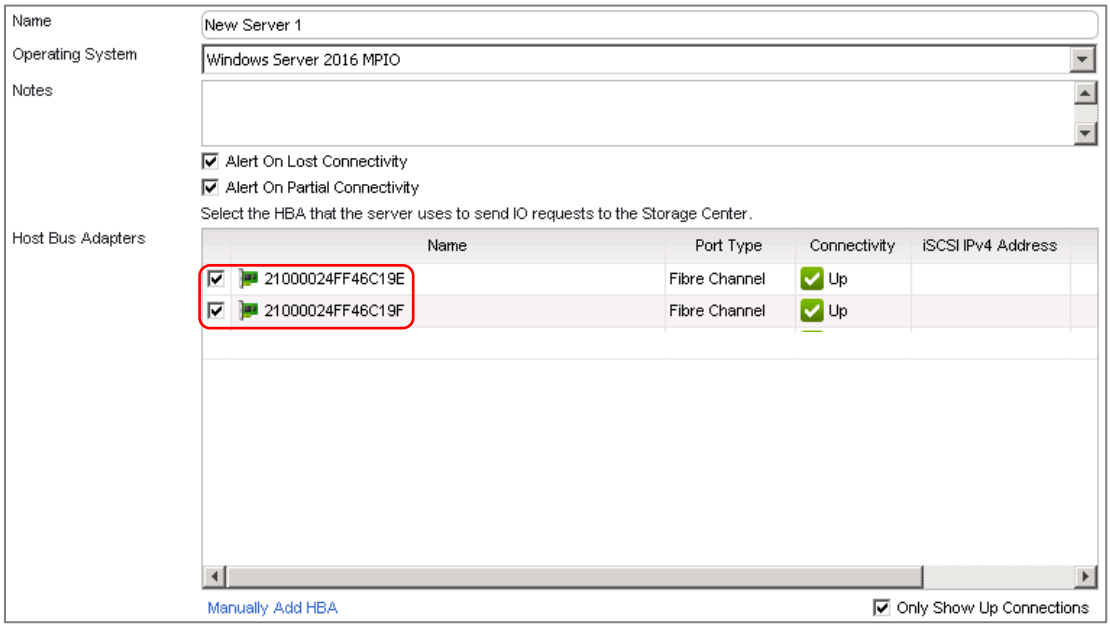


3. Configure the settings and advanced settings for each HBA. For guidance with QLogic HBAs, see the *Dell EMC SC Series Storage and Microsoft Windows Server 2016* best practices guide.

4. For each HBA, perform **Scan Fibre Devices**. The HBA will scan the fabric looking for storage devices. Although none will be found at this point, this advertises the presence of the HBA WWN to the SC Series array so that the WWN is visible.



5. Log in to the desired SC Series array using the Dell Storage Manager client.
6. Under **Hardware**, expand the **Servers** folder to the desired location.
7. Right-click the desired folder and select **Create Server.**
8. The WWN for each of the server HBAs should be listed as available. Select the HBAs and configure the other options as desired. Although HBAs can added by manually entering the WWN (if the server or HBA is off line for example), this is not advised. Mapping HBAs that are visible is preferable because it confirms correct configuration of front-end cabling, zoning, and other configurations.

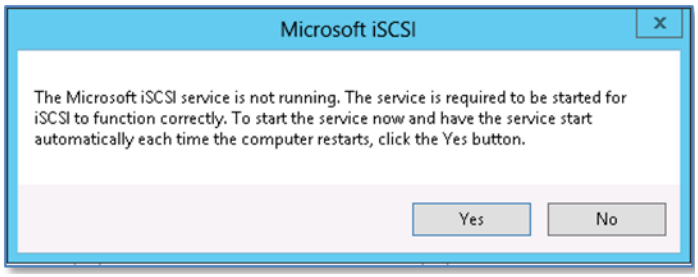


9. Once created, verify that the server object lists the HBAs with a status of **Up**.
10. Exit from the HBA BIOS, reboot, and log in to Windows.
11. Create and map at least one SC Series volume to the server.
12. Configure the MPIO settings (see section 5).

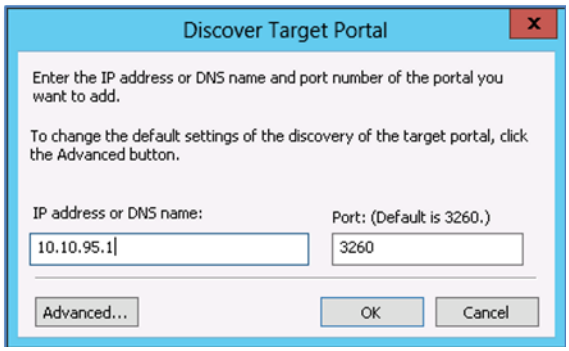
4.3 Manual server configuration with iSCSI

Use the **Configure this host to access a Storage Center** option in the Dell Storage Manager client to automatically configure a new iSCSI server object on the SC Series array, as shown in section 4.1. In cases where this is not possible, create the server object manually using the following steps.

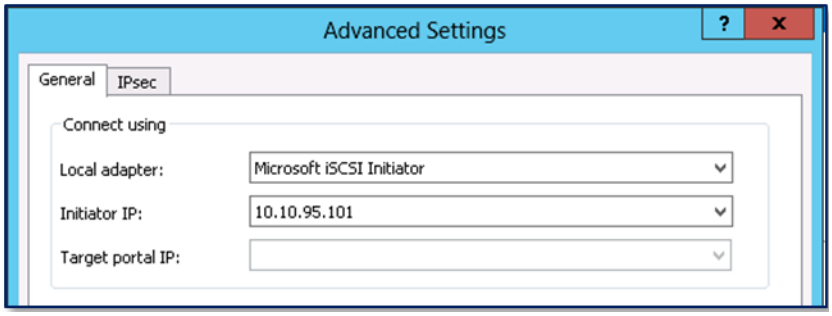
1. Configure two physical NIC ports on the server to use iSCSI.
2. Configure one NIC (including the necessary cabling and switching configurations) to access one virtual iSCSI fault domain, and configure the second NIC to access the other virtual iSCSI fault domain.
3. Once configured, the server should be able to ping both of the virtual iSCSI IP addresses associated with the two iSCSI fault domains on the SC array. In this example the IPs are 10.10.95.1 (iSCSI Fault Domain 1) and 10.10.128.1 (iSCSI Fault Domain 2).
4. Log on to the Windows server and launch the iSCSI initiator software.
5. Click **Start** > **Administrative Tools** > **iSCSI Initiator**. Click **Yes** if prompted to start the iSCSI service.



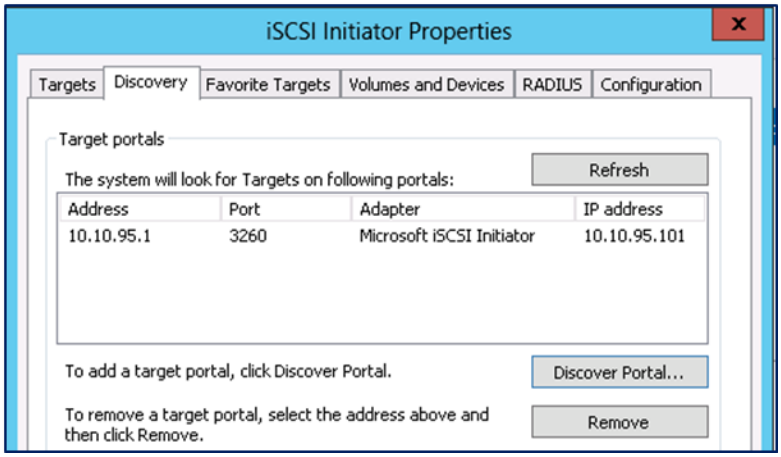
6. Select the **Discovery** tab, and click **Discover Portal**.
7. Enter the IP address of the control port for iSCSI Fault Domain 1 on the SC Series array, and click **Advanced**.



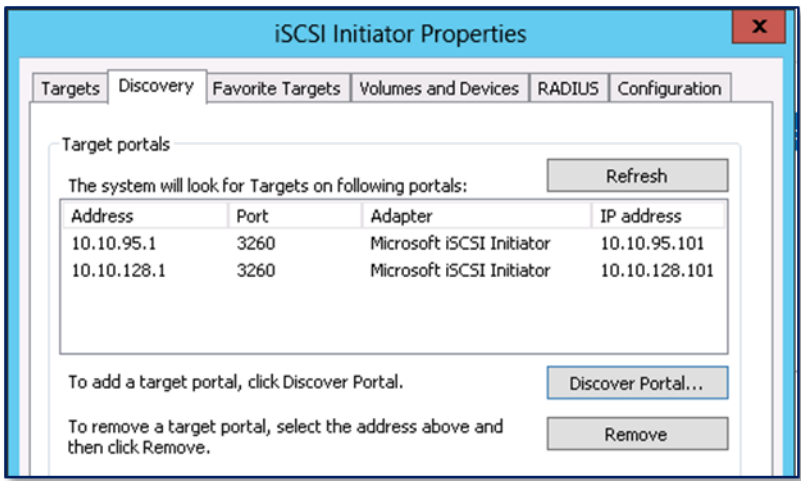
8. From the **Local adapter** drop-down menu, select **Microsoft iSCSI Initiator**. From the **Initiator IP** drop-down menu, select the local IP address of the server NIC that is to be associated with iSCSI Fault Domain 1. The initiator IP in this example is 10.10.95.101.



9. Click **OK**, and then **OK** again to return to the iSCSI Initiator properties window.
10. Verify that the target IP address and adapter IP address are displayed in the **Target portals** section.

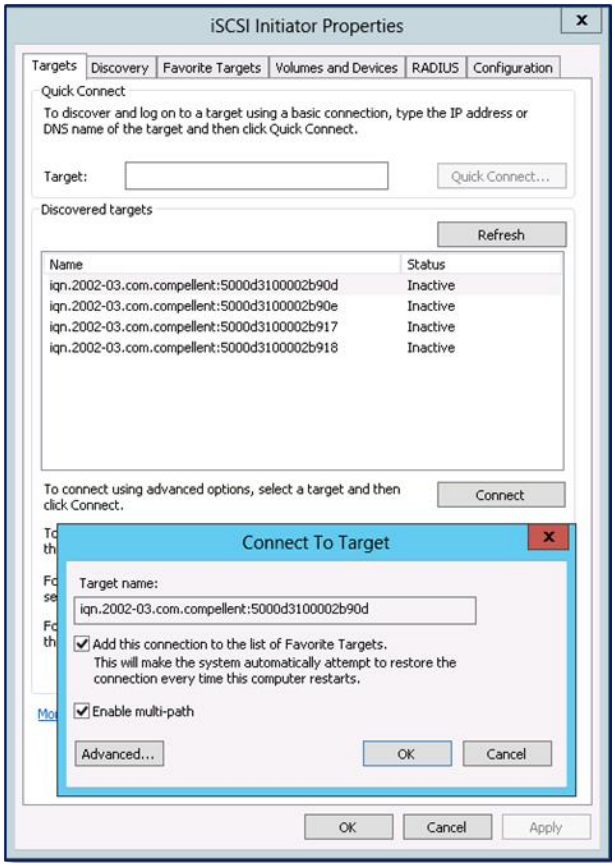


11. Repeat steps 6–10 to configure the second server NIC for the second iSCSI virtual fault domain. In this example, the IPs are 10.10.128.1 and 10.10.128.101.
12. When completed, verify that both pairs of iSCSI initiators and targets are listed.

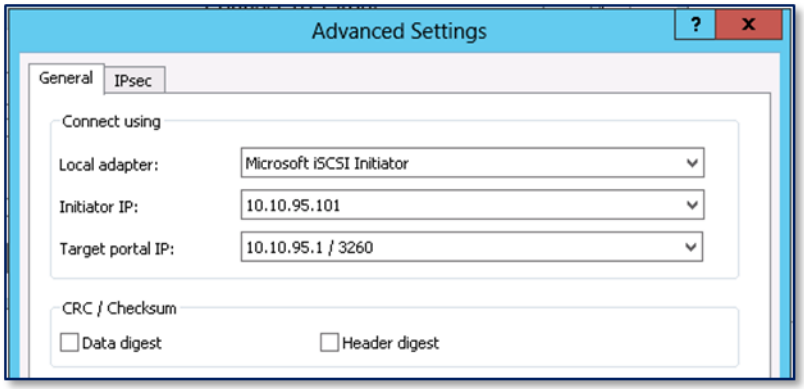


13. Select the **Targets** tab. This should be populated with the discovered iSCSI target ports on the array.
14. Highlight the first target, and click **Connect**.

15. On the **Connect To Target** screen, verify that both **Add this connection to the list of Favorite Targets** and **Enable multi-path** are checked.
16. Click **Advanced** to display additional options.

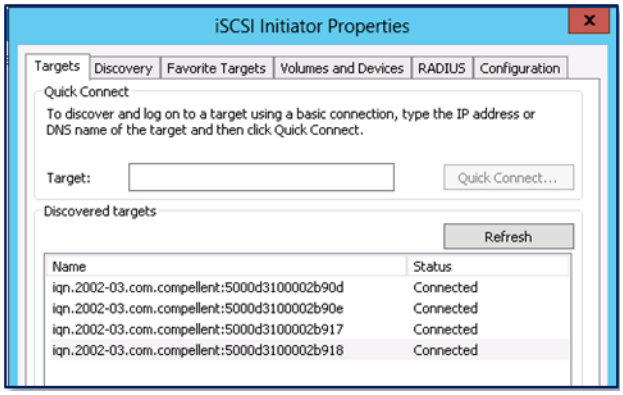


17. Set **Local adapter** to **Microsoft iSCSI Initiator**.
18. Select the correct IP addresses for the **Target portal IP** and **Initiator IP** from the drop-down menus.

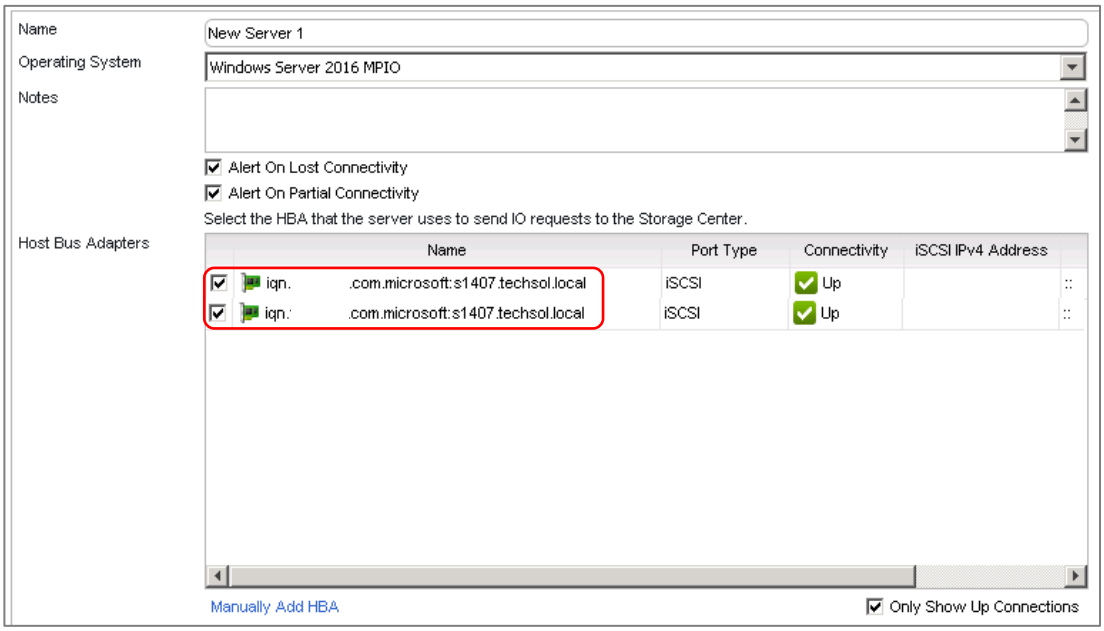


19. Click **OK**, and click **OK** again to return to the iSCSI Initiator properties window.
20. Repeat steps 14–19 for each additional target listed.

21. When finished, verify that all targets show with a status of **Connected**.



22. Click **OK** to exit the iSCSI Initiator Properties window.
23. Log in to the desired SC Series array using the Dell Storage Manager client.
24. Under **Hardware**, expand the **Servers** folder to the desired location.
25. Right-click the desired folder and select **Create Server.**
26. Under **Host Bust Adapter**, select the iSCSI ports for Fault Domains 1 and 2.



27. Once created, verify that the server object lists the HBAs with a status of **Up**.
28. Create and map at least one SC Series volume to the server.
29. Configure the MPIO settings (see section 5.)

4.3.1 Manual server configuration with SAS FE

Use the **Configure this host to access a Storage Center** option in the Dell Storage Manager client to automatically configure a new server object on the SC series, as shown in section 4.1. In cases where this is not possible, follow the configuration steps in the *Dell EMC SC Series Storage with SAS Front-end for Microsoft Hyper-V* configuration guide. Once completed, create and map at least one SC Series volume to the server, and then configure the MPIO settings (see section 5).

4.4 Restrict volume mapping paths

On an SC Series array that is configured to use both FC and iSCSI, it is possible to configure hosts to use FC, iSCSI, or both transports concurrently when mapping a SAN volume. While this is not a common configuration, there are valid use cases, such as when an environment migrates from one type of transport to another, and for a time, both transports are needed. If the SC Series array and a host support both FC and iSCSI when mapping a new volume, all available FC and iSCSI paths are mapped for that volume unless the advanced mapping button is used to restrict mapping paths to FC only, iSCSI only, or a specific FC HBA port or iSCSI port. To restrict mapping paths when mapping a volume to a server:

1. Log in to the Dell Storage Manager client.
2. Under the **Storage** tab, expand **Volumes** and locate desired volume.
3. Right-click the volume and select **Map Volume to Server**. The **Map Volume to Server** window appears.
4. Select a server and click **Next**.
5. Click **Advanced Options**.
6. Under **Restrict Mapping Paths**, uncheck the box to **Map to All Available Ports**.
7. Select one of the following:
   - **Map using specific server ports** (check the specific server ports desired)
   - **Limit ports by transport type** (select the desired transport from the drop-down menu)

Note: The option to limit ports by transport type is only available on SC Series arrays that have more than one transport type available (Fibre Channel and iSCSI).

Note: Using mixed transports concurrently on the same Windows server volume is not supported with Windows Server 2012 R2 and newer. With Windows Server 2012 R2 and newer, when a LUN is presented to the host that is using both Fibre Channel and iSCSI, the host will default to one transport (typically Fibre Channel is chosen as the preferred transport by the host) and ignore the other transport. If all paths for the preferred transport go down, the host may not send data using the alternate transport without a disk re-scan, and this may cause a service interruption. This is default Windows Server behavior. For servers configured to use both FC and iSCSI, mapping one data volume with FC ports only, and another data volume with iSCSI ports only, is supported as long as each volume is configured to use only a single transport.

To view the list of mapped paths for a volume that are already mapped to a server, expand the **Volumes** tree, select the desired volume, click the **Mappings** tab, and view the information under **Mapping Details**.

5 Configure MPIO

This section describes how to associate the Microsoft DSM with SC Series volumes and how to set up and configure the Microsoft DSM based on the failover and load-balancing preferences of an organization. These instructions assume that server objects are created in Dell Storage Manager and that at least one volume is mapped to each server using FC, iSCSI, or SAS FE with MPIO enabled.

Note: When the MPIO configuration is complete, refer to appendix A for important MPIO-specific hotfix and registry settings.

5.1 Associate SC Series volumes with the Microsoft DSM

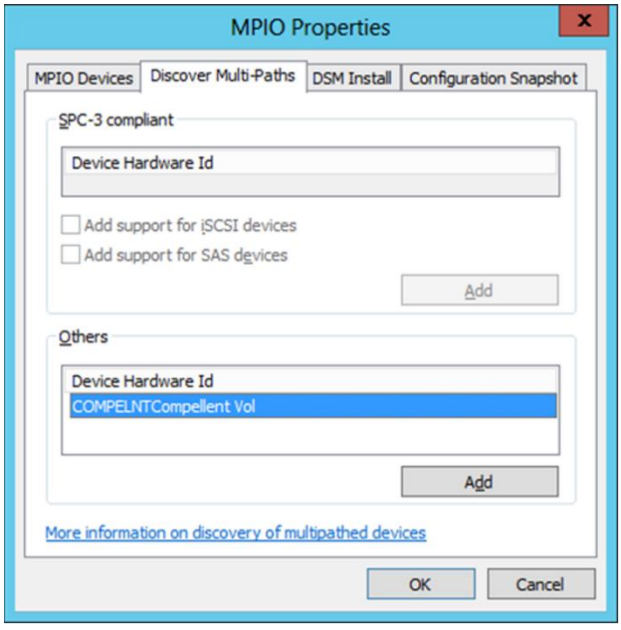
At this point, the Microsoft MPIO DSM has been installed but not configured. SC Series volumes must be associated with the DSM so that the DSM can manage MPIO characteristics. The Microsoft DSM manages all Fibre Channel, iSCSI, and SAS FE volumes presented.

Note: The software iSCSI initiator included in Windows Server 2008 R2 or later provides the necessary performance and stability required for iSCSI connections to an SC Series array. However, Dell supports the use of an iSCSI HBA.

5.1.1 Using the MPIO configuration tool (GUI)

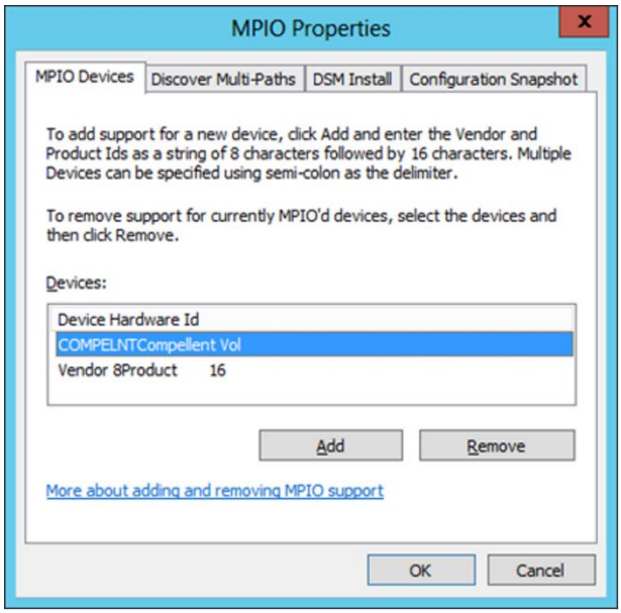
To associate SC Series volumes with the DSM through the use of the MPIO configuration tool, follow these steps:

1. Open the MPIO configuration tool by clicking **Start > Administrative Tools > MPIO**.
2. Click the **Discover Multi-Paths** tab.
3. In the **Others** window, **COMPELNTCompellent Vol** should be listed. If not, it may be necessary to perform a disk rescan in Disk Management.
4. Click **COMPELNTCompellent Vol** to select it and click **Add**.



5. When prompted, click **Yes** to reboot the server (a reboot is required).

6. After rebooting, open the MPIO configuration tool and verify that **COMPELNTCompellent Vol** is listed under **Devices** under the **MPIO Devices** tab.



7. Click **OK** to close the window.

5.1.2 Using PowerShell (Server 2012 or later)

Windows Server 2012 or later includes the MPIO module in Windows PowerShell. Although the **mpclaim** command is included in Windows Server 2012 and above, Microsoft recommends using PowerShell.

To associate the SC Series volumes with the DSM through the use of PowerShell, follow these steps.

1. Open a PowerShell window with elevated (administrator) privileges.
2. On Windows Server Core installations, type **powershell** and press [Enter] at the command prompt.
3. At the PowerShell prompt, enter:

```
New-MSDSMSupportedHW -VendorID "COMPELNT" -ProductID "Compellent Vol"
```

4. SC Series storage is now supported through the Microsoft DSM. To claim all available SC Series volumes to be used by MPIO, enter the following command:

```
Update-MPIOClaimedHW -Confirm:$false
```

5. To reboot the server (required), enter the following command:

```
shutdown -r -t 0
```

5.1.3 Using the MPCLAIM command

This command provides the same result as the MPIO configuration utility (GUI) or PowerShell. It associates SC Series volumes with the DSM and then reboots the server.

1. Open a command prompt with elevated (administrator) privileges.

2. Enter the following command. To bypass the reboot option, if rebooting later is desired, use **-n** in place of **–r**).

   ```
   mpclaim.exe -r -i -d "COMPELNTCompellent Vol"
   ```

3. Once the server reboots, use Disk Management to verify that the configuration is correct. There should only be one instance of each SAN volume listed in Disk Management.

5.2 Changing the default load balance policy

Once SC Series volumes are associated with the Microsoft DSM on a Windows server, no further steps are necessary unless changing the Windows default MPIO load balancing policy is necessary. The default load balance policy on a Windows server can be changed system-wide or on a per-volume basis.

The supported Windows Server MPIO policies are as follows:

- Dell Storage Center OS (SCOS) 6.5 and earlier: round robin (default) and failover only
- SCOS 6.6 and later: round robin (default), failover only, and least queue depth
- SAS FE: round robin with subset (default), least queue depth, and weighted paths

To change the system-wide Windows default MPIO load balance policy to another supported load balance policy, use MPCLAIM or PowerShell.

5.2.1 Using the MPCLAIM command

To use the MPCLAIM command to change the default load balance policy, open a command prompt with elevated (administrator) privileges and enter the following:

```
mpclaim.exe -L -M <0-7> -d "COMPELNTCompellent Vol"
```

<0-7> refers to the desired load balance policy as shown in Table 1.

Table 1 MPCLAIM load balance options

Parameter	Definition
0	Clear the policy
1	Failover only
2	Round robin
3	Round robin with subset
4	Least queue depth
5	Weighted paths
6	Least blocks
7	Vendor specific

For example, to change all SC Series volumes to a failover only policy, enter the following command:

```
mpclaim.exe -L -M 1 -d "COMPELNTCompellent Vol"
```

5.2.2 Using PowerShell (Windows Server 2012 or later)

The MPIO module in PowerShell can be used to set the host server default load balance policy. For example, to change the default load balance policy from round robin (RR) to failover only (FOO), open a PowerShell window with elevated (administrator) privileges and enter:

```
Set-MSDSMGlobalDefaultLoadBalancePolicy –Policy "FOO"
```

To change the default load balancing back to round robin, enter:

```
Set-MSDSMGlobalDefaultLoadBalancePolicy –Policy "RR"
```

To verify the default load balancing policy, enter:

```
Get-MSDSMGlobalDefaultLoadBalancePolicy
```

- If the default policy is set to round robin, the result will return **RR**.
- If the default policy is set to failover only, the result will return **FOO**.

5.3 Per-volume load balance settings

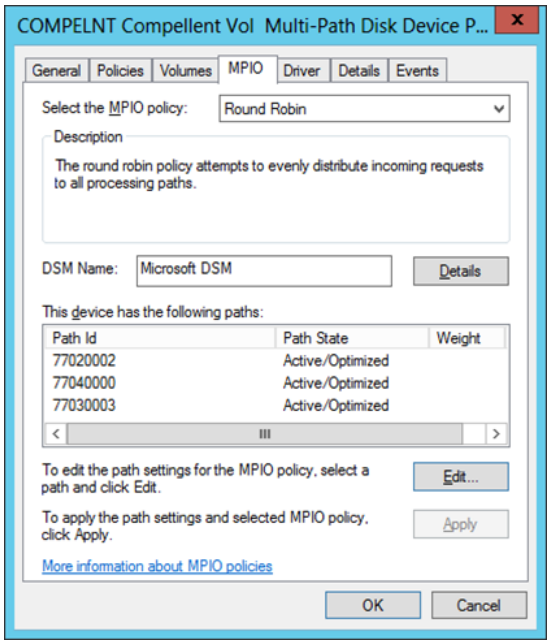
The MPIO load balance policy can also be changed on a per-volume basis. This allows organizations with different workloads on difference volumes with different load balancing requirements to run on the same server. Use Disk Management or the MPCLAIM utility to change the per-volume policy.

Note: The PowerShell MPIO module does not include cmdlets that can change the default load balance policy on a specific volume.

5.3.1 Using the disk management GUI:

1. Click **Start > Administrative Tools > Computer Management**.
2. In the tree view, click **Storage > Disk Management**.
3. Right-click the desired disk number and select **Properties**.
4. Select the **MPIO** tab.

5. From the drop-down menu, select the appropriate MPIO policy for the volume. Make sure the chosen policy is supported or Windows will revert to the current default policy.



5.3.2 Using the MPCLAIM command

To change the default load balancing policy on a single volume, open a command prompt or PowerShell window with elevated (administrator) privileges (commands will work in both).

Note: The load balancing policy cannot be changed from round robin to failover only using the MPCLAIM command. MPCLAIM only supports switching from failover only to round robin.

To list all MPIO volumes on the system, enter:

```
mpclaim -s -d
```

In this example, the load balancing policy is set to round robin (RR) for disks 0 and 1; and to failover only (FOO) for disk 2.

```
PS C:\Windows\system32> mpclaim -s -d

For more information about a particular disk, use 'mpclaim -s -d #' where # is the MPIO disk number.

MPIO Disk     System Disk  LB Policy     DSM Name
-------------------------------------------------------------------------------
MPIO Disk2    Disk 2       FOO           Microsoft DSM
MPIO Disk1    Disk 1       RR            Microsoft DSM
MPIO Disk0    Disk 0       RR            Microsoft DSM
PS C:\Windows\system32>
```

Figure 5 Listing MPIO volumes

The syntax to change the load balancing policy on a specific volume is:

```
mpclaim -l -d <disk #> <0-7>
```

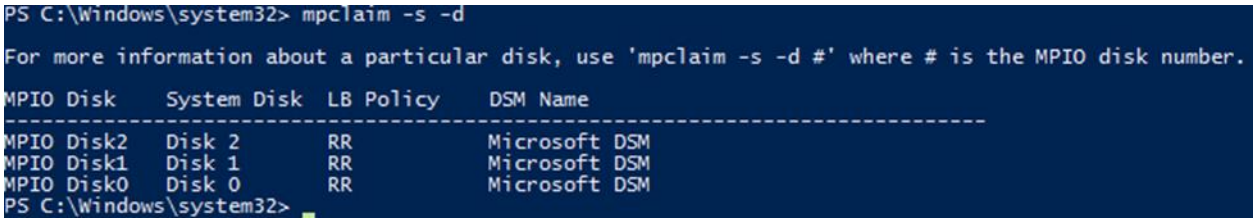
Refer to Table 1 for a list of load balancing policies and the associated numbers for the MPCLAIM command.

To change the load balancing policy of MPIO disk 2 from failover only to round robin, enter:

```
mpclaim -l -d 2 2
```

To verify the new settings, enter:

```
mpclaim -s -d
```



Visit Microsoft TechNet for more information about using MPCLAIM.

A Windows Server single-path and MPIO configuration recommendations for SC Series storage

Observe the following guidelines before using this section.

- The recommended updates and hotfixes in this section list the names (msdsm.sys, mpio.sys, storport.sys, and msiscsi.sys) and modified dates of storage-specific files that are loaded when the associated update or hotfix is applied. If a newer version of the file listed is already loaded on the server, the recommended update or hotfix does not need to be loaded.
- In some cases, prerequisite updates must be installed on the server before the following hotfixes can be installed. Read the prerequisite information for each applicable hotfix before proceeding.
- Updates and hotfixes are listed in the order in which they should be installed.
- The following registry settings should be made on all Windows Server hosts that use the Microsoft DSM to access LUNs on SC Series arrays in order to ensure proper behavior and performance. This includes hosts configured to use single-path and MPIO.
- Using mixed transports concurrently on the same Windows server volume is not supported with Windows Server 2012 R2 and newer. With Windows Server 2012 R2 and newer, when a LUN is presented to the host that is using both Fibre Channel and iSCSI, the host will default to one transport (typically Fibre Channel is chosen as the preferred transport by the host) and ignore the other transport. If all paths for the preferred transport go down, the host may not send data using the alternate transport without a disk re-scan, and this may cause a service interruption. This is default Windows Server behavior. For servers configured to use both FC and iSCSI, mapping one data volume with FC ports only, and another data volume with iSCSI ports only, is supported, as long as each volume is configured to use only a single transport.

A.1 Recommended updates and hotfixes for Windows Server 2008 R2 SP1

See the Microsoft Update Catalog at https://www.catalog.update.microsoft.com/Home.aspx to locate specific KB downloads.

Table 2 Recommended updates and hotfixes for Windows Server 2008 R2 SP1

KB number	Title	Link
KB3125574	Convenience rollup update for Windows 7 SP1 and Windows Server 2008 R2 SP1 (May 2016) **msdsm.sys** version 6.1.7601.23403 (3/25/16) **mpio.sys** version 6.1.7601.23403 (3/25/16) **msiscsi.sys** version 6.1.7601.23403 (3/25/16) **storport.sys** version 6.1.7601.23403 (3/25/16)	http://support.microsoft.com/kb/3125574

A.2 Recommended updates and hotfixes for Windows Server 2012 (non-R2 version)

See the Microsoft Update Catalog at https://www.catalog.update.microsoft.com/Home.aspx to locate specific KB downloads.

Table 3 Recommended updates and hotfixes for Windows Server 2012 (non-R2 version)

KB number	Title	Link
KB3018489	"No host bus adapter is present" error when querying SAS cable issues in Windows Server 2012 R2 or Windows Server 2012 **storport.sys** version 6.2.9200.17188 (11/19/14)	http://support.microsoft.com/kb/3018489
KB3046101	Server may freeze during startup when ALUA-capable storage is used in Windows Server 2012 R2 or Windows Server 2012 **mpio.sys** version 6.2.9200.17071 (8/5/14) **msdsm.sys** version 6.2.9200.17362 (5/6/15)	http://support.microsoft.com/kb/3046101
KB3102997	Data is corrupted after iSCSI sessions or paths recover in Windows Server 2012 R2 or Windows Server 2012 **msiscsi.sys** version 6.2.9200.21687 (11/8/15)	http://support.microsoft.com/kb/3102997

A.3 Recommended updates and hotfixes for Windows Server 2012 R2

Microsoft now publishes updates for Windows Server 2012 R2 cumulatively. Any updates for storage-related files are included in the monthly cumulative updates.

See the Microsoft Update Catalog at https://www.catalog.update.microsoft.com/Home.aspx to locate specific KB downloads.

Table 4 Recommended updates and hotfixes for Windows Server 2012 R2

KB Number	Title	Link
KB4054519	December 12, 2017—KB4054519 (Monthly Rollup) **msdsm.sys** version 6.3.9600.18592 (2/10/17) **mpio.sys** version 6.3.9600.18728 (6/11/17) **msiscsi.sys** version 6.3.9600.18728 (6/11/17) **storport.sys** version 6.3.9600.18833 (10/5/17)	http://support.microsoft.com/kb/4054519

A.4 Recommended updates and hotfixes for Windows Server 2016

Microsoft publishes updates for Windows Server 2016 cumulatively. Any updates for storage-related files are included in the monthly cumulative updates.

See the Microsoft Update Catalog at https://www.catalog.update.microsoft.com/Home.aspx to locate specific KB downloads.

Table 5 Recommended updates and hotfixes for Windows Server 2016

KB Number	Title	Link
KB4056890	Cumulative Update for Windows Server 2016 – January 3, 2018 **msdsm.sys** version 10.0.14393.1532 (7/12/17) **mpio.sys** version 10.0.14393.1532 (7/12/17) **msiscsi.sys** version 10.0.14393.1532 (7/12/17) **storport.sys** version 10.0.14393.2007 (21/31/17)	http://support.microsoft.com/kb/4056890

A.5 Recommended registry settings for Windows Server

The recommend registry settings listed in this section can be applied using the registry editor (regedit.exe) or through PowerShell. The registry editor can be used on all versions of Windows Server Desktop (Windows Server with a GUI).

Refer to section A.7 for a PowerShell script that will apply recommended registry settings to all versions of Windows Server.

Note: Recommended registry settings apply to all versions of Windows Server unless directly specified.

Table 6 Recommended registry settings location: HKLM\SYSTEM\CurrentControlSet\Services\mpio\Parameters

Setting name	Description	Default value	Recommended value
PDORemovePeriod	This setting controls the number of seconds that the multipath pseudo-LUN remains in system memory, even after losing all paths to the device. When this timer value is exceeded, pending I/O operations will be failed, and the failure is exposed to the application rather than attempting to continue to recover active paths. The maximum time allowed is MAXULONG (49,000 days).	20	120

Setting name	Description	Default value	Recommended value
PathRecoveryInterval	This represents the period after which PathRecovery is attempted. This setting is only used if it is not set to 0 and UseCustomPathRecoveryInterval is set to 1.	40	25
UseCustomPathRecoveryInterval	If this key exists and is set to 1, it allows the use of PathRecoveryInterval.	0	1
PathVerifyEnabled	This flag enables path verification by MPIO on all paths every N seconds (where N depends on the value set in PathVerificationPeriod). This Boolean function must be filled with either 0 (disable) or 1 (enable). By default, it is disabled.	0	1
PathVerificationPeriod	This setting is used to indicate the number of seconds with which MPIO has been requested to perform path verification. This field is only honored if PathVerifyEnabled is TRUE. This timer is specified in seconds. The default is 30 seconds. The maximum allowed is MAXULONG.	30	no change
RetryCount	This setting specifies the number of times a failed I/O if the DSM determines that a failing request must be retried. This is invoked when DsmInterpretError() returns Retry = TRUE. The default setting is 3.	3	no change (FC or iSCSI systems) 15 (front-end SAS systems only)
RetryInterval	This setting specifies the interval of time (in seconds) after which a failed request is retried (after the DSM has decided so, and assuming that the I/O has been retried a fewer number of times than RetryCount). This value is specified in seconds. The default is 1 second.	1	no change

Note: The registry settings in Table 7 need to be created on a Windows Server 2008 R2 server. Both settings should be created as DWORD (32-bit) values.

Table 7 Recommended disk registry settings location: HKLM\SYSTEM\CurrentControlSet\Services\mpio\Parameters

Setting name	Description	Default value	Recommended value
DiskPathCheckEnabled	If the DiskPathCheckEnabled key is set to a nonzero value, the MPIO component creates a path recovery worker.	-	1
DiskPathCheckInterval	If the DiskPathCheckInterval key is set to 0, or if the key does not exist, the MPIO component uses a default time interval. The default time interval is half of the time that is set in the PDORemovePeriod parameter.	-	25

Note: The registry settings in Table 8 only apply to Windows Server 2012 or later.

Table 8 Recommended disk registry settings location: HKLM\SYSTEM\CurrentControlSet\Services\mpio\Parameters

Setting name	Description	Default value	Recommended value
DiskPathCheckDisabled	If the DiskPathCheckDisabled key is set to zero, the MPIO component creates a path recovery worker.	0	no change
DiskPathCheckInterval	If the DiskPathCheckInterval key is set to 0, or if the key does not exist, the MPIO component uses a default time interval. The default time interval is half of the time that is set in the PDORemovePeriod parameter.	10	25

Table 9 Recommended disk registry settings location: HKLM\SYSTEM\CurrentControlSet\Services\disk

Setting name	Description	Default value	Recommended value
TimeoutValue	Disk time-out is a registry setting that defines the time that Windows will wait for a hard disk to respond to a command. Installing host bus adapters (HBA) or other storage controllers can cause this key to be created and configured.	60	no change

A.6 iSCSI initiator settings (single-path and MPIO)

This appendix contains recommended changes for iSCSI initiators. These changes apply to single-path and MPIO configurations that use iSCSI to connect to SC Series storage.

Table 10 Recommended iSCSI initiator registry settings location: HKLM\SYSTEM\CurrentControlSet\Control\Class\{4D36E97B-E325-11CE-BFC1-08002BE10318}\<Instance Number>\Parameters

Setting name	Description	Default value	Recommended value
MaxRequestHoldTime	This is the maximum number of seconds that requests are queued if connection to the target is lost and the connection is being retried. After this hold period, requests will be failed with **error no device** and device (disk) will be removed from the system.	60	90
LinkDownTime	This value determines how long requests will be held in the device queue and retried if the connection to the target is lost. If MPIO is installed this value is used. If MPIO is not installed MaxRequestHoldTime is used instead.	15	35
TCPConnectTime	Timeout given to TCP when a Connect request is sent.	15	no change
TCPDisconnectTime	Timeout given to TCP when a Disconnect request is sent.	15	no change
WMIRequestTimeout	Timeout value set for WMI requests such as LoginToTarget or LogoutFromTarget, SendTargets.	30	no change
DelayBetweenReconnect	If a connection is dropped while it is in FullFeature phase, the driver will attempt to re-login. This parameter sets the delay between each re-login attempts.	5	no change
MaxConnectionRetries	Maximum number of times a lost TCP connection will be retried.	4294967295 (indefinitely)	no change
MaxPendingRequests	This setting controls the maximum number of outstanding requests allowed by the initiator. At most this many requests will be sent to the target before receiving response for any of the requests.	255	no change
EnableNOPOut	If set to 1, the initiator will send NOP OUT PDUs to target if there is no activity for 2 minutes.	0	1
MaxTransferLength	This is maximum data size of an I/O request.	262144 (256KB)	no change

Setting name	Description	Default value	Recommended value
MaxBurstLength	This is the negotiated Max Burst Length.	262144 (256KB)	no change
FirstBurstLength	This is the negotiated First Burst Length.	65536 (64KB)	no change
MaxRecvDataSegmentLength	This is the negotiated MaxRecvDataSegmentLength.	65536 (64KB)	no change
IPSecConfigTimeout	This timeout value is used when the driver calls the discovery service to configure\release IPsec for an iSCSI connection.	60	no change
InitialR2T	If set to Non-Zero value, initiator will request InitialR2T (InitialR2T=Yes). Else initiator will not request InitialR2T (InitialR2T=No).	0	no change
ImmediateData	If set to Non-Zero value, initiator will request ImmediateData (ImmediateData=Yes). Else initiator will not request ImmediateData (ImmediateData=No).	1 (Yes)	no change
PortalRetryCount	This value is used to determine how many times a connect request to a target portal should be retried if the portal is down.	5	no change
NetworkReadyRetryCount	This value is used to determine how many times initiator should retry getting the IP address of NIC corresponding to the PortNumber specified in the login request.	10	no change
ErrorRecoveryLevel	Error recovery level that the initiator will request.	2	no change

Note the following additional guidelines:

Enable RFC1323 timestamps (TCP High Performance Extensions) to prevent sequence number wrap under high load, known as Prevention Against Wrapped Sequence (PAWS) or similar issues. High-load iSCSI connections are prone to this issue, particularly at 10GbE.

```
netsh int tcp set global timestamps=enabled
```

Disable Nagle's Algorithm: To disable delayed ACK and Nagle's algorithm, create the following entries for each SAN interface subkey in the Windows Server registry:

```
HKEY LOCAL_MACHINE \ SYSTEM \ CurrentControlSet \ Services \ Tcpip \ Parameters
\ Interfaces \ <SAN interface GUID>
```

- Entries:

  ```
  TcpAckFrequency
  TcpNoDelay
  ```

- Value type:

  ```
  REG_DWORD, number
  ```

- Value to disable:

  ```
  1
  ```

Disable NIC Interrupt Modulation:

1. Click **Adapter Settings**.
2. Right-click the adapter and select **Properties**.
3. Under the **Networking** tab, click **Configure**.
4. Under the **Advanced** tab, select **Interrupt Moderation** and choose **Disabled**.

Note: A reboot is required for any registry changes to take effect. Alternatively, unloading and reloading the initiator driver will also cause the change to take effect. In the Device Manager GUI, look under **Storage controllers**, right-click **Microsoft iSCSI Initiator,** and select **Disable** to unload the driver. Then select **Enable** to reload the driver.

A.7 PowerShell script

Use the PowerShell script in this section to set the recommended registry settings on Windows Server 2008 R2 or newer.

```
# MPIO Registry Settings script
# This script will apply recommended Dell Storage registry settings
# on Windows Server 2008 R2 or newer
#
# THIS CODE IS MADE AVAILABLE AS IS, WITHOUT WARRANTY OF ANY KIND.
# THE ENTIRE RISK OF THE USE OR THE RESULTS FROM THE USE OF THIS CODE
# REMAINS WITH THE USER.

# Assign variables

$MpioRegPath   = "HKLM:\SYSTEM\CurrentControlSet\Services\mpio\Parameters"
$IscsiRegPath  = "HKLM:\SYSTEM\CurrentControlSet\Control\Class\"
$IscsiRegPath += "{4d36e97b-e325-11ce-bfc1-08002be10318}\000*"

# General settings

Set-ItemProperty -Path $MpioRegPath -Name "PDORemovePeriod" `
-Value 120
Set-ItemProperty -Path $MpioRegPath -Name "PathRecoveryInterval" `
-Value 25
Set-ItemProperty -Path $MpioRegPath -Name "UseCustomPathRecoveryInterval" `
-Value 1
Set-ItemProperty -Path $MpioRegPath -Name "PathVerifyEnabled" `
-Value 1

# Apply OS-specific general settings

$OsVersion = ( Get-WmiObject -Class Win32_OperatingSystem ).Caption

If ( $OsVersion -match "Windows Server 2008 R2" )
{
    New-ItemProperty -Path $MpioRegPath -Name "DiskPathCheckEnabled"  -Value 1 `
                     -PropertyType DWORD `
                     -Force

    New-ItemProperty -Path $MpioRegPath -Name "DiskPathCheckInterval" -Value 25`
                     -PropertyType DWORD `
                     -Force
}
Else
{
    Set-ItemProperty -Path $MpioRegPath -Name "DiskPathCheckInterval" -Value 25
}

# iSCSI settings

If ( ( Get-Service -Name "MSiSCSI" ).Status -eq "Running" )
{
    # Get the registry path for the Microsoft iSCSI initiator parameters

    $IscsiParam = Get-Item -Path $IscsiRegPath `
                  | Where-Object { ( Get-ItemProperty $_.PSPath ).DriverDesc `
                                   -eq `
                                   "Microsoft iSCSI Initiator" } `
                  | Get-ChildItem `
                  | Where-Object { $_.PSChildName -eq "Parameters" }
```

```
    # Set the Microsoft iSCSI initiator parameters

    Set-ItemProperty -Path $IscsiParam.PSPath -Name "MaxRequestHoldTime" `
-Value 90
    Set-ItemProperty -Path $IscsiParam.PSPath -Name "LinkDownTime" `
-Value 35
    Set-ItemProperty -Path $IscsiParam.PSPath -Name "EnableNOPOut" `
-Value 1
}
Else
{
    Write-Host "iSCSI Service is not running."
    Write-Host "iSCSI registry settings have NOT been configured."
}

Write-Host "MPIO registry settings have been configured successfully."
Write-Host "The system must be restarted for the changes to take effect."
```

B Additional resources

B.1 Technical support and resources

Dell.com/support is focused on meeting customer needs with proven services and support.

Dell TechCenter is an online technical community where IT professionals have access to numerous resources for Dell software, hardware, and services.

Storage Solutions Technical Documents on Dell TechCenter provide expertise that helps to ensure customer success on Dell EMC storage platforms.

B.2 Related documentation

Table 11 Referenced or recommended resources

Vendor	Resource
Dell	Dell Storage SC Series: Microsoft Multipath I/O Best Practices
Dell	Dell EMC SC Series Storage: Microsoft Windows Server 2016 Best Practices
Dell	Windows Server 2012 R2 Best Practices for Dell Compellent Storage Center
Microsoft	Microsoft MPIO Step-by-Step Guide (2008 R2)
Microsoft	Configuring iSCSI MPIO on Windows Server 2008 R2
Microsoft	MPCLAIM Reference Guide
Microsoft	Managing MPIO with Windows PowerShell on Windows Server 2012
Microsoft	Multipath I/O (MPIO) Cmdlets in Windows PowerShell Reference Windows 2012 R2
Microsoft	Microsoft iSCSI Initiator Documentation
Microsoft	Configuring MPIO Timers