



Hewlett Packard
Enterprise

HPE MSA 1060/2060/2062 Storage Management Guide

Abstract

This guide covers concepts used to administer an HPE MSA 1060/2060/2062 Storage system and provides information about managing the system by using its web interface, the Storage Management Utility (SMU).

Part Number: R0Q73-90009
Published: September 2020
Edition: 1

Notices

The information contained herein is subject to change without notice. The only warranties for Hewlett Packard Enterprise products and services are set forth in the express warranty statements accompanying such products and services. Nothing herein should be construed as constituting an additional warranty. Hewlett Packard Enterprise shall not be liable for technical or editorial errors or omissions contained herein.

Confidential computer software. Valid license from Hewlett Packard Enterprise required for possession, use, or copying. Consistent with FAR 12.211 and 12.212, Commercial Computer Software, Computer Software Documentation, and Technical Data for Commercial Items are licensed to the U.S. Government under vendor's standard commercial license.

Links to third-party websites take you outside the Hewlett Packard Enterprise website. Hewlett Packard Enterprise has no control over and is not responsible for information outside the Hewlett Packard Enterprise website.

Acknowledgments

Intel®, Itanium®, Pentium®, Intel Inside®, and the Intel Inside logo are trademarks of Intel Corporation in the United States and other countries.

Microsoft® and Windows® are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

Adobe® and Acrobat® are trademarks of Adobe Systems Incorporated.

Java® and Oracle® are registered trademarks of Oracle and/or its affiliates.

UNIX® is a registered trademark of The Open Group.

Revision History

R0Q73-90009
Initial HPE release.

September 2020

Contents

1 Getting started	9
Product features	9
Configuring and provisioning a new storage system	10
Using the interface	10
Web browser requirements and setup	10
Areas of the interface	11
Icons in the interface	11
Tips for using the SMU	13
Tips for using tables	13
Exporting data to a CSV file	14
Size representations	14
Signing in and signing out	14
2 System concepts	16
Virtual storage	16
Disk groups	16
Disk sector format	17
Virtual disk group configuration	17
Removing disk groups from virtual pools	18
Read-cache disk groups	18
RAID levels	18
MSA-DP+	20
Disk group utilities	20
Disk-group expansion	20
Disk-group verify	21
Disk-group scrub	21
SSDs	22
Gauging the percentage of life remaining for SSDs	22
All-flash array	23
SSD management	23
SSD read cache	23
Spares	24
Pools	24
Virtual pools and disk groups	25
Changing pool settings	25
Volumes	26
Volume cache options	26
Using write-back or write-through caching	27
Cache optimization mode	27
Optimizing read-ahead caching	27
Read-cache disk groups	28
Overcommitting volumes	28
Automated tiered storage	28
Volume tier affinity	29
Initiators, hosts, and host groups	29
CHAP	29
Host ports	30
Attaching volumes to hosts	31
Snapshots	32
Snapshot trees	32
Rollback and reset snapshot features	33
Copying volumes or snapshots	33
Reconstruction	33
MSA-DP+ reconstruction	34
Quick rebuild	35
Updating firmware	35
Managed logs	35
Saving log data to a file	36

LDAP	37
Feature overview	37
Protocols and services	38
LDAP server/client details	38
Recovery	39
DNS settings	39
Peer connections	40
Replication	41
Replicating virtual volumes	41
Creating a virtual pool for replication	44
Setting up snapshot space management in the context of replication	44
Replication and empty allocated pages	45
Disaster recovery	45
Creating a replication set	45
Replicating between current and legacy systems	47
CHAP and replication	47
Full disk encryption	48
Rescanning disks	49
Clearing disk metadata	49
Data protection with a single controller	50
SAS cabling (for MSA 1060 only)	51
Event history	51
Audit logs	52
System metrics	52
3 Dashboard	53
Alerts panel	53
Compact view	53
Expanded view	53
Capacity panel	54
Compact view	54
Expanded view	54
Performance panel	54
Compact view	54
Expanded view	55
Performance metrics	55
Activity panel	57
Compact view	57
Expanded view	57
4 Provisioning	59
Working with volumes	59
Volumes table	59
Data Protection table	60
Creating volumes	61
Modifying volumes	62
Deleting volumes and snapshots	62
Attaching volumes to hosts	63
Detaching volumes from hosts	63
Expanding volumes	63
Rolling back volumes	64
Creating snapshots	64
Resetting snapshots	64
Copying volumes or snapshots	64
Aborting a volume copy	65
Add data protection	65
Creating a replication set	65
Modifying a replication set	66
Deleting a replication set	66
Initiating or scheduling a replication	67
Suspending a replication	68

Aborting a replication set	68
Resuming a replication	68
Managing replication schedules	69
Working with hosts	69
Creating hosts	69
Attaching hosts to volumes	70
Detaching hosts from volumes	70
Removing initiators from a host	70
Removing hosts from a host group	70
Adding hosts to a host group	70
Deleting hosts	70
Deleting host groups	71
Adding initiators to a host	71
Renaming hosts	71
Changing a host profile	71
Renaming host groups	71
Renaming initiators	71
5 Settings	72
Network settings	72
Configuring controller network ports	72
Configuring DNS settings	73
Enabling or disabling system-management services	74
Viewing certificate information	75
User settings	75
Managing local users	75
Managing LDAP users	76
Managing SNMPv3 users	77
System settings	78
Setting system identification information	78
Setting the date and time	78
Securing the system with FDE	79
Setting system properties	79
Notification settings	81
Email notifications	81
SNMP notifications	81
Syslog notifications	81
Configuring iSCSI host port settings	82
Configuring iSCSI CHAP settings	82
Changing iSCSI configuration settings	83
Peer connection settings	83
Querying peer connections	83
Modifying peer connection settings	83
Deleting a peer connection	83
6 Maintenance	85
Storage panel	85
Viewing information about a pool	85
Changing pool settings	85
Viewing information about disk groups in a pool	86
Adding a disk group to a pool	86
Renaming a disk group	86
Deleting a disk group from a pool	86
Expanding an MSA-DP+ disk group	87
Verifying a disk group	87
Scrubbing a disk group	87
Hardware panel	87
Firmware panel	88
Viewing information about installed and active system firmware bundles	88
Updating system firmware	89
Updating disk firmware	91

Using an update server	91
Best practices for updating firmware	92
About panel	93
Support panel	93
7 Support and other resources	94
Accessing Hewlett Packard Enterprise Support	94
Accessing updates	94
Remote support	95
Warranty information	95
Regulatory information	95
Documentation feedback	96
A Other management interfaces	97
SNMP reference	97
Supported SNMP versions	97
Standard MIB-II behavior	97
Enterprise traps	97
FA MIB 2.2 SNMP behavior	98
External details for certain FA MIB 2.2 objects	103
Configuring SNMP event notification in the SMU	105
SNMP management	105
Enterprise trap MIB	106
FA MIB 2.2 and 4.0 differences	108
Using FTP and SFTP	109
Downloading system logs	109
Transferring log data to a log-collection system	110
Downloading historical disk-performance statistics	111
Updating firmware	112
Installing a license file	116
Installing a security certificate	116
Downloading system heat map data	117
Using SMI-S	118
Embedded SMI-S array provider	119
About the MSA 1060/2060/2062 SMI-S provider	120
SMI-S profiles	121
Supported CIM operations	122
Life cycle indications	123
SMI-S configuration	124
Listening for managed-logs notifications	125
Testing SMI-S	125
Troubleshooting	125
Using SLP	126
B Administering a log-collection system	128
How log files are transferred and identified	128
Log file details	128
Storing log files	128
C Settings changed by restoring defaults	130
D System configuration limits	134
Glossary	136
Index	148

Figures

Figure 1 LDAP overview	37
Figure 2 Replication process for initial replication	42
Figure 3 Replication process for replications subsequent to the initial replication	43

Tables

Table 1	Areas of the SMU interface	11
Table 2	Icons in the interface	12
Table 3	Storage size representations in base 2 and base 10	14
Table 4	Decimal (radix) point character by locale	14
Table 5	Example applications and RAID levels	19
Table 6	RAID level comparison	19
Table 7	Number of disks per RAID level to optimize virtual disk group performance	19
Table 8	Event severity icons and meanings	51
Table 9	Available performance metrics	55
Table 10	FA MIB 2.2 objects, descriptions, and values	98
Table 11	connUnitRevsTable index and description values	103
Table 12	connUnitSensorTable index, name, type, and characteristic values	104
Table 13	connUnitPortTable index and name values	105
Table 14	Supported SMI-S profiles	121
Table 15	CIM Alert indication events	123
Table 16	Life cycle indications	123
Table 17	CLI commands for SMI-S protocol configuration	124
Table 18	Troubleshooting	125
Table 19	Interfaces advertised by SLP	126
Table 20	SLP attributes shown for a storage system	126
Table 21	Settings changed by restore defaults	130
Table 22	System configuration limits	134

1 Getting started

The Storage Management Utility (SMU) is a web-based application for configuring, monitoring, and managing the storage system. The SMU is also referred to as the web-browser interface (WBI).

Each controller module in the storage system contains a web server, which is accessed when you sign in to the SMU. You can access all functions from either controller in a dual-controller system. If one controller becomes unavailable, you can continue to manage the storage system from the partner controller.

In addition to the SMU, each controller module in the storage system has the following interfaces: SNMP, FTP, SFTP, SMI-S, SLP, CLI, API. For information about using the CLI and API, see the *HPE MSA 1060/2060/2062 CLI Reference Guide*.

Product information that is specific to a product model is identified by model name in the text. Otherwise, the content of this guide applies to all models.

Product features

The SMU gives you access to many features that help you manage the storage system. Some of the key features include:

- **Storage system setup:** the capability to initially connect to a system using the SMU, which employs intuitive preboarding and onboarding steps to guide you through initial setup of your storage, as described in "[Configuring and provisioning a new storage system](#)" on the next page.
- **MSA-DP+ data protection:** the capability to support a RAID-based data protection level emphasizing efficiency, as described in "[MSA-DP+](#)" on page 20.
- **Replication:** the capability to replicate block-level data from a volume in a primary system to a volume in a secondary system, as described in "[Replication](#)" on page 41.
- **Update firmware:** the capability to notify users of available firmware updates to controller modules, expansion modules, and disk modules with newer/compatible firmware versions as they become available, as described in "[Updating firmware](#)" on page 35.
- **Performance metrics:** the ability to monitor storage system performance and statistics via data-driven graphing—displaying dynamic or historical metrics—as described in "[Performance panel](#)" on page 54.
- **Alerts:** a robust storage enclosure health and notification system designed to identify actionable conditions and promote best practices, as described in "[Alerts panel](#)" on page 53.
- **LDAP integration:** the capability to use the external Lightweight Directory Access Protocol services on Windows systems for user authentication and authorization, as described in "[LDAP](#)" on page 37.
- **SSDs:** the ability to use solid-state drives to enhance storage system performance, as described in "[SSDs](#)" on page 22.
- **Virtual storage:** a storage model that maps logical components to physical media—using paged-storage technology—to virtualize data storage, as described in "[Virtual storage](#)" on page 16.
- **IPv6 support:** the capability for the storage system to support IPv6 (Internet Protocol version 6) functionality (in addition to IPv4), as described in "[Configuring controller network ports](#)" on page 72.
- **REST API support:** the REST (Representational State Transfer) API provides the management data in a stateless, cacheable data representation. Read-only access is provided to physical and logical components related to the storage provisioning model, including disks, storage pools, volumes, and enclosures.

The public REST API called DMTF Redfish and SNIA Swordfish are supported:

- For technical information about DMTF Redfish, see <https://www.dmtf.org/standards/redfish>
- For technical information about SNIA Swordfish, see <https://www.snia.org/forums/smi/swordfish>

- The base URL for accessing the REST API capability is "https://ip/redfish" (enter the unquoted portion of the URL string into your browser address field using a valid controller-module-IP-address in place of the variable text).
- **SCVMM support:** enables integration with Microsoft System Center Virtual Machine Manager.

Configuring and provisioning a new storage system

When you connect to the system for the first time, a wizard in the SMU guides you through the first-time setup of your system. This process is referred to as preboarding and onboarding. During preboarding you are led through steps to prepare the system for use and are prompted to do the following:

- Create a username, password, and select a language (once complete, you will be logged into the system as this user)
- Set up an update server to receive automatic firmware update notifications

NOTE This may require a proxy to access HPE public websites on the Internet.

- Update firmware
- Install a license

NOTE The user created during the preboarding process will have managing capabilities and will be able to change system settings.

During onboarding you are led through steps to configure and provision the system. These steps include:

- Configuring system settings
 - Network settings (IPv4, IPv6, DNS)
 - Date and time (NTP)
 - User definitions (local, LDAP, SNMPv3)
 - Notifications (email, SNMP, syslog)
 - FC or iSCSI settings (host port, network, CHAP)
- Configuring storage settings
 - Disk group and pool creation
- Provisioning storage
 - Creating host groups (naming initiators, assigning initiators to hosts, creating a single host)
 - Creating volumes and attaching them to hosts

Follow the on-screen directions to complete setting up your system. Once you complete the preboarding and onboarding steps you will be taken to the system ["Dashboard" on page 53](#). Here is where you begin to use the SMU to monitor, manage, and provision the storage system.

Using the interface

This section specifies web-browser requirements, describes the user interface, and provides tips for using it.

Web browser requirements and setup

Supported browser versions:

- Apple Safari 11 and newer (Mac)
- Google Chrome 70 and newer

- Microsoft Internet Explorer 10 and 11
- Mozilla Firefox 68 and newer

For best results, use the following guidelines:

- To see the help window, enable pop-up windows.
- To optimize the display, use a color monitor and set its color quality to the highest setting.
- To navigate beyond the sign-in page (with a valid user account):
 - Ensure that your browser is set to use TLS 1.2.
 - Verify that the browser is set to allow cookies, at least for the IP addresses of the storage system network ports.
 - For Internet Explorer, set the browser's local-intranet security option to medium or medium-low.
 - For Internet Explorer, add each controller's network IP address as a trusted site.

NOTE By default, your system is loaded with self-signed certificates. HPE recommends that you generate new self-signed certificates on each controller using the `create certificate` CLI command. Browser messages warning you about security or privacy concerns due to self-signed or untrusted certificates or invalid certificate authorities are expected, and warnings can be safely bypassed if you trust that you are contacting the correct controller within your network. Depending on the browser and its settings, once you navigate through the browser warning, a security exception may be created and the warning would no longer appear. Your browser address bar will still indicate the connection is not trusted or not secure, but you can safely ignore this if you trust you are accessing the correct controller within your network.


Areas of the interface

The main areas of the SMU interface are the banner, the menu pane, and the management pane, as represented by the following table. For more information about an item in the banner or menu pane, click its name in the table.

Clicking an option on the menu pane expands a dropdown list of menu choices. Clicking a menu option displays applicable content in the management pane.

The management pane shows system status relating to the selected menu in a summary format, allowing you to monitor and interact with the system. Where applicable, you can expand summary sections by clicking the slide-over arrows to view more information about the system status and make applicable changes to system settings and configuration. You can click on the information icon to view content that defines or explains more information about a feature/option. For more information about the icons used in the interface, see "[Icons in the interface](#)" below.

Table 1 Areas of the SMU interface

Banner:	Product name	 Help	"Setting the date and time" on page 78	"User settings" on page 75	Log Out
Menu pane:	"Dashboard" on page 53	Management pane			
	"Provisioning" on page 59				
	"Settings" on page 72				
	"Maintenance" on page 85				









Icons in the interface

The table below displays a list of the most common icons found in the SMU.







Table 2 Icons in the interface

Icon	Name	Use
	Abort/Cancel	Aborts or cancels an operation.
	Apply	Applies an edited operation or selection.
	Cancel	Cancels an edited operation or selection.
	Critical	Indicates that the item's health is critical, or that an alert or event has Critical severity.
	Collapse	Collapses a table row to hide information about an object.
	Dashboard	Indicates that the Dashboard menu is selected.
	Degraded	Indicates that the item's health is degraded, or that an alert or event has Error severity.
	Delete	Lets you delete a value or object.
	Disconnect	Indicates that the host is attached to a volume.
	Disk	Indicates an operation was performed on a disk.
	Disk group	Indicates an operation was performed on a disk group.
	Edit	Lets you edit a single value or options within an entire row or table.
	Error/Fault	Indicates that there is an error or fault with the system.
	Expand	Expands a table row to provide more detail about an object.
	Export/Upload	Lets you export or upload a file.
	Favorite	Indicates that the graph selected is a favorite and will display in the dashboard's compact view.
	Healthy/OK alert	Indicates that the item's health is good, or an alert or event is resolved or acknowledged.
	Host	Identifies a host.
	Host group	Identifies a host group.
	Information	Opens a small window that defines or provides more information about a feature or option.
	Informational	Indicates that an alert or event is informational.
	Initiator	Identifies an initiator.
	Maintenance	Indicates that the Maintenance menu is selected.
	Maintenance tasks	Indicates that either a maintenance needs to be performed or has already been performed to the specified item.
	Primary replication volume	Identifies the primary replication volume.
	Provisioning	Indicates that the Provisioning menu is selected.
	Resume	Resumes a suspended operation.
	Schedule	Indicates that a specified task will take place at defined times.
	Secondary replication volume	Identifies the secondary replication volume.
	Secured	Indicates that the system is secured using FDE.
	Settings	Indicates that the Settings menu is selected.




Table 2 Icons in the interface (continued)

Icon	Name	Use
 or 	Slide-over arrows	Opens or closes a panel that contains detailed information about an object.
	Snapshot	Indicates that a snapshot of the volume was created.
	Suspend	Suspends (pauses) an in-progress operation.
	Unsecured	Indicates that the system is not secured using FDE.
	Volume	Identifies the primary volume.
	Volume copy	Indicates the volume is being copied to a new volume.
	Warning	Indicates that an alert or event has Warning severity.

Tips for using the SMU


- Do not use the browser's Back, Forward, Reload, or Refresh buttons. The SMU has a single page for which content changes as you perform tasks and automatically updates to show current data.
- If you are signed in to the SMU and the controller you are accessing goes offline, the system informs you that the system is unavailable or that communication has been lost. After the controller comes back online, close and reopen the browser and start a new SMU session.
- As you set options in panels, the SMU informs you whether a value is invalid or a required option is not set.
- Confirmation buttons become active only after you set all required options.
- A red asterisk (*) identifies a required setting.
- Click the  icon to expand a panel and view additional details or perform actions. Click the  icon to collapse a panel and view summary information.
- Click the  icon to expand a table and see additional details or perform actions. Click the  icon to collapse a table and hide detailed information.
- Click the  icon to open the information window to learn more about an option. Click the icon again to close the information window.
- Click the  icon to edit content within a text box or table.
- In the Hardware panel (Maintenance > Hardware), click on a component such as an enclosure or disk to display information about that component.
- If your session is inactive for too long, you will be signed out automatically. This timer resets after each action you perform. One minute before automatic sign-out you will be prompted to continue using the SMU.

Tips for using tables

- Click the  icon to expand a table and see additional details or perform actions. Click the  icon to collapse a table and hide detailed information.
- The presence of a slide-over arrow icon  at the end of a table row indicates that you can view more information about the option and perform actions.
- Use the Search bar in the table header to search for specific content within the table. Not all tables have a search option.
- Table items are sorted by the highlighted column heading.

- To sort items by a specific column, click the arrow icon in the column heading to reorder items from low to high. Click the arrow icon again to reorder items from high to low.
- To filter items in a table, select the filter content from the Filter By drop-down list. Not all tables have a filtering option.
- To select items in a table, use the check boxes in the left column. Clear the check boxes to deselect items.
- To scroll through a table, click within the table and scroll.

Exporting data to a CSV file

You can export performance data to a downloadable comma-separated values (CSV) file that you can view in a spreadsheet for further analysis. The exported CSV file contains all of the content in the graph. To export performance data, click the  icon.

Size representations

Parameters such as names of users and volumes have a maximum length in bytes. When encoded in UTF-8, a single character can occupy multiple bytes. Typically:

- 1 byte per character for English, Dutch, French, German, Italian, and Spanish
- 3 bytes per character for Chinese, Japanese, and Korean

Operating systems usually show volume size in base-2. Disk drives usually show size in base-10. Memory (RAM and ROM) size is always shown in base-2. In the SMU, the base for entry and display of storage-space sizes can be set per user. When entering storage-space sizes only, either base-2 or base-10 units can be specified.

Table 3 Storage size representations in base 2 and base 10

Base-2		Base-10	
Unit	Size in bytes	Unit	Size in bytes
KiB (kibibyte)	1,024	KB (kilobyte)	1,000
MiB (mebibyte)	1,024 ²	MB (megabyte)	1,000 ²
GiB (gibibyte)	1,024 ³	GB (gigabyte)	1,000 ³
TiB (tebibyte)	1,024 ⁴	TB (terabyte)	1,000 ⁴
PiB (pebibyte)	1,024 ⁵	PB (petabyte)	1,000 ⁵
EiB (exbibyte)	1,024 ⁶	EB (exabyte)	1,000 ⁶

The locale setting determines the character used for the decimal (radix) point, as shown below.

Table 4 Decimal (radix) point character by locale

Language	Character	Examples
English, Chinese, Japanese, Korean	Period (.)	146.81 GB 3.0 Gbit/s
Dutch, French, German, Italian, Spanish	Comma (,)	146,81 GB 3,0 Gbit/s

Signing in and signing out

Multiple users can be signed in to each controller simultaneously.

For each active SMU session, an identifier is stored in the browser. Depending on how your browser treats this session identifier, you might be able to run multiple independent sessions simultaneously. For example, each instance of Internet Explorer can run a separate SMU session, but all instances of Firefox, Chrome, Edge, and Safari share the same SMU session.

NOTE If the initial user has not been created, see ["Configuring and provisioning a new storage system "](#) on page 10 for directions on signing in to the system for the first time. Otherwise, see the following procedure.

To sign in

1. In the web browser address field, type `https://<controller-network-port-IP-address>`, then press **Enter**. (Do not include a leading zero in an IP address. For example, enter 10.14.33 and not 10.14.033.) The SMU sign-in page displays. If the sign-in page does not display, verify that you have entered the correct IP address.

NOTE HTTPS is enabled by default. To enable HTTP, see ["Enabling or disabling system-management services"](#) on page 74 or see the `set protocols` CLI command.

2. On the sign-in page, enter the username and password of an authorized user.

NOTE A local username is case sensitive and can have a maximum of 29 bytes. The name cannot already exist in the system, include spaces, or include the following: " , < \ :

NOTE A local password is case sensitive and can have 8–32 characters. If the password contains only printable ASCII characters, then it must contain at least one uppercase character, one lowercase character, one numeric character, and one non-alphanumeric character. A password can include printable UTF-8 characters except for the following: a space or " ' , < >

3. To display the interface in a language different than the one configured for the user, select the language from the user-language list. Language preferences can be configured for the system and for individual users. The default language is English.
4. Click **Log In**. If the user authentication fails, a message indicates the system is unable to authenticate the login. If the system is available, the Dashboard displays. Otherwise, a message indicates that the system is unavailable.

When you are ready to end your session, click **Log Out** in the banner. Do not simply close the browser window.

2 System concepts

This section provides overviews of system features and concepts.

Virtual storage

Virtual storage is a method of mapping logical storage requests to physical storage (disks). It inserts a layer of virtualization such that logical host I/O requests are mapped onto pages of storage. Each page is then mapped onto physical storage. Within each page the mapping is linear, but there is no direct relationship between adjacent logical pages and their physical storage.

A page is a range of contiguous LBAs in a disk group, which is one of up to 16 disk groups that are grouped into a pool. Thus, a virtual volume as seen by a host represents a portion of storage in a pool. Multiple virtual volumes can be created in a pool, sharing its resources. This allows for a high level of flexibility, and the most efficient use of available physical resources.

Some advantages of using virtual storage are:

- It allows performance to scale as the number of disks in the pool increases.
- It virtualizes physical storage, allowing volumes to share available resources in a highly efficient way.
- It allows a volume to be comprised of more than 16 disks.
- It enables you to easily add storage on the fly.

Virtual storage provides the foundation for data-management features such as:

- ["Automated tiered storage" on page 28](#)
- ["Read-cache disk groups" on page 28](#)
- ["Replication" on page 41](#)
- ["Quick rebuild" on page 35](#)
- ["Snapshots" on page 32](#)
- ["Overcommitting volumes" on page 28](#)
- ["Copying volumes or snapshots" on page 33](#)

Disk groups

A *disk group* is an aggregation of disks of the same type, using a specific RAID level for the purpose of storing volume data. Disk groups are used in virtual storage environments and are added to pools to configure storage. A *pool* is an aggregation of one or more disk groups that serves as a container for volumes. Disk groups and pools are mutually inclusive. A pool cannot exist without at least one disk group in it, and you cannot create a disk group without selecting the pool it will reside in.

All disks in a disk group must be the same type (SSD, enterprise SAS, or midline SAS). A disk group can contain disks with different capacities, sector formats, and models. If you mix disks with different capacities, the smallest disk determines the logical capacity of all other disks in the disk group regardless of RAID levels except MSA-DP+. For example, the capacity of a disk group composed of one 1.2 TB disk and one 2.4 TB disk is equivalent to a disk group composed of two 1.2 TB disks. To maximize disk usage, use disks of similar size.

For more information, see:


- ["MSA-DP+" on page 20](#)
- ["Disk sector format" on the facing page](#)
- ["Virtual disk group configuration" on the facing page](#)
- ["Read-cache disk groups" on page 28](#)

- ["Removing disk groups from virtual pools" on the next page](#)
- ["Disk-group expansion" on page 20](#)
- ["Disk-group verify" on page 21](#)
- ["Disk-group scrub" on page 21](#)
- ["Changing pool settings" on page 25](#)

Disk sector format

The system supports 512-byte native sector size disks, 512-byte emulated sector size disks, or a mix of these sector formats. The system identifies the sector format used by a disk, disk group, or pool as follows:

- 512n—All disks use the 512-byte native sector size. Each logical block and physical block is 512 bytes.
- 512e—All disks use 512-byte emulated sector size. Each logical block is 512 bytes and each physical block is 4096 bytes. Eight logical blocks will be stored sequentially in each physical block. Logical blocks may or may not be aligned with physical block boundaries.
- Mixed—The disk group contains a mix of 512n and 512e disks. For consistent and predictable performance, do not mix disks of different sector size types (512n, 512e).

 **CAUTION** The emulation for 512e disks supports backward-compatibility for many applications and legacy operating systems that do not support 4K native disks. However, older versions of application software, such as virtualization software that resides between the operating system and your storage firmware, may not fully support 512e disk emulation. If not, performance degradation might result. Ensure that you have upgraded to the most recent version of any software that might be affected, and see its documentation for further information.

Virtual disk group configuration


A virtual disk group requires the selection of a pool (A or B) along with a specified number of available disks, RAID level, and spare size. If the virtual pool does not exist at the time of adding the disk group, the system will automatically create it. Multiple disk groups (up to 16) can be added to a single virtual pool. A virtual pool may contain from 1 to 16 disk groups. To add disk groups to a pool (Maintenance > Storage), expand the Disk Groups section for the specified pool (A or B) and then select **Add Disk Group** to access the panel. Panel content is dynamic, displaying options based on protection (RAID) level selected and the available disks.

Disk group configuration requires you to select a protection level. Depending on the level selected, additional configuration options may display. Only fault tolerant protection levels are available for creating virtual disk groups. Supported protection levels for virtual disk groups are: RAID 1, RAID 5, RAID 6, RAID 10, and MSA-DP+. If RAID 10 is specified, the disk group must have at least two subgroups.

Available disks are listed in the middle panel, and the summary panel will update as you select disks. The disk group will be added to the pool once you complete your selections and choose **Add Disk Group**.

Virtual disk groups can be comprised of either all spinning disks or all SSDs. If the system contains only SSDs, it will be treated as an all-flash array. For more information, see ["All-flash array" on page 23](#). Creating disk groups that contain only SSDs in combination with disk groups that contain only spinning disks will allow tiering within a pool. This requires an Advanced Data Services license. For more information, see ["Automated tiered storage" on page 28](#).

If a virtual disk group comprised of spinning disks is created, you can create a read-cache disk group comprised of SSDs without an Advanced Data Services license. A pool may contain either a read-cache disk group or a virtual disk group containing SSDs, but not both. For more information, see ["Read-cache disk groups" on page 28](#).

 **TIP** For optimal performance, all virtual disk groups in the same tier should have the same RAID level, capacity disks, and physical number of disks.

If the owning controller fails, the partner controller assumes temporary ownership of the pool and resources owned by the failed controller. If the host fault-tolerant cabling configuration, with appropriate mapping, is used to connect the controllers to hosts, LUNs for both controllers are accessible through the partner controller, so I/O to volumes can continue without interruption.

Removing disk groups from virtual pools


You can remove one or more disk groups, but not all, from a virtual pool without losing data as long as there is enough space available in the remaining disk groups to move the data into. When a virtual disk group that contains active volume data is removed, that volume data will drain (be moved) to other disk group members within the pool (if they exist). If the pool has enough space to contain the data, the disk group is removed. If the pool does not have enough space to contain the data, the disk group is not removed.

When the last disk group is removed, the pool ceases to exist and will be deleted from the system automatically. Alternatively, the entire pool can be deleted, which automatically deletes all volumes and disk groups residing on that pool.

NOTE Disk group removal (draining) can take a very long time depending on a number of factors in the system, including but not limited to: the amount of I/O traffic to the system (e.g., active I/O pages to the draining disk group); the type of the disk group page migration (enterprise SAS, midline SAS, SSD); the size of the draining disk group(s) in the system; and the number of disk groups draining at the same time.

NOTE If you remove the last disk group in a virtual pool, a warning displays prompting you to confirm removing the disk group. If the reply is *yes*, the pool will be removed. If the reply is *no*, the disk group and the pool will remain.

Removing a disk group from a pool:

In the Maintenance > Storage panel, locate the disk group to remove, click the  icon, and follow on-screen directions.

Read-cache disk groups

A read-cache disk group is a special type of a virtual disk group that is used to cache virtual pages to improve read performance. Only a single read-cache disk group may exist within a pool. Read cache does not add to the overall capacity of the pool to which it has been added. You can add or remove it from the pool without any adverse effect on the volumes and their data for the pool, other than to impact the read-access performance.

You can create a read-cache disk group for a virtual pool if the system includes available SSDs and the pool does not contain a virtual disk group comprised of SSDs (known as a Performance tier). A virtual pool cannot contain both read cache and a Performance tier.

To increase the size of read cache within a pool, you must remove the read-cache disk group and then re-add a larger read-cache disk group. It is possible to have a read-cache disk group that consists of one or two disks. For more information on read cache, see ["SSD read cache" on page 23](#).

RAID levels

The controllers enable you to set up and manage disk groups, the storage for which may be spread across multiple disks. This is accomplished through firmware resident in the controller. RAID refers to disk groups in which part of the storage capacity may be used to achieve fault tolerance by storing redundant data. The redundant data enables the system to reconstruct data if a disk in the disk group fails.

For a description of the MSA-DP+ data protection level, see ["MSA-DP+" on page 20](#).



TIP Choosing the right RAID level for your application improves performance.

In the SMU you can create MSA-DP+, RAID-1, RAID-5, RAID-6, and RAID-10 disk groups.

The following tables:

- Provide examples of appropriate RAID levels for different applications.
- Compare the features of different RAID levels.
- Suggest the number of disks to select for different RAID levels (virtual disk groups).

Table 5 Example applications and RAID levels

Application	RAID level
Workgroup servers	1 or 10
Network operating system, databases, high availability applications, workgroup servers	5
Mission-critical environments that demand high availability and use large sequential workloads	6
Provides flexible storage and fast rebuilds. Well-suited for most workloads other than those using very few disks, or requiring a high number of writes.	MSA-DP+

Table 6 RAID level comparison

RAID level	Min. disks	Description	Strengths	Weaknesses
1	2	Disk mirroring	Very high performance and data protection; minimal penalty on write performance; protects against single disk failure	High redundancy cost overhead: because all data is duplicated, twice the storage capacity is required
5	3	Block-level data striping with distributed parity	Best cost/performance for transaction-oriented networks; very high performance and data protection; supports multiple simultaneous reads and writes; can also be optimized for large, sequential requests; protects against single disk failure	Write performance is slower than RAID 1
6	4	Block-level data striping with double distributed parity	Best suited for large sequential workloads; non-sequential read and sequential read/write performance is comparable to RAID 5; protects against dual disk failure	Higher redundancy cost than RAID 5 because the parity overhead is twice that of RAID 5; not well-suited for transaction-oriented network applications; non-sequential write performance is slower than RAID 5
10 (1+0)	4	Stripes data across multiple RAID-1 sub-groups	Highest performance and data protection (protects against multiple disk failures)	High redundancy cost overhead: because all data is duplicated, twice the storage capacity is required; requires minimum of four disks
MSA-DP+	12	Distributed erasure coding with dual disk failure protection	Very fast rebuilds, no spare disks (built-in spare capacity), large storage pools, simplified initial deployment and expansion	Requires minimum of 12 disks

Table 7 Number of disks per RAID level to optimize virtual disk group performance

RAID level	Number of disks (data and parity)
1	2 total (no parity)
5	3 total (2 data disks, 1 parity disk); 5 total (4 data disks, 1 parity disk); 9 total (8 data disks, 1 parity disk)
6	4 total (2 data disks, 2 parity disks); 6 total (4 data disks, 2 parity disks); 10 total (8 data disks, 2 parity disks)
10	4–16 total
MSA-DP+	12–128 total

MSA-DP+

MSA-DP+ is a RAID-based data protection level that:

- Maximizes flexibility
- Provides built-in spare capacity
- Optimizes performance
- Allows for very fast rebuilds, large storage pools, and simplified expansion

If a disk fails in an MSA-DP+ disk group, and the failed disk is replaced with a new disk in the same slot, the replacement disk will be added to the disk group automatically. All disks in an MSA-DP+ disk group must be the same type (enterprise SAS, for example), but can have different capacities, provided the range of difference does not exceed a factor of two. For example, mixing a 600GB disk and a 1.2TB disk is acceptable; but mixing a 6TB disk and a 16TB disk could prove problematic. It is conceivable that a sizeable difference between mixed disk capacities (ratio greater than two) could prevent consuming space on disks due to insufficient distributed space required to support striping.

NOTE HPE recommends not mixing disks if the ratio of the largest disk to the smallest disk is greater than two.

All disks in an MSA-DP+ disk group are used to hold user data, but not all disks will be used by each page of data. To increase fault tolerance, any available capacity on disks can be allocated as spare for reconstruction purposes. When new data is added, new disks are added, or the system recognizes that data is not distributed across disks in a balanced way, the system moves the data to maintain balance across the disk group.

Spare drives are not used by MSA-DP+ disk groups since *the RAID design provides* built-in spare capacity that is spread across all disks in the disk group. In the case of a disk failure, data will be redistributed to many disks in the disk group, allowing for quick rebuilds and minimal disruption to I/O.

The system will automatically default to a target spare capacity that is the sum of the largest two disks in the MSA-DP+ disk group, which is large enough to fully recover fault tolerance after loss of any two disks in the disk group. The actual spare capacity value can change depending on the current available spare capacity in the disk group. Spare capacity is determined by the system as disks are added to a disk group, or when disk groups are created, expanded, or rebalanced.

NOTE If a disk fails in an MSA-DP+ disk group and is replaced by a new disk in the same slot as the failed disk, the disk group automatically incorporates the replacement disk into the disk group.

NOTE For information about manually setting spare size, see the `add disk-group` command in the *HPE MSA 1060/2060/2062 CLI Reference Guide*. The `spare-capacity` parameter enables setting of the target spare capacity for an MSA-DP+ disk group.

MSA-DP+ disk groups can be expanded to either replenish current target spare capacity or to increase usable capacity. You can expand an MSA-DP+ disk group from the Maintenance > Storage panel.

Disk group utilities

This section provides information about disk group utilities.

Disk-group expansion

Virtual disk-group expansion is only available with the MSA-DP+ protection level. An MSA-DP+ virtual disk group can consist of 12–128 disks of the same type. Host I/O to the disk group can continue while the expansion proceeds. This task cannot be performed on a non-MSA-DP+ virtual disk group.

When expanding a disk group, all disks in the group must be the same type (enterprise SAS, for example). Disk groups support a mix of 512n and 512e disks. However, for best performance, all disks should use the same sector format. For more information about disk groups, see ["Disk groups" on page 16](#).

NOTE To expand a virtual pool, add a disk group as described in ["Disk groups" on page 16](#), or expand an MSA-DP+ virtual disk group.

MSA-DP+ disk groups are expanded when disks are added to the group. The controller determines how the additional disks are used, either to replenish spare capacity to equal target capacity, to increase usable capacity, or both.

For MSA-DP+ disk groups, expansion is very fast. The controller invokes rebalance to redistribute spare capacity evenly across all disk members of the group to allow uniformly distributed usable capacity. Due to the possible need to rebalance, and to maintain fault tolerance and target spare capacity, any new usable capacity may not be immediately available. Monitor the Activity panel for progress on these activities, and check for updated usable capacity when the activities are complete. When set to the default spare capacity, the system will try to replenish spare capacity to be the sum of the largest two disks in the group.

In the Maintenance > Storage panel, locate the MSA-DP+ disk group to expand, access its slide-over panel, click **Expand Disk Group**, and follow the on-screen directions.

Disk-group verify

If you suspect parity or mirror mismatches with a fault-tolerant disk group, check its integrity using the disk-group verify utility. For example, if you have not recently checked the system for parity inconsistencies—and are concerned about disk health—verify disk groups.

The disk-group verify utility analyzes redundant disk groups to find and fix inconsistencies between redundancy data and user data. It acts on all disks in the disk group, but not leftover disks. This task can be performed only on a disk group whose status is FTOL (fault tolerant). It cannot be performed on a read-cache disk group.

The disk-group verify utility will:

- Find and optionally fix parity mismatches for protection levels 5, 6, and MSA-DP+
- Find, but not fix, mirror mismatches for protection levels 1 and 10

Verification can last over an hour, depending on disk-group size, utility priority, and the amount of I/O activity. You can use a disk group while it is being verified.


When verification is completed, event 21 is logged. It specifies the number of inconsistencies found. If verification fails to complete, a Warning is issued. Follow recommended Error or Warning conditions described for event 21 in the *HPE MSA 1060/2060/2062 Event Descriptions Reference Guide*.

While verification is running you can see its progress and cancel, if necessary.

To run the verify utility, see ["Verifying a disk group" on page 87](#).

Disk-group scrub

The disk-group scrub utility analyzes specified disk groups to find and fix errors.

 **TIP** The disk-group scrub utility operates similarly to disk-group verify, and can find media errors for any protection level and for a read cache disk group. By default, the utility is enabled to run periodically.

The disk-group scrub utility acts on all disks in the disk group, but not leftover disks.

The disk-group scrub utility will:

- Check redundancy data (parity) and correct it for protection levels 5, 6, and MSA-DP+
- Find, but not fix, mirror mismatches for protection levels 1 and 10

The system reads both copies of mirror data to find any mismatches.

- Find and fix media errors for all redundant protection levels

Media errors occur when the system cannot read one of the copies of mirror data, due to a disk error such as an Unrecoverable Read Error (URE). (RAID-1 and RAID-10).

Verify that all blocks are readable (NRAID and RAID-0).

Scrub can last well over an hour, depending on disk-group size, utility priority, and the amount of I/O activity. You can use a disk group while it is being scrubbed. While scrub is running, you can monitor progress and cancel if necessary. When scrub is complete, event 207 is logged. Follow recommended Error or Warning conditions described for event 207 in the Event Descriptions Reference Guide.

To run the scrub utility, see ["Scrubbing a disk group" on page 87](#).

SSDs

The use of solid-state drives (SSDs) may greatly enhance the performance of a system. Since the SSDs do not have moving parts, data that is random in nature can be accessed much faster. You can use SSDs for virtual disk groups in a system that contains only SSDs without an Advanced Data Services license, or in a system that uses SSDs in combination with spinning disks with an Advanced Data Services license. When combined with virtual disk groups that consist of other classes of disks, improved read and write performance is possible through automated tiered storage. Alternatively, you can use one or two SSDs in read-cache disk groups to increase read performance for pools without an Advanced Data Services license. The application workload of a system determines the percentage of SSDs of the total disk capacity that is needed for best performance.

The rules for using SSDs and spinning disks are:

- If the first disk group is provisioned with SSDs and the system does not have the Advanced Data Services license installed, then the system will expect to be provisioned as an all-flash array and allow only SSDs to be used in all other disk groups.
- If the first disk group is provisioned with spinning disks and does not have a Advanced Data Services license installed, then the system can only be provisioned to use spinning disks in virtual disk groups and use SSDs as read cache.
- If the first disk group is provisioned with spinning disks or SSDs and has a Advanced Data Services license installed, then the system can be provisioned to use spinning disks in virtual disk groups and use SSDs either in virtual disk groups or as read cache.

For more information, see:

- ["Read-cache disk groups" on page 28](#)
- ["Gauging the percentage of life remaining for SSDs" below](#)
- ["All-flash array" on the facing page](#)
- ["SSD management" on the facing page](#)
- ["SSD read cache" on the facing page](#)

Gauging the percentage of life remaining for SSDs

An SSD can be written and erased a limited number of times. Through the SSD Life Left disk property, you can gauge the percentage of disk life remaining. This value is polled every 5 minutes. When the value decreases to 20%, an event is logged with Informational severity. This event is logged again with Warning severity when the value decreases to 5%, 2% or 1%, and 0%. If a disk crosses more than one percentage threshold during a polling period, only the lowest

percentage will be reported. When the value decreases to 0%, the integrity of the data is not guaranteed. To prevent data integrity issues, replace the SSD when the value decreases to 5% of life remaining.

Under Maintenance > Hardware within the SMU, select the SSD. See the SSD Life Left label under Disk Information to view the percentage of SSD life remaining. To view the percentage of SSD life remaining using the CLI, enter the `show disks` CLI command with the `detail` parameter as described in the CLI Reference Guide.

All-flash array

An all-flash array enables systems to run exclusively with virtual disk groups that consist of only SSDs; they have one tier that consists solely of SSDs and do not require an Advanced Data Services license. If a system includes disk groups with spinning disks, those disk groups must be removed before the system can be used as an all-flash array. Once the system is established as an all-flash array, only disk groups containing SSDs can be added to the system.

If you are using SSDs and spinning disks and the first disk group is provisioned with spinning disks, then the system will not be treated as an all-flash array. For information about the rules for using SSDs and spinning disks, see ["SSDs" on the previous page](#).

SSD management

SSDs use multiple algorithms to manage SSD endurance features. This includes overprovisioning to minimize write amplification. SSDs use data retention algorithms to monitor and mitigate cell level decay.

Overprovisioning

The write amplification factor of an SSD is defined as the ratio of the amount of data actually written by the SSD to the amount of host/user data requested to be written. Data written in sequential LBAs aligned on 4KB boundaries results in the best write amplification factor. The worst write amplification factor typically occurs for randomly written LBAs of transfer sizes less than 4KB, originating on LBAs not on 4KB boundaries. Try to align your data on 4KB boundaries.

Drive writes per day (DWPD)

Disk vendors rate SSD endurance by how many writes can occur over the lifetime of an SSD. As lower-cost SSDs that support fewer drive writes per day become available, the cost/benefit analysis regarding which SSDs to use is highly dependent on your applications and I/O workload, together with the ratio of SSDs to conventional drives. For example, a ratio of 10% SSDs to 90% conventional drives—when combined with the storage system tiering algorithm—can yield dramatic performance improvements.

Since the storage system tiering algorithm automatically moves “hot” data to SSDs and less-used “cool” data to conventional disks, applications and environments that require mission-critical movement of frequently accessed “hot” data might dictate a higher ratio of SSDs to conventional disks.

Because data is characterized every five seconds and moved to the appropriate storage device, no fixed rule is used to determine which SSDs are used. For this reason, using SSDs with the same DWPD values is advised.

SSD read cache

Unlike tiering, where a single copy of specific blocks of data resides in either spinning disks or SSDs, the read cache feature uses one SSD read cache disk group per pool as a read cache for “hot” pages only. Each read cache disk group consists of one or two SSDs with a maximum usable capacity of 4TB. A separate copy of the data is also kept in spinning disks. All-flash arrays do not allow the creation of a read-cache disk group. Read cache contents are lost when a controller restart or failover occurs. This does not cause data loss or corruption, as the read cache only duplicates the content that exists in the fault-tolerant disk groups. Taken together, these attributes have several advantages:

- The performance cost of moving data to read-cache is lower than a full migration of data from a lower tier to a higher tier.
- Read cache is not fault tolerant, potentially lowering system cost.
- Controller read cache is effectively extended by two orders of magnitude, or more.

- When a read-cache group consists of one SSD, it automatically uses RAID. When a read-cache group consists of two SSDs, it automatically uses RAID 0.

NOTE For more information about SSDs, see ["SSDs" on page 22](#).

Spares

Spare disks are unused disks in your system that automatically replace a failed disk, restoring fault tolerance to disk groups in the system. Designate spares from the Maintenance > Storage panel. Types of spares include:

- Global spare. Reserved for use by any fault-tolerant disk group to replace a failed disk.
- Dynamic spare. Available compatible disk that is automatically assigned to replace a failed disk in a fault-tolerant disk group. This option is enabled by default.

NOTE MSA-DP+ disk groups do not use global spares or dynamic spares. For information on how MSA-DP+ disk groups manage sparing, see ["MSA-DP+" on page 20](#).

A controller automatically reconstructs a fault-tolerant disk group (RAID 1, 5, 6, 10) when one or more of its disks fails and a compatible spare disk is available. A disk is compatible if it has enough capacity to replace the failed disk and is the same type (Enterprise SAS, for example). It is not advisable to mix 10k and 15k disks in a single disk group. If the disks in the system are FDE-capable and the system is secure, spares must also be FDE-capable.

NOTE Sufficient disks must remain in the disk group so that reconstruction is possible.

When a disk fails, the system looks for a global spare. If it does not find a compatible global spare and the dynamic spares option is enabled, it takes any available compatible disk. If no compatible disk is available, reconstruction cannot start.

In the SMU you can designate a maximum of 64 global spares. If a disk in any fault-tolerant disk group fails, a global spare (which must be the same size or larger and the same type as the failed disk) is automatically used to reconstruct the disk group (RAID 1, 5, 6, 10). At least one disk group must exist before you can add a global spare. A spare must have sufficient capacity to replace the smallest disk in an existing disk group.

The disk group will remain in critical status until the data, parity, or mirror data is completely written to the spare, at which time the disk group will return to fault-tolerant status.

Disk groups support a mix of 512n, and 512e disks. However, for consistent and predictable performance, do not mix disks of different rotational speed or sector size types (512n, 512e). If a global spare has a different sector format than the disks in a disk group, an event will appear when the system chooses the spare after a disk in the disk group fails. For more information about disk groups, see ["Disk groups" on page 16](#).

Pools

A *pool* is an aggregation of one or more disk groups that serves as a container for volumes. A *disk group* is a group of disks of the same type, using a specific RAID level. For virtual pools, when volumes are added to a pool the data is distributed across the pool's disk groups.

If the owning controller fails, the partner controller assumes temporary ownership of the pool and resources owned by the failed controller. If a fault-tolerant cabling configuration, with appropriate mapping, is used to connect the controllers to hosts, LUNs for both controllers are accessible through the partner controller so I/O to volumes can continue without interruption.

You can configure disks into disk groups. For information about how provisioning disks works, see ["Adding a disk group to a pool" on page 86](#).

Virtual pools and disk groups

The volumes within a virtual pool are allocated virtually (separated into fixed size pages, with each page allocated according to the algorithm within the tiers and disk groups in the pool) and thinly (meaning that they initially exist as an entity but don't have any physical storage allocated to them). They are also allocated on-demand (as data is written to a page, it is allocated).

NOTE The physical capacity limit for a virtual pool is 1 PiB.

You can remove one or more disk groups, but not all, from a virtual pool without losing data as long as there is enough space available in the remaining disk groups to move the data into. When the last disk group is removed, the pool ceases to exist, and will be deleted from the system automatically. Alternatively, the entire pool can be deleted, which automatically deletes all volumes and disk groups residing on that pool. Deleting a pool that contains data will cause permanent data loss.

If a system has two SSDs, each virtual pool can also have a read-cache disk group. Unlike the other disk group types, read-cache disk groups are used internally by the system to improve read performance and do not increase the available capacity of the pool. See ["Read-cache disk groups" on page 28](#) for more information.

Resolving a pool conflict caused by inserting a foreign disk group


If you insert a virtual disk group, a disk that contains a virtual disk group, or a disk that was actively part of a virtual disk group from one system into another system, the latter system will attempt to create a virtual pool for that disk group. If that system already has a virtual pool with the same name, the pool for the inserted disk group will be offline. For example, if `NewSystem` has pool A and you insert a disk group that came from `OldSystem`'s pool A, the disk group imported from `OldSystem`'s pool A will be offline.

NOTE You cannot access the two sets of pool A data (`OldSystem` and `NewSystem`) concurrently on a single storage system.

! **IMPORTANT** If you are unable to find a pool with a duplicate name, or are unsure of how to safely proceed, please download logs from the system and contact technical support for assistance with offline disk groups.

Changing pool settings

Each virtual pool has three thresholds for page allocation as a percentage of pool capacity. You can set the low and middle thresholds. The high threshold is automatically calculated based on the available capacity of the pool minus 200 GB of reserved space.

You can view and change settings that govern the operation of each virtual pool from the pools panel (Maintenance > Storage): To see information about disk groups in a pool, expand the row. To change pool settings, click the  icon in the pool row. Options include:

- **Low Threshold.** When this percentage of virtual pool capacity has been used, the system will generate an alert and informational event 462 to notify the administrator. This value must be less than the Middle Threshold value. The default is 50%.
- **Middle Threshold.** When this percentage of virtual pool capacity has been used, the system will generate an alert and event 462 to notify the administrator to add capacity to the pool. This value must be between the Low

Threshold and High Threshold values. The default is 75%. If the pool is not overcommitted, the alert will have Informational severity. If the pool is overcommitted, the alert will have Warning severity.

- High Threshold. When this percentage of virtual pool capacity has been used, the system will generate an alert and event 462 to alert the administrator to add capacity to the pool. This value is automatically calculated based on the available capacity of the pool minus 200 GB of reserved space. If the pool is not overcommitted, the alert will have Informational severity. If the pool is overcommitted, the alert will have Warning severity and the system will use write-through cache mode until virtual pool usage drops back below this threshold.
- Pool Overcommit. This check box controls whether overcommitting is enabled, and whether storage-pool capacity may exceed the physical capacity of disks in the system. For information about overcommitting, see ["Overcommitting volumes" on page 28](#). This option is enabled by default.

NOTE For more information about events, see the Event History panel (Maintenance > Support > Event history) or refer to the Event Descriptions Reference Guide.

NOTE If your system has a replication set, the pool might be unexpectedly overcommitted because of the size of the internal snapshots of the replication set.

NOTE If the pool is overcommitted and has exceeded its high threshold, its health will show as degraded in the Storage panel (Maintenance > Storage). If you try to disable overcommitment and the total space allocated to thin-provisioned volumes exceeds the physical capacity of their pool, an error will state that there is insufficient free disk space to complete the operation and overcommitment will remain enabled.

To check if the pool is overcommitted, go to Maintenance > Storage, then expand the pool row. If the Pool Overcommitted value is True, the pool is overcommitted. If the value is False, the pool is not overcommitted.

Volumes

A volume is a logical subdivision of a virtual pool and can be attached to hosts. An attached volume provides addressable storage to a host (for example, a file system partition you create with your operating system or third-party tools). For more information about attaching volumes to hosts, see ["Attaching volumes to hosts" on page 31](#).

For virtual pools, when volumes are added to a pool the data is distributed across the pool's disk groups.

Virtual volumes make use of a method of storing data in virtualized pages. These pages may be spread throughout the underlying physical storage and allocated on-demand. Virtualized storage therefore has a dynamic mapping between logical and physical blocks.


A maximum of 1024 virtual volumes can exist per system.

Volume cache options

You can set options that optimize reads and writes performed for each volume. It is recommended that you use the default settings. For more information, see the following topics:

- ["Using write-back or write-through caching" on the facing page](#)
- ["Cache optimization mode" on the facing page](#)
- ["Optimizing read-ahead caching " on the facing page](#)
- ["Read-cache disk groups" on page 28](#)

Using write-back or write-through caching


 **CAUTION** Only disable write-back caching if you fully understand how the host operating system, application, and adapter move data. If used incorrectly, you might hinder system performance.

Write-back is a cache-writing strategy in which the controller receives the data to be written to disks, stores it in the memory buffer, and immediately sends the host operating system a signal that the write operation is complete, without waiting until the data is actually written to the disk. Write-back cache is saved to non-volatile storage in the event of a power loss. Write-back cache mirrors all of the data from one controller module cache to the other in the event of a controller fault, and the remaining controller completes the write operation to the disks. When modifying a volume you can change its write-back cache setting. Write-back cache improves the performance of write operations and the throughput of the controller.


When write-back cache is disabled, write-through becomes the cache-writing strategy. Using write-through cache, the controller writes the data to the disks before signaling the host operating system that the process is complete. Write-through cache has lower write throughput performance than write-back, but it is the safer strategy, with minimum risk of data loss on power failure. However, write-through cache does not mirror the write data because the data is written to the disk before posting command completion and mirroring is not required. You can set conditions that cause the controller to change from write-back caching to write-through caching. For more information, see "[Setting system cache properties](#)" on page 80.

In both caching strategies, active-active failover of the controllers is enabled.

You can enable and disable the write-back cache for each volume. By default, volume write-back cache is enabled. Because controller cache is backed by supercapacitor technology, if the system loses power, data is not lost. For most applications, this is the preferred setting.

 **TIP** The best practice for a fault-tolerant configuration is to use write-back caching.


Cache optimization mode

 **CAUTION** Changing the cache optimization setting while I/O is active can cause data integrity issues or data loss. Before changing this setting, quiesce I/O from all initiators.

You can change the cache optimization mode to one of the following modes of operation:

- **Standard.** In this mode of operation, the controller sets volume cache parameters to address both sequential I/O and random I/O tasks. This optimization is the choice for most workloads. In this mode, the cache is kept coherent with the partner controller. This mode provides high performance and high redundancy, and it is the default.
- **No-mirror.** In this mode of operation, the controller cache performs the same as the standard mode with the exception that the cache metadata is not mirrored to the partner. While this improves the response time of write I/O, it comes at the cost of redundancy. If this option is used, the user can expect higher write performance but is exposed to data loss if a controller fails.
- **Cache-Hit.** This controller cache mode of operation is optimized for workloads that are localized, that is, a substantial percentage of all accesses are hits in the controller's cache. In this mode, the cache is kept coherent with the partner controller.

Optimizing read-ahead caching

 **CAUTION** Only change read-ahead cache settings if you fully understand how the host operating system, application, and adapter move data so that you can adjust the settings accordingly.

You can optimize a volume for sequential reads or streaming data by changing its read-ahead cache settings.

You can change the amount of data read in advance. Increasing the read-ahead cache size can greatly improve performance for multiple sequential read streams:

- The **Adaptive** option works well for most applications: it enables adaptive read-ahead, which allows the controller to dynamically calculate the optimum read-ahead size for the current workload. This is the default.
- The **Stripe** option sets the read-ahead size to one stripe. The controllers treat RAID-1 disk groups internally as if they have a stripe size of 512 KB, even though they are not striped.
- Specific size options let you select an amount of data for all accesses. Options include 512 KB, 1 MB, 2 MB, 4 MB, 8 MB, 16 MB, 32 MB.
- The **Disabled** option turns off read-ahead cache. This is useful if the host is triggering read ahead for what are random accesses. This can happen if the host breaks up the random I/O into two smaller reads, triggering read ahead.

Read-cache disk groups

A read-cache disk group is a special type of a virtual disk group that is used to cache virtual pages to improve read performance. Only a single read-cache disk group may exist within a pool. Read cache does not add to the overall capacity of the pool to which it has been added. You can add or remove it from the pool without any adverse effect on the volumes and their data for the pool, other than to impact the read-access performance.

You can create a read-cache disk group for a virtual pool if the system includes available SSDs and the pool does not contain a virtual disk group comprised of SSDs (known as a Performance tier). A virtual pool cannot contain both read cache and a Performance tier.

To increase the size of read cache within a pool, you must remove the read-cache disk group and then re-add a larger read-cache disk group. It is possible to have a read-cache disk group that consists of one or two disks. For more information on read cache, see ["SSD read cache" on page 23](#).

Overcommitting volumes

Overcommitting is a virtual storage feature that allows a system administrator to overcommit physical storage resources. This allows the host system to operate as though it has more storage available than is actually allocated to it. When physical resources fill up, the administrator can add physical storage by adding additional disk groups or expanding an MSA-DP+ disk group.

Automated tiered storage

Automated tiered storage is a virtual storage feature that automatically moves data residing in one class of disks to a more appropriate class of disks based on data access patterns, with no manual configuration necessary. Automated tiered storage operates as follows:

- Frequently accessed, “hot” data can move to disks with higher performance.
- Infrequently accessed, “cool” data can move to disks with lower performance and lower costs.
- Each virtual disk group, depending on the type of disks it uses, is automatically assigned to one of the following tiers:
 - Performance—This highest tier uses SSDs, which provide the best performance but also the highest cost. For more information on SSDs, see ["SSDs" on page 22](#).
 - Standard—This middle tier uses enterprise-class spinning SAS disks, which provide good performance with mid-level cost and capacity.
 - Archive—This lowest tier uses midline spinning SAS disks, which provide the lowest performance with the lowest cost and highest capacity.

When the status of a disk group in the Performance tier becomes `CRIT` (critical), the system will automatically drain data from that disk group to disk groups using spinning disks in other tiers, provided those disk groups can contain the

data from the degraded disk group. This occurs because similar wear across the SSDs is likely, so more failures may be imminent.

NOTE If the system uses only SSDs, data is moved to another fault tolerant SSD tier that has free capacity.

Automated tiered storage rebalancing happens when adding or removing a disk group in a system.

Volume tier affinity

The volume tier affinity feature enables tuning the tier-migration algorithm for a virtual volume when creating or modifying the volume so that the volume data automatically moves to a specific tier, if possible. If space is not available in a volume's preferred tier, another tier will be used. There are three volume tier affinity settings:

- **No Affinity**—This setting uses the highest performing tiers available first and only uses the Archive tier when space is exhausted in the other tiers. Volume data will swap into higher performing tiers based on frequency of access and tier space availability. This is the default.
- **Archive**—This setting prioritizes the volume data to the lowest performing tier available. Volume data can move to higher performing tiers based on frequency of access and available space in the tiers.
- **Performance**—This setting prioritizes volume data to the higher performing tiers. If no space is available, lower performing tier space is used. Performance affinity volume data will swap into higher tiers based upon frequency of access or when space is made available.

Initiators, hosts, and host groups

An initiator represents an external port to which the storage system is connected. The external port may be a port in an I/O adapter (such as an FC HBA) in a server.

For ease of management, you can group from 1 to 128 initiators that represent a server into a host. A host is a user-defined object that represents a server to which the storage system is attached, and is used to define a mapping relationship to storage.

Further, you can group 1–128 hosts into a host group. A host group is a user-defined set of hosts. Doing so enables you to attach all grouped initiators in a host, or all initiators and hosts in a group, instead of for each initiator or host individually.

The controllers automatically discover initiators that have sent a SCSI `INQUIRY` command or `REPORT LUNS` command to the storage system, which typically happens when a host boots up or rescans for devices. When the command is received, the system saves the initiator ID. You can also manually create entries for initiators as described in the CLI Reference Guide by setting a nickname to a specified unique ID. For example, you might want to define an initiator before a controller port is physically connected through a switch to a server.

In the SMU, you must assign a nickname to an initiator in order for it to be added to a host. An initiator can be a member of only one host. A host can be a member of only one group. A host cannot have the same name as another host, but can have the same name as any initiator. A host group cannot have the same name as another host group, but can have the same name as any host. A maximum of 32 host groups can exist. Once you have created a host, you can edit the profile specific to the operating system for that initiator.

CHAP


A storage system with iSCSI ports can be protected from unauthorized access via iSCSI by enabling Challenge Handshake Authentication Protocol (CHAP). CHAP authentication occurs during an attempt by a host to log in to the system. This authentication requires an identifier for the host and a shared secret between the host and the system. Optionally, the storage system can also be required to authenticate itself to the host. This is called mutual CHAP. You are prompted to optionally configure CHAP settings during the onboarding process. Once onboarding is complete, you

can enable or disable CHAP and create new CHAP records from the Settings > iSCSI panel. Steps involved to enable CHAP include:

- Decide on host node names (identifiers) and secrets. The host node name is its IQN. A secret must have 12–16 characters, and include spaces and printable UTF-8 characters except: " <

This authentication requires an identifier for the host and a shared secret between the host and the system. The CHAP secret is a text string that is known to both the initiator and the storage array before they negotiate a communication link. Mutual CHAP authenticates the target to the initiator. Without Mutual CHAP, only the initiator is authenticated to the target.

- Define CHAP records in the storage system.
- Enable CHAP on the storage system (during onboarding or from the Settings > iSCSI > Configuration panel). Note that this applies to all iSCSI hosts, in order to avoid security exposures. Any current host connections will be terminated when CHAP is enabled and will need to be re-established using a CHAP login.
- Define a CHAP record for the host iSCSI initiator on the host.
- Establish a new connection to the storage system using CHAP. The host should be displayable by the storage system, as well as the ports through which connections were made.

 **CAUTION** Changing iSCSI configuration settings after onboarding can invalidate CHAP settings. This could disrupt connectivity between the host and the storage system.


If it becomes necessary to add more hosts after CHAP is enabled, additional CHAP node names and secrets can be added. If a host attempts to log in to the storage system, it will become visible to the system, even if the full login is not successful due to incompatible CHAP definitions. This information may be useful in configuring CHAP entries for new hosts, and becomes visible when an iSCSI discovery session is established because the storage system does not require discovery sessions to be authenticated. CHAP authentication must succeed for normal sessions to access LUNs from the storage array.

To use CHAP between peers in a replication set, see "[CHAP and replication](#)" on page 47.

Host ports

MSA 1060/2060/2062 controller enclosures support FC, iSCSI, and SAS host interface protocols. FC and SAS controller host-port settings are not configurable in the SMU.

iSCSI controller host-port settings should be configured, preferably, during onboarding, in order to enable the system to communicate with iSCSI hosts. This process includes choosing the system's iSCSI network configuration type (either IPv4 or IPv6), entering the IP address of at least one host port on each controller, and providing the netmask and gateway for assigned port IP addresses. When initial iSCSI configuration is complete, you can view and change host port settings.

 **CAUTION** Changing host port settings while initiators are in use can disrupt host to LUN connections.

Interrelated information about host ports is available from the following sources:

- "[Configuring iSCSI host port settings](#)" on page 82.
- For information about setting host parameters, see the CLI Reference Guide.
- For information about host interface protocols, see the Installation Guide.
- For information about supported host port configurations for MSA 1060, see <https://www.hpe.com/support/MSA1060QuickSpecs>.
- For information about supported host port configurations for MSA 2060, see <https://www.hpe.com/support/MSA2060QuickSpecs>.

- For information about supported host port configurations for MSA 2062, see <https://www.hpe.com/support/MSA2062QuickSpecs>.

Attaching volumes to hosts

A volume must be attached to one or more hosts (or host groups) to enable them to access the volume.

You can attach a volume to hosts as part of creating the volume, or afterward. When attaching a volume you can choose whether to create new hosts, or to use existing hosts. For information about creating hosts, see "[Attaching volumes to hosts](#)" on page 63.


When an attachment is created, the system automatically assigns a unique LUN to the volume, sets default permission access to read-write, and sets port access to all ports. After an attachment is created, you can change the LUN, port access, and access permissions. Both controllers share a set of LUNs, and any available LUN can be assigned to a volume.


The storage system uses Unified LUN Presentation (ULP), which can expose all LUNs through all host ports on both controllers. The interconnect information is managed by the controller firmware. ULP appears to the host as an active-active storage system where the host can choose any available path to access a LUN regardless of which controller owns the storage pool the volume resides on. With ULP, the controllers' operating/redundancy mode is shown as Active-Active ULP. ULP uses the T10 Technical Committee of INCITS Asymmetric Logical Unit Access (ALUA) extensions, in SPC-3, to negotiate paths with aware host systems. Unaware host systems see all paths as being equal.

NOTE LUN 0 is not used for SAS hosts.

The system also sets properties that specify whether the volume is attached to at least one host, whether the host was discovered, and whether the volume is accessible through redundant paths (through host ports in each controller module).

NOTE A replication set's secondary volume cannot be attached to hosts. To enable such access, create a snapshot of the secondary volume and attach the snapshot to the host.

 **IMPORTANT** To avoid multiple hosts mounting the volume and causing data integrity issues, the host computer systems must be cooperatively managed, such as by using cluster software. If multiple hosts mount a volume without being cooperatively managed, volume data is at risk for data integrity failures.

 **CAUTION** Volume attachment changes take effect immediately. Make changes to volumes when the volumes are not in use. Before changing a LUN, be sure to unmount the volume.

You can perform the following attachment actions:

- View information about hosts attached to a volume (Provisioning > Volumes)
- Attach volumes to hosts or host groups (Provisioning > Volumes > Attach to Hosts)
- Detach volumes from hosts or host groups (Provisioning > Volumes > Detach from Hosts)
- View information about volumes attached to a host (Provisioning > Hosts)
- Attach hosts to volumes (Provisioning > Hosts > Attach to Volumes)
- Detach hosts from volumes (Provisioning > Hosts > Detach from Volumes)

Snapshots

The system can create snapshots of volumes. Snapshots provide data protection by enabling you to create and save source volume data states at the point in time when the snapshot was created. Snapshots can be created manually or you can schedule snapshot creation. After a snapshot has been created, the source volume can be expanded, but the snapshot volume cannot be expanded.

A base of 64 snapshots is included with your system without an additional license. With a license, you can create up to the maximum number of snapshots for your product. To view the maximum number of snapshots for your system, see ["System configuration limits" on page 134](#).

When you reach the maximum base number of snapshots for your system, before you can create a new snapshot, you must either purchase or install a license that increases the maximum number of snapshots or delete an existing snapshot.

The system treats a snapshot like any other volume.

- Snapshots attach to hosts with read-write access by default. You can then change permissions to read-only access or no access, depending on the purpose of the snapshot.
- Snapshots use the rollback feature, which replaces the data of a source volume or snapshot with the data of a snapshot that was created from it.
- Snapshots use the reset snapshot feature, which enables you to replace the data in a snapshot with the current data in the source volume. When you reset a snapshot, the snapshot name and attachments are not changed.

The `set snapshot-space` CLI command enables you to set the percent of the pool that can be used for snapshots (the snapshot space). Optionally, you can specify a limit policy to enact when the snapshot space reaches the percentage. You can set the policy to either notify you via events that the percentage has been reached (in which case the system continues to take snapshots, using the general pool space), or to notify you and trigger automatic deletion of snapshots. If automatic deletion is triggered, snapshots are deleted according to their configured retention priority. For more information, see the CLI documentation.

Creating snapshots is a fast and efficient process that merely consists of pointing to the same data to which the source volume or snapshot points. (A snapshot takes up no space unless it is directly modified, or the source volume or source snapshot to which the snapshot refers to is modified.) Space does not have to be reserved for snapshots because all space in the pool is available for them, based upon the limit policy that is set. It is easy to take snapshots of snapshots and use them in the same way that you would use any volume. Since snapshots have the same structure as volumes, the system treats them the same way.

For more information, see:

- ["Snapshot trees" below](#)
- ["Rollback and reset snapshot features" on the facing page](#)

Snapshot trees

Because a snapshot can be the source of other snapshots, a single volume can be the progenitor of many levels of snapshots. Originating from an original base volume, the levels of snapshots create a snapshot tree that can include up to 254 snapshots, each of which can also be thought of as a leaf of the tree. When snapshots in the tree are the source of additional snapshots, they create a new branch of the snapshot tree and are considered the parent snapshot of the child snapshots, which are the leaves of the branch.


The tree can contain snapshots that are identical to the volume or have content that has been later modified. Once the 254-snapshot limit has been reached, you cannot create additional snapshots of any item in the tree until you manually delete snapshots from the tree. You can only delete snapshots that do not have any child snapshots.

You can expand the base volume of a snapshot tree, but you cannot expand any snapshots in the tree.

Rollback and reset snapshot features

With the rollback feature, if the contents of the selected snapshot have changed since it was created, the modified contents will overwrite those of the source volume or snapshot during a rollback. Since snapshots are copies of a point in time, a modified snapshot cannot be reverted. If you want a snapshot to provide the capability to “revert” the contents of the source volume or snapshot to when the snapshot was created, create a snapshot for this purpose and archive it so you do not change the contents. For more information, see ["Rolling back volumes" on page 64](#).

As an alternative to taking a new snapshot of a volume, you can replace the data in a standard snapshot with the current data in the source volume. The snapshot name and host attachments are not changed. For snapshots, the reset snapshot feature is supported for all snapshots in a tree hierarchy. However, a snapshot can only be reset to the immediate parent volume or snapshot from which it was created.

 **CAUTION** To avoid data integrity issues, detach a snapshot from hosts before resetting the snapshot.

You can either reset a snapshot immediately, or schedule the reset. For more information, see ["Resetting snapshots" on page 64](#).

Copying volumes or snapshots

The volume copy feature (Provisioning > Volumes > volume slide-over > Copy Volume) enables you to copy a base volume or snapshot to a new volume. It creates a complete “physical” copy of a base volume or snapshot within a storage system. The copy is an exact duplicate of the source as it existed at the time the copy operation was initiated, consumes the same amount of space as the source, and is independent from an I/O perspective. In contrast, the snapshot feature creates a point-in-time “logical” copy of a volume, which remains dependent on the source volume.

The volume copy feature provides the following benefits:

- **Additional data protection:** An independent copy of a volume provides additional data protection against a complete source volume failure. If the source volume fails, the copy can be used to restore the volume to the point in time when the copy was created.
- **Non-disruptive use of production data:** With a mounted independent copy of the volume, resource contention and the potential performance impact on production volumes is mitigated. Data blocks between the source and the copied volumes are independent (versus shared with snapshots) so that I/O is to each set of blocks respectively. Application I/O transactions are not competing with each other when accessing the same data blocks.

The copy operation is performed directly from the source. This source data may change if modified data is to be included in the copy and there are snapshots attached and in use.

You must detach the volume before copying it. It is highly recommended to unmount it on the host first, so that the host can flush its cache, before detaching it.

The volume will not be available for read or write access until the copy is complete, at which time you can reattach the volume.

Reconstruction

If one or more disks fail in a disk group, adequate drives remain in the disk group for data integrity, and sufficient spare capacity is available, the storage system automatically uses the spare capacity to reconstruct the disk group. Disk group reconstruction does not require I/O to be stopped, so volumes can continue to be used while reconstruction is in progress.

If sufficient spare capacity is not available, reconstruction does not start automatically.

- For MSA-DP+, see the MSA-DP+ see "[MSA-DP+ reconstruction](#)" below.
- For RAID levels other than MSA-DP+, to start reconstruction manually, replace each failed disk with a compatible disk. If the dynamic spares feature is not enabled, designate each replacement disk as a spare. If the dynamic spares feature is enabled, the storage system rescans the bus, finds the new disk, automatically designates it a spare, and starts reconstructing the disk group (as described in "[Spares](#)" on page 24).

For virtual storage, reconstruction of all disk groups uses a quick-rebuild feature. For information about quick rebuild, see "[Quick rebuild](#)" on the facing page.

For descriptions of LED states, such as for disk failure and reconstruction, see the *HPE MSA 1060/2060/2062 Installation Guide*.

NOTE Reconstruction can take hours or days to complete, depending on the disk group RAID level and size, disk speed, host I/O activity, and other processes running on the storage system.

At any time after disk failure, you can remove the failed disk and replace it with a new disk of the same type in the same slot.

MSA-DP+ reconstruction

Reconstruction of an MSA-DP+ disk group is similar to reconstruction of a RAID-6 disk group, and can be impacted by host I/O activity and other processes running on the storage system. MSA-DP+ reconstruction differs from reconstruction of a RAID-6 disk group as follows:

- When one disk is failed, not all stripes will be degraded: there will be a mix of fault tolerant and degraded stripes.
- When two disks are failed, not all stripes will be critical: there will be a mix of fault tolerant, degraded, and critical stripes.
- Reconstruction will generally complete more quickly than for RAID-6.
- Reconstruction will start immediately without waiting for replacement of the failed disk.

NOTE If a disk fails in an MSA-DP+ disk group and is replaced by a new disk in the same slot as the failed disk, the disk group automatically incorporates the replacement disk into the disk group.

- Reconstruction will start on spare capacity already available in the MSA-DP+ disk group.
- When there are critical stripes (and enough spare space), there will be two separate reconstruction phases: a first phase to repair critical stripes (to degraded state) and a second phase to repair the degraded stripes. Each phase will have its own start and end events. Because of the two-phase rebuild, MSA-DP+ might take longer to reconstruct to fault-tolerant state than a critical RAID-6 running two-disk reconstruct. However, the first phase reconstruction of MSA-DP+, from critical state to degraded state, will be much faster. You can monitor reconstruction and rebalancing progress from the Activity panel.

If the MSA-DP+ disk group has no spare space, the `REFT` (rebalance fault tolerant stripes) utility will run. As spare space is completely used, some stripes are critical, some are fault tolerant, and most are degraded. This utility attempts to rebalance stripe health away from the critical state and towards the degraded state. Stripes that are fault tolerant give up one of their disks, making them degraded. This disk capacity is then used to make a critical stripe zone degraded. It is recommended that spare space is added to the pool by either replacing failed disks or expanding the MSA-DP+ disk group, and never to let spare space run out. However, if spare space is lost, the `REFT` utility attempts to give the MSA-DP+ disk group the best redundancy across the whole disk group.

NOTE Rebalancing—applicable only to MSA-DP+—will commence on the newly replaced drive. Use cases for rebalancing are described below:

- If the failed disk is replaced immediately, such that all stripe zones are fault tolerant, then only rebalancing occurs.
 - If the failed disk is replaced later, and more disks have failed (such that there is limited or no spare space), then multiple stripe zones have likely become degraded or critical. Reconstruction will be followed by rebalancing.
 - If no default spare space was selected, then reconstruction will occur without subsequent rebalancing.
-

Quick rebuild

Quick rebuild is a method for reconstructing virtual disk groups that reduces the time that user data is less than fully fault-tolerant after a disk failure in a disk group. Taking advantage of virtual storage knowledge of where user data is written, quick rebuild first rebuilds the data stripes that contain user data.

Typically, storage is only partially allocated to volumes so the quick-rebuild process completes significantly faster than a standard rebuild. Data stripes that have not been allocated to user data are reconstructed in the background, using a lightweight process that allows future data allocations to be more efficient.

Quick rebuild applies to all RAID levels, including MSA-DP+. For an MSA-DP+ disk group, depending on how much space is actually allocated, quick rebuild can be faster than RAID rebuild.

Within a few minutes after a quick rebuild completes, a scrub starts on the disk group.

For more information about disk-group reconstruction, see ["Reconstruction" on page 33](#).

Updating firmware

Controller modules, expansion modules, and disk drives contain firmware. Users must have a `manage` role to update the disk drive or system firmware. The SMU provides options for you to update system firmware, disk drive firmware, and to use an update server (Maintenance > Firmware). For information on these options, see:

- ["Updating system firmware" on page 89](#)
- ["Updating disk firmware" on page 91](#)
- ["Using an update server" on page 91](#)

For more information, see ["Best practices for updating firmware" on page 92](#).

Managed logs

As the storage system operates, it records diagnostic data in several types of log files. The size of any log file is limited, so over time and during periods of high activity, these logs can fill up and begin overwriting their oldest data. Enabling the managed logs feature (Settings > System > Properties > Managed Logs Properties) allows log data to be transferred to a log-collection system, and stored for later retrieval before any log data is lost. The *log-collection system* is a host computer that is designated to receive the log data transferred from the storage system. The transfer does not remove any data from the logs in the storage system. This feature is disabled by default.

The managed logs feature can be configured to operate in *push mode* or *pull mode*:

- In push mode, when log data has accumulated to a significant size, the storage system sends notifications with attached log files via email to the log-collection system. The notification will specify the storage-system name, location, contact, and IP address, and will contain a single log segment in a compressed zip file. The log segment will be uniquely named to indicate the log-file type, controller (A or B), and the date/time of creation. The file name format is `logtype_yyyy_mm_dd_hh_mm_ss.zip`. To activate push mode, select the Include Logs check box in the Settings > System > Properties > Managed Logs Properties panel.
- In pull mode, when log data has accumulated to a significant size, the system sends notifications via email, SMI-S, or SNMP to the log-collection system, which can then use FTP or SFTP to transfer the appropriate logs from the storage

system. The notification will specify the storage-system name, location, contact, and IP address and the log-file type (region) that needs to be transferred. To activate pull mode, deselect the Include Logs check box in the Settings > System > Properties > Managed Logs Properties panel.

The managed logs feature monitors the following controller-specific log files:

- Expander Controller (EC) log, which includes EC debug data, EC revisions, and PHY statistics
- Storage Controller (SC) debug log and controller event log
- SC crash logs, which include the SC boot log
- Management Controller (MC) log

Each log-file type also contains system-configuration information. The capacity status of each log file is maintained, as well as the status of what data has already been transferred. Three capacity-status levels are defined for each log file:

- Need to transfer—The log file has filled to the threshold at which content needs to be transferred. This threshold varies for different log files. When this level is reached:
 - In push mode, informational event 400 and all untransferred data is sent to the log-collection system.
 - In pull mode, informational event 400 is sent to the log-collection system, which can then request the untransferred log data. The log-collection system can pull log files individually, by controller.
- Warning—The log file is nearly full of untransferred data. When this level is reached, warning event 401 is sent to the log-collection system.
- Wrapped—The log file has filled with untransferred data and has started to overwrite its oldest data. When this level is reached, informational event 402 is sent to the log-collection system.

Following the transfer of a log's data in push or pull mode, the log's capacity status is reset to zero to indicate that there is no untransferred data.

NOTE In push mode, if one controller is offline then its partner will send the logs it has acquired from the offline controller along with its own logs.

Saving log data to a file

Typical log data that can be written to a compressed file include:

- Device status summary, which includes basic status and configuration data for the system
- The event log from each controller
- The debug log from each controller
- The boot log, which shows the startup sequence, from each controller
- Critical error dumps from each controller, if critical errors have occurred

Logs do not include user data.

NOTE The controllers share one memory buffer for gathering log data and loading firmware. Do not perform more than one log saving operation at a time. Do not try to perform a firmware update operation while performing a log saving operation. Also, do not attempt to gather performance metrics while performing a log saving operation.

Alternative methods for obtaining log data are to use the Collect Logs action (Maintenance > Support) or the `get logs` command in the FTP or SFTP interface. These methods will transfer the entire contents of a log file without changing its capacity-status level. Use of Collect Logs or `get logs` is expected as part of providing information for a technical support request.

For information about using the FTP or SFTP interface, see ["Using FTP and SFTP" on page 109](#).

LDAP

You can configure the storage system to use external Lightweight Directory Access Protocol (LDAP) services provided from Windows Server 2016 or 2019 Active Directory for user authentication and authorization.

Feature overview

There are two sources of user credentials for the storage system. The primary source is local users created by using the options in the Local Users panel of the SMU (Settings > Users > Local) or by using the `create user` CLI command. For more information on this command, see the CLI documentation. For more information on adding local users with the SMU, see "Managing local users" on page 75. Though local users can be standard or SNMPv3 users, the LDAP feature supports only standard users.

The secondary source for user credentials is a Windows 2016 or 2019 Active Directory LDAP server, as illustrated below. Users logging in using their LDAP credentials must authenticate using these credentials and be members of a group that is authorized to access the storage system. The group will exist on the LDAP server and will be listed under the `memberOf` attribute for the user account. The same group name must also exist in the storage system and be created by using the LDAP Users panel of the SMU (Settings > Users > LDAP) or the `create user-group` CLI command. Users logging in by this method are not explicitly registered or stored in the storage system; their login, logout, and activity is recorded in an audit log stored in each controller module. For more information about audit logs, see "Audit logs" on page 52.

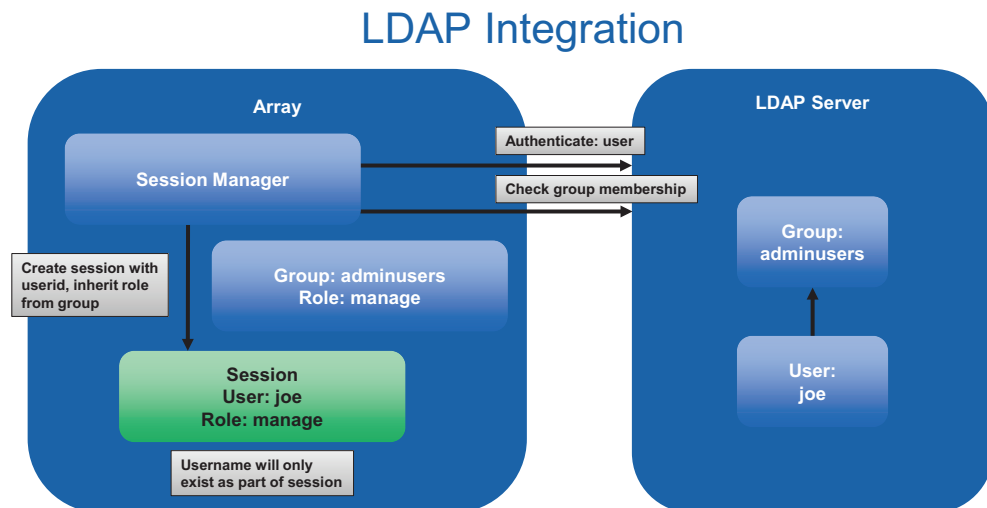


Figure 1 LDAP overview

The system supports a maximum of five user groups to allow different permissions and/or user preference options. User group permissions are defined by assigning roles, as for local users. User group preference options that can be set in the SMU include the locale, temperature-scale, and timeout. User group preference options that can be set only in the CLI include the storage size base, precision, and units. User groups can be created whether the LDAP feature is enabled or disabled, but have no purpose if LDAP is not enabled.

Individual user preferences are not saved in the storage system for LDAP authenticated users. Any settings made to the login session are not retained after the session terminates. If the user wants to retain any preferences for the session, these must be saved as part of the user group. Any changes made to a user group will affect all members of that group.

LDAP users with a `manage` role can create, modify, and delete both local users and user groups. LDAP users with a `standard` role can change settings for the current user group except for the user type and role. LDAP users with a `standard` role also cannot change the settings of other user groups.

The username/password entered will be authenticated with local users within the system first. If local authentication fails and LDAP is enabled, the username will be checked against the LDAP server(s).

Protocols and services

Before enabling the LDAP feature, unsecured protocols and services (Telnet, HTTP, FTP, unsecured SMI-S, and debug) must be disabled.

When the LDAP feature is enabled, only secure protocols and services (SSH, HTTPS, SFTP, and secure SMI-S) can be enabled. The LDAP feature must be disabled before unsecured protocols can be re-enabled.

HTTPS, SSH, SFTP, and SMI-S are the only interfaces that support LDAP. Attempting to use an LDAP login through any other interface will fail.

LDAP server/client details

The LDAP server must be an Active Directory server running Windows 2016 or 2019. The server must allow basic authentication using an LDAP over SSL (LDAPS) interface; that is, a TLS v1.2 connection.

The client storage system allows one primary server and port and an alternate server and port to be configured. At login, the storage system will only connect over TLS. If the storage system cannot connect to the primary server it will automatically try the alternate server. The storage system will only connect to a single Active Directory forest.

The client will look at the common name (CN) for the LDAP group's distinguished name (DN). The group can be part of any organizational unit (OU) or Active Directory forest as long as the CN value matches the client's group name.

For example, assume domain `bigco2.com.local` includes OU `colo`, in which user `alice` is a member of group `ArrayAdmins` in the same OU. The group's DN is:

```
cn=ArrayAdmins,ou=colo,dc=bigco2,dc=com,dc=local
```

When the MSA LDAP client performs a search on the server, it will query the `UserObject` that represents user `alice`. The client will limit the response to a maximum of 100 groups to be read from the server. The first group found that matches a group created on the storage system will be used to authenticate user `alice`. The client will timeout if it has not received a response in 20 seconds.

In the above example, the user group `ArrayAdmins` has been created on the storage system. When the user `alice` attempts to log in to the storage system either through the SMU or the CLI, the group from Active Directory matches the storage system user group and `alice` is granted access.

It is recommended that:

- A user should only be a member of one group that exists in the storage system. A user that is a member of more than one LDAP group in the storage system could have permission or configuration parameter inconsistencies.
- The LDAP user be in no more than 100 LDAP groups.

The following example shows the data to enter in the LDAP Configuration panel to configure a storage system to accomplish the above.

1. Configure the storage system to connect to the primary LDAP server and an alternate LDAP server. IP addresses or Fully Qualified Domain Name (FQDN) may be used. The primary connection is configured at `10.235.217.52` using standard TLS port `636`. The alternate connection is configured at `10.235.217.51` using the same port. If the primary connection fails, the system will try the alternate connection. If the alternate connection fails, authentication will fail. The user search base defines the domain and OU.
 - a. Access the LDAP Settings section (**Settings > Users > LDAP**).
 - b. Select the **Enable LDAP** check box.
 - c. In the User Search Base field, enter `ou=colo,dc=bigco2,dc=com,dc=local`.
 - d. In the Server field, enter `10.235.217.52`.
 - e. In the Port field, enter `636`.

- f. In the Alternate Server field, enter **10.235.217.51**.
 - g. In the Alternate Port field, enter **636**.
 - h. Select **Set LDAP**.
2. Create an LDAP user group named `ArrayAdmins` (matching the group name on the LDAP server) with the Standard role and access to the SMU and CLI interfaces.
 - a. Click **Add New User Group**.
 - b. In the **User Group Name** field, enter **ArrayAdmins**.
 - c. Select **WBI** and **CLI** to define the interfaces.
 - d. Select **Standard** and **Monitor** to define the roles.
 - e. Select the language, temperature preference, and timeout options.
 - f. Select **Create User Group**. When user `alice` attempts an SSH login to the storage system, the system connects to the configured LDAP server using the supplied credentials to perform authentication.

There are two login formats that the storage system allows when connecting to an Active Directory LDAP server. When using SSH, two backslashes may be required for certain clients, such as the OpenSSH client.

- Email-address format. For example:

```
ssh alice@bigoc2.com.local@10.235.212.161
```

- Domain\username format. For example:

```
ssh bigoc2\\alice@10.235.212.161
```

Using the domain\username format has this restriction: the username can contain no more than 20 characters to be backward-compatible with Windows clients before Windows 2000. For more information about restrictions for these attributes, see Microsoft Active Directory documentation.

NOTE By default when creating a new user object in Windows Server 2016 or 2019, both the `sAMAccountName` and `userPrincipalName` attributes are populated.

Recovery

If the LDAP server becomes permanently unavailable or no users exist in the LDAP database and local user account passwords are forgotten or compromised, physical access to a controller module serial port will be required. If this occurs, contact technical support for assistance.

DNS settings

You can set a domain hostname for each controller module to identify it for management purposes by configuring settings in the DNS panel (Settings > Network > DNS). The DNS server name supports IPv4 and IPv6 formats, and the system supports a maximum of three DNS servers per controller. Configuring the storage system to communicate with a DNS server within your network allows network changes, such as frequent IP address changes in a DHCP environment, to occur without interrupting notifications sent by the system to users.

The controller will advertise the domain hostname to DNS servers, and the DNS servers will in turn create and advertise a fully qualified domain name (FQDN) for the controller by appending the domain hostname to the DNS domain string that identifies the controller.

The hostname must differ for each controller, is not case sensitive, and can have from 1 to 63 bytes. The name must start with a letter and end with a letter or digit, and can include letters, numbers, or hyphens, but no periods.

After a reachable DNS server is configured on the system, you can configure an SMTP server using a name such as `mysmtpserver.example.com`. Further, you could configure search domain `example.com` and SMTP server `mysmtpserver` and reach the same destination.

You must use this feature to configure DNS parameters before you configure system parameters in any environments where DNS will be required to resolve server names.

If the controller is able to look up the domain name from a DNS server, the FQDN for each controller is also shown.

Peer connections

A peer connection enables bi-directional communication between a local system and a remote system to transfer data between the two systems. Creating a peer connection requires a name for the peer connection and either an IP address of a single available iSCSI host port on the remote system, or a WWN of a single available FC host port on the remote system. Only iSCSI and FC host ports are used for the peer connection. SAS host ports do not support peer connections.

The peer connection is defined by the ports that connect the two peer systems, as well as the name of the peer connection. The local system uses the remote address to internally run the `query peer-connection` CLI command. The results of the query are used to configure the peer connection.

The prerequisites to create a peer connection are:

- Both systems must be licensed to use replication.
- Both systems must have iSCSI or FC host ports. Ports at both ends of the connection must use the same protocol.
- Both systems must be connected to the same fabric or network via a switch; direct connection between storage systems is not supported.
- All host port addresses in both systems must be unique, even for ports not in use.
- If iSCSI CHAP is configured for the peer connection, the authentication must be valid.

NOTE For information on creating a peer connection between a system with MSA 1060/2060/2062 controllers and a system with MSA 1050/2050/2052 controllers, see ["Replicating between current and legacy systems" on page 47](#).

You can create a maximum of one peer connection per storage system for MSA 1060 storage systems and four peer connections per storage system for MSA 2060/2062 storage systems. However, only one peer connection is allowed to a particular remote system. Attempting to create a second peer connection to the same system will fail.

While creating the peer connection, the local system receives information about all host ports on the remote system as well as the remote system's licensing and host port health. It also links host ports of the selected host port type on the local system to those reachable on the remote system, so all ports of that type are available as part of the peer connection. Once created, the peer connection exists on both the local and remote systems.

Replications use a bi-directional communication path between the systems when exchanging information and transferring replicated data. Because the peer connection is bi-directional, replication sets can be created from both systems with replication occurring from either direction. Due to the relationship between peer connections and replication sets, creating a peer connection is part of the process of creating a replication set.

To create a peer connection, create a replication set (Provisioning > Volumes > Data Protection > Add Data Protection > Remote Replication). Select one or more volumes to add to the replication set, then follow the on-screen directions to establish a peer connection between the primary and secondary systems. Directions include steps to enter the secondary system's port address, the connection name, and the username and password of a user with a manage role on the remote system. For more information, see ["Add data protection" on page 65](#).

If a single host port loses connectivity, event 112 will be logged. See the Event Descriptions Reference Guide for more information. Because a peer connection is likely to be associated with multiple host ports, the loss of a single host port may degrade performance but usually will not cause the peer connection to be inaccessible.

For more information about replication, see ["Replication" on the facing page](#). For more information about how CHAP interacts with replication, see ["CHAP and replication" on page 47](#). For information about modifying a peer connection, see ["Peer connection settings" on page 83](#).

Replication

Replicating virtual volumes

Remote Snap for virtual storage is a licensed feature that provides a remote copy of a volume or snapshot on a remote system by periodically updating the remote copy to contain a point-in-time consistent image of a source volume. After an initial image has been replicated, subsequent replications only send changed data to the remote system. All replications, including the initial one, only replicate data that has been written as opposed to replicating all of the data from the source. Replication can be used for disaster recovery, to preserve data, and to back up data to off-site locations. It can also be used to distribute data.

For more information about replication for virtual storage, see ["Replicating between current and legacy systems" on page 47](#) and ["CHAP and replication" on page 47](#).

Replication prerequisites

To replicate a volume, you must first create a peer connection or use an existing one, and create a replication set. A peer connection establishes bi-directional communication between a local and remote system, both of which must have FC or iSCSI ports, a virtual pool, and an Advanced Data Services license. The system establishes a peer connection by connecting a host port on the local system with a user-specified host port on the remote system, then exchanging information and setting up a long-term communication path in-band. Because the communication path establishes a peer connection between the two systems, replications can occur in either direction.

To verify that a host port address is available before creating a peer connection in the SMU, specify a peer system IP address and then choose **Query Peer Connection** (Settings > Peer Connections). Alternatively, use the `query peer-connection` CLI command. This command provides information about the remote system, such as inter-connectivity between the two systems, licensing, and pool configuration. For more information on this command, see the CLI Reference Guide. For more information on peer connections, see ["Peer connections" on the previous page](#), ["Peer connection settings" on page 83](#), and ["Deleting a peer connection" on page 83](#).

In the SMU, creating a peer connection, or selecting an existing one, is part of creating a replication set. After you create or select a peer connection, you can continue to create a replication set. A replication set specifies one or more volumes or snapshots on one system of the peer connection, known as the primary system in the context of replication, to replicate across the peer connection. When you create a replication set, corresponding volumes are automatically created on the other system of the peer connection, known as the secondary system, along with the infrastructure needed for replication. The infrastructure consists of internal snapshots used for replication operations. A replication set for a volume consumes two internal snapshots each for the primary volume and the secondary volume if the queue policy is set to `Discard`, or three each if the queue policy is set to `Queue Latest`.

For a replication set, the term *primary* refers to the source volume and the system in which it resides, and the term *secondary* is used for the remote copy and the system in which it resides. The secondary volume is meant to be an exact copy of the primary volume from the last time that replication occurred. To guarantee that the contents from that point in time match, the secondary volume cannot be mapped, rolled back, or modified except through replication.

While you cannot modify the secondary volume, you can create a snapshot of the secondary volume that you can map, mount, roll back, and otherwise treat like any volume or snapshot. You can regularly take snapshots to maintain a history of the replications for backup or archiving, or enable snapshot history for the replication set. These snapshots also can be used in disaster recovery. For more information on replication sets, see ["Add data protection" on page 65](#), ["Modifying a replication set" on page 66](#), and ["Deleting a replication set" on page 66](#).

NOTE HPE recommends that both systems in a peer relationship run the same firmware version. If you want to create a peer connection between a system running newer firmware and a system running older firmware, log in to the newer system and run commands to create and modify peers from that system. When replicating between HPE MSA 1050/2050/2052 and MSA 1060/2060/2062 systems, either system can be set to primary.

Replication process

After you create a peer connection and replication set, you can then replicate volumes between the systems. The initial replication differs slightly from all subsequent replications in that it copies all of the allocated pages of the primary volume to the secondary volume. Depending on how large your source volume is and the speed of the network connection, this initial replication may take some time.

Each subsequent replication is completed by resetting one of the internal snapshots of the primary volumes to contain the contents last replicated and then resetting the other internal snapshot to the current primary volume contents and comparing the changes. The system writes any changes it finds on the internal primary snapshot to the internal secondary snapshot, after which the secondary volume is updated to contain the contents of the secondary snapshot. (This internal process happens automatically, and is not accessible to user control.)

The progress and status of the initial and subsequent replications are tracked and displayed. The timestamps for replication reflect the time zones of the respective systems. When viewed on a secondary system in a different time zone, for example, replication information will reflect the time zone of the secondary system. For more information on replicating, see ["Aborting a replication set" on page 68](#), ["Initiating or scheduling a replication" on page 67](#), ["Resuming a replication" on page 68](#), and ["Suspending a replication" on page 68](#).

You can initiate a replication manually or by using a schedule. When creating a schedule for a replication set, you cannot specify for replication to occur more frequently than once an hour. For more information on scheduling replication, see ["Initiating or scheduling a replication" on page 67](#).

Initial replication

The following figure illustrates the internal processes that take place during the initial replication of a single volume.

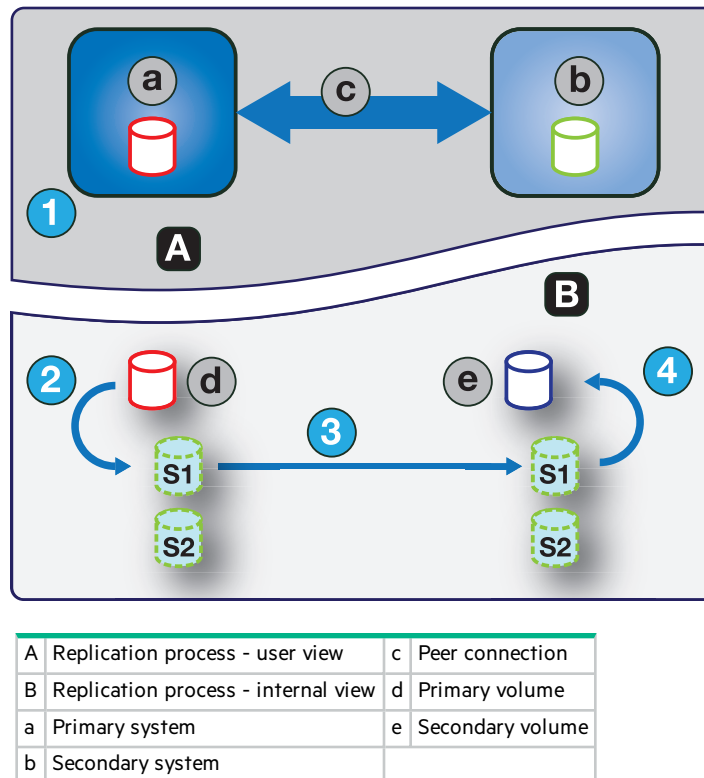


Figure 2 Replication process for initial replication

The two internal snapshots for each volume on the primary and secondary systems all have distinct roles. For both systems, they are labeled S1 (Snapshot 1) and S2 (Snapshot 2) in the two figures above and below. When a replication

set is created, the primary volume and its internal snapshots all contain the same data. The secondary volume and its internal snapshots do not contain any data. Between the time that the replication set was created and the initial replication occurs, it is possible that hosts have written additional data to the primary volume.

During initial replication, the following sequence takes place. The user or a schedule initiates replication on the primary system (step 1). The snapshot, S1, of the primary volume contents, which might be different than when the replication set was created, are reset to the current contents of the volume (step 2). The S1 data, which matches that of the primary volume, is replicated in its entirety to its S1 counterpart on the secondary system and replaces the data that the secondary system S1 contains (step 3). The S1 contents on the secondary system replace the contents of the secondary volume (step 4). The contents of the primary and secondary volumes are now synchronized.

Subsequent replications

The following figure illustrates the internal process that takes place in replications subsequent to the initial replication of a single volume.

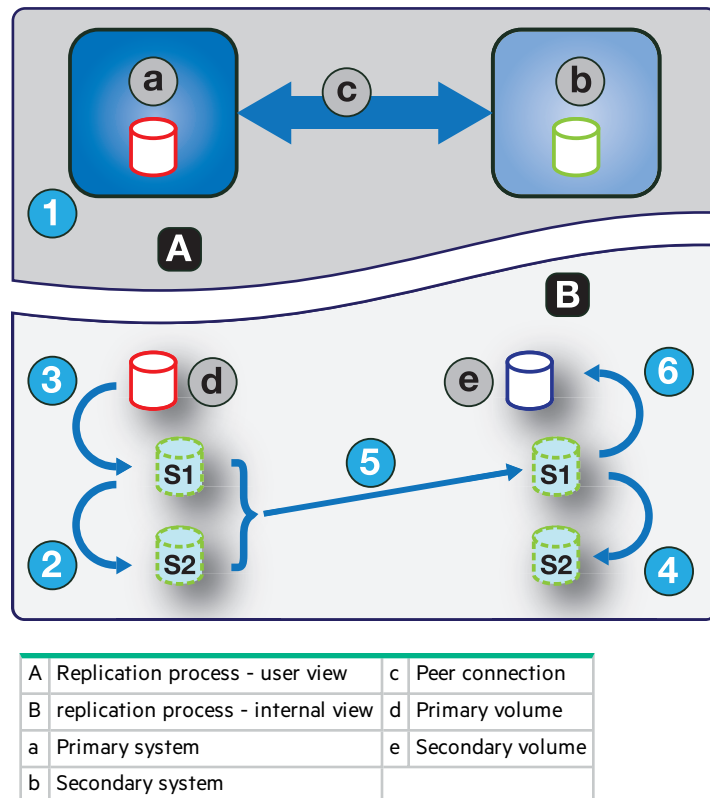


Figure 3 Replication process for replications subsequent to the initial replication

During the initial replication, the entire contents of the primary volume are replicated to the secondary volume. In subsequent replications, only data that is new or modified since the last replication operation is replicated. This is accomplished by comparing a snapshot of the primary volume data from the last replication with a current snapshot of the primary volume. With the exception of this comparison, the process for both the initial and subsequent replications is similar.

During replications subsequent to the initial replication, the following sequence takes place. The user or a schedule initiates replication on the primary system (step 1). On the primary system, S2 is reset to the current contents of S1 (step 2). (The S2 contents can then be used for comparison during step 5.) S1 is reset to the current primary volume contents on the primary system (step 3). On the secondary system, S2 is reset to the current contents of S1 (step 4). The S1 contents on the primary system, which match that of the primary volume at the time the replication was initiated, are

compared to the S2 contents on the primary system. Only the data that is the delta between S1 and S2 is replicated to its S1 counterpart on the secondary system, which is updated with the delta data. The data comparison and replication occur together (step 5). The S1 contents on the secondary system replace the contents of the secondary volume (step 6). The contents of the primary and secondary volumes are now synchronized.

Internal snapshots

When first created from the primary volume, the internal snapshots consume very little space but will grow as data is written to the volume. Just as with any virtual snapshot, the amount of disk space used by an internal snapshot depends on the difference in the number of shared and unique pages between itself and the volume. The snapshot will not exceed the amount of disk space used by the primary volume. At most, the two internal snapshots together for each volume may consume twice the amount of disk space as the primary volume from which they are snapped.

Even though the internal snapshots are hidden from the user, they do consume snapshot space (and thus pool space) from the virtual pool. If the volume is the base volume for a snapshot tree, the count of maximum snapshots in the snapshot tree may include the internal snapshots for it even though they are not listed. Internal snapshots count against system limits, but do not display and do not count against license limits.

Creating a virtual pool for replication

When you create a virtual pool, specify that it has enough space for four times the anticipated size of the primary volume (to account for the primary volume, plus the same amount of space for each of the two internal snapshots, and possible queued replication). This is the maximum amount of space that you will need for replication. Also, for a pool on the primary system, allow additional space for other uses of the pool.

Setting up snapshot space management in the context of replication

Snapshot space management is the ability to control the number of snapshots and the amount of storage space they can consume in a pool.

There are several factors to consider when managing snapshot space for the primary and secondary systems, especially when setting up the snapshot space and policies for the pool:

- Make sure that there is enough space in the pool for the base volume and replication-set needs. See guidelines provided in ["Creating a virtual pool for replication"](#) above.
- To adjust the snapshot space of the pool, increase the value of the limit parameter of the `set snapshot-space` CLI command. For more information on the `set snapshot-space` CLI command, see the CLI Reference Guide.
- To create more snapshot space, increase the size of the pool, add disk groups to the pool, or expand existing MSA-DP+ groups. It may be necessary to insert additional disks if the system doesn't have any available.

If the snapshots are taking up more space than anticipated, consider the following approaches to address the issue:

- Limit the number of snapshots created by the replication-set.
- Fine-tune the pool's snapshot space allocation and policies.

Limiting the number of snapshots created is the most straightforward approach. You can set the number of snapshots taken by the snapshot history feature via the CLI. Use the `set replication-set` CLI command, specifying the `snapshot-count` parameter. Reducing the `snapshot-count` number will save space. For more information on the `set replication-set` CLI command, see the CLI Reference Guide.

Fine-tuning the overall pool's snapshot space management is the other approach. You can adjust the `snapshot-space-limit` and `limit-policy` parameters of the pool to reduce the number of retained snapshots, or you can relax the `snapshot-retention-priority` parameter used with the `set replication-set` CLI command. Relaxing the `snapshot-retention-priority` parameter allows the pool to be more aggressive in deleting older, less important snapshots when there is pressure on the pool to free-up snapshot space. For more information on the `set replication-set` CLI command, see the CLI Reference Guide.

To monitor the snapshot space for virtual pools, use the `show snapshot-space` CLI command. To monitor the size of the internal snapshots, use the `show snapshots` CLI command with its `type` parameter set to `replication`. For more information on the `show snapshots` CLI command, see the CLI Reference Guide.

Replication and empty allocated pages

Deleting data from a volume can result in deallocation of pages on that volume. These pages consume space in the volume and in the pool. Pages deallocated before the initial replication will not be copied to the secondary volume. Pages deallocated since the last replication cause a page consisting of zeroes to be written to the secondary volume during replication. This can result in a difference in the number of allocated pages between the primary and secondary volumes. A virtual storage background task automatically reclaims pages consisting of all zeroes, eventually freeing up the secondary volume snapshot space that these reclaimed pages consumed. Freeing up this space is not immediate and happens over a period of time.

Disaster recovery

For information about recovering a replication set, see the `recover replication-set` CLI command in the CLI Reference Guide.

Creating a replication set

You can create a replication set, which specifies the components of a replication. The Data Protection Configuration wizard enables you to create replication sets. You can access this wizard from the Provisioning > Volumes panel. For more information, see ["Add data protection" on page 65](#).

Performing this action creates the replication set and the infrastructure for the replication set. For a selected volume or snapshot, the action creates a secondary volume and the internal snapshots required to support replications. By default, the secondary volume and infrastructure are created in the pool corresponding to the one for the primary volume (A or B). Optionally, you can select the other pool.

If a peer connection is not already created, the Data Protection Configuration wizard prompts you to create one. A replication set can specify only one peer connection and pool. When creating a replication set, communication between the peer connection systems must be operational during the entire process.

If a replication set is deleted, the internal snapshots created by the system for replication are also deleted. After the replication set is deleted, the primary and secondary volumes can be used like any other base volumes.

Primary volumes

The volume or snapshot that will be replicated is called the primary volume. Each volume can belong to only one replication set.

Secondary volumes

When the replication set is created—either through the CLI or the SMU—secondary volumes are created automatically. Secondary volumes cannot be mapped, moved, expanded, deleted, or participate in a rollback operation. If you need access to the data on secondary volumes, create a snapshot of the secondary volume and use the snapshot for mapping and accessing data.

Queuing replications

You can specify the action to take when a replication is running and a new replication is requested.

- **Discard.** Discard the new replication request.
- **Queue Latest.** Take a snapshot of the primary volume and queue the new replication request. If the queue contained an older replication request, discard that older request. A maximum of one replication can be queued. This is the default.

For information on queuing replications between a system with MSA 1060/2060/2062 controllers and a system with MSA 1050/2050/2052 controllers, see ["Replicating between current and legacy systems" on page 47](#).

If the queue policy is set to Queue Latest and a replication is running and another is queued, you cannot change the queue policy to discard. You must manually remove the queued replication before you can change the policy using the `clear replication-queue` CLI command. For more information about this command, see the CLI Reference Guide.

Maintaining replication snapshot history

A replication set can be configured to maintain a replication snapshot history. As part of handling a replication, the replication set will automatically take a snapshot of the secondary and/or primary volume, thereby creating a history of data that has been replicated over time. This feature can be enabled for a secondary volume or for a primary volume and its secondary volume. When this feature is enabled:

- For a primary volume, when a replication starts it will create a snapshot of the data image being replicated.
- For a secondary volume, when a replication successfully completes it will create a snapshot of the data image just transferred to the secondary volume. (This is in contrast to the primary volume snapshot, which is created before the sync.) If replication does not complete, a snapshot of the secondary volume will not be created.
- You can set the number of snapshots to retain from 1–16, referred to as the snapshot retention count. This setting applies to management of snapshots for both the primary and secondary volume and can be changed at any time. Its value must be greater than the number of existing history snapshots in the replication set, regardless of whether snapshot history is enabled. If you select a snapshot retention count value that is less than the current number of snapshots, an error message displays. Thus, you must manually delete the excess snapshots before reducing the snapshot count setting. When the snapshot count is exceeded, the oldest unmapped snapshot will be discarded automatically.
- You set the basename of the snapshot. The snapshots are named `basename_nnnn` where `_nnnn` starts at 0001 and increments for each subsequent snapshot. If primary volume snapshots are enabled, snapshots with the same name will exist on the primary and secondary systems. The snapshot number is incremented each time a replication is requested, whether or not the replication completes — for example, if the replication was queued and subsequently removed from the queue.
- If the replication set is deleted, any existing snapshots automatically created by snapshot history rules will not be deleted. You will be able to manage those snapshots like any other snapshots.
- If you begin keeping a snapshot history after a number of replications have occurred, the snapshot number in the name will reflect the total number of replications that have occurred.
- Manually creating a snapshot will not increase the snapshot count associated with the snapshot history. Manually created snapshots are not managed by the snapshot history feature. The snapshot history feature generates a new name for the snapshot that it intends to create. If a volume of that name already exists, the snapshot history feature will not overwrite that volume. Snapshot numbering will continue to increment, so the next time the snapshot history feature runs, the new snapshot name will not conflict with that existing volume name.
- The snapshot basename and snapshot retention count settings only take effect when snapshot history is set to secondary or both, although these settings can be changed at any time.
- A mapped snapshot history snapshot will not be deleted until after it is unmapped.
- A snapshot created by this feature is counted against the system-wide maximum snapshots limit, with the following result:
 - If the snapshot count is reached before the system limit, then the snapshot history is unchanged.
 - If the system limit is reached before the snapshot count, then the snapshot history stops adding or updating snapshots.
- The snapshot space management feature, accessible only through the CLI, enables users to monitor and control the amount of space that snapshots can consume in a pool. In addition to configuring a snapshot space limit, you can also specify a limit policy to enact when the snapshot space reaches the configured limit. An event is logged, and if the policy is set to delete, automatic deletion of snapshots occurs. If automatic deletion is triggered, snapshots are deleted according to their configured retention priority.

- You can set the retention priority for snapshots to the following. In a snapshot tree, only leaf snapshots can be deleted automatically.
 - **never-delete.** Snapshots will never be deleted automatically to make space. The oldest snapshot in the snapshot history will only be deleted once the snapshot count has been exceeded. This is the default.
 - **high.** If snapshot space is exhausted, retained snapshots can be deleted after all eligible (system-wide) medium-priority snapshots have been deleted.
 - **medium.** If snapshot space is exhausted, retained snapshots can be deleted after all eligible (system-wide) low-priority snapshots have been deleted, regardless of retention schedule.
 - **low.** If snapshot space is exhausted, retained snapshots can be deleted at any time, regardless of retention schedule.

When this option is disabled, snapshot history will not be kept. If this option is disabled after a replication set has been established, any existing snapshots will be kept, but not updated.

Replicating between current and legacy systems

With the exception of using the disaster recovery features in the CLI, replications are compatible between a system with HPE MSA 1060/2060/2062 controllers and a system with HPE MSA 1050/2050/2052 controllers running the latest major firmware version, because both systems support the same replication features. For information on disaster recovery features, see the CLI Reference Guide.

CHAP and replication

If you want to use Challenge Handshake Authentication Protocol (CHAP) for the iSCSI connection between peer systems, see the procedure below to set up CHAP. Make sure that you configure both systems in this way. In a peer connection, both systems will alternately act as an originator (initiator) and recipient (target) of a login request.

If only one system has CHAP enabled and the two systems do not have CHAP records for each other, or the CHAP records have different secrets, the system with CHAP enabled will be able to modify the peer connection. However, it will be unable to perform any other replication operations, such as creating replication sets, initiating replications, replicating snapshots, or suspending replication operations. The system that does not have CHAP enabled will be unable to perform any replication operations, including modifying and deleting the peer connection. For full replication functionality for both systems, set up CHAP for a peer connection.

If the two systems have CHAP records for each other with the same secret, they can perform all replication operations whether or not CHAP is enabled on either system. In other words, even if CHAP is not enabled on either system, or if it is enabled on only one system or both systems, either system can work with peer connections, replication sets, and replications.

If you want to use Challenge Handshake Authentication Protocol (CHAP) for the iSCSI connection between peer systems, see the following procedure to configure CHAP. In a peer connection, both systems will alternately act as an originator (initiator) and recipient (target) of a login request. Peer connections support one-way CHAP only.

To set up CHAP for a peer connection (using the CLI):

1. If you haven't already configured CHAP, run `query peer-connection` from either the local system or the remote system to ensure that they have connectivity.
2. If you have an existing peer connection, stop I/O to it.
3. On the local system, use the `create chap-record` command to create a CHAP record for one-way CHAP to allow access by the remote system.
4. On the remote system, use the `create chap-record` command to create a CHAP record for one-way CHAP to the local system. Note that the same CHAP record used from the local system may also be used here but the configuration is still one-way CHAP.

5. On each system, enable CHAP by running: `set iscsi-parameters chap on`

⚠ CAUTION Enabling or disabling CHAP will cause all iSCSI host ports in the system to be reset and restarted. This may prevent iSCSI hosts from being able to reconnect if their CHAP settings are incorrect.

6. Wait one minute for the commands in step 3 through step 5 to complete before attempting to use the peer connection.
7. Run `query peer-connection` from the local system and then from the remote system to ensure communication can be initiated from either system.
 - If both succeed, you can create, set, or perform replication on that peer connection.
 - If either fails, it is likely that you must fix a CHAP configuration issue and then repeat step 3 through step 7 as appropriate. If you need to modify a CHAP record, use the `set chap-record` command.

Full disk encryption

Full disk encryption (FDE) is a method by which you can secure the data residing on the disks. It uses self-encrypting drives (SED), which are also referred to as FDE-capable disks. When secured and removed from a secured system, FDE-capable disks cannot be read by other systems.

The ability to secure a disk and system relies on passphrases and lock keys. A passphrase is a user-created password that allows users to manage lock keys. You can enable FDE protection by setting the FDE passphrase the system uses to write to and read from FDE-capable disks (Settings > System > Security). From the passphrase, the system generates the lock key ID that is used to secure the FDE-capable disks. If the system is unable to interpret the lock key on the FDE-capable disk, the disk's encrypted data is inaccessible.

ⓘ IMPORTANT Be sure to record the passphrase as it cannot be recovered if lost.

A lock key is generated by the system, based upon the passphrase, and manages the encryption and decryption of data on the disks. A lock key is persisted on the storage system and is not available outside the storage system.

Data that was present on the system before it was secured is accessible in the same way it was when the system was unsecured. However, if a disk is transferred to an unsecured system or a system with a different passphrase, the data is not accessible.

Clearing the lock keys and power cycling the system denies access to data on the disks. Clear lock keys only when the system will not be under your physical control.


If the lock keys are cleared while the system is secured, the system will enter the FDE lock-ready state, in preparation for the system being powered down and transported. After the system has been transported and powered up, the system and disks will enter the secured, locked state; disks will be in the `UNUSABLE` state. Pools and disk-groups will be unavailable. All data on the disks is inaccessible until the system is secured with the original passphrase and lock key ID.

A system and the FDE-capable disks in the system are initially unsecured but can be secured at any point. Until the system is secured, FDE-capable disks function exactly like disks that do not support FDE.

FDE operates on a per-system basis, not a per-disk group basis. To use FDE, all disks in the system must be FDE-capable.

⚠ CAUTION Do not change FDE configuration settings while running I/O. Temporary data unavailability may result, and the proper setting of lock keys from the passphrase could potentially be impacted.

Secured disks and systems can be repurposed. You can repurpose a system to erase all data on the system and return its FDE state to unsecured. You can repurpose a disk that is no longer part of a disk group. After a disk is repurposed in a secured system, the disk is secured using the system lock key ID and the new encryption key on the disk, making the disk usable to the system. Repurposing a disk in an unsecured system removes all associated lock keys and makes that disk available to any system.

 **CAUTION** Repurposing a disk changes the encryption key on the disk and effectively deletes all data on the disk. Repurpose a disk only if you no longer need the data on the disk.

NOTE If you insert an FDE disk into a secured system and the disk does not come up in the expected state, perform a manual rescan. See "[Rescanning disks](#)" below.

Rescanning disks

A rescan (Maintenance > Hardware > Actions) forces a rediscovery of disks and enclosures in the storage system. If both Storage Controllers are online and can communicate with both expansion modules in each connected enclosure, a rescan also reassigns enclosure IDs to follow the enclosure cabling order of controller A. For further cabling information, refer to your product's Installation Guide.

You might need to rescan disk channels after system power-up to display enclosures in the proper order. The rescan temporarily pauses all I/O processes, then resumes normal operation. It can take up to two minutes for enclosure IDs to be corrected.

You do not have to perform a manual rescan after inserting or removing non-FDE disks. The controllers automatically detect these changes. When disks are inserted, they are detected after a short delay, which allows the disks to spin up.

Clearing disk metadata

You can clear metadata from a leftover disk to make it available for use. This action is accessible via Maintenance > Hardware > Disk > Actions when a leftover (LEFTOVR) disk is selected. Choosing this action clears metadata only from leftover disks. If you specify disks that are not leftovers, the disks are not changed.

CAUTION

- Only use this action when all disk groups are online and leftover disks exist. Improper use of this action may result in data loss.
 - Do not use this action when a disk group is offline and one or more leftover disks exist.
 - Do not use this action on disks that have gone leftover due to disk errors.
 - If you are uncertain whether to use this action, contact technical support for assistance.
-

Each disk in a disk group has metadata that identifies the owning disk group, the other disks in the disk group, and the last time data was written to the virtual pool.


The following situations cause a disk to become *leftover*:

- The disks' timestamps do not match so the system designates members having an older timestamp as leftovers.
- A disk is not detected during a rescan, then is subsequently detected.
- A disk in a disk group is logically or physically removed from the system, and is later returned after the system has noted its removal.

When a disk becomes a leftover, the following changes occur:

- The disk's health becomes Degraded and its usage value becomes LEFTOVR.
- The disk is automatically excluded from the disk group, causing the disk group's health to become Degraded or Fault, depending on the RAID level.
- The disk's fault LED is illuminated amber.

If a compatible spare is available, and the health of the disk group is Degraded or Critical, the disk group will use it to start reconstruction. When reconstruction is complete, you can clear the leftover disk's metadata. Clearing the metadata will delete all data on the disk and change the disk's health to OK and its usage value to AVAIL. The disk may become available for use in a new disk group.

 **TIP** If a spare is not available to begin reconstruction, or reconstruction has not completed, keep the leftover disk so that you will have an opportunity to recover its data.

NOTE MSA-DP+ disk groups do not use spares for reconstruction.

NOTE Disk health considerations:

- Before clearing metadata from a LEFTOVR disk to reuse it, check whether the disk previously reported excessive media errors. If so, the disk is probably not safe to use, and should be replaced.
 - If a disk's metadata has been cleared, verify that the disk's health is OK.
 - When rebuilding a disk group, do not use an unhealthy disk from which metadata has been cleared.
-

Data protection with a single controller

The system can operate with a single controller if its partner has gone offline or has been removed. Because single-controller operation is not a redundant configuration, this section presents some considerations concerning data protection.

NOTE MSA 1060/2060/2062 controller enclosures do not support transporting cache from one controller module to another.

The default caching mode when a system is operating with a single controller for a volume is write back, as opposed to write through. In write-back mode, the host is notified that the controller has received the write when the data is present in the controller cache. In write-through mode, the host is notified that the controller has received the write when the data is written to disk. Therefore, in write-back mode, data is held in the controller cache until it is written to disk.

If the controller fails while in write-back mode, unwritten cache data likely exists. The same is true if the controller enclosure or the enclosure of the target volume is powered off without a proper shutdown. Data remains in the controller cache and associated volumes will be missing that data on the disk.

If the controller can be brought back online long enough to perform a proper shutdown and the disk group is online, the controller should be able to write its cache to disk without causing data loss.

If the controller cannot be brought back online long enough to write its cache data to disk, please contact technical support.

To avoid the possibility of data loss in case the controller fails, you can change the caching mode of a volume to write through. While this will cause a performance degradation, this configuration guards against data loss. While write-back mode is much faster, this mode is not guaranteed against data loss in the case of a controller failure. If data protection is more important, use write-through caching. If performance is more important, use write-back caching.

For more information about volume cache options, see ["Volume cache options" on page 26](#). To edit volume cache options, select **Provisioning > Volumes** and view the volume's slide-over panel.

For more information about changing system cache settings, see ["Setting system cache properties" on page 80](#).

SAS cabling (for MSA 1060 only)

For systems with 2-port SAS controller modules, host ports can be configured through the SMU or CLI to use bifurcated cables (also known as fanout cables) or standard cables. A standard cable can connect one port on a SAS host to one controller port, using four PHY lanes per port. A fanout cable can connect one port on each of two SAS hosts to one controller port, using two PHY lanes per port. Using fanout cables instead of standard cables doubles the number of hosts that can be attached to a single system. It will also halve the maximum bandwidth available to each host, but overall bandwidth available to all hosts is unchanged. Configuration must be the same for all ports on both controllers, so a mix of standard cables and fanout cables cannot be used on one system. Use of fanout cables is enabled by default.

Before changing a SAS cabling configuration, it is important to suspend host I/O. Once you have switched the configuration through the firmware, you can disconnect the existing cables and switch to the other type of cables. For information on how to connect and disconnect cables, refer to your product's Installation Guide.

Select Maintenance > Hardware panel > Rear View to see an interactive graphical representation of the enclosure's back panel. Selecting a host port icon from a controller will display port information, health status, and Actions available for the selected device (port). See also ["Maintenance" on page 85](#) for more information.

If you connect a cable that does not match the cable type for the configuration, the system will generate an alert—and event 569—warning that a SAS host cable mismatch has been detected for the indicated port number. While host I/O could be established, half of the PHY lanes for each port will be disabled. If a cable mismatch occurs, change the port mode of the system using either the Enable Fanout Cable Support or Disable Fanout Cable Support action, or connect cables of the appropriate type for the configuration. See information about event 569 in the Event Descriptions Reference Guide. For more information about SAS fanout cables used with MSA 1060 SAS enclosures, refer to the Installation Guide.

When configuring the host-interface settings for a 2-port MSA SAS controller module, the current link speed, number of PHY lanes expected for the SAS port, and number of PHY lanes active for each SAS port are displayed. The number of ports that appear depends on the configuration. Changing the host-interface settings interrupts I/O and restarts the Storage Controllers.

Event history

If you are having a problem with the system, review the event history (Maintenance > Support > Event History) to view event details and recommended actions before calling technical support. Information shown might enable you to resolve the problem.

All events are logged, regardless of notification settings. For information about notification settings, see ["Notification settings" on page 81](#).

The event history table lists a collapsed view of the most recent events logged by either controller module, up to 1000. For each event, the table shows the date and time when the event occurred (with one-second granularity), the severity, which controller module logged the event, the event code, and a message. For information about using tables, see ["Tips for using tables" on page 13](#).

Table 8 Event severity icons and meanings







	Critical	A failure occurred that may affect data integrity, system stability, or cause a controller to shut down. Correct the problem immediately.
	Error	A failure occurred that may affect data integrity or system stability. Correct the problem as soon as possible.

Table 8 Event severity icons and meanings (continued)

	Warning	A problem occurred that may affect system stability but not data integrity. Evaluate the problem and correct it if necessary.
	Informational	A configuration or state change occurred, or a problem occurred that the system corrected. No action is required.
	Resolved	A condition that caused an event to be logged has been resolved. No action is required.

When reviewing the event history, look for recent Critical, Error, or Warning events. For each, click the  icon to view additional information and recommended actions. Follow the recommended actions to resolve the problems.

To take action to correct an event, see the ["Alerts panel" on page 53](#).

Audit logs

User login, logout, and actions through all interfaces for both local and LDAP users will be recorded in an audit log that is accessible from Maintenance > Support > Audit Log Activity. For actions that change storage system parameters, the audit log will contain the timestamp, username, and actions that were run as well as the status code returned by that action. The audit log will include operations performed using the SMU, CLI, and FTP/SFTP protocols, but will not contain specific value changes, such as old and new settings.

Audit logs record host IP address information for all interfaces, as well as SNMP SET requests. Each controller maintains its own audit log, and each audit log can contain up to 2MB of data. The system will maintain 2MB of audit log data per controller and the log will wrap once the 2MB limit has been reached.

Audit log data will persist after the `restore defaults` CLI command is run and is not mirrored to the partner controller. In a failover scenario, the failed controller's audit log cannot be retrieved. Audit log data is cleared during factory refurbishment.

When you download controller logs, audit logs will be included. Audit logs are not associated with the managed logs feature.

System metrics

There are two types of metrics: historical and dynamic. The sampling interval for a dynamic metric is 5 seconds while that of a historical metric is 5 minutes. The system samples every metric at a dynamic sampling interval. The last few minutes of samples are kept in cache and cache is flushed automatically at historical sampling intervals with calculated maximum, minimum, and average data points retained in the historical database. Only a few dynamically sampled user-selected data series are retained. For such user selected data series, several hours of data points are available. The Performance panel provides charting and data comparison capabilities for metrics that are maintained in the system. For more information, see the topic about the ["Performance panel" on page 54](#).

3 Dashboard

Use the system dashboard to monitor the system and see an overview of system status, including:

- Health and performance alerts in the ["Alerts panel" below](#)
- Trends in capacity usage in the ["Capacity panel" on the next page](#)
- Changes in performance indicators in the ["Performance panel" on the next page](#)
- System activity in the ["Activity panel" on page 57](#)

Each panel has a compact view, which is the summary information that appears on the dashboard itself, and an expanded view that provides more detailed information about the topic and lets you take specific actions based on the information.

Alerts panel

Use the Alerts panel to monitor system health and performance issues and to track and acknowledge the resolution of these issues.

For alert severity level meanings, see ["Icons in the interface" on page 11](#).

Compact view


The compact view on the dashboard provides a snapshot of the system's overall health, including a count of health alerts, information alerts, and unacknowledged alerts. Click **System Health | Health Alerts** to view a scrollable list of unresolved health alerts that are affecting system health. Click **Information Alerts** to view a scrollable list of unresolved informational alerts that notify you of actions to take to improve system performance. Click **Alerts to Acknowledge** to view a scrollable list of all resolved and unresolved health and information alerts that need acknowledgment. Once acknowledged and resolved, alerts are removed from the list.

Click **Acknowledge** or the slide-over arrow next to it to open the Alerts panel expanded view.

Expanded view

The expanded view shows the scrollable Active Alerts table and lists detailed alert information. The alerts that display are dynamic and based upon the type of alerts you want to view (Health Alerts, Information Alerts, Alerts to Acknowledge, or History). Click on the name of an alert type to view more information. For each alert the table shows:

- How long the alert has been active
- The alert severity
- The affected system component
- A description of the problem
- Whether the alert has been resolved (Alerts to Acknowledge)
- Whether the alert has been acknowledged (Health Alerts, Information Alerts, Alerts to Acknowledge) (Alerts to Acknowledge: present if not acknowledged; not present if acknowledged, and checked in other lists)

Click  to see additional detail:

- The date and time when the issue was detected
- The date and time when the issue was resolved, if applicable
- A more detailed description of the problem, if available
- One or more recommended actions to resolve the problem, if applicable
- A **View on System** link to view component details, for certain types of events

To acknowledge an alert, click **Acknowledge**. If the alert is resolved then the entry is removed from the Alerts to Acknowledge table and will only display in the History table. Unresolved alerts will remain in the Health Alerts or Information Alerts list until they are resolved.

To acknowledge all alerts, click **Acknowledge All Alerts** in the Alerts to Acknowledge table. This will remove all current alerts from the list and place them in the History table. Unresolved alerts will remain in the Health Alerts or Information Alerts list until they are resolved.



Click **History** to view a scrollable, read-only log of conditions that have caused the system to generate alerts. Use it to identify components that repeatedly cause alerts. This information can provide valuable troubleshooting information to end users and support personnel. Historical alerts remain in the History table until it reaches its threshold limit of 512. When it does, it begins to wrap.

Capacity panel


Use the Capacity panel to monitor storage usage trends at the disk group and volume level.

Compact view

The compact view on the dashboard shows a capacity graph for each configured pool. Each capacity graph uses a segmented radial bar. The radial bar segments are color-coded as follows:

Color	Represents
	Pool space that is allocated to volumes in the pool.
	Unallocated pool space that remains available to the system.

Text labels on each capacity graph identify the pool and report metrics for capacity use and availability.

Click the  icon to see the expanded view.

Expanded view

The expanded view shows:

- System level counts of volumes, snapshots, and disks that are in use versus system configuration limits.
- For each configured pool, the panel shows:
 - The capacity graph, with a link to view the I/O workload.
 - Counts of volumes and snapshots that are in use in that pool versus system configuration limits.
 - A pool allocation graph, with color-coding defined on-screen. Pool allocation is represented as a segmented horizontal bar. Text labels on the pool allocation graph report metrics for volume allocated, snapshot allocated, total committed pool allocation, and unused capacity.
 - A tiering capacity graph, with color-coding defined on-screen. Tiering capacity is represented as a segmented horizontal bar. Text labels on the tiering capacity graph report metrics for allocated and available capacity on each available tier.
- Volumes for each pool defined (click the arrow to expand the row). For each configured volume, the panel shows:
 - A filtering field with drop-down selection.
 - A table providing data for each volume: name, attached hosts, creation date, tree size, and capacity utilization.

Performance panel


Use the Performance panel to monitor system performance and statistics.

Compact view

The compact view on the dashboard shows consolidated metrics for up to eight graphs selected as favorites in the expanded view. By default, three graphs are shown: System IOPS (read and write), System Latency (read and write), and

System Throughput (read and write).


NOTE Compact view does not display live metrics. If the Live option is selected in the expanded view, the graphs in the compact view display the most recent historical data for the last four hour period.

Click the  icon to see the expanded view.

Expanded view

The expanded view shows more detailed information and provides options to view metrics within a select time range, add graphs, configure existing graphs, and to select up to eight graphs as favorites to show in the compact view. You can also choose to display live data up to the last 15 minutes.

NOTE Viewing live data is only available in the expanded view. It is not shown in compact view.

You can view and compare data-point values by hovering the cursor over the graph, which shows the values in a pop-up table. To see average and peak values for data in a graph, click the  icon.

Performance metrics

Table 9 Available performance metrics

Metric	Description	Storage object ^{1,2}				
		Controller	Host port	Pool	System	Volume
IOPS	Total —Sum of read IOPS and write IOPS. Read —Number of I/Os per second. Write —Number of I/Os second.	✓	✓	CLI	✓	✓
Throughput	Total —Sum of read bytes per second and write bytes per second. Read —Number of bytes read per second. Write —Number of bytes written per second.	✓	✓	CLI	✓	✓
Latency	Average Response time —Average response time of an operation in microseconds. Operations include both reads and writes. Total —Sum of read and write average responses in microseconds. Read Average —I/O read average response time in microseconds. Write Average —I/O write average response time in microseconds. Max Response time —Sum of read maximum response time and write maximum response time. Total —Sum of read and write maximum responses in microseconds. Read Max —Maximum I/O read response time in microseconds. Write Max —Maximum I/O write response time in microseconds.	✓	✓	CLI	✓	✓

Table 9 Available performance metrics (continued)

Average Queue Depth	<p>Read—Average number of pending read operations being serviced since the last sampling time. This value represents periods of activity only and excludes periods of inactivity.</p> <p>Write—Average number of pending write operations being serviced since the last sampling time. This value represents periods of activity only and excludes periods of inactivity.</p>		✓	CLI		✓
Cache	<p>Read Ahead Ops—Number of times that read ahead pre-fetched data for host reads.</p> <p>Small Destages—Number of partial stripe destages. (These tend to be very inefficient compared to full stripe writes.)</p> <p>Write Cache Percent—Percentage of write cache currently being used in tenths of a percent.</p> <p>Write Cache Space—Current size of write cache in 16KB chunks.</p>	✓		CLI		✓

1—Metrics for the Pool storage object are not graphed in the SMU, but are accessible via the CLI.

2—Metrics for the System storage object are synthesized from data captured by Controller storage objects in the storage system.

Collecting performance data

View performance metrics data for a specified period by choosing an option from the **Timeframe** drop-down list. Your selection determines your viewing window.


Live performance metrics reveal the system's current performance within the last 15 minutes and are sampled every five seconds. The remaining options let you choose to display the system's historical performance up to the last eight days and are sampled every five minutes. All metrics are retained in memory on controller A regardless of whether you are logged in to the SMU.

The collection of metrics never stops, except in cases where the system gets reset. The list of metrics collected is defined for the system, and not an individual user. If one user redefines the metrics to track, all user sessions will be affected.

Controller A retains all of the metrics in memory. If controller A is restarted then all metrics will be lost. If controller B is restarted then metrics will continue to be available.

Displaying performance data


Performance metrics are displayed in graphs, allowing for easy charting, data comparison, and analysis. Data points in each graph line up from top to bottom, allowing you to easily compare data points between graphs when hovering over them.







 **TIP** Clicking on an object in the legend of a graph highlights that object's data by muting other objects.

The following options are available when in expanded view:

- Click the **Data Timeframe** dropdown to view metrics within a select time range. **Last 1 day** is the default.

NOTE Choosing **Live** refreshes the graphs every five seconds while in expanded view and displays up to the last 15 minutes of data in five second increments. Viewing live graphs can only be done in expanded view. Graphs shown in compact view reflect the data time frame selected in expanded view *except for the Live option*. If Live is selected in expanded view, static graphs covering the most recent historical data for the last four hour period display when you return to compact view.

- Click the  icon to view average and peak data values.

- Click **Add Graph** to build a graph by selecting metrics from a predefined list. Graph settings are unique to each graph. The maximum number of objects that can be included in any single graph is four (volumes, host ports, etc.). Additionally, each object can be charted up to three times in the same graph for a comparison (for example, read vs write vs total operations).
- Click the  icon to designate performance metric favorites (displayed in compact view). Default favorites include System IOPS, System Throughput, and System Latency (displaying both Read/Write).
- Click the  or  icon to move the graph up or down in the display.
- Click the  icon to access the graph's configuration options.
- Click the  icon to download historical performance metrics in CSV format.
- Click the  icon to remove the graph from view. (The graph can be re-added if needed.)

The system retains historical data for one week, or since the last controller restart if that is more recent. By default, the graphs show the latest 100 data points. If a time range or count of samples returns more than 100 data points, then adjacent data samples will be combined until at most 100 data points for the time range or count exist. These combined data points will then be graphed.

Activity panel

Use the Activity panel to monitor system activities that are currently running, those that are scheduled, and those that have been recently completed. Activities include Scheduled Tasks, Jobs, and Utilities.


Compact view

The compact view on the dashboard shows the most recent system activities that are in progress, are scheduled, or have completed:

- **In Progress:** Activities that have started but are not yet complete. This includes disk-group jobs such as initialization and scrub, and long-running application activities such as replicating volumes. A progress bar shows status using green fill and text reporting percentage complete.

NOTE The SMU uses the last 1000 events to display the activity progress. If a long-running application activity start event is not found, it will report **Timestamp Unavailable**.

- **Scheduled:** Activities that users have scheduled to run. This includes enabling and disabling disk spin down (DSD); taking and resetting snapshots; copying volumes; and replicating volumes.
- **Recent:** System activities and user actions that have already completed. For example, a disk-group scrub job completed or a volume was deleted.

Click the  icon to see the expanded view.

Expanded view

The expanded view enables you to view In Progress, Scheduled, or Recent activities in a tabular format and act on them.

The In Progress table shows all activities that are in progress, in reverse-chronological order by start time by default. For a selected activity, based on its type, you can view extra information or configuration associated with the activity; view or modify its schedule; or perform actions such as suspending, resuming, or aborting it.

The Scheduled table shows all activities that are scheduled to run. For a selected activity, its schedule can be viewed or modified, and configuration specific to the scheduled operation can be modified.

The Recent table shows a history of activity on the system, including both successful and unsuccessful operations. Where errors occur and more information can be gathered, you can select an entry and view details.

The Filter By drop-down list enables selection of activities to display and monitor.

For tips on using tables, see ["Tips for using tables" on page 13](#).

4 Provisioning

Use the Provisioning panel to view, create, and manage volumes, hosts, replication sets, and snapshots. For more information, see:

- ["Working with volumes" below](#)
- ["Working with hosts" on page 69](#)

Working with volumes

The Volumes panel (Provisioning > Volumes) provides options to create volumes, add data protection to volumes, and to display a list of existing volumes and snapshots on the system. For information about creating volumes, see ["Creating volumes" on page 61](#).

If no pools are configured, the panel displays a prompt for you to add storage. If storage is configured, the top portion of the panel displays a color-coded graph for each pool that shows the amount of space on the system that is allocated to the base volume, allocated to snapshots, the total committed to volumes (reserved for the system but not written to), and unused space.


Volumes table



To perform an action on an existing volume or snapshot, select one or more volumes or snapshots and choose an option from the drop-down list:

- ["Deleting volumes and snapshots" on page 62](#)
- ["Attaching volumes to hosts" on page 63](#)
- ["Detaching volumes from hosts" on page 63](#)
- ["Expanding volumes" on page 63](#)
- ["Add data protection" on page 65](#)
- ["Rolling back volumes" on page 64](#)
- ["Resetting snapshots" on page 64](#)
- ["Copying volumes or snapshots" on page 64](#)



Other actions to perform on an existing volume or snapshot include:

- ["Modifying volumes" on page 62](#)
- ["Aborting a volume copy" on page 65](#)
- ["Creating snapshots" on page 64](#)

Click the volume slide-over  to view volume or snapshot details and to perform more actions on a volume or snapshot.

- The Overview tab shows volume capacity usage, volume copy activity, and lists all of the volume settings. Click the  icon to make changes to these settings. Click **Expand Volume** to expand the size of the volume. Click **Copy Volume** to copy the volume. Follow the on-screen directions for more details. For more information, see:
 - ["Copying volumes or snapshots" on page 33](#)
 - ["Cache optimization mode" on page 27](#)
 - ["Optimizing read-ahead caching" on page 27](#)
 - ["Volume tier affinity" on page 29](#)
- The Snapshot tab displays the snapshots associated with the volume, along with any associated schedules. Click the  icon to edit snapshot schedules. The Snapshot Tree table lists a hierarchical table of the snapshot tree for the selected volume. Click a volume or a snapshot of the volume, then choose an option from the drop-down list to

perform an action. Click the parent volume or snapshot, then choose **Add Data Protection** and follow the on-screen directions to create local snapshots.

- ["Rolling back volumes" on page 64](#)
- ["Deleting volumes and snapshots" on page 62](#)
- ["Resetting snapshots" on page 64](#)
- ["Copying volumes or snapshots" on page 64](#)
- The Attached Hosts tab displays a table listing the hosts attached to the selected volume or snapshot and lets you attach the volume or snapshot to a host or host group. Hover over icons in the list to see more information. Click the  icon to edit permissions, LUN IDs, and ports. The table shows the following information about each attached host:
 - Name. The name of the attached host.
 - Discovered. Shows if the host is currently logged into the system.
 - Redundant. Shows if the host is logged into both controllers of the system.
 - Mapped. Shows if the volume is presented to both controllers.
 - Permissions. Displays the volume access permissions.
 - LUN. Displays the ID used to identify the volume on the host.
 - Ports. Displays the ports that the LUN is presented (the default is all ports).
 - Unmap. A clickable option allowing you to detach the host from the volume.
- The Replications tab displays the replication sets associated with the volume, along with any associated schedules. Click **Add Data Protection** to access the Data Protection Configuration wizard; click **Start Replication**, **Suspend Replication**, or **Remove Replication** to perform the action; click the  icon to edit replication schedules and replication details. For more information about replications, see ["Replication" on page 41](#) and ["Add data protection" on page 65](#).


For more information about hosts and initiators, see ["Initiators, hosts, and host groups" on page 29](#). For more information about replications, see ["Replication" on page 41](#) and ["Add data protection" on page 65](#).


Data Protection table

Click **Data Protection** in the Volumes table (Provisioning > Volumes) to display a list of existing volumes on the system that are protected by a replication set or a snapshot. Click **Add Data Protection** to access the Data Protection Configuration wizard to protect your volumes using remote replication or local snapshots. To perform an action on one or more volumes in the table, select the volumes and then choose an option from the drop-down list:


NOTE Some options require that only one volume is selected.

- ["Rolling back volumes" on page 64](#)
- ["Resetting snapshots" on page 64](#)
- ["Add data protection" on page 65](#)
- ["Deleting volumes and snapshots" on page 62](#)
- ["Copying volumes or snapshots" on page 64](#)

Click the slide-over  to perform more actions on a volume or snapshot.



- The Overview tab displays the volume settings. Click the  icon to make changes to these settings. Click **Copy Volume** to copy the volume. Follow the on-screen directions for more details.

NOTE Snapshots cannot be expanded.

- The Snapshots tab displays the snapshots associated with the volume, along with any associated schedules. Click the  icon edit snapshot schedules. The Snapshot Tree table lists a hierarchical view of the snapshots for the selected volume. Click a snapshot, then choose **Add Data Protection** and follow the on-screen directions to create local snapshots, or choose an option from the drop-down list to perform an action:

- ["Rolling back volumes" on page 64](#)
- ["Deleting volumes and snapshots" on the next page](#)
- ["Resetting snapshots" on page 64](#)
- ["Copying volumes or snapshots" on page 64](#)

! **IMPORTANT** When creating a snapshot, you will be prompted to set a snapshot schedule. This is the only place where you can schedule a snapshot using the SMU. If you do not set a snapshot schedule when prompted, you will be unable to do so using the SMU after the snapshot is created. For information about creating a snapshot schedule using the `set schedule` CLI command, see the CLI Reference Guide.

- The Attached Hosts tab displays a table listing the hosts attached to the selected volume or snapshot and lets you attach the volume or snapshot to a host or host group. Hover over icons in the list to see more information. Click the  icon to edit permissions, LUN IDs, and ports. The table shows the following information about each attached host:
 - Name. The name of the attached host.
 - Discovered. Shows if the host is currently logged into the system.
 - Redundant. Shows if the host is logged into both controllers of the system.
 - Mapped. Shows if the volume is presented to both controllers.
 - Permissions. Displays the volume access permissions.
 - LUN. Displays the ID used to identify the volume on the host.
 - Ports. Displays the ports that the LUN is presented (the default is all ports).
 - Unmap. A clickable option allowing you to detach the host from the volume.
- The Replications tab displays the replication set associated with the volume, along with any associated schedules. If there is no existing replication set for the volume, click **Add Data Protection** to access the Data Protection Configuration wizard; if there is a replication set for the volume, click **Start Replication**, **Suspend Replication**, or **Remove Replication** to perform the action; click the  icon to edit any replication schedules and replication details. For more information about replications, see ["Replication" on page 41](#) and ["Add data protection" on page 65](#).

NOTE Selecting **Start Replication** or **Remove Replication** will begin the action without any warning.

See the following topics for more information:

- ["Snapshots" on page 32](#)
- ["Volumes" on page 26](#)
- ["Replication" on page 41](#)
- ["Initiators, hosts, and host groups" on page 29](#)
- ["Copying volumes or snapshots" on page 33](#)
- ["Data protection with a single controller" on page 50](#)

Creating volumes

Click **Create Volumes** (Provisioning > Volumes) to open the Create Volumes wizard to add volumes to a pool. The top portion of the panel displays a color-coded graph for each pool on the system. The graph indicates the amount of space on the system that is allocated to volumes; the total volumes committed (reserved for the system but not written to); the

space occupied by added volumes; the space required for the new volume you are creating; unused space; and the space that is overcommitted if the Pool Overcommit setting is enabled.

Follow the on-screen directions to create one or more new volumes to add them to the table. Fields with a red asterisk are required. Choose **Continue** when you finish creating volumes. The wizard prompts you to attach the volume to a host or host group, or allows you to create the volumes and attach hosts or host groups later. Choose the former option to attach the volumes to new or existing hosts or host groups. Choose the latter option to create volumes that are not attached to hosts or host groups. New volumes are listed in the Volumes table.

You can create an individual volume or multiple volumes.

For more information, see:

- ["Volumes" on page 26](#)
- ["Initiators, hosts, and host groups" on page 29](#)


NOTE Volume sizes are aligned to 4.2-MB (4-MiB) boundaries. When a volume is created or expanded, the resulting size will be decreased to the nearest 4.2-MB boundary. For the maximum volume size supported by the system, see ["System configuration limits" on page 134](#).

Modifying volumes

Change the volume settings from the Volumes table (Provisioning > Volumes) by selecting the volume's slide-over to access the Overview panel. Here you can expand volumes, copy volumes, modify the volume name, and select cache setting options and tier affinity settings. If the volume is not a snapshot or a secondary volume involved in replication, you can expand the volume size.

For more information, see:

- ["Volume cache options" on page 26](#)
- ["Volume tier affinity" on page 29](#)


 **CAUTION** Only change the volume cache settings if you fully understand how the host operating system, application, and host adapter move data so that you can adjust the settings accordingly.

Deleting volumes and snapshots

You can delete volumes and snapshots from the:

- Volumes table (Provisioning > Volumes)
- Data Protection table (Provisioning > Volumes > Data Protection)
- Snapshots panel (Provisioning > Volumes > slide-over > Snapshots)

From the slide-over you can only delete the selected volume (the volume for which the slide-over is opened) and its children. Clicking the slide-over for the base volume enables deleting the entire tree.

 **CAUTION** Deleting a volume or snapshot removes its host attachments and schedules and deletes its data.

Select a volume or snapshot, then choose **Delete Volumes** from the drop-down list. Follow the on-screen directions to complete the action. The following rules apply:

- You can select from 1-100 items (volumes, snapshots, or both) to delete.
- You cannot delete a volume that is part of a replication set.
- Ensure that hosts are not accessing the volumes or snapshots to be deleted.

NOTE To delete a volume with child snapshots, delete all of the child snapshots first.

NOTE To delete a volume that is part of a replication set, delete the replication set first.

Attaching volumes to hosts

Attach volumes to hosts from the:

- Volumes table (Provisioning > Volumes). Select the volume and choose **Attach to Hosts** from the drop-down list. Follow the on-screen directions to complete the action.
- Attached Hosts panel (Provisioning > Volumes > slide-over > Attached Hosts)
Follow the on-screen directions to complete the action.

NOTE From the slide-over you can only attach the selected volume (the volume for which the slide-over is opened).

Detaching volumes from hosts

You can detach volumes from hosts from the:

- Volumes table (Provisioning > Volumes). Select a volume from the Volumes table and choose **Detach from Hosts** from the drop-down list.
- Attached Hosts panel (Provisioning > Volumes > slide-over > Attached Hosts > unmap)
- Data Protection table (Provisioning > Volumes > Data Protection > slide-over > Attached Hosts > unmap)
Follow the on-screen directions to complete the action.

NOTE From the slide-over you can only detach the selected volume (the volume for which the slide-over is opened).

Expanding volumes

You can expand the size of a volume from the:

- Volumes table (Provisioning > Volumes). Select the volume and choose **Expand Volumes** from the drop-down list.
- Overview panel (Provisioning > Volumes > slide-over > Overview > Expand Volume)
- Data Protection table (Provisioning > Volumes > Data Protection > slide-over > Overview > Expand Volume)
Follow the on-screen directions to complete the action.

NOTE From the slide-over you can only expand the selected volume (the volume for which the slide-over is opened).

The top portion of the panel displays a color-coded graph for each pool on the system. The graph indicates the amount of space on the system that is allocated to volumes; the total volumes committed (reserved for the system but not written to); the space occupied by added volumes; the space required for the new volume you are creating; unused space; and the space that is overcommitted if the Pool Overcommit setting is enabled.

Volume sizes are aligned to 4.2-MB (4-MiB) boundaries. When a volume is created or expanded, the resulting size will be decreased to the nearest 4.2-MB boundary.

NOTE If overcommitting the physical capacity of the system is enabled, the system will warn you via alerts (and event 462) before the pool runs out of physical storage.

NOTE You can expand the base volume of a snapshot tree, but you cannot expand any snapshots in the tree.

Rolling back volumes

You can replace the data of a source volume or snapshot with the data of a snapshot that was created from it by accessing the:

- Volumes table (Provisioning > Volumes)
- Data Protection table (Provisioning > Volumes > Data Protection)
- Snapshots panel (Provisioning > Volumes > slide-over > Snapshots)

Select the volume or snapshot, then choose **Rollback Volumes** from the drop-down list. Follow the on-screen directions to complete the action.

NOTE Volumes protected by a snapshot have a  icon under Protection type on the Data Protection tab.

For more information, see "[Snapshots](#)" on page 32.

Creating snapshots

You can create snapshots of a volume by accessing the:

- Volumes table (Provisioning > Volumes), selecting the volume, and choosing **Add Data Protection** from the drop-down list.
- Volumes table (Provisioning > Volumes > Data Protection > Add Data Protection)
- Snapshots panel (Provisioning > Volumes > slide-over > Snapshots)

Follow the on-screen directions to complete the action. For more information about snapshots, see "[Snapshots](#)" on page 32.

Resetting snapshots

You can replace the data of a standard snapshot with the current data from its parent volume by accessing the:

- Volumes table (Provisioning > Volumes)
- Volumes table (Provisioning > Volumes > Data Protection)
- Snapshots panel (Provisioning > Volumes > slide-over > Snapshots)

Select the volume and choose **Reset Snapshot** from the drop-down list. Follow the on-screen directions to complete the action.

NOTE Any snapshot in a snapshot tree can be reset, but the data source can only be the snapshot's immediate parent. The snapshot's volume characteristics are not changed.

Copying volumes or snapshots

You can copy a volume or snapshot to a new volume by accessing the:


- Volumes table (Provisioning > Volumes)
- Volumes table (Provisioning > Volumes > Data Protection)

- Overview panel (Provisioning > Volumes > slide-over > Overview)
- Snapshots panel (Provisioning > Volumes > slide-over > Snapshots)

Select the volume and choose **Copy Volume** from the drop-down list. Follow the on-screen directions to complete the action. For more information, see ["Copying volumes or snapshots" on page 33](#).

NOTE You must detach the volume before copying it.

Aborting a volume copy


You can abort a volume copy operation (Provisioning > Volumes) by selecting the slide-over of the volume being copied. In the Overview panel, click the  icon next to the progress indicator. Follow the prompts to abort the operation.

Add data protection

Choosing **Add Data Protection** opens the Data Protection Configuration wizard where you are led through the process of adding data protection to a selected volume by either creating local snapshots or creating a remote replication set. The options that display in the wizard are dependent upon how the wizard is accessed:

- Provisioning > Volumes > menu list > Add Data Protection
- Provisioning > Volumes > Data Protection > Add Data Protection
- Provisioning > Volumes > slide-over > Snapshots
- Provisioning > Volumes > slide-over > Replications

Follow the on-screen directions to complete the action.

 **IMPORTANT** When creating a remote replication or local snapshots, you will be prompted to set a schedule. This is the only place where you can set either a replication or snapshot schedule using the SMU. If you do not set a schedule when prompted, you will be unable to do so using the SMU after the replication set or snapshot is created. For information about creating a schedule using the `create schedule` CLI command, see the CLI Reference Guide.

See the following topics for more information:

- ["Replication" on page 41](#)
- ["Snapshots" on page 32](#)
- ["Modifying a replication set" on the next page](#)
- ["Deleting a replication set" on the next page](#)
- ["Initiating or scheduling a replication" on page 67](#)
- ["Aborting a replication set" on page 68](#)
- ["Suspending a replication" on page 68](#)
- ["Resuming a replication" on page 68](#)
- ["Managing replication schedules" on page 69](#)

Creating a replication set


Choosing **Add Data Protection** opens the Data Protection Configuration wizard where you are led through the process of creating a replication set for a selected volume. The options that display in the wizard are dependent upon how the wizard is accessed:

- Provisioning > Volumes > menu list > Add Data Protection
- Provisioning > Volumes > Data Protection > Add Data Protection
- Provisioning > Volumes > slide-over > Replications

Follow the on-screen directions to complete the action.

! **IMPORTANT** When creating a remote replication, you will be prompted to set a replication schedule. This is the only place where you can schedule a replication set using the SMU. If you do not set a replication schedule when prompted, you will be unable to do so using the SMU after the replication set is created. For information about creating a schedule using the `create schedule` CLI command, see the CLI Reference Guide.

Modifying a replication set

You can modify a replication set's name, queue policy, snapshot history settings, and associated schedules (Provisioning > Volumes) by selecting the slide-over to access the Replications panel. Click the  icon next to the options you want to modify in the Replication Details section.

NOTE Modifying a replication set's name does not affect the schedule.

TIP

- If you change the Snapshot Base Name while a replication is running, for the current replication it will affect the name of the snapshot on the secondary system. For that replication only, the names of the snapshots on the primary and secondary systems will differ.
 - If you reduce the snapshot count setting to a value less than the current number of snapshots, the operation will fail. Thus, you must manually delete the excess snapshots before reducing the snapshot count setting. If you change this parameter while a replication is running, for the current replication it will affect only the secondary system. In this case the value can only be increased, so you might have one less expected snapshot on the primary system than on the secondary system.
-

See the following topics for more information:

- ["Queuing replications" on page 45](#)
- ["Maintaining replication snapshot history" on page 46](#)

Deleting a replication set

You can delete a replication set (Provisioning > Volumes) by selecting the slide-over to access the Replications panel. Click **Remove Replication**. The replication set is deleted.

When you delete a replication set, all infrastructure created by the system (internal snapshots required to support replications) is also deleted. The primary and secondary volumes no longer have restrictions and function like all other base volumes and snapshots.

If you want to delete a replication set that has a replication in progress, you must first suspend, and then abort, the replication for that replication set. When a replication set is deleted, the snapshots created from the snapshot history feature will not be deleted; however, the schedule for the replication set will be deleted if one had been created. You will be able to manage those snapshots like any other snapshots.

For more information, see:

- ["Aborting a replication set" on page 68](#)
- ["Suspending a replication" on page 68](#)
- ["Maintaining replication snapshot history" on page 46](#)

NOTE If the peer connection is down and there is no communication between the primary and secondary systems, use the `local-only` parameter of the `delete replication-set` CLI command on both systems to delete the replication set. For more information, see the CLI documentation.

Initiating or scheduling a replication

After you have created a replication set, you can copy the selected volume on the primary system to the secondary system by initiating replication (Provisioning > Volumes). Select the slide-over to access the Replications panel, and then click **Start Replication**.

- If a replication is not in progress, the local system begins replicating the contents of the replication set volume to the remote system and a progress bar indicates the status of the replication set.
- If a replication set is already in progress, then the outcome of this replication request depends on the Queue Policy setting specified. For more information on setting the queue policy, see ["Queuing replications" on page 45](#).

The first time that you initiate replication, a full copy of the allocated pages for the volume is made to the secondary system. Thereafter, the primary system only sends the contents that have changed since the last replication.

You can manually initiate replication after you create a replication set. You can create a scheduled task to automatically initiate replication from the Data Protection Configuration wizard when you create the replication set. You can initiate replications and manage replication schedules only from a replication set's primary system.

! **IMPORTANT** When creating a remote replication, you are prompted to create a replication schedule. This is the only time where you can schedule a replication set using the SMU. If you do not set a replication schedule when prompted, you will be unable to do so in the SMU after the replication set is created. For information about creating a schedule using the `create schedule` CLI command, see the CLI Reference Guide.

NOTE If you change the time zone of the secondary system in a replication set whose primary and secondary systems are in different time zones, you must reset the secondary system to enable management interfaces to show proper time values for replication operations, such as the start, end and estimated completion replication times. To reset the time values, log into one of the controllers on the secondary system, and restart only one of Storage Controllers using either the `restart sc a` or `restart sc b` CLI command.


If a replication operation encounters a problem, the system suspends the replication set. The replication operation will attempt to resume if it has been more than 10 minutes since the replication set was suspended. If the operation has not succeeded after six attempts using the 10-minute interval, it will switch to trying to resume if it has been over an hour and the peer connection is healthy.

NOTE Host port evaluation is done at the start or resumption of each replication operation.



- At most, two ports will be used.
 - Ports with optimized paths will be used first. Ports with unoptimized paths will be used if no optimized path exists. If only one port has an optimized path, then only that port will be used.
 - Ports with both paths optimized will share the replication traffic between the two ports. The amount of replication traffic each port moves is dependent upon other operations occurring on each port.
 - The replication will not use another available port until all currently used ports become unavailable.
-

NOTE If a single host port loses connectivity, event 112 will be logged. Because a peer connection is likely to be associated with multiple host ports, the loss of a single host port may degrade performance but usually will not cause the peer connection to be inaccessible. For more information see the Event Descriptions Reference Guide.

Suspending a replication


You can suspend replication operations for a specified replication set (Provisioning > Volumes) by selecting the slide-over to access the Replications panel. If the replication is in progress, click the  icon next to the progress indicator. If the replication is in an unsynchronized or ready state, click **Suspend Replication**.

You can suspend replications only from a replication set's primary system.

When you suspend a replication set, all replications in progress are paused and no new replications are allowed to occur. The replication set will stay in a suspended state until you resume it by clicking the  icon, or abort it by clicking the  icon. Resuming the replication set continues the replications that were in progress and allows new replications to occur. Aborting the replication set cancels the replication. For more information, see ["Aborting a replication set" below](#) or ["Resuming a replication" below](#).

If replications are attempted while the operation is suspended, such as manual or scheduled replications, the replications will fail.


Aborting a replication set

Aborting a replication set cancels the replication. You can abort running or suspended replication operations for a specified replication set (Provisioning > Volumes) by selecting the slide-over to access the Replications panel. Click the  icon next to the progress indicator.

You can abort replications only from a replication set's primary system.

NOTE If you abort the initial replication for a replication set, the snapshot space allocated for that replication in the primary pool and the secondary pool will not be freed. To free that space, either re-run the initial replication or delete the replication set.



Resuming a replication


You can resume the replication operations of a specified suspended replication set (Provisioning > Volumes) by selecting the slide-over to access the Replications panel. Click the  icon next to the progress indicator.

You can resume replications only from a replication set's primary system.

When a replication set is suspended, all replications in progress are paused and no new replications are allowed to occur. When you resume replications, all paused replications are resumed and new replications are allowed to occur depending on the queue policy setting. For more information on setting the queue policy, see ["Queuing replications" on page 45](#).

Managing replication schedules

You can modify or delete scheduled replication tasks from the primary system (Provisioning > Volumes) by selecting the slide-over to access the Replications panel. Click the  icon in the Replication Schedules table and follow the on-screen directions to modify the schedule. Click the  icon to delete the schedule.

 **IMPORTANT** This option is unavailable if a replication set schedule is not defined. See ["Add data protection" on page 65](#) for more information.


Working with hosts

The Hosts panel (Provisioning > Hosts) provides options to create hosts and host groups, display a list of existing hosts, host groups, and initiators that are a part of an existing host or host group, and display a list of all initiators. For more information about creating hosts, see ["Creating hosts" below](#). To perform an action on an existing host or host group, select one or more hosts, host groups, or initiators from the table and then choose an option from the drop-down list:


- ["Attaching hosts to volumes" on the next page](#)
- ["Detaching hosts from volumes " on the next page](#)
- ["Removing initiators from a host" on the next page](#)
- ["Removing hosts from a host group" on the next page](#)
- ["Adding hosts to a host group" on the next page](#)
- ["Deleting hosts" on the next page](#)
- ["Deleting host groups" on page 71](#)

Other actions to take on this tab include:

- ["Renaming hosts" on page 71](#)
- ["Changing a host profile" on page 71](#)
- ["Renaming host groups" on page 71](#)
- ["Renaming initiators" on page 71](#)

Click the  icon to expand the host row to see initiator details. Select a host or initiator to perform an action from the drop-down list.

Click the host slide-over to view the Overview tab, where you can edit the name of the host and nickname of each initiator. Click the **Attached Volumes** tab to see information about attached volumes, attach a volume to the host, and to unmap volumes from the host. Follow the on-screen directions for more details.

Click the initiator slide-over  to view the Overview tab and see initiator details. Click the **Attached Volumes** tab to see information about volumes attached to the initiator.

Click the **All Initiators** tab to display a list of existing initiators on the system. To perform an action, select one or more initiators from the table and then choose an option from the drop-down list:

- ["Adding initiators to a host" on page 71](#)
- ["Removing initiators from a host" on the next page](#)

For more information about hosts and initiators, see ["Initiators, hosts, and host groups" on page 29](#).

Creating hosts

Click **Create Hosts** (Provisioning > Hosts) to open the Create Hosts wizard to create hosts and host groups from existing initiators. Follow the on-screen directions to create one or more new hosts and attach those hosts or host groups to initiators. Fields with a red asterisk are required. The wizard prompts you to create a new host or host group, add

initiators, and create or select a volume to attach to the host or host group. All selected volumes will be attached to the newly created host.

NOTE If you have a small monitor, you may have to scroll to the bottom of the wizard to see all of the available options.

For more information about volumes, see ["Volumes" on page 26](#). For more information about hosts, host groups, and initiators, see ["Initiators, hosts, and host groups" on page 29](#).

Attaching hosts to volumes

Attach hosts to volumes from the Hosts table (Provisioning > Hosts) by selecting the host and choosing **Attach Volumes** from the drop-down list or from the Attached Volumes panel (slide-over > Attached Volumes). Follow the on-screen directions to complete the action.

Detaching hosts from volumes

Detach hosts from volumes from the Hosts table (Provisioning > Hosts) by selecting the host and choosing **Detach Volumes** from the drop-down list or from the Attached Volumes panel (slide-over > Attached Volumes). Follow the on-screen directions to complete the action.

Removing initiators from a host

You can remove initiators from a host or host group from the Hosts table (Provisioning > Hosts > All Initiators) by selecting the initiator and choosing **Remove From Host** from the drop-down list. Follow the on-screen directions to complete the process. Removing an initiator from a host will ungroup the initiator, but will not delete it or change its mapping. This action is disabled if:

- The selected initiator is the only one attached to the host. You must delete the host to free up in the initiator.
- The selected initiator is not currently attached to a host.

Removing hosts from a host group

You can remove hosts from a host group (Provisioning > Hosts) by selecting the host from the Hosts table and choosing **Remove From Host Group** from the drop-down list. Follow the on-screen directions to complete the process.

Removing a host from a host group will ungroup the host, but will not delete it or change its mapping. To delete a host group, see ["Deleting host groups" on the facing page](#).

Adding hosts to a host group

You can add hosts to a new or existing host group from the Hosts table (Provisioning > Hosts) by selecting the host or host group and choosing **Add to Host Group** from the drop-down list. Follow the on-screen instructions to complete the process. Keep the following rules in mind when adding hosts to a host group:

- The host must be attached with the same access, port, and LUN settings to the same volumes as every other host in the host group.
- A host group can contain a maximum of 128 hosts.

Deleting hosts

You can delete hosts that are not grouped (Provisioning > Hosts) by selecting the host from the Hosts table and choosing **Delete Host** from the drop-down list. Follow the on-screen directions to complete the process.

Deleting a host will ungroup its initiators, but they will still be visible if they are physically connected to the system. The host will detach from any attached volumes and the host device will lose access to all volume data.


Deleting host groups

You can delete host groups (Provisioning > Hosts) by selecting the host group from the Hosts table and choosing **Delete Host Group** from the drop-down list. Follow the on-screen directions to complete the process.


Deleting a host group will ungroup the hosts from the group but will not delete them. You will lose access to any volumes that were attached to the host group. You will retain access to any volumes that were attached to hosts in the group.

Adding initiators to a host


You can add existing initiators to an existing host from the Hosts table (Provisioning > Hosts > All Initiators) by selecting the initiator and choosing **Add to Existing Host** from the drop-down list. Follow the on-screen directions to complete the process. Keep the following rules in mind when adding initiators to a host:

- The initiator must be attached with the same access, port, and LUN settings to the same volumes as every other initiator in the host. An initiator must be named (nicknamed) to be added to a host; if it is not already named, a default name will be assigned. Click the initiator slide-over  to edit/add an initiator nickname.
- A host can contain a maximum of 128 initiators.


Renaming hosts

You can rename hosts from the Overview panel (Provisioning > Hosts > Hosts and Host Groups > slide-over). Click  next to the hostname to modify it.


Changing a host profile


You can change the profile for the initiators of hosts from the Overview panel (Provisioning > Hosts > Hosts and Host Groups > slide-over). Click  within the Hosts table, then choose an option from the Profile drop-down menu.

Renaming host groups

You can rename host groups from the Overview panel (Provisioning > Hosts > Hosts and Host Groups > slide-over). Click  next to the host group name to modify it.

Renaming initiators

You can rename initiator nicknames from the Overview panel (Provisioning > Hosts > Hosts and Host Groups > slide-over). Click  next to the initiator name to modify it.

You can also edit an initiator nickname from (Provisioning > All Initiators > slide-over). Click  next to the initiator name to modify it.

5 Settings

Use the Settings panel to view and manage system configuration settings, including:

- ["Network settings" below](#)
- ["User settings" on page 75](#)
- ["System settings" on page 78](#)
- ["Notification settings" on page 81](#)
- ["Configuring iSCSI host port settings " on page 82](#)
- ["Peer connection settings" on page 83](#)

Access the panel by choosing the applicable option from the Settings menu pane.

Network settings

The Network panel (Settings > Network) provides options for you to configure IPv4 and IPv6 network-port settings, configure a DNS server, enable or disable system management services, and view certificates.

- ["Configuring controller network ports" below](#)
- ["Configuring DNS settings" on the facing page](#)
- ["Enabling or disabling system-management services" on page 74](#)
- ["Viewing certificate information" on page 75](#)

Configuring controller network ports

The system provides concurrent support for IPv4 and IPv6 protocols. Both protocols can be set up at the same time by configuring the network parameters.

You can manually set static IP address parameters for network ports, or you can specify that IP values be set automatically, using DHCP (Dynamic Host Configuration Protocol) for IPv4 or DHCPv6 or SLAAC (Stateless address auto-configuration) for IPv6.

NOTE SLAAC relies on Neighbor Discovery Protocol (NDP), and is the simplest way to provide an IPv6 address to a client.

If (Settings > Network > IPv6 > (controller A|B) > Source > Auto) is selected, the system will use an automated method—defined via the network configuration: which could be DHCPv6 or SLAAC—to auto-configure the address. The Auto setting presents a single IPv6 address. If a DHCPv6 address is available, DHCPv6 will provide the interface address; otherwise, the SLAAC address will be used.

When setting IP address values, you can choose IPv4 formatting, IPv6 formatting, or both for each controller. Additionally, you can set the addressing mode and IP address version differently for each controller and use them concurrently. For example, you could set IPv4 on controller A to Manual to enable static IP addressing, and IPv6 on controller A to Auto to enable automatic IP addressing. Given that network parameter settings are independent between the two protocols, you can set them as needed for IP addressing on controller B.

When using DHCP mode, the system obtains values for the network port IP address, subnet mask, and gateway from a DHCP server if one is available. If a DHCP server is unavailable, the system will use its default values (see bullet lists and **IMPORTANT** note provided in the next paragraph). You must have some means of determining what addresses have been assigned, such as the list of bindings on the DHCP server. You can retrieve the DHCP assigned IP addresses either through the USB serial console login page, which lists IPv4 and IPv6; via CLI commands; or from the DHCP server list of

MAC address to IP address leases. When using Auto mode, addresses are retrieved from both DHCP and SLAAC. DNS settings are also automatically retrieved from the network.

The factory-default IP address source is set to DHCP. When DHCP is enabled in the storage system, the following initial values are set and remain set until the system is able to contact a DHCP server for new addresses:

- Controller A IP address: 10.0.0.2
- Controller B IP address: 10.0.0.3
- IP subnet mask: 255.255.255.0
- Gateway IP address: 10.0.0.0

! **IMPORTANT** The following IP addresses are reserved for internal use by the storage system: 169.254.255.1, 169.254.255.2, 169.254.255.3, and 169.254.255.4. Because these addresses are routable, do not use them anywhere in your network.

For IPv6, when Manual mode is enabled you can enter up to four static IP addresses for each controller. When Auto is enabled, the following initial values are set and remain set until the system is able to contact a DHCPv6 and/or SLAAC server for new addresses:

- Controller A IP address: fd6e:23ce:fed3:19d1::1
- Controller B IP address: fd6e:23ce:fed3:19d1::2
- Gateway IP address: fd6e:23ce:fed3:19d1::3


⚠ **CAUTION** Changing IP address settings can cause management hosts to lose access to the storage system after the changes are applied in the confirmation step.

Once you set the type of controller network ports to use, you can configure domain names using the Domain Name Service (DNS). DNS accepts IPv4 and IPv6 address formats. For more information about the DNS feature, see "[DNS settings](#)" on page 39.

NOTE DNS settings are automatically applied when using DHCP for IPv4 and Auto for IPv6.

Configuring DNS settings

Configure domain names using DNS (Settings > Network > DNS) after setting the type of controller network ports to use (IPv4 and/or IPv6). When configuring DNS settings, note the following:

- The system supports a maximum of three DNS servers per controller.
- DNS hostnames must differ for each controller, are not case sensitive, and can have from 1 to 63 bytes. The name must start with a letter and end with a letter or digit, and can include letters, numbers, or hyphens, but no periods.
- In the DNS Servers fields for each controller, specify up to three named server addresses that are recognized within your network to be queried by the DNS resolver. The resolver will query the network in the order listed until reaching a valid destination address. Any valid setting is treated as enabling DNS resolution for the system.
- In the DNS Search Domains fields for each controller, specify up to three domain names to search when resolving hostnames that are configured in the storage system. The resolver will query the network in the order listed until finding a match.
- To reset a hostname for a controller to its default setting, click the **Reset Host Name** button for that controller.
- To clear a DNS server or search domain for a controller, click the  icon for that setting.
- To clear all configured DNS servers and search domains for a controller, click the **Clear DNS** button for that controller.

For more information about the DNS feature, see "[DNS settings](#)" on page 39.

Enabling or disabling system-management services

You can enable or disable management interface services to limit the ways in which users and host-based management applications can access the storage system. Network management services operate outside the data path and do not affect host I/O to the system. To allow specific users to access the SMU, CLI, or other interfaces, see ["User settings" on the facing page](#).

Enable the services that you want to use to manage the storage system and disable others by choosing options on the Services panel (Settings > Network > Services).

Web and API

- HTTPS. Enable the use of HTTPS to provide secure access to the SMU, the web application that is the primary interface for managing the system. By default, HTTPS is enabled.
- HTTP. Enable the use of HTTP to provide access to the SMU. By default, HTTP is disabled.

NOTE One of the above settings must be enabled to provide access to the SMU.

Command Line Interface

- SSH. Enable the use of SSH to provide secure access to the CLI, an advanced-user interface used to manage the system and to write scripts or to run scripts. By default, SSH is enabled.
- Telnet. Enable the use of Telnet to access the CLI to manage the system and to write scripts or run scripts. By default, Telnet is disabled.
- SSH Port. If you enable SSH, specify the port number to use. The default is 22.

For information about setting options to control CLI behavior—to include setting its output mode—see the `set cli-parameters` command in the CLI Reference Guide.

File Transfer Protocol

- FTP. A secondary interface for uploading firmware updates, installing a license, and downloading logs. FTP is disabled by default.
- SFTP. A secure secondary interface for uploading firmware updates, downloading logs, installing a license, and installing security certificates and keys. All data sent between the client and server will be encrypted. SFTP is enabled by default.
- SFTP Port. If you enable SFTP, specify the port number to use. The default is 1022.

Storage Management Initiative Specification

- SMI-S. Used for remote management of the system through your network. Select this check box to enable unencrypted communication between SMI-S clients and the embedded SMI-S provider in each controller module via SMI-S port 5988. Clear this check box to disable the active port and use of SMI-S. SMI-S is disabled by default.
- SMI-S Encryption. Used for remote management of the system through your network. Select this check box to enable encrypted communication, which disables SMI-S port 5988 and enables SMI-S port 5989 instead. Clear this check box to disable port 5989 and enable port 5988. This is the default.

Other Interfaces

- SNMP. Enables or disables Simple Network Management Protocol (SNMP). SNMP is used for remote monitoring of the system through your network. This is disabled by default.
- SLP. Enables or disables the Service Location Protocol (SLP) interface. SLP is a discovery protocol that enables computers and other devices to find services in a LAN without prior configuration. This system uses SLP v2. SLP is enabled by default.

Viewing certificate information

You can view controller certificate information in the Certificates panel (Settings > Network > Certificates). By default, the system generates a unique SSL certificate for each controller. For the strongest security, you can replace the default system-generated certificate with a certificate issued from a trusted certificate authority.

The Certificates panel shows information for the active SSL certificates that are stored on the system for each controller. Controller A and Controller B tabs contain unformatted certificate text for each of the corresponding controllers. The panel also shows one of the following status values as well as the creation date for each certificate:

- Customer-supplied. Indicates that the controller is using a certificate that you have uploaded.
- System-generated. Indicates that the controller is using an active certificate and key that were created by the controller.
- Unknown status. Indicates that the controller's certificate cannot be read. This situation occurs most often when a controller is restarting or certificate replacement is still in progress.

You can use your own certificates by uploading them through SFTP or by using the contents parameter of the `create certificate` CLI command to create certificates with your own unique certificate content. For a new certificate to take effect, you must restart the affected Management Controller. To restart a controller, select **Maintenance > Hardware > Front View > Restart/Shutdown System > Restart MC** and follow the on-screen instructions.

To verify that the certificate replacement was successful and the controller is using the certificate that you have supplied, make sure the certificate status is customer-supplied, the creation date is correct, and the certificate content is the expected text.

User settings

The Users panel (Settings > Users) provides options for you to manage local users, LDAP users and user groups, and SNMPv3 users. Options on this panel let you add, modify, and delete users; set user permissions; and set system preferences based on individual user profiles.

- ["Managing local users" below](#)
- ["Managing LDAP users" on the next page](#)
- ["Managing SNMPv3 users" on page 77](#)

Managing local users


The Local Users panel (Settings > Users > Local) provides options to add new users and modify system permissions for existing users. The first user that completes the onboarding process during system setup will have the manage role. A user with the manage role can add up to nine additional users (SNMPv3 users count towards this limit), modify any user, and delete any user other than the current user.

Users assigned a standard or monitor role can change their own username, password, language and temperature preference, and timeout setting. Standard and monitor users cannot change their access to user interfaces or roles, and they cannot change the settings of other users.

Manage and standard users can both access one or more of the following management interfaces: the SMU, CLI, SMI-S, or FTP and SFTP. Monitor users can only access the SMU and the CLI management interfaces.

NOTE To secure the system, each user should have a unique username and password.

Local user options

The following options are available to users with a manage or standard role when adding or modifying users. To add new users, click **Add New Users**, and to modify users click the  icon.

- Username. A username is case sensitive and can have a maximum of 29 bytes. The name cannot already exist in the system, include spaces, or include any of the following: " , < \
- Password. A password is case sensitive and can have from 8 to 32 characters. If the password contains only printable ASCII characters, then it must contain at least one uppercase character, one lowercase character, one numeric character, and one non-alphanumeric character. A password can include printable UTF-8 characters except for the following: a space or " ' , < > \
- Language. Select a display language for the user. The default is English. Installed language sets include Chinese-Simplified, Chinese-Traditional, Dutch, English, French, German, Italian, Japanese, Korean, and Spanish. The locale determines the character used for the decimal (radix) point, as shown in ["Size representations" on page 14](#). The locale setting is determined by the Language setting, which can be accessed by selecting the pencil icon for any user in the table.
- Temperature Preference. Select whether to use the Celsius or Fahrenheit scale for display of temperatures. The default is Celsius.
- Timeout. Select the amount of time that the user's session can be idle before the user is automatically signed out (from 2 to 720 minutes). The default is 30 minutes.

The following options are available to users with a manage role when adding or modifying users:

- Interfaces. Select one or more of the following interfaces:
 - WBI. Enables access to the SMU. This is the default.
 - CLI. Enables access to the command-line interface. This is the default.
 - SMI-S. Enables access to the SMI-S interface, which is used for remote management of the system through your network.
 - FTP. Enables access to the FTP interface or the SFTP interface, which can be used instead of the SMU to install firmware updates and to download logs.
- Roles. Select one or more of the following roles:
 - Manage. Enables the user to change system settings.
 - Standard. Enables the user to change system settings except for: creating or deleting local users, modifying user role and interfaces, configuring LDAP, performing write operations through FTP or SFTP, performing file uploads from the SMU (WBI), or using the CLI `restore defaults` command.
 - Monitor. Enables the user to view but not change system status and settings.

Managing LDAP users

The LDAP Configuration panel (Settings > Users > LDAP) provides options for users with a manage role to create up to five user groups to allow for different permissions and/or user preference options. User group permissions are defined by assigning roles. User group preference options include selecting interfaces, roles, language and temperature preference, and a timeout setting.

Users logging into the SMU using their LDAP credentials must authenticate using these credentials and be members of a group that is authorized to access the storage system. The username and password entered will be authenticated with local users within the system first. If local authentication fails, the username will be checked against the LDAP server(s).

Individual user preferences are not saved in the storage system for LDAP authenticated users. Any settings made to the login session are not retained after the session terminates. If the user wants to retain any preferences for the session, these must be saved as part of the user group. Any changes made to a user group will affect all members of that group.

To enable LDAP, you must select the Enable LDAP checkbox and enter the user search base, server address, and port. If the port is left blank it will default to 636. For more information about these options, see ["LDAP" on page 37](#).

LDAP user group options

As a user with the manage role, you can modify or delete any user group. As a user with only a standard or monitor role, you can change settings for the current user group with the exception of user roles and interfaces. You also cannot

change the settings of other user groups.

- User Group Name. A user group name is case sensitive and can have a maximum of 29 bytes. The name cannot already exist in the system or include any of the following: " , < \
- Interfaces. Select one or more of the following interfaces:
 - SMU. Enables access to the SMU. This is the default.
 - CLI. Enables access to the command-line interface. This is the default.
 - SMI-S. Enables access to the SMI-S interface, which is used for remote management of the system through your network.
 - FTP. Enables access to the FTP interface or the SFTP interface, which can be used instead of the SMU to install firmware updates and to download logs.
- Roles. Select one or more of the following roles:
 - Manage. Enables the user to change system settings.
 - Standard. Enables the user to change system settings except for: creating or deleting local users, modifying user role and interfaces, configuring LDAP, performing write operations through FTP or SFTP, performing file uploads from the SMU, or using the CLI `restore defaults` command.
 - Monitor. Enables the user to view but not change system status and settings.
- Language. Select a display language for the user. The default is English. Installed language sets include Chinese-Simplified, Chinese-Traditional, Dutch, English, French, German, Italian, Japanese, Korean, and Spanish. The locale determines the character used for the decimal (radix) point, as shown in ["Size representations" on page 14](#).
- Temperature Preference. Select whether to use the Celsius or Fahrenheit scale for display of temperatures. The default is Celsius.
- Timeout. Select the amount of time that the user's session can be idle before the user is automatically signed out (from 2 to 720 minutes). The default is 30 minutes.

Managing SNMPv3 users

The SNMPv3 Users panel (Settings > Users > SNMPv3) provides options to create SNMPv3 users who can either access the Management Information Base (MIB) or receive trap notifications. SNMPv3 users manage SNMPv3 security features, such as authentication and encryption.

For information about the MIB, see ["SNMP reference" on page 97](#).

NOTE The Engine ID is used to uniquely identify SNMPv3 entities. The Engine ID will be generated from the controller MAC address.

SNMPv3 user options

The following options are available to SNMPv3 users:

- Username. A username is case sensitive and can have a maximum of 29 bytes. The name cannot already exist in the system, include spaces, or include any of the following: " , < \
- Password. A password is case sensitive and can have from 8 to 32 characters. If the password contains only printable ASCII characters, then it must contain at least one uppercase character, one lowercase character, one numeric character, and one non-alphanumeric character. A password can include printable UTF-8 characters except for the following: a space or " ' , < > \
- Authentication Type. Select whether to use **MD5** or **SHA** (SHA-1) authentication, or no authentication. The default is MD5. If authentication is enabled, the password set in the Password and Confirm Password fields must include a minimum of 8 characters and follow the other SNMPv3 privacy password rules.

- Privacy Type. Select whether to use **DES** or **AES** encryption, or no encryption. The default is none. To use encryption you must also set a privacy password and enable authentication.
- Privacy Password. If the privacy type is set to use encryption, specify an encryption password. This password is case sensitive and can have from 8 to 32 characters. If the password contains only printable ASCII characters, then it must contain at least one uppercase character, one lowercase character, one numeric character, and one non-alphabetic character. A password can include printable UTF-8 characters except for the following: a space or " ' , < > \
- Trap Host Address. Specify the network address of the host system that will receive SNMP traps. The value can be an IPv4 address, IPv6 address, or FQDN.

System settings

The System panel (Settings > System) provides options for you to set system identification information, set the system date and time, secure the system using FDE, and set system properties.

- ["Setting system identification information" below](#)
- ["Setting the date and time" below](#)
- ["Securing the system with FDE" on the facing page](#)
- ["Setting system properties" on the facing page](#) (cache, disk, scrub, managed logs, and firmware)

Setting system identification information

The Identification panel (Settings > System > Identification) provides options for you to specify information to identify the system. Enter the name of the system, the name of the person or team that manages the system, the location of the system, and any additional information about the system's use or configuration. The system name is shown in the SMU browser title bar or tab and is included in notification emails. All of the information is included in system debug logs for reference by service personnel.

Setting the date and time

Set the date and time (Settings > System > Date and Time) so that entries in system logs and notifications have correct time stamps. The banner displays the system date and time in the format *year-month-day hour:minutes:seconds*.

NOTE You can also access the Date and Time panel by clicking on the date and time displayed in the banner.

It is important to set the date and time so that entries in system logs and notifications have correct time stamps. Access the Date and Time panel by clicking on the date and time displayed in the banner or by clicking Settings > System > Date and Time.

You can set the date and time manually or configure the system to use Network Time Protocol (NTP) to obtain date and time from an available network-attached server. Using NTP allows multiple storage devices, hosts, log files, and such to be synchronized. The NTP server address value can be an IPv4 address, IPv6 address, or FQDN. If NTP is enabled but no NTP server is present, the date and time are maintained as if NTP was not enabled.

NTP server time is provided in the UTC time scale, which provides several benefits:

- To synchronize the times and logs between storage devices installed in multiple time zones, set all the storage devices to use UTC.
- To use the local time for a storage device, set its time zone offset.
- If a time server can provide local time rather than UTC, configure the storage devices to use that time server, with no further time adjustment.


! **IMPORTANT** Whether NTP is enabled or disabled, the storage system does not automatically make time adjustments for Daylight Savings Time. You must make such adjustments manually by changing the time zone offset.

NOTE If you change the time zone of the secondary system in a replication set whose primary and secondary systems are in different time zones, you must restart the secondary system to enable management interfaces to show proper time values for replication operations, such as the start, end and estimated completion replication times.

Securing the system with FDE

The Full Disk Encryption panel (Settings > System > Security) provides options for you to enable FDE protection to secure all of the user data on a storage system. To secure the system, all disks must be FDE-capable.

The Security panel indicates whether or not the system is secured. To secure the system, click **Secure System** to enter a passphrase that will enable the system to write to and read from FDE-capable disks. The system uses the passphrase to generate a lock key ID that is used to secure the FDE-capable disks. If the system is unable to interpret the lock key on the FDE-capable disk, the disk's encrypted data is inaccessible.


 **IMPORTANT** Be sure to record the passphrase as it cannot be recovered if lost.

Once the passphrase is entered and confirmed, the System Status will indicate that the system is secured and the Security panel will provide options to:

- Change the passphrase. Enter a new passphrase.
- Lock the system for transport. Lock down the disks in preparation for transport. Use this option when the system will not be under your physical control.


Lock keys are generated from the passphrase and manage locking and unlocking the FDE-capable disks in the system. Clearing the lock keys and power cycling the system denies access to encrypted data on the disks. If the lock keys are cleared while the system is secured, the system will enter the FDE lock-ready state, in preparation for the system being powered down and transported.

After the system has been transported and powered up, the system and disks will enter the secured, locked state; disks will be in the `UNUSABLE` state. Pools and disk-groups will be unavailable. To restore access to encrypted data, enter the passphrase for the system's lock key ID. Disk groups will be dequarantined, pool health will be restored, and volumes will become accessible.

 **CAUTION** Do not change FDE configuration settings while running I/O. Temporary data unavailability may result, and the proper setting of lock keys from the passphrase could potentially be impacted.

Repurposing secured disks

Click **Repurpose Secured Disks** to repurpose a disk that is no longer part of a disk group. Repurposing a disk resets the encryption key on the disk, effectively deleting all data on the disk. After a disk is repurposed in a secured system, the disk is secured using the system lock key ID and the new encryption key on the disk, making the disk usable to the system. Repurposing a disk in an unsecured system removes all associated lock keys and makes that disk available to any system.

 **CAUTION** Repurposing a disk changes the encryption key on the disk and effectively deletes all data on the disk. Repurpose a disk only if you no longer need the data on the disk.

For more information about using FDE, see ["Full disk encryption" on page 48](#).

Setting system properties

Use the System Properties panel to change system cache properties, disk properties, scrub properties, managed logs properties, and firmware properties.

- ["Setting system cache properties" below](#)
- ["Setting system disk properties" below](#)
- ["Setting system scrub properties" below](#)
- ["Setting system managed logs properties" on the facing page](#)
- ["Setting partner firmware update" on the facing page](#)


! **IMPORTANT** Settings that could potentially prevent the system from detecting or recovering from failure:

- Disabling background scrub will prevent automatic detection of disk defects for disk-group members.
(Enabled by default)
- Disabling background disk scrub will prevent automatic detection of disk defects for non-disk-group members.
(Enabled by default)
- Disabling SMART (Self-Monitoring Analysis and Reporting Technology) will prevent the system from monitoring disk failures.
(Enabled by default)
- Disabling dynamic sparing will prevent the system from automatically integrating replacement disks into disk-groups.
(Enabled by default)
- Disabling auto-stall-recovery will prevent the system from automatically recovering at least one controller to continue operation when a controller stall is preventing I/O.
(Enabled by default)
- Disabling controller failure, fan failure, supercap failure, power supply failure, overtemperature failure, and notify controller will prevent changing the write-back/write-through setting when error conditions, which reference using write-back or write-through caching, are detected.
(Triggers enabled by default)

For more information about setting advanced system configuration parameters, see the `set advanced-settings` CLI command within the CLI Reference Guide.

Setting system cache properties

The Cache Properties panel (Settings > System > Properties > Cache Properties) lets you set the synchronize-cache mode, missing LUN response, host control of the system's write-back cache setting, and auto-write-through cache triggers. If you are experiencing performance issues, verify that the cache properties are set to optimize system performance. See the help tips in the panel for specific information regarding each option.

 **TIP** You can change the cache parameters for a specific volume from the Overview tab of the Volumes table (Provisioning > Volumes > slide-over). For more information on performance cache options, see the `set volume-cache-parameters` CLI command in the CLI Reference Guide.


Setting system disk properties

The Disk Properties panel (Settings > System > Properties > Disk Properties) provides options to enable disk monitoring and failure analysis (SMART); change polling frequency to alert you to temperature changes, power supply and fan status, and the presence or absence of disks; enable dynamic spare capability; and enable disk spin down (DSD). See the help tips in the panel for specific information regarding each option. For more information about dynamic spares, see ["Spares" on page 24](#).

Setting system scrub properties

The Scrub Properties panel (Settings > System > Properties > Scrub Properties) provides options to enable scrub operations to inspect and fix errors found on disks and in disk groups. HPE recommends that both of these options be

enabled. See the help tips in the panel for specific information regarding each option.


 **TIP** If scrub options are disabled, you can still scrub a selected disk group. See ["Disk-group scrub" on page 21](#).

Setting system managed logs properties

Enabling the Managed Logs feature (Settings > System > Properties > Managed Logs Properties) transfers system log files containing diagnostic data to an external log collection system for retainment. For more information, see ["Managed logs" on page 35](#). Entering an email address in the Log Destination Email text box will enable the system to attach log files to managed-log email notifications sent by the log collection system. See the help tips in the panel for specific information regarding each option.


Setting partner firmware update

When Partner Firmware Update is enabled (Settings > System > Properties > Firmware Properties), firmware on the partner controller is automatically updated when firmware on the primary controller is updated.

 **IMPORTANT** HPE recommends PFU be enabled. Disable this option only if told to do so by a service technician.

Notification settings

The Notifications panel (Settings > Notifications) provides options to send system alert notifications to users through email, SNMP trap hosts, or a remote syslog server. For more information about alerts, see ["Alerts panel" on page 53](#).

 **TIP** You should enable at least one notification service to monitor the system.

Email notifications

You can choose to be notified by email when system alerts occur. Alert notifications can be sent to a maximum of three email addresses. Weekly alerts concerning system health issues will also be sent until corrective action has been taken and the system health value has returned to OK.

Enter information in the panel's text boxes to receive alert notifications. For details about panel options, refer to the on-screen tool tips.

NOTE If the mail server is not on the local network, make sure that the gateway IP address was set in ["Configuring controller network ports" on page 72](#).

SNMP notifications

The SNMP panel provides options to send alert notifications to SNMP trap hosts. You must enable SNMP for the system to send alert notifications to SNMP users. Enter information in the panel's text boxes to receive alert notifications. For details about panel options, refer to the on-screen tool tips. See ["Enabling or disabling system-management services" on page 74](#) for more information.

Syslog notifications

The Syslog panel lets you set remote syslog notifications to allow alerts to be logged by the syslog of a specified host computer. Syslog is a protocol for sending alert messages across an IP network to a logging server. This feature supports User Datagram Protocol (UDP), but not Transmission Control Protocol (TCP). For details about panel options, refer to the on-screen tool tips.


Configuring iSCSI host port settings

Use the options in the iSCSI Host Ports panel (Settings > iSCSI > Host Ports) to reset host links and to change the iSCSI IP address, netmask, and gateway for each port on each controller. The panel includes the following options:

Reset Host Links. Making a configuration or cabling change on a host might cause the storage system to stop accepting I/O requests from that host. For example, this problem can occur after moving host cables from one HBA to another on the host. To remedy this you might need to reset controller host links (channels).

IP Address. For IPv4 or IPv6, the port IP address. For corresponding ports in each controller, assign one port to one subnet and the other port to a second subnet. Ensure that each iSCSI host port in the storage system is assigned a different IP address. For example, in a system using IPv4:

- Controller A port 1: 10.10.10.100
- Controller A port 2: 10.11.10.120
- Controller B port 1: 10.10.10.110
- Controller B port 2: 10.11.10.130

 **CAUTION** Changing IP address settings can cause data hosts to lose access to the storage system.

Netmask. For IPv4, enter the subnet mask for the assigned port IP address. The default is 255.255.255.0

Gateway. For IPv4, enter the gateway IP address for the assigned port IP address. The default is 0.0.0.0.

Default Router. For IPv6, enter the default router for the assigned port IP address. If the gateway was set for IPv4 and then ports were switched to IPv6, the default is ::IPv4-address. Otherwise, the default is :: (the short form of all zeroes).

NOTE For information about setting host parameters, see the CLI Reference Guide.


Configuring iSCSI CHAP settings

For iSCSI, you can use Challenge Handshake Authentication Protocol (CHAP) to perform authentication between the initiator and target of a login request. To perform this authentication, a database of CHAP records must exist on the initiator and target. Each CHAP record can specify one name-secret pair to authenticate the initiator only (one-way CHAP) or two pairs to authenticate both the initiator and the target (mutual CHAP). For a login request from an iSCSI host to a controller iSCSI port, the host is the initiator and the controller port is the target.

During onboarding, you are prompted to enable CHAP, add new records, and edit and delete previously defined records. When CHAP is enabled and the storage system is the recipient of a login request from a known originator (initiator), the system will request a known secret. If the originator supplies the secret, the connection will be allowed.

To enable or disable CHAP configuration settings after onboarding is complete, check or uncheck the CHAP Authentication box (Settings > iSCSI > Configuration).

Regardless of whether CHAP is enabled, you can add, delete, or edit CHAP records (Settings > iSCSI > CHAP).

 **CAUTION** Editing or deleting CHAP records may disrupt connectivity to the host using that record.


Special considerations apply when CHAP is used in a system with a peer connection, which is used in replication. In a peer connection, a storage system can act as the originator or recipient of a login request. If the originator has CHAP enabled—but the recipient does not—the originator is able to modify the peer connection to enable CHAP on the recipient. Provided the two systems have CHAP records for one another—and share the same secret—the recipient is able to authenticate the peer connection.

For more information, see:

- ["Peer connections" on page 40](#)
- ["CHAP and replication" on page 47](#)
- ["Initiators, hosts, and host groups" on page 29](#)

Changing iSCSI configuration settings

The iSCSI configuration panel (Settings > iSCSI > Configuration) provides options for you to view the system's configuration, or to alter it if the network configuration was modified. Panel options include the ability to change the IP version and to enable/disable jumbo frames to allow for larger data transfers, CHAP, and iSNS. IPv4 uses 32-bit addresses. IPv6 uses 128-bit addresses.

 **CAUTION** Use extreme caution if making iSCSI configuration changes after onboarding. Modifications will disrupt connectivity to the host and disconnect the system from the network.


Peer connection settings

The Peer Connections panel (Settings > Peer Connections) provides options to query a peer connection and to modify and delete peer connections.

Querying peer connections

You can query a peer connection to view information about systems you might use in a peer connection before creating the peer connection, or to view information about systems currently in a peer connection before modifying or deleting the peer connection. To query a system, specify a peer system IP address, then choose Query Peer Connection.

Modifying peer connection settings


Choosing the  icon from the Current Peer Connections section of the panel lets you change the name of a current peer connection or the port address of the remote system from either the local system or the remote system without changing the peer connection type or local port settings. For example, you could configure a peer connection and then move one of the peers to a different network.

Changing the peer connection name will not affect the network connection so any running replications will not be interrupted.

NOTE Changing the remote port address will modify the network connection, which is permitted only if no replications are running and new replications are prevented from running. For the peer connection, abort any running replications and either suspend its replication sets or make sure its network connection is offline. After you have modified the peer connection, you can resume replication sets. For information about modifying a peer connection between a system with MSA 1060/2060/2062 controllers and a system with MSA 1050/2050/2052 controllers, see ["Replicating between current and legacy systems" on page 47](#).

If CHAP is enabled on one system within a peer connection, be sure that CHAP is configured properly on the corresponding peer system before initiating this operation. For more information about configuring CHAP, see ["CHAP and replication" on page 47](#).

Deleting a peer connection

Choosing the  icon from the Current Peer Connections section of the panel lets you delete a peer connection if there are no replication sets that belong to the peer connection. If there are replications sets that belong to the peer connection, you must delete them before you can delete the peer connection. For more information, see ["Deleting a replication set" on page 66](#).

NOTE If the peer connection is down and there is no communication between the primary and secondary systems, use the `local-only` parameter of the `delete replication-set` CLI command to delete the replication set.

NOTE If CHAP is enabled on one system within a peer connection, be sure that CHAP is configured properly on the corresponding peer system before initiating this operation. For more information about configuring CHAP, see "[CHAP and replication](#)" on page 47.

6 Maintenance

Use the Maintenance panel to manage the system's storage configuration, hardware, and firmware. You can also view information about the storage system and perform support-related actions. See the following topics for more information.

- ["Storage panel" below](#)
- ["Hardware panel" on page 87](#)
- ["Firmware panel" on page 88](#)
- ["About panel" on page 93](#)
- ["Support panel" on page 93](#)

Storage panel

The Storage panel (Maintenance > Storage) shows the system's storage configuration, including pools, disk groups, and spares and enables you to change the configuration. To learn about pools and disk groups, see ["Pools" on page 24](#). To learn about spares, see ["Spares" on page 24](#).

A storage system can have one pool per controller module. This panel shows a Pool table for each pool, and a Spares table. In this panel you can:

- View information about a pool
- Change pool settings
- View information about disk groups in a pool
- Add a disk group to a pool
- Rename a disk group
- Delete a disk group from a pool
- Expand an MSA-DP+ disk group
- Verify a disk group
- Scrub a disk group

Viewing information about a pool



If a pool contains at least one disk group, the Pool table shows this basic information:

- Size (total capacity)
- Health
- Available (unused capacity)
- Overcommit size

Expand the pool row to see this additional information:

- Whether overcommit is enabled
- Whether the pool is overcommitted
- Low threshold, medium threshold, and high threshold values
- Pool serial number

Changing pool settings

To change pool settings, in the pool row click the  icon. For more information about each setting, click its  icon.

Viewing information about disk groups in a pool

To see information about disk groups in a pool, in a Pool table expand the Disk Groups row. For each disk group, the Disk Groups table shows this basic information:

- Name
- Level (disk-protection level)
- Type
- Health
- Number of disks
- Size
- Job (type and percent of progress)

In the disk group's slide-over panel, the Overview tab shows this information:

- The progress of any current job on the disk group
- Disk group name
- Serial number
- Chunk size
- Owner (preferred and current)
- Sector format
- Creation date
- Minimum disk size
- Active disk spin down
- Size
- Free
- Protection level
- Number of disks
- Target spare capacity (MSA-DP+)
- Actual spare capacity (MSA-DP+)
- Status


In the disk group's slide-over panel, the Disks tab shows information about each disk. Disk location is shown in the format *enclosure-number.disk-slot-number*.

Adding a disk group to a pool


In the Maintenance > Storage panel, in the pool where you want to add the disk group, click **Add Disk Group** and follow the on-screen directions.

For more information about available protection levels, see ["RAID levels" on page 18](#).

Renaming a disk group

In the Maintenance > Storage panel, locate the disk group to rename, display its slide-over panel, click the  icon, and follow the on-screen directions.

Deleting a disk group from a pool


In the Maintenance > Storage panel, locate the disk group to delete, click the  icon, and follow the on-screen directions.

Expanding an MSA-DP+ disk group

In the Maintenance > Storage panel, locate the disk group to verify, display its slide-over panel, click **Expand Disk Group**, and follow the on-screen directions.

Verifying a disk group


In the Maintenance > Storage panel, locate the disk group to verify, display its slide-over panel, click **Verify Disk Group**, and follow the on-screen directions.

To cancel verification, click the  icon.

For more information about the verify utility, see ["Disk-group verify" on page 21](#).

Scrubbing a disk group

In the Maintenance > Storage panel, locate the disk group to scrub, display its slide-over panel, click **Scrub Disk Group**, and follow the on-screen directions.

To cancel scrub, click the  icon.

For more information about the scrub utility, see ["Disk-group scrub" on page 21](#).

Hardware panel

The Hardware panel (Maintenance > Hardware) shows the system's hardware configuration, including attached enclosures and their components.

The panel has three sections:

- The top section shows basic information about each enclosure: ID, Rack number, Rack position, Disk slots (used and total).
- For the selected enclosure, the middle section shows a front view or rear view of the position of components in the enclosure. To the right of the enclosure view, a box shows the health of the selected component and available actions that pertain for that component.
- For the selected enclosure or component, the bottom section shows additional information.

This table lists available actions for a given device.

View	Device	Available actions
Front or Rear	Enclosure	Restart/shutdown system
		Rescan all disks
		Turn on locator LED
Front	Disk (healthy)	Turn on locator LED
	Disk (leftover)	Turn on locator LED
		Clear disk metadata
Rear	Power supply	None
	Controller module	Turn on locator LED
	Host port	Reset host port
	Network port	None
	Expansion port	None

This table lists the information shown for a given device.

Device	Information shown
Enclosure	Enclosure ID, Status, Vendor, Model, Disk count, WWN, Midplane serial number, Revision, Part number, Manufacturing date, Manufacturing location, EMP A revision, EMP B revision, EMP A bus ID, EMP B bus ID, EMP A target ID, EMP B target ID, Midplane type, Enclosure power (watts), PCIe 2-capable
Disk	Location, Serial number, Usage, Description, Size, Status, R/min (RPM), Vendor, Model, Revision, Power on hours, Sector format, Transfer rate, Smart, Disk spin down count, FDE state, FDE lock key
Power supply	Status, Vendor, Model, Serial number, Revision, Location, Part number, Manufacturing date, Manufacturing location
Controller module	Controller ID, IP Address, Description, Status, Model, Serial number, System cache memory, Revision, CPLD version, Storage Controller version, Storage Controller CPU type, Part number, Position, Hardware version, Manufacturing date, Manufacturing location
FC host port	Name, Port type, Status, Topology, Configured speed, Actual speed, Primary loop ID, Target ID, SFP status, Part number, Supported speeds
iSCSI host port	Name, Port type, Status, Gateway, Netmask, MAC address, IP address, IP version, ID, SFP status, Part number, Configured speed, Actual speed, 10G Compliance, Cable length, Cable technology, Ethernet compliance
SAS host port	Name, Port type, Status, Actual speed, Topology, Expected lanes, Active lanes, Disabled lanes, ID
Network port	ID, IPv4 address mode, IPv4 address, IPv4 network mask, IPv4 gateway, MAC address, IPv6 auto config, IPv6 gateway, IPv6 auto address, IPv6 manual address (1 to 4)
Expansion port	Enclosure ID, Controller ID, Name, Status

Firmware panel


The Firmware panel (Maintenance > Firmware) shows information about system and disk firmware versions, and enables you to perform firmware updates. You can also configure access to an update server.

The system stores two bundles of system firmware:

- Active firmware: The firmware bundle that is activated and in use.
- Installed / Not Active firmware: Another firmware bundle that is installed and available to be activated. This may be a newer bundle or an older, previously active bundle.

In this panel you can:

- View information about the system's current firmware bundle
- View whether the system's Partner Firmware Update option is enabled
- View information about installed and active system firmware bundles
- Install a new firmware bundle
- Activate an installed firmware bundle
- View information about current disk firmware and available updates
- Update disk firmware
- Configure access to an update server
- View update server information

 **TIP** To aid successful installation and activation of system firmware be sure to read the on-screen directions.

Viewing information about installed and active system firmware bundles

The System tab shows this basic information about each installed bundle version:

- Bundle version
- Build date

- Status

The expanded view shows this bundle-component version information:

- GEM version
- MC firmware (Management Controller)
- MC loader
- MC OS version
- CPLD revision (Programmable Logic Device)
- ASIC controller version (Storage Controller)
- SC firmware

Updating system firmware

Before performing a firmware update, see "[Best practices for updating firmware](#)" on page 92.

In an MSA 1060/2060/2062, both controllers must run the same firmware version. Storage systems with peer connections should run the same or compatible firmware versions. You can find and install an HPE Smart Component from the website: <https://www.hpe.com/storage/msafirmware>. Follow the instructions on the HPE website.

NOTE HPE recommends using the HPE Smart Component when updating firmware.

In the System tab, the process to update firmware is to install firmware bundles obtained from HPE and then activate a particular bundle. The following controller firmware-update scenarios are supported:

- Automatic. The partner firmware update (PFU) option is enabled (the default). When you activate controller module firmware on one controller, the firmware is automatically copied over and activated on the partner controller first, and then activated on the current controller. PFU provides for updating expansion module firmware in similar fashion.

NOTE HPE recommends enabling the PFU option for controller firmware updates. PFU is enabled by default and should remain enabled. Disable this option only if instructed to do so by a qualified service technician.

- Manual. PFU is disabled. When you update controller module or enclosure IOM firmware on one controller, you must log into the partner controller and manually perform the same updates.

Updating controller firmware with the PFU option enabled will ensure that the same firmware version is installed in both controller modules. Access this option by clicking **Settings > System > Properties > Firmware Properties**. PFU uses the following algorithm to determine which controller module will update its partner:

- If both controllers are running the same firmware version, no change is made.
- The controller installed first will send its configuration and settings to the partner controller. Similarly, if a controller is replaced, it will receive configuration information from the partner controller. In both cases, subsequent firmware update behavior for both controllers is determined by the system's unified PFU setting.
- If both controllers were already installed in the system, then the controller with firmware installed first will send its configuration and settings to the partner controller.
- If both controllers are newly installed, then controller A is transferred to controller B.

If the system is connected to the Update Server and an update is available, a link will display to retrieve the latest firmware. See "[Using an update server](#)" on page 91 for more information.

For information about supported releases for firmware update, see the MSA Storage Firmware page at <https://www.hpe.com/storage/msafirmware>.

To install a firmware bundle, follow the on-screen directions and "[Best practices for updating firmware](#)" on page 92.

To activate a firmware bundle, click its **Activate this Version** link to display the Activate Firmware dialog and then follow the on-screen directions to enable activation to proceed. Using the recommended HPE Smart Component activates the firmware. As part of the activation process the system will perform these steps: check bundle integrity, check system health, update firmware on the partner controller module, restart the partner controller module, update firmware on the local controller module, and restart the local controller module. After the local controller module has restarted, the SMU login screen will reappear. After you log back in, the Maintenance > Firmware panel will show that the new firmware is active on the system. An alert will also be generated to inform you that the firmware has been upgraded.

If firmware activation fails, go to Maintenance > Support > Collect Logs and fill in the necessary fields and collect the logs. Such logs will be needed for any support request generated by this failure.

 **TIP**

- Firmware update typically takes 5 minutes for a controller with current CPLD firmware, or up to 20 minutes for a controller with downlevel CPLD firmware. Expand the firmware row to view the CPLD version (Maintenance > Firmware). If the controller enclosure has connected enclosures, allow additional time for each expansion module's enclosure management processor (EMP) to be updated. This typically takes 2.5 minutes for all EMPs in an MSA 1060/2060/2062 disk enclosure.
- If the Storage Controller cannot be updated, the update operation is canceled. Verify that you specified the correct firmware file and repeat the update. Run the `check firmware-upgrade-health` CLI command to determine if any problems need to be resolved before attempting to update the firmware. If this problem persists, contact technical support.
- When firmware update on the local controller is complete, the Management Controller restarts. Until the restart is complete, sign-in pages say that the system is currently unavailable. When this message is cleared, you may sign in again.
- If PFU is enabled, the amount of time required for updating both controllers is less than 10 minutes.
- If PFU is enabled for the system (Settings > System > Properties > Firmware Properties > Partner Firmware Update checkbox), after firmware update has completed on both controllers, check the system health. If the system health is Degraded and the health reason indicates that the firmware version is incorrect, verify that you specified the correct firmware file and repeat the update. If this problem persists, contact technical support.

Updating expansion module firmware

An expansion enclosure contains two expansion modules. Each expansion module contains an EMP. All modules of the same model should run the same firmware version. If PFU is enabled, the system automatically updates expansion modules from the active bundled firmware when new firmware becomes available. If PFU is disabled, a replacement expansion module will be updated automatically. If PFU is disabled, you must locate, install, and activate compatible firmware on the replacement expansion module. For more information, see relevant command topics below.


NOTE See the following interrelated commands in the *HPE MSA 1060/2060/2062 CLI Reference Guide*:

- activate firmware
 - check firmware-upgrade-health
 - check update-server
 - show firmware-bundles
 - show firmware-update-status
 - show system
 - show update-server
 - show versions
-

Updating disk firmware

If the system is connected to the Update Server and an update is available, a link will display to retrieve the latest firmware. See "[Using an update server](#)" below for more information.

NOTE HPE only provides the HPE Smart Component when updating disk firmware. To install an HPE Smart Component, follow the instructions on the HPE website at <https://www.hpe.com/storage/msafirmware>.

 **IMPORTANT** Before updating disk firmware, stop I/O to the storage system. During the update all volumes will be temporarily inaccessible to hosts. If I/O is not stopped, mapped hosts will report I/O errors. Volume access is restored after the update completes.

Using an update server

Configuring the update server for the storage system enables the system to periodically retrieve a manifest of available firmware, IOM, or disk firmware update components from HPE. If system or drive firmware updates are available, alert notifications are generated. The General section on the Firmware panel displays the most recent date and time that the system checked for available manifest updates (Last Check) and the most recent status of the updates (Last Status).

In order to retrieve the update notifications, a connection to HPE's publicly available manifest is required. This URL points to a manifest file that documents supported upgrade paths. By default, the URL for the update server is <https://www.hpe.com/support/MSAmanifest>.

NOTE A valid DNS server must be configured for the update server manifest to be located as configured from the factory.

To configure the update server, go to Maintenance > Firmware > Update Server. The configured update server URL displays in the Resource URL text box. Click **Set Update Server**. Once access to an update server is configured, the General Information section shows the update server's Resource URL and the time, date, and status of the last check.

For environments that are behind a firewall and do not have direct access to the Internet, you can configure a proxy server to act as an intermediary between the storage system and the external URL to receive the manifest. Only HTTP is supported to the proxy server, though the proxy itself can support HTTPS traffic to the final endpoint. The proxy server is used only with the update server feature.

To configure a proxy server, expand Proxy Parameters, enable the Proxy State checkbox, and then set the proxy hostname or IP address and port number (if any). If required by the proxy, also enter a username and password. To clear the configured username and password, click **Clear Proxy**.

To disable a configured proxy server, expand Proxy Parameters and clear the Proxy State checkbox.

To manage updates locally using the update server within your firewall, configure the storage system to work with a local copy of the manifest on an internal website:

- Download the publicly available manifest from <https://www.hpe.com/support/MSAmanifest> and place it on an internal website. Note the manifest's URL.

NOTE The manifest is a standard JSON (JavaScript Object Notation) file.

- Configure the storage system to access the manifest that was downloaded to the internal website by entering its URL in the Resource URL text box and then click **Set Update Server**. This enables the system to generate alerts and send notifications on available updates. Updates display in the Status column of the System tab or the Update column of the Disks tabs.

NOTE The update server retrieves only the manifest to validate and process updates within the MSA controller. It does not send or retrieve any data.


- Download firmware component updates using a system with Internet access from <https://www.hpe.com/support>.

NOTE Some components require product entitlement and a valid HPE Passport.

- Post the downloaded firmware components to an internal site and edit the manifest JSON file to point to the internal component location. Doing so allows each MSA system to have access via links in the SMU to the firmware updates applicable to that specific system.
- Regularly update the manifest on the internal server with HPE's publicly available manifest to be aware of the most recent update components available.

Best practices for updating firmware

- In the Alerts panel on the dashboard, verify that the system health is OK. If the system health is not OK, expand the view to see the active health alerts and resolve all problems before you update firmware. For information about Active Alerts, see "[Alerts panel](#)" on page 53.
- Run the `check firmware-upgrade-health` CLI command before upgrading firmware. This command performs a series of health checks to determine whether any conditions exist that must be resolved before upgrading firmware. Any conditions that are detected are listed with their potential risks. For information about this command, see the CLI Reference Guide.
- If any unwritten cache data is present, firmware update will not proceed. Before you can update firmware, unwritten data must be removed from cache. See information about event 44 in the Event Descriptions Reference Guide and information about the `clear cache` command in the CLI Reference Guide.

 **CAUTION** Removing unwritten data may result in data loss. Contact technical support for assistance.

- If a disk group is quarantined, resolve the problem that is causing it to be quarantined before updating firmware. See information about events 172 and 485 in the Event Descriptions Reference Guide.
- To ensure success of an online update, select a period of low I/O activity. This helps the update to complete as quickly as possible and avoids disruption to host and applications due to timeouts. Attempting to update a storage system that is processing a large, I/O-intensive batch job may cause hosts to lose connectivity with the storage system.
- Confirm PFU is enabled by clicking **Settings > System > Properties > Firmware Properties**.

- Do not perform a power cycle or controller restart during a firmware update. If the update is interrupted or there is a power failure, the module might become inoperative. If this occurs, contact technical support. The module might need to be returned to the factory for reprogramming.

About panel

The About panel (Maintenance > About) provides links to useful websites and shows information about the system, its hardware, and its storage configuration. General system information includes:

- System name
- System contact
- System location
- System information
- Product brand
- Product ID
- Controller A firmware
- Controller B firmware

Hardware information displays the Enclosure number, SKU Part Number, and SKU Serial Number for each enclosure (disks excluded). Expand the table to see the following for each customer FRU in each enclosure.

- FRU name
- Description
- Part number
- Serial number
- Configuration serial number
- Location

Storage information includes the following for each pool:

- Pool ID
- Total size
- Available size
- Snap size
- Overcommit state
- Disk groups
- Volumes
- Sector format
- Health

Support panel

The Support panel (Maintenance > Support) enables you to perform these support-related actions:

- Collect logs
- View the system's licensing serial number and install a license for advanced features
- View the system event history
- View controller module audit logs

For details, see the on-screen directions.

7 Support and other resources

Accessing Hewlett Packard Enterprise Support

- For live assistance, go to the Contact Hewlett Packard Enterprise Worldwide website:
<https://www.hpe.com/info/assistance>
- To access documentation and support services, go to the Hewlett Packard Enterprise Support Center website:
<https://www.hpe.com/support/hpesc>

Information to collect

- Technical support registration number (if applicable)
- Product name, model or version, and serial number
- Operating system name and version
- Firmware version
- Error messages
- Product-specific reports and logs
- Add-on products or components
- Third-party products or components

Accessing updates

- Some software products provide a mechanism for accessing software updates through the product interface. Review your product documentation to identify the recommended software update method.
- To download product updates:

Hewlett Packard Enterprise Support Center

<https://www.hpe.com/support/hpesc>

Hewlett Packard Enterprise Support Center: Software downloads

<https://www.hpe.com/support/downloads>

Software Depot

<https://www.hpe.com/support/softwaredepot>

- To subscribe to eNewsletters and alerts:
<https://www.hpe.com/support/e-updates>
- To view and update your entitlements, and to link your contracts and warranties with your profile, go to the Hewlett Packard Enterprise Support Center **More Information on Access to HP Support Materials** page:
<https://www.hpe.com/support/AccessToSupportMaterials>

! **IMPORTANT** Access to some updates might require product entitlement when accessed through the Hewlett Packard Enterprise Support Center. You must have an HPE Passport set up with relevant entitlements.

Remote support

Remote support is available with supported devices as part of your warranty or contractual support agreement. It provides intelligent event diagnosis, and automatic, secure submission of hardware event notifications to Hewlett Packard Enterprise, which will initiate a fast and accurate resolution based on your product's service level. Hewlett Packard Enterprise strongly recommends that you register your device for remote support.

If your product includes additional remote support details, use search to locate that information.

Remote support and Proactive Care information

HPE Get Connected

<https://www.hpe.com/services/getconnected>

HPE Proactive Care services

<https://www.hpe.com/services/proactivecare>

HPE Datacenter Care services

<https://www.hpe.com/services/datacentercare>

HPE Proactive Care service: Supported products list

<https://www.hpe.com/services/proactivecaresupportedproducts>

HPE Proactive Care advanced service: Supported products list

<https://www.hpe.com/services/proactivecareadvancedsupportedproducts>

Proactive Care customer information

Proactive Care central

<https://www.hpe.com/services/proactivecarecentral>

Proactive Care service activation

<https://www.hpe.com/services/proactivecarecentralgetstarted>

Warranty information

To view the warranty information for your product, see the links provided below:

HPE ProLiant and IA-32 Servers and Options

<https://www.hpe.com/support/ProLiantServers-Warranties>

HPE Enterprise and Cloudline Servers

<https://www.hpe.com/support/EnterpriseServers-Warranties>

HPE Storage Products

<https://www.hpe.com/support/Storage-Warranties>

HPE Networking Products

<https://www.hpe.com/support/Networking-Warranties>

Regulatory information

To view the regulatory information for your product, view the *Safety and Compliance Information for Server, Storage, Power, Networking, and Rack Products*, available at the Hewlett Packard Enterprise Support Center:

<https://www.hpe.com/support/Safety-Compliance-EnterpriseProducts>

Additional regulatory information

Hewlett Packard Enterprise is committed to providing our customers with information about the chemical substances in our products as needed to comply with legal requirements such as REACH (Regulation EC No 1907/2006 of the European Parliament and the Council). A chemical information report for this product can be found at:

<https://www.hpe.com/info/reach>

For Hewlett Packard Enterprise product environmental and safety information and compliance data, including RoHS and REACH, see:

<https://www.hpe.com/info/ecodata>

For Hewlett Packard Enterprise environmental information, including company programs, product recycling, and energy efficiency, see:

<https://www.hpe.com/info/environment>

Documentation feedback

Hewlett Packard Enterprise is committed to providing documentation that meets your needs. To help us improve the documentation, send any errors, suggestions, or comments to Documentation Feedback (docsfeedback@hpe.com). When submitting your feedback, include the document title, part number, edition, and publication date located on the front cover of the document. For online help content, include the product name, product version, help edition, and publication date located on the legal notices page.

A Other management interfaces

SNMP reference

This topic describes the Simple Network Management Protocol (SNMP) capabilities that HPE MSA 1060/2060/2062 storage systems support. This includes standard MIB-II, the FibreAlliance SNMP Management Information Base (MIB) version 2.2 objects, and enterprise traps.


The storage systems can report their status through SNMP. SNMP provides basic discovery using MIB-II, more detailed status with the FA MIB 2.2, and asynchronous notification using enterprise traps.

SNMP is a widely used network monitoring and control protocol. It is an application layer protocol that facilitates the exchange of management information between network devices. It is part of the Transmission Control Protocol/Internet Protocol (TCP/IP) protocol suite.

SNMP enables network administrators to manage network performance, find and solve network problems, and plan for network growth. Data is passed from SNMP agents reporting activity on each network device to the workstation console used to oversee the network. The agents return information contained in a Management Information Base (MIB), which is a data structure that defines what is obtainable from the device and what can be controlled (turned on and off, and so on).

Supported SNMP versions

The storage systems allow use of SNMPv2c or SNMPv3. SNMPv2c uses a community-based security scheme. For improved security, SNMPv3 provides authentication of the network management system that is accessing the storage system, and encryption of the information transferred between the storage system and the network management system.

When SNMPv3 is disabled, SNMPv2c will be active. When SNMPv3 is enabled, SNMPv2c will be inactive. To enable SNMPv3, create a user with the `snmpuser` interface (Settings > Users > SNMPv3 > Add New SNMPv3 User). To disable SNMPv3, delete all SNMPv3 users (Settings > Users > SNMPv3 > )

Whether you use SNMPv2c or v3, note that the only SNMP-writable information is the system contact, name, and location. System data, configuration, and state cannot be changed via SNMP.

Standard MIB-II behavior

MIB-II is implemented to support basic discovery and status.

An SNMP object identifier (OID) is a number assigned to devices in a network for identification purposes. OID numbering is hierarchical. Using the IETF notation of digits and dots resembling very long IP addresses, various registries such as ANSI assign high-level numbers to vendors and organizations. They, in turn, append digits to the number to identify individual devices or software processes.

The system object identifier (`sysObjectID`) for HPE MSA 1060/2060/2062 storage systems is 1.3.6.1.4.1.11.2.51, where 51 is assigned for hpMSA. System uptime is an offset from the first time this object is read.

In the system group, all objects can be read. The contact, name, and location objects can be set.

In the interfaces group, an internal PPP interface is documented, but it is not reachable from external to the device.

The address translation (`at`) and external gateway protocol (`egp`) groups are not supported.

Enterprise traps

Traps can be generated in response to events and alerts occurring in the storage system. These events and alerts can be selected by severity and by individual type. A maximum of three SNMP trap destinations can be configured by IP address.

Enterprise event and alert severities include informational, minor, major, and critical. There is a different trap type for each of these severities. The trap format is represented by the enterprise traps MIB `msa2000traps.mib`. Information included is the event/alert ID, the event/alert code type, and a text description generated from the internal event/alert. Equivalent information can also be sent using email or pop-up alerts to users who are logged in to the SMU.

The text of the trap MIB is included at the end of this appendix.

FA MIB 2.2 SNMP behavior

The FA MIB 2.2 objects are in compliance with the FibreAlliance MIB v2.2 Specification (FA MIB2.2 Spec).

FA MIB 2.2 is a subset of FA MIB 4.0, which is included with HPE System Insight Manager (SIM) and other products. The differences are described in ["FA MIB 2.2 and 4.0 differences" on page 108](#).

FA MIB 2.2 was never formally adopted as a standard, but it is widely implemented and contains many elements useful for storage products. This MIB generally does not reference and integrate with other standard SNMP information. It is implemented under the experimental subtree.

Significant status within the device includes such elements as its temperature and power sensors, the health of its storage elements such as virtual disks, and the failure of any redundant component including an I/O controller. While sensors can be individually queried, for the benefit of network management systems all the above elements are combined into an "overall status" sensor. This is available as the unit status (`connUnitStatus` for the only unit).

The revisions of the various components within the device can be requested through SNMP.

The port section is only relevant to products with Fibre Channel host ports.

The event table allows 400 recently-generated events to be requested. Informational, minor, major, or critical event types can be selected. Whichever type is selected enables the capture of that type and more severe events. This mechanism is independent of the assignment of events to be generated into traps.

The traps section is not supported. It has been replaced by an ability to configure trap destinations using the CLI or the SMU. The statistics section is not implemented.

The following table lists the MIB objects, their descriptions and the value set in the storage systems. Unless specified otherwise, objects are *not* settable.

Table 10 FA MIB 2.2 objects, descriptions, and values

Object	Description	Value
<code>RevisionNumber</code>	Revision number for this MIB	0220
<code>UNumber</code>	Number of connectivity units present	1
<code>SystemURL</code>	Top-level URL of the device. For example, <code>http://10.1.2.3</code> . If a web server is not present on the device, this string is empty in accordance with the FA MIB2.2 Spec.	Default: <code>http://10.0.0.1</code>
<code>StatusChangeTime</code>	<code>sysuptime</code> timestamp of the last status change event, in centiseconds. <code>sysuptime</code> starts at 0 when the Storage Controller boots and keeps track of the up time. <code>statusChangeTime</code> is updated each time an event occurs.	0 at startup

Table 10 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
ConfigurationChangeTime	sysuptime timestamp of the last configuration change event, in centiseconds. sysuptime starts at 0 when the Storage Controller boots and keeps track of the up time. configurationChangeTime is updated each time an event occurs.	0 at startup
ConnUnitTableChangeTime	sysuptime timestamp of the last update to the connUnitTable (an entry was either added or deleted), in centiseconds	0 always (entries are not added to or deleted from the connUnitTable)
connUnitTable	Includes the following objects as specified by the FA MIB2.2 Spec	
connUnitId	Unique identification for this connectivity unit	Total of 16 bytes comprised of 8 bytes of the node WWN or similar serial number-based identifier (for example, 1000005013b05211) with the trailing 8 bytes equal to zero
connUnitGlobalId	Same as connUnitId	Same as connUnitId
connUnitType	Type of connectivity unit	storage-subsystem(11)
connUnitNumports	Number of host ports in the connectivity unit	Number of host ports
connUnitState	Overall state of the connectivity unit	online(2) or unknown(1), as appropriate
connUnitStatus	Overall status of the connectivity unit	ok(3), warning(4), failed(5), or unknown(1), as appropriate
connUnitProduct	Connectivity unit vendor's product model name	Model string
connUnitSn	Serial number for this connectivity unit	Serial number string
connUnitUpTime	Number of centiseconds since the last unit initialization	0 at startup
connUnitUrl	Same as systemURL	Same as systemURL
connUnitDomainId	Not used; set to all 1s as specified by the FA MIB2.2 Spec	0xFFFF
connUnitProxyMaster	Stand-alone unit returns yes for this object	yes(3) since this is a stand-alone unit
connUnitPrincipal	Whether this connectivity unit is the principal unit within the group of fabric elements. If this value is not applicable, returns unknown.	unknown(1)
connUnitNumSensors	Number of sensors in the connUnitSensorTable	33
connUnitStatusChangeTime	Same as statusChangeTime	Same as statusChangeTime
connUnitConfigurationChangeTime	Same as configurationChangeTime	Same as configurationChangeTime
connUnitNumRevs	Number of revisions in the connUnitRevsTable	16
connUnitNumZones	Not supported	0
connUnitModuleId	Not supported	16 bytes of 0s
connUnitName	Settable: Display string containing a name for this connectivity unit	Default: Uninitialized Name
connUnitInfo	Settable: Display string containing information about this connectivity unit	Default: Uninitialized Info

Table 10 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
connUnitControl	Not supported	invalid(2) for an SNMP GET operation and not settable through an SNMP SET operation.
connUnitContact	Settable: Contact information for this connectivity unit	Default: Uninitialized Contact
connUnitLocation	Settable: Location information for this connectivity unit	Default: Uninitialized Location
connUnitEventFilter	Defines the event severity that will be logged by this connectivity unit. Settable only through the SMU.	Default: info(8)
connUnitNumEvents	Number of events currently in the connUnitEventTable	Varies as the size of the Event Table varies
connUnitMaxEvents	Maximum number of events that can be defined in the connUnitEventTable	400
connUnitEventCurrID	Not supported	0
connUnitRevsTable	Includes the following objects as specified by the FA MIB2.2 Spec	
connUnitRevsUnitId	connUnitId of the connectivity unit that contains this revision table	Same as connUnitId
connUnitRevsIndex	Unique value for each connUnitRevsEntry between 1 and connUnitNumRevs	See "External details for connUnitRevsTable" on page 103
connUnitRevsRevId	Vendor-specific string identifying a revision of a component of the connUnit	String specifying the code version. Reports "Not Installed or Offline" if module information is not available.
connUnitRevsDescription	Display string containing description of a component to which the revision corresponds	See "External details for connUnitRevsTable" on page 103
connUnitSensorTable	Includes the following objects as specified by the FA MIB2.2 Spec	
connUnitSensorUnitId	connUnitId of the connectivity unit that contains this sensor table	Same as connUnitId
connUnitSensorIndex	Unique value for each connUnitSensorEntry between 1 and connUnitNumSensors	See "External details for connUnitSensorTable" on page 104
connUnitSensorName	Display string containing textual identification of the sensor intended primarily for operator use	See "External details for connUnitSensorTable" on page 104
connUnitSensorStatus	Status indicated by the sensor	ok(3), warning(4), or failed(5) as appropriate for FRUs that are present, or other(2) if FRU is not present.
connUnitSensorInfo	Not supported	Empty string
connUnitSensorMessage	Description the sensor status as a message	connUnitSensorName followed by the appropriate sensor reading. Temperatures display in both Celsius and Fahrenheit. For example, CPU Temperature (Controller Module A): 48C 118F). Reports "Not installed" or "Offline" if data is not available.
connUnitSensorType	Type of component being monitored by this sensor	See "External details for connUnitSensorTable" on page 104
connUnitSensorCharacteristic	Characteristics being monitored by this sensor	See "External details for connUnitSensorTable" on page 104

Table 10 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
connUnitPortTable	Includes the following objects as specified by the FA MIB2.2 Spec	
connUnitPortUnitId	connUnitId of the connectivity unit that contains this port	Same as connUnitId
connUnitPortIndex	Unique value for each connUnitPortEntry between 1 and connUnitNumPorts	Unique value for each port, between 1 and the number of ports
connUnitPortType	Port type	not-present(3), or n-port(5) for point-to-point topology, or l-port(6)
connUnitPortFCClassCap	Bit mask that specifies the classes of service capability of this port. If this is not applicable, returns all bits set to zero.	Fibre Channel ports return 8 for class-three
connUnitPortFCClassOp	Bit mask that specifies the classes of service that are currently operational. If this is not applicable, returns all bits set to zero.	Fibre Channel ports return 8 for class-three
connUnitPortState	State of the port hardware	unknown(1), online(2), offline(3), bypassed (4)
connUnitPortStatus	Overall protocol status for the port	unknown(1), unused(2), ok(3), warning(4), failure(5), notparticipating(6), initializing(7), bypass(8)
connUnitPortTransmitter Type	Technology of the port transceiver	unknown(1) for Fibre Channel ports
connUnitPortModuleType	Module type of the port connector	unknown(1)
connUnitPortWwn	Fibre Channel World Wide Name (WWN) of the port if applicable	WWN octet for the port, or empty string if the port is not present
connUnitPortFCId	Assigned Fibre Channel ID of this port	Fibre Channel ID of the port All bits set to 1 if the Fibre Channel ID is not assigned or if the port is not present
connUnitPortSn	Serial number of the unit (for example, for a GBIC). If this is not applicable, returns an empty string.	Empty string
connUnitPortRevision	Port revision (for example, for a GBIC)	Empty string
connUnitPortVendor	Port vendor (for example, for a GBIC)	Empty string
connUnitPortSpeed	Speed of the port in KByte per second (1 KByte = 1000 Byte)	Port speed in KByte per second, or 0 if the port is not present
connUnitPortControl	Not supported	invalid(2) for an SNMP GET operation and not settable through an SNMP SET operation
connUnitPortName	String describing the addressed port	See "External details for connUnitPortTable" on page 105
connUnitPortPhysical Number	Port number represented on the hardware	Port number represented on the hardware
connUnitPortStatObject	Not supported	0 (No statistics available)
connUnitEventTable	Includes the following objects as specified by the FA MIB2.2 Spec	
connUnitEventUnitId	connUnitId of the connectivity unit that contains this port	Same as connUnitId
connUnitEventIndex	Index into the connectivity unit's event buffer, incremented for each event	Starts at 1 every time there is a table reset or the unit's event table reaches its maximum index value

Table 10 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
connUnitEventId	Internal event ID, incremented for each event, ranging between 0 and connUnitMaxEvents	Starts at 0 every time there is a table reset or connUnitMaxEvents is reached
connUnitREventTime	Real time when the event occurred, in the following format: DDMMYYYY HHMMSS	0 for logged events that occurred prior to or at startup
connUnitSEventTime	sysuptime timestamp when the event occurred	0 at startup
connUnitEventSeverity	Event severity level	error(5), warning(6) or info(8)
connUnitEventType	Type of this event	As defined in CAPI
connUnitEventObject	Not used	0
connUnitEventDescr	Text description of this event	Formatted event, including relevant parameters or values
connUnitLinkTable	Not supported	N/A
connUnitPortStatFabricTable	Not supported	N/A
connUnitPortStatSCSITable	Not supported	N/A
connUnitPortStatLANTable	Not supported	N/A
SNMP Traps	The following SNMP traps are supported	
trapMaxClients	Maximum number of trap clients	1
trapClientCount	Number of trap clients currently enabled	1 if traps enabled; 0 if traps not enabled
connUnitEventTrap	This trap is generated each time an event occurs that passes the connUnitEventFilter and the trapRegFilter	N/A
trapRegTable	Includes the following objects per the FA MIB2.2 Spec	
trapRegIpAddress	IP address of a client registered for traps	IP address set by user
trapRegPort	User Datagram Protocol (UDP) port to send traps to for this host	162
trapRegFilter	Settable: Defines the trap severity filter for this trap host. The connUnit will send traps to this host that have a severity level less than or equal to this value.	Default: warning(6)
trapRegRowState	Specifies the state of the row	READ: rowActive(3) if traps are enabled. Otherwise rowInactive(2) WRITE: Not supported
Enterprise-specific fields	Includes the following objects	
cpqSiSysSerialNum	System serial number	For example, 3CL8Y40991
cpqSiSysProductId	System product ID	For example, 481321-001
cpqSiProductName	System product name	For example, HPE MSA 2060

Table 10 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
cpqHoMibStatusArray	An array of MIB status structures. Octets 0–3 in block 0 are reserved for systems management and serve as an aggregate of the other MIBs.	Octet 0: 0. Octet 1 (overall status): 0 = Not available; 1 = Unknown/other; 2 = OK/normal; 3 = Degraded/warning; 4 = Failed/critical Octet 2 (system flags): 9 = device is not a server and web-based management is enabled Octet 3 (device type): 14 = enclosure For example, 00.02.09.14 (hex)
cpqHoGUID	Globally unique identifier formed from the product ID and serial number	For example, 4813213CL8Y40991

External details for certain FA MIB 2.2 objects

Tables in this topic specify values for certain objects described in [Table 10](#).

External details for connUnitRevsTable

Table 11 connUnitRevsTable index and description values

connUnitRevsIndex	connUnitRevsDescription
1	CPU Type for Storage Controller (Controller A)
2	Bundle revision for Controller (Controller A)
3	Build date for Storage Controller (Controller A)
4	Code revision for Storage Controller (Controller A)
5	Code baselevel for Storage Controller (Controller A)
6	FPGA code revision for Memory Controller (Controller A)
7	Loader code revision for Storage Controller (Controller A)
8	CAPL revision (Controller A)
9	Code revision for Management Controller (Controller A)
10	Loader code revision for Management Controller (Controller A)
11	Code revision for Expander Controller (Controller A)
12	CPLD code revision (Controller A)
13	Hardware revision (Controller A)
14	Host interface module revision (Controller A)
15	HIM revision (Controller A)
16	Backplane type (Controller A)
17	Host interface hardware (chip) revision (Controller A)
18	Disk interface hardware (chip) revision (Controller A)
19	CPU Type for Storage Controller (Controller B)
20	Bundle revision for Controller (Controller B)
21	Build date for Storage Controller (Controller B)
22	Code revision for Storage Controller (Controller B)
23	Code baselevel for Storage Controller (Controller B)

Table 11 connUnitRevsTable index and description values (continued)

connUnitRevsIndex	connUnitRevsDescription
24	FPGA code revision for Memory Controller (Controller B)
25	Loader code revision for Storage Controller (Controller B)
26	CAPI revision (Controller B)
27	Code revision for Management Controller (Controller B)
28	Loader code revision for Management Controller (Controller B)
29	Code revision for Expander Controller (Controller B)
30	CPLD code revision (Controller B)
31	Hardware revision (Controller B)
32	Host interface module revision (Controller B)
33	HIM revision (Controller B)
34	Backplane type (Controller B)
35	Host interface hardware (chip) revision (Controller B)
36	Disk interface hardware (chip) revision (Controller B)

External details for connUnitSensorTable**Table 12 connUnitSensorTable index, name, type, and characteristic values**

connUnitSensorIndex	connUnitSensorName	connUnitSensorType	connUnitSensorCharacteristic
1	Onboard Temperature 1 (Controller A)	board(8)	temperature(3)
2	Onboard Temperature 1 (Controller B)	board(8)	temperature(3)
3	Onboard Temperature 2 (Controller A)	board(8)	temperature(3)
4	Onboard Temperature 2 (Controller B)	board(8)	temperature(3)
5	Onboard Temperature 3 (Controller A)	board(8)	temperature(3)
6	Onboard Temperature 3 (Controller B)	board(8)	temperature(3)
7	Disk Controller Temperature (Controller A)	board(8)	temperature(3)
8	Disk Controller Temperature (Controller B)	board(8)	temperature(3)
9	Memory Controller Temperature (Controller A)	board(8)	temperature(3)
10	Memory Controller Temperature (Controller B)	board(8)	temperature(3)
11	Capacitor Pack Voltage (Controller A)	board(8)	power(9)
12	Capacitor Pack Voltage (Controller B)	board(8)	power(9)
13	Capacitor Cell 1 Voltage (Controller A)	board(8)	power(9)
14	Capacitor Cell 1 Voltage (Controller B)	board(8)	power(9)
15	Capacitor Cell 2 Voltage (Controller A)	board(8)	power(9)
16	Capacitor Cell 2 Voltage (Controller B)	board(8)	power(9)
17	Capacitor Cell 3 Voltage (Controller A)	board(8)	power(9)
18	Capacitor Cell 3 Voltage (Controller B)	board(8)	power(9)
19	Capacitor Cell 4 Voltage (Controller A)	board(8)	power(9)
20	Capacitor Cell 4 Voltage (Controller B)	board(8)	power(9)
21	Capacitor Charge Percent (Controller A)	board(8)	other(2)
22	Capacitor Charge Percent (Controller B)	board(8)	other(2)
23	Overall Status	enclosure(7)	other(2)
24	Upper IOM Temperature (Controller A)	enclosure(7)	temperature(3)
25	Lower IOM Temperature (Controller B)	enclosure(7)	temperature(3)

Table 12 connUnitSensorTable index, name, type, and characteristic values (continued)

connUnitSensorIndex	connUnitSensorName	connUnitSensorType	connUnitSensorCharacteristic
26	Power Supply 1 (Left) Temperature	power-supply(5)	temperature(3)
27	Power Supply 2 (Right) Temperature	power-supply(5)	temperature(3)
28	Upper IOM Voltage, 12V (Controller A)	enclosure(7)	power(9)
29	Upper IOM Voltage, 5V (Controller A)	enclosure(7)	power(9)
30	Lower IOM Voltage, 12V (Controller B)	enclosure(7)	power(9)
31	Lower IOM Voltage, 5V (Controller B)	enclosure(7)	power(9)
32	Power Supply 1 (Left) Voltage, 12V	power-supply(5)	power(9)
33	Power Supply 1 (Left) Voltage, 5V	power-supply(5)	power(9)
34	Power Supply 1 (Left) Voltage, 3.3V	power-supply(5)	power(9)
35	Power Supply 2 (Right) Voltage, 12V	power-supply(5)	power(9)
36	Power Supply 2 (Right) Voltage, 5V	power-supply(5)	power(9)
37	Power Supply 2 (Right) Voltage, 3.3V	power-supply(5)	power(9)
38	Upper IOM Voltage, 12V (Controller A)	enclosure(7)	currentValue(6)
39	Lower IOM Voltage, 12V (Controller B)	enclosure(7)	currentValue(6)
40	Power Supply 1 (Left) Current, 12V	power-supply(5)	currentValue(6)
41	Power Supply 1 (Left) Current, 5V	power-supply(5)	currentValue(6)
42	Power Supply 2 (Right) Current, 12V	power-supply(5)	currentValue(6)
43	Power Supply 2 (Right) Current, 5V	power-supply(5)	currentValue(6)

External details for connUnitPortTable**Table 13 connUnitPortTable index and name values**

connUnitPortIndex	connUnitPortName
0	Host Port 0 (Controller A)
1	Host Port 1 (Controller B)
2	Host Port 2 (Controller B)
3	Host Port 3 (Controller B)

Configuring SNMP event notification in the SMU

1. Verify that the storage system's SNMP service is enabled. See ["Enabling or disabling system-management services" on page 74](#).
2. Configure and enable SNMP traps. See ["Managing SNMPv3 users" on page 77](#).
3. Optionally, configure a user account to receive SNMP traps. See ["Managing SNMPv3 users" on page 77](#).

SNMP management

You can manage storage devices using SNMP with a network management system such as HPE Systems Insight Manager (SIM) or HP Instant Support Enterprise Edition (ISEE). See their documentation for information about loading MIBs, configuring events, and viewing and setting group objects.

In order to view and set system group objects, SNMP must be enabled in the storage system ["Enabling or disabling system-management services" on page 74](#). To use SNMPv3, it must be configured in both the storage system and the network management system that intends to access the storage system or receive traps from it. In the storage system, SNMPv3 is configured through the creation and use of SNMP user accounts, as described in ["User settings" on page 75](#). The same users, security protocols, and passwords must be configured in the network management system.

Enterprise trap MIB

The following pages show the source for the `msa2000traps.mib`. This MIB defines the content of the SNMP traps that HPE MSA 1060/2060/2062 storage systems generate.

```
-- MSA2000 Array MIB for SNMP Traps
--
-- $Revision: 1.4 $
--
-- Copyright (c) 2008 Hewlett-Packard Development Company, L.P.
-- Copyright (c) 2005-2008 Dot Hill Systems Corp.
-- Confidential computer software. Valid license from HP required for possession,
-- use or copying. Consistent with FAR 12.211 and 12.212, Commercial Computer
-- Software, Computer Software Documentation, and Technical Data for Commercial
-- Items are licensed to the U.S. Government under vendor's standard commercial
-- license.
--
-- MSA2000traps MIB Revision
-- =====
-- Revision 1.1 2008/02/27
-- Initial revision
-- Revision 1.2 2008/03/18
-- Updated copyright notice
-- Revision 1.3 2008/06/26
-- Replaced filename 'fa-mib40' with module name 'FCMGMT-MIB'.
-- Added OIDs hp, nm and hpMSA
-- Added Object type mibName
-- Above changes made to work for HP StorageWorks Management
-- Pack for SCOM 2007.
-- Revision 1.4 2016/08/12
-- Added support for Resolved severity 3005, set to Informatinal
-----

MSA2000TRAPS-MIB
-- Last edit date: Feb 27th, 2008
DEFINITIONS ::= BEGIN
IMPORTS
    enterprises
        FROM RFC1155-SMI
    TRAP-TYPE
        FROM RFC-1215
    connUnitEventId, connUnitEventType, connUnitEventDescr
        FROM FCMGMT-MIB;

--Textual conventions for this MIB
-----

-- vendor
hp      OBJECT IDENTIFIER ::= { enterprises 11 }
nm      OBJECT IDENTIFIER ::= { hp 2 }
hpMSA   OBJECT IDENTIFIER ::= { nm 51 }

mibName OBJECT-TYPE
```

```

SYNTAX INTEGER
ACCESS read-only
STATUS mandatory
DESCRIPTION
"Product name"
::= { hpMSA 1 }

```

-- Related traps

```

msaEventInfoTrap TRAP-TYPE
    ENTERPRISE hpMSA
    VARIABLES { connUnitEventId,
                connUnitEventType,
                connUnitEventDescr }
    DESCRIPTION
        "An event has been generated by the storage array.
        Recommended severity level (for filtering): info"

    -- Trap annotations are as follows:
    --#TYPE "Informational storage event"
    --#SUMMARY "Informational storage event # %d, type %d, description: %s"
    --#ARGUMENTS {0,1,2}
    --#SEVERITY INFORMATIONAL
    --#TIMEINDEX 6
    ::= 3001

msaEventWarningTrap TRAP-TYPE
    ENTERPRISE hpMSA
    VARIABLES { connUnitEventId,
                connUnitEventType,
                connUnitEventDescr }
    DESCRIPTION
        "An event has been generated by the storage array.
        Recommended severity level (for filtering): warning"

    -- Trap annotations are as follows:
    --#TYPE "Warning storage event"
    --#SUMMARY "Warning storage event # %d, type %d, description: %s"
    --#ARGUMENTS {0,1,2}
    --#SEVERITY MINOR
    --#TIMEINDEX 6
    ::= 3002

msaEventErrorTrap TRAP-TYPE
    ENTERPRISE hpMSA
    VARIABLES { connUnitEventId,
                connUnitEventType,
                connUnitEventDescr }
    DESCRIPTION
        "An event has been generated by the storage array.
        Recommended severity level (for filtering): error"

    -- Trap annotations are as follows:

```

```

--#TYPE "Error storage event"
--#SUMMARY "Error storage event # %d, type %d, description: %s"
--#ARGUMENTS {0,1,2}
--#SEVERITY MAJOR
--#TIMEINDEX 6
::= 3003

msaEventCriticalTrap TRAP-TYPE
    ENTERPRISE hpMSA
    VARIABLES { connUnitEventId,
                connUnitEventType,
                connUnitEventDescr }
    DESCRIPTION
        "An event has been generated by the storage array.
        Recommended severity level (for filtering): critical"

-- Trap annotations are as follows:
--#TYPE "Critical storage event"
--#SUMMARY "Critical storage event # %d, type %d, description: %s"
--#ARGUMENTS {0,1,2}
--#SEVERITY CRITICAL
--#TIMEINDEX 6
::= 3004

msaEventResolvedTrap TRAP-TYPE
    ENTERPRISE hpMSA
    VARIABLES { connUnitEventId,
                connUnitEventType,
                connUnitEventDescr }
    DESCRIPTION
        "An issue has been resolved on the array.
        Recommended severity level (for filtering): resolved"

-- Trap annotations are as follows:
--#TYPE "Resolved storage event"
--#SUMMARY "Resolved storage event # %d, type %d, description: %s"
--#ARGUMENTS {0,1,2}
--#SEVERITY INFORMATIONAL
--#TIMEINDEX 6
::= 3005

END

```

FA MIB 2.2 and 4.0 differences

FA MIB 2.2 is a subset of FA MIB 4.0. Therefore, SNMP elements implemented in MSA 1060/2060/2062 systems can be accessed by a management application that uses FA MIB 4.0.

The following tables are *not* implemented in 2.2:

- connUnitServiceScalars
- connUnitServiceTables
- connUnitZoneTable
- connUnitZoningAliasTable

- connUnitSnsTable
- connUnitPlatformTable

The following variables are *not* implemented in 2.2:

- connUnitFabricID
- connUnitNumLinks
- connUnitVendorId
- connUnitPortProtocolCap,
connUnitPortProtocolOp,
connUnitPortNodeWwn,
connUnitPortHWState
- connUnitLinkCurrIndex

Using FTP and SFTP

Although the SMU is the preferred interface for downloading log data and historical disk-performance statistics, updating firmware, and installing a license, you can also use FTP and SFTP to do these tasks — and to install security certificates and keys.

NOTE HPE recommends using SFTP rather than FTP because it is a secured protocol.

! **IMPORTANT** Do not attempt to do more than one of the operations at the same time. They can interfere with each other and the operations may fail. Specifically, do not try to do more than one firmware update at the same time or try to download system logs while doing a firmware update.

Downloading system logs

To help service personnel diagnose a system problem, you might be asked to provide system log data. You can download this data by accessing the system's FTP or SFTP interface and running the `get logs` command. When both controllers are online, regardless of operating mode, `get logs` will download a single, compressed zip file that includes:

- Device status summary, which includes basic status and configuration data for the system
- Each controller's MC logs
- Each controller's event log
- Each controller's debug log
- Each controller's boot log, which shows the startup sequence
- Critical error dumps from each controller, if critical errors have occurred
- CAPI traces from each controller

Use a command-line-based FTP/SFTP client. A GUI-based FTP/SFTP client might not work.

To download system logs

1. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers. See ["Configuring controller network ports" on page 72](#).
 - b. Verify that the system's FTP/SFTP service is enabled and take note of the FTP/SFTP service port. See ["Enabling or disabling system-management services" on page 74](#).

- c. Verify that the user you will log in as has permission to use the FTP interface. The same setting allows a user to transfer files using both FTP and SFTP. See ["User settings" on page 75](#).
2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the destination directory for the log file.
3. Using the FTP/SFTP port specified in the system services settings, enter:

```
psftp controller-network-address -Pport or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022
```

```
ftp 10.1.0.9
```

4. Log in as a user that has permission to use the FTP/SFTP interface.
5. Make sure the client is in binary transfer mode. Enter:

```
binary
```

6. Enter:

```
get logs filename.zip
```

where *filename* is the file that will contain the logs. It is recommended to choose a filename that identifies the system, controller, and date.

For example:

```
get logs Storage2_A_20120126.zip
```

7. In FTP, wait for the message `Operation Complete` to appear. No messages are displayed in SFTP; instead, the `get` command will return once the logs collection is finished.
8. Quit the FTP/SFTP session.

NOTE You must uncompress a zip file before you can view the files it contains. To examine diagnostic data, first view `store_yyyy_mm_dd_hh_mm_ss.logs`.

Transferring log data to a log-collection system

If the log-management feature is configured in pull mode, a log-collection system can access the storage system's FTP or SFTP interface and use the `get managed-logs` command to retrieve untransferred data from a system log file. This command retrieves the untransferred data from the specified log to a compressed zip file on the log-collection system. Following the transfer of a log's data, the log's capacity status is reset to zero to indicate that there is no untransferred data. Log data is controller specific.

For an overview of the log-management feature, see ["Managed logs" on page 35](#).

Use a command-line-based FTP/SFTP client. A GUI-based FTP client might not work.

To transfer log data to a log-collection system

1. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers. See ["Configuring controller network ports" on page 72](#).
 - b. Verify that the system's FTP/SFTP service is enabled. See ["Enabling or disabling system-management services" on page 74](#).
 - c. Verify that the user you will log in as has permission to use the FTP/SFTP interface. The same setting allows a user to transfer files using both FTP and SFTP. See ["User settings" on page 75](#).

2. On the log-collection system, open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the destination directory for the log file.

3. Enter:

```
psftp controller-network-address -P port or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022
```

```
ftp 10.1.0.9
```

4. Log in as a user with permission to use the FTP/SFTP interface.
5. Make sure the client is in binary transfer mode. Enter:

```
binary
```

6. Enter:

```
get managed-logs: log-type filename.zip
```

where:

- *log-type* specifies the type of log data to transfer:
 - *crash1*, *crash2*, *crash3*, or *crash4*: One of the Storage Controller's four crash logs.
 - *ecdebug*: Expander Controller log.
 - *mc*: Management Controller log.
 - *scdebug*: Storage Controller log.
- *filename* is the file that will contain the transferred data. It is recommended to choose a filename that identifies the system, controller, log type, and date.

For example:

```
get managed-logs: scdebug Storage2-A_scdebug_2011_08_22.zip
```

In FTP, wait for the message `Operation Complete` to appear. No messages are displayed in SFTP; instead, the `get` command will return once the data transfer is finished.

7. Quit the FTP/SFTP session.

NOTE You must uncompress a zip file before you can view the files it contains.

Downloading historical disk-performance statistics

You can access the storage system's FTP/SFTP interface and use the `get perf` command to download historical disk-performance statistics for all disks in the storage system. This command downloads the data in CSV format to a file, for import into a spreadsheet or other third-party application.

The number of data samples downloaded is fixed at 100 to limit the size of the data file to be generated and transferred. The default is to retrieve all the available data (up to six months) aggregated into 100 samples. You can specify a different time range by specifying a start and end time. If the specified time range spans more than 100 15-minute samples, the data will be aggregated into 100 samples.

The resulting file will contain a row of property names and a row for each data sample, as shown in the following example. For property descriptions, see the topic about the `disk-hist-statistics` basetype in the CLI Reference Guide.

```
"sample-time", "durable-id", "serial-number", "number-of-ios", ...  
"2012-01-26 01:00:00", "disk_1.1", "PLV2W1XE", "2467917", ...
```

```
"2012-01-26 01:15:00", "disk_1.1", "PLV2W1XE", "2360042", ...  
...
```

Use a command-line-based FTP/SFTP client. A GUI-based FTP/SFTP client might not work.

To retrieve historical disk-performance statistics

1. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers. See ["Configuring controller network ports" on page 72](#).
 - b. Verify that the system's FTP/SFTP service is enabled. See ["Enabling or disabling system-management services" on page 74](#).
 - c. Verify that the user you will log in as has permission to use the FTP/SFTP interface. The same setting allows a user to transfer files using both FTP and SFTP. See ["User settings" on page 75](#).

2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the destination directory for the log file.

3. Enter:

```
psftp controller-network-address -P port or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022
```

```
ftp 10.1.0.9
```

4. Log in as a user with permission to use the FTP/SFTP interface.
5. Make sure the client is in binary transfer mode. Enter:

```
binary
```

6. Enter:

```
get perf [:date/time-range] filename.csv
```

where:

- *date/time-range* is optional and specifies the time range of data to transfer, in the format: *start.yyyy-mm-dd.hh:mm. [AM|PM].end.yyyy-mm-dd.hh:mm. [AM|PM]*. The string must contain no spaces.
- *filename* is the file that will contain the data. It is recommended to choose a filename that identifies the system, controller, and date.

For example:


```
get perf: start.2012-01-26.12:00.PM.end.2012-01-26.23:00.PM Storage2_A_20120126.csv
```

7. In FTP, wait for the message `Operation Complete` to appear. No messages are displayed in SFTP; instead, the `get` command will return once the download is finished.
8. Quit the FTP/SFTP session.

Updating firmware

As a user in the `manage` role, you can update the versions of firmware in controller modules, expansion modules (in disk enclosures), and disks.

NOTE HPE recommends using the HPE Smart Component when updating firmware.

 **TIP** To ensure success of an online update, select a period of low I/O activity. This helps the update complete as quickly as possible and avoids disruptions to host and applications due to timeouts. Attempting to update a storage system that is processing a large, I/O-intensive batch job will likely cause hosts to lose connectivity with the storage system.

 **IMPORTANT**

- If a disk group is quarantined, resolve the problem that is causing the disk group to be quarantined before updating firmware. See information about events 172 and 485 in the Event Descriptions Reference Guide.
 - If any unwritten cache data is present, firmware update will not proceed. Before you can update firmware, unwritten data must be removed from cache. See information about event 44 in the Event Descriptions Reference Guide and information about the `clear cache` command in the CLI Reference Guide.
 - If the system's health is `Fault`, firmware update will not proceed. Before you can update firmware, you must resolve the problem specified by the Health Reason value in the System Overview panel.
-

Updating controller-module firmware

In a dual-controller system, both controllers should run the same firmware version. Storage systems in a replication set should run the same or compatible firmware versions. You can update the firmware in each controller module by loading a firmware file obtained from the HPE web download site, <https://www.hpe.com/storage/msafirmware>. To install a firmware Smart Component, follow the instructions on the HPE website. Otherwise, to install a firmware binary file, follow the steps below.

If you have a dual-controller system and the Partner Firmware Update (PFU) option is enabled, when you update one controller the system automatically updates the partner controller. If PFU is disabled, after updating firmware on one controller you must log into the partner controller's IP address and perform this firmware update on that controller also.

For best results, ensure the storage system is in a healthy state before starting firmware update.

NOTE For information about supported releases for firmware update, see the product's Release Notes.

To update controller module firmware

1. Obtain the appropriate firmware file and download it to your computer or network.
2. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers.
 - b. Verify that the system's FTP/SFTP service is enabled.
 - c. Verify that the user you will log in as has permission to use the FTP/SFTP interface. The same setting allows a user to transfer files using both FTP and SFTP.
3. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory containing the firmware file to load.
4. Enter:

```
psftp controller-network-address -P port or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022
```

```
ftp 10.1.0.9
```

5. Log in as an FTP/SFTP user.
6. Make sure the client is in binary transfer mode. Enter:

binary

7. Enter:

```
put firmware-file flash
```

CAUTION Do not perform a power cycle or controller restart during a firmware update. If the update is interrupted or there is a power failure, the module might become inoperative. If this occurs, contact technical support. The module might need to be returned to the factory for reprogramming.

NOTE If you attempt to load an incompatible firmware version, the message `*** Code Load Fail. Bad format image. ***` is displayed and after a few seconds the FTP/SFTP prompt is redisplayed. The code is not loaded.

Firmware update typically takes 10 minutes for a controller having current CPLD firmware, or 20 minutes for a controller with downlevel CPLD firmware. If the controller enclosure has attached enclosures, allow additional time for each expansion module's enclosure management processor (EMP) to be updated. This typically takes 2.5 minutes for each EMP in an MSA 1060/2060/2062 disk enclosure.

NOTE If you are using a Windows FTP/SFTP client, during firmware update a client-side FTP/SFTP application issue or time out setting can cause the FTP/SFTP session to be aborted. If this issue persists try using the SMU to perform the update, use another client, or use another FTP/SFTP application.

If the Storage Controller cannot be updated, the update operation is canceled. If the FTP/SFTP prompt does not return, quit the FTP/SFTP session and log in again. Verify that you specified the correct firmware file and repeat the update. If this problem persists, contact technical support.

When firmware update on the local controller is complete, the FTP session returns to the `sftp>` prompt, and the FTP/SFTP session to the local MC is closed. You will need to monitor the system using a management interface to determine when the update is complete. If PFU is enabled, both controllers will update. If the SMU is open, it will display a pop-up showing update progress. Progress can also be monitored using the `show firmware-update-status` CLI command. For more information on this command, see the CLI Reference Guide.

8. Quit the FTP/SFTP session.
9. Clear your web browser's cache, then sign in to the SMU. If PFU is running on the controller you sign in to, a dialog box shows PFU progress and prevents you from performing other tasks until PFU is complete.

NOTE If PFU is enabled for the system, after firmware update has completed on both controllers, check the system health. After firmware update has completed on both controllers, if the system health is Degraded and the health reason indicates that the firmware version is incorrect, verify that you specified the correct firmware file and repeat the update. If this problem persists, contact technical support.

Updating expansion-module firmware

A disk enclosure contains two expansion modules. Each expansion module contains an enclosure management processor (EMP). All modules of the same product model should run the same firmware version.

You can update the firmware in each expansion-module EMP by loading a firmware file obtained from the HPE web download site, <https://www.hpe.com/storage/msafirmware>. To install a firmware Smart Component, follow the instructions on the HPE website. Otherwise, to install a firmware binary file, follow the steps below.

You can specify to update all expansion modules or only specific expansion modules. If you specify to update all expansion modules and the system contains more than one type of enclosure, the update will be attempted on all enclosures in the system. The update will only succeed for enclosures whose type matches the file, and will fail for enclosures of other types.

To update expansion-module firmware

1. As a user with a `manage` role, obtain the appropriate firmware file and download it to your computer or network.
2. If you want to update all expansion modules, continue with the next step. Otherwise, in the SMU, determine the address of each expansion module to update:
 - a. In the Configuration View panel, select a disk enclosure.
 - b. In the enclosure properties table, note each EMP's bus ID and target ID values. For example, 0 and 63, and 1 and 63. Bus 0 is the bus that is native to a given controller, while bus 1 is an alternate path through the partner controller. It is recommended to perform update tasks consistently through one controller to avoid confusion.
3. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers.
 - b. Verify that the system's FTP/SFTP service is enabled.
 - c. Verify that the user you will log in as has permission to use the FTP/SFTP interface. The same setting allows a user to transfer files using both FTP and SFTP.

4. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory containing the firmware file to load.

5. Enter:

```
psftp controller-network-address -P port or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022
```

```
ftp 10.1.0.9
```

6. Log in as an FTP/SFTP user.
7. Make sure the client is in binary transfer mode. Enter:

```
binary
```

8. Either:

To update all expansion modules, enter:

```
put firmware-file encl
```

To update specific expansion modules, enter:

```
put firmware-file encl:EMP-bus-ID:EMP-target-ID
```

△ CAUTION Do not perform a power cycle or controller restart during the firmware update. If the update is interrupted or there is a power failure, the module might become inoperative. If this occurs, contact technical support. The module might need to be returned to the factory for reprogramming.

It typically takes 2.5 minutes to update each EMP in an MSA 1060/2060/2062 disk enclosure. In FTP, wait for a message that the code load has completed. No messages are displayed in SFTP.

NOTE If the update fails, verify that you specified the correct firmware file and try the update a second time. If it fails again, contact technical support.

9. If you are updating specific expansion modules, repeat the previous step for each remaining expansion module that needs to be updated.
10. Quit the FTP/SFTP session.
11. Verify that each updated expansion module has the correct firmware version.

Updating disk firmware

You can update disk firmware by loading a firmware file obtained from the HPE web download site, <https://www.hpe.com/storage/msafirmware>. To install a firmware Smart Component, follow the instructions on the HPE website.

Installing a license file

1. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers.
 - b. Verify that the system's FTP/SFTP service is enabled.
 - c. Verify that the user you will log in as has permission to use the FTP/SFTP interface. The same setting allows a user to transfer files using both FTP and SFTP.
2. Ensure that the license file is saved to a network location that the storage system can access.
3. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory containing the license file to load.
4. Log in to the controller enclosure that the file was generated for:

```
psftp controller-network-address -P port or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022
```

```
ftp 10.1.0.9
```

5. Log in as an FTP/SFTP user.
6. Make sure the client is in binary transfer mode. Enter:

```
binary
```

7. Enter:

```
put license-file license
```

For example:

```
put certificate.txt license
```

In FTP, a message confirms whether installation succeeded or failed. If installation succeeds, licensing changes take effect immediately. No messages are displayed in SFTP.

Installing a security certificate

The storage system supports use of unique certificates for secure data communications, to authenticate that the expected storage systems are being managed. Use of authentication certificates applies to the HTTPS protocol, which is used by the web server in each controller module.

As an alternative to using the CLI to create a security certificate on the storage system, you can use FTP/SFTP to install a custom certificate on the system. A certificate consists of a certificate file and an associated key file. The certificate can be created by using OpenSSL, for example, and is expected to be valid. If you replace the controller module in which a custom certificate is installed, the partner controller will automatically install the certificate file to the replacement controller module.

To install a security certificate

1. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers. See ["Configuring controller network ports" on page 72](#).
 - b. Verify that the system's FTP/SFTP service is enabled. See ["Enabling or disabling system-management services" on page 74](#).
 - c. Verify that the user you will log in as has permission to use the FTP/SFTP interface. The same setting allows a user to transfer files using both FTP and SFTP. See ["Managing local users" on page 75](#).

2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory that contains the certificate files.

3. Enter:

```
psftp controller-network-address -P port or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022
```

```
ftp 10.1.0.9
```

4. Log in as a user that has permission to use the FTP/SFTP interface.
5. Make sure the client is in binary transfer mode. Enter:

```
binary
```

6. Enter:

```
put certificate-file-name cert-file
```

where *certificate-file-name* is the name of the certificate file for your specific system.

7. Enter:

```
put key-file-name cert-key-file
```

where *key-file-name* is the name of the security key file for your specific system.

The new security certificate takes effect.

Downloading system heat map data

If requested by support engineers for analysis, you can download cumulative I/O density data, also known as heat map data, from the system.

To gather this data, access the storage system's FTP/SFTP interface and use the `get logs` command with the `heatmap` option to download a log file in CSV format. The file contains data for the past seven days from both controllers.

1. In the SMU, prepare to use FTP/SFTP:
 - a. Determine the network-port IP addresses of the system's controllers. See ["Configuring controller network ports" on page 72](#).
 - b. Verify that the system's FTP/SFTP service is enabled. See ["Enabling or disabling system-management services" on page 74](#).

- c. Verify that the user you will log in as has permission to use the FTP/SFTP interface. The same setting allows a user to transfer files using both FTP and SFTP. See ["Managing local users" on page 75](#).
2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the destination directory for the log file.
3. Enter:

```
psftp controller-network-address -P port or ftp controller-network-address
```

For example:

```
psftp 10.235.216.152 -P 1022  
ftp 10.1.0.9
```

4. Log in as a user that has permission to use the FTP/SFTP interface.
5. Make sure the client is in binary transfer mode. Enter:

```
binary
```

6. Enter:

```
get logs:heatmap filename.csv
```

where: *filename* is the file that will contain the data.

For example:

```
get logs:heatmap IO_density.csv
```

In FTP, wait for the message `Operation Complete` to appear. No messages are displayed in SFTP; instead, the `get` command will return once the download is finished.

7. Quit the FTP/SFTP session.

Using SMI-S

This topic provides information for network administrators who are managing the storage system from a storage management application through the Storage Management Initiative Specification (SMI-S). SMI-S is a Storage Networking Industry Association (SNIA) standard that enables interoperable management for storage networks and storage devices.

SMI-S replaces multiple disparate managed object models, protocols, and transports with a single object-oriented model for each type of component in a storage network. The specification was created by SNIA to standardize storage management solutions. SMI-S enables management applications to support storage devices from multiple vendors quickly and reliably because they are no longer proprietary. SMI-S detects and manages storage elements by type, not by vendor.

The key SMI-S components are:

- Web-based Enterprise Management (WBEM). A set of management and Internet standard technologies developed to unify the management of enterprise computing environments. WBEM includes the following specifications:
 - CIM XML: defines XML elements, conforming to DTD, which can be used to represent CIM classes and instances.
 - CIMxml Operations over HTTP/HTTPS: defines a mapping of CIM operations onto HTTP/HTTPS; used as a transport mechanism.
- Common Information Model (CIM). The data model for WBEM. Provides a common definition of management information for systems, networks, applications and services, and allows for vendor extensions. SMI-S is the interpretation of CIM for storage. It provides a consistent definition and structure of data, using object-oriented techniques. The standard language used to define elements of CIM is MOF.

- Service Location Protocol (SLP). Enables computers and other devices to find services in a local area network without prior configuration. SLP has been designed to scale from small, unmanaged networks to large enterprise networks.

For more information about using SMI-S, see the following topics:

- ["Embedded SMI-S array provider" below](#)
- ["About the MSA 1060/2060/2062 SMI-S provider" on the next page](#)
- ["SMI-S profiles" on page 121](#)
- ["Supported CIM operations" on page 122](#)
- ["Life cycle indications" on page 123](#)
- ["SMI-S configuration" on page 124](#)
- ["Listening for managed-logs notifications" on page 125](#)
- ["Testing SMI-S" on page 125](#)
- ["Troubleshooting" on page 125](#)

Embedded SMI-S array provider

The embedded SMI-S array provider provides an implementation of SMI-S 1.5 using `cim-xml` over HTTP/HTTPS. SMI-enabled management clients such as HPE SIM or HPE Storage Essentials can perform storage management tasks such as monitoring, configuring or event-management. The provider supports the Array and Server profiles with additional (or supporting) subprofiles. The Server profile provides a mechanism to tell the client how to connect and use the embedded provider. The Array profile has the following supporting profiles and subprofiles:

- Array profile
- Block Services package
- Physical Package package
- Health package
- Multiple Computer System subprofile
- Masking and Mapping profile
- FC Initiator Ports profile
- SAS Initiator Ports profile
- iSCSI Initiator Ports profile
- Disk Drive Lite profile
- Extent Composition subprofile
- Storage Enclosure profile
- Fan profile
- Power Supply profile
- Sensors profile
- Access Points subprofile
- Location subprofile
- Software Inventory subprofile
- Block Server Performance subprofile
- Copy Services subprofile
- Job Control subprofile
- Storage Enclosure subprofile (if expansion enclosures are attached)
- Disk Sparing subprofile
- Object Manager Adapter subprofile

- Thin Provisioning profile
- Pools from Volumes profile

The embedded SMI-S provider supports:

- HTTPS using SSL encryption on the default port 5989, or standard HTTP on the default port 5988. Both ports cannot be enabled at the same time.
- SLPv2
- CIM Alert and Lifecycle indications
- Microsoft Windows Server 2016 or 2019 Server Manager and System Center Virtual Machine Manager

SMI-S implementation

SMI-S is implemented with the following components:

- CIM server (called a CIM Object Manager or CIMOM), which listens for WBEM requests (CIM operations over HTTP/HTTPS) from a CIM client, and responds.
- CIM provider, which communicates to a particular type of managed resource (for example, MSA 1060/2060/2062 Storage systems), and provides the CIMOM with information about them. In theory, providers for multiple types of devices (for example, MSA 1060/2060/2062 Storage systems and Brocade switches) can be plugged into the same CIMOM. However, in practice, all storage vendors provide the CIMOM and a single provider together, and they do not co-exist well with solutions from other vendors.

These components may be provided in several different ways:

- Embedded agent: The hardware device has an embedded SMI-S agent. No other installation of software is required to enable management of the device.
- SMI solution: The hardware or software ships with an agent that is installed on a host. The agent needs to connect to the device and obtain unique identifying information.

SMI-S architecture

The architecture requirements for the embedded SMI-S Array provider are to work within the Management Controller (MC) architecture, use limited disk space, use limited memory resources and be as fast as a proxy provider running on a server. The CIMOM used is the open source SFCB CIMOM.

SFCB is a lightweight CIM daemon that responds to CIM client requests and supports the standard CIM XML over `http/https` protocol. The provider is a CMPI (Common Management Protocol Interface) provider and uses this interface. To reduce the memory footprint, a third-party package called CIRCLE is used. For more information on SFCB go to <http://sourceforge.net/projects/sblim/files/sblim-sfcb>.

About the MSA 1060/2060/2062 SMI-S provider

The provider is an SMI-S 1.5 provider which passes CTP 1.5 tests. Full provisioning is supported.

The MSA 1060/2060/2062 SMI-S provider is a full-fledged embedded provider implemented in the firmware. It provides an industry-standard WBEM-based management framework. SMI-S clients can interact with this embedded provider directly and do not need an intermediate proxy provider. The provider supports active management features such as RAID provisioning.

The classes for Hewlett Packard Enterprise are `HP_XXX`. The device namespace for Hewlett Packard Enterprise is `/root/hpq.SMI_XXX`. The device namespace is `/root/smis`.

The embedded CIMOM can be configured either to listen to secure SMI-S queries from the clients on port 5989 and require credentials to be provided for all queries, or to listen to unsecured SMI-S queries from the clients on port 5988. This provider implementation complies with the SNIA SMI-S specification version 1.5.0.

NOTE Port 5989 and port 5988 cannot be enabled at the same time.

The namespace details are given below.

- Implementation Namespace - `root/hpqi`
- Interop Namespace - `root/interop`

The embedded provider set includes the following providers:

- Instance Provider
- Association Provider
- Method Provider
- Indication Provider

The embedded provider supports the following CIM operations:

- `getClass`
- `enumerateClasses`
- `enumerateClassNames`
- `getInstance`
- `enumerateInstances`
- `enumerateInstaneceNames`
- `associators`
- `associatorNames`
- `references`
- `referenceNames`
- `invokeMethod`

SMI-S profiles

SMI-S is organized around profiles, which describe objects relevant for a class of storage subsystem. SMI-S includes profiles for arrays, FC HBAs, FC switches, and tape libraries. Profiles are registered with the CIM server and advertised to clients using SLP. HPE SIM determines which profiles it intends to manage, and then uses the CIM model to discover the actual configurations and capabilities.

Table 14 Supported SMI-S profiles

Profile/subprofile/package	Description
Array profile	Describes RAID array systems. It provides a high-level overview of the array system.
Block Services package	Defines a standard expression of existing storage capacity, the assignment of capacity to Storage Pools, and allocation of capacity to be used by external devices or applications.
Physical Package package	Models information about a storage system's physical package and optionally about internal sub-packages.
Health package	Defines the general mechanisms used in expressing health in SMI-S.
Server profile	Defines the capabilities of a CIM object manager based on the communication mechanisms that it supports.
FC Initiator Ports profile	Models the Fibre Channel-specific aspects of a target storage system.
SAS Initiator Ports subprofile	Models the SAS-specific aspects of a target storage system.
iSCSI Initiator Ports subprofile	Models the iSCSI-specific aspects of a target storage system.

Table 14 Supported SMI-S profiles (continued)

Profile/subprofile/package	Description
Access Points subprofile	Provides addresses of remote access points for management services.
Fan profile	Specializes the DMTF Fan profile by adding indications.
Power Supply profile	Specializes the DMTF Power Supply profile by adding indications.
Profile Registration profile	Models the profiles registered in the object manager and associations between registration classes and domain classes implementing the profile.
Software subprofile	Models software or firmware installed on the system.
Masking and Mapping profile	Models device mapping and masking abilities for SCSI systems.
Disk Drive Lite profile	Models disk drive devices.
Extent Composition	Provides an abstraction of how it virtualizes exposable block storage elements from the underlying Primordial storage pool.
Location subprofile	Models the location details of product and its sub-components.
Sensors profile	Specializes the DMTF Sensors profile.
Software Inventory profile	Models installed and available software and firmware.
Storage Enclosure profile	Describes an enclosure that contains storage elements (e.g., disk or tape drives) and enclosure elements (e.g., fans and power supplies).
Multiple Computer System subprofile	Models multiple systems that cooperate to present a “virtual” computer system with additional capabilities or redundancy.
Copy Services subprofile	Provides the ability to create and delete local snapshots and local volume copies (clones), and to reset the synchronization state between a snapshot and its source volume.
Job Control subprofile	Provides the ability to monitor provisioning operations, such as creating volumes and snapshots, and mapping volumes to hosts.
Disk Sparing subprofile	Provides the ability to describe the current spare disk configuration, to allocate/de-allocate spare disks, and to clear the state of unavailable disk drives.
Object Manager Adapter subprofile	Allows the client to manage the Object Manager Adapters of a SMI Agent. In particular, it can be used to turn the indication service on and off.
Thin Provisioning profile	Specializes the Block Services Package to add support for thin provisioning of volumes. SMI-S does not support the creation of virtual pools. However, a client can create virtual volumes.
Pools from Volumes profile	Models a pool created from other volumes. This profile is used in conjunction with the Thin Provisioning profile to model virtual storage pools.

Block Server Performance subprofile

The implementation of the block server performance subprofile allows use of the `CIM_`
`BlockStorageStatisticalData` classes and their associations, and the `GetStatisticsCollection`,
`CreateManifestCollection`, `AddOrModifyManifest` and `RemoveManifest` methods.

The Block Server Performance subprofile collection of statistics updates at 60-second intervals.

Supported CIM operations

SFCB provides a full set of CIM operations including `GetClass`, `ModifyClass`, `CreateClass`, `DeleteClass`,
`EnumerateClasses`, `EnumerateClassNames`, `GetInstance`, `DeleteInstance`, `CreateInstance`,
`ModifyInstance`, `EnumerateInstances`, `EnumerateInstanceNames`, `InvokeMethod` (`MethodCall`),
`ExecQuery`, `Associators`, `AssociatorNames`, `References`, `ReferenceNames`, `GetQualifier`,
`SetQualifier`, `DeleteQualifier`, `EnumerateQualifiers`, `GetProperty` and `SetProperty`.

CIM Alerts

The implementation of alert indications allows a subscribing CIM client to receive events such as FC cable connects, Power Supply events, Fan events, Temperature Sensor events and Disk Drive events.

If the storage system's SMI-S interface is enabled, the system will send events as indications to SMI-S clients so that SMI-S clients can monitor system performance. For information about enabling the SMI-S interface, see ["SMI-S configuration" on the next page](#).

In a dual-controller configuration, both controller A and B alert events are sent via controller A's SMI-S provider.

The event categories in [Table 15](#) pertain to FRU assemblies and certain FRU components.

Table 15 CIM Alert indication events

FRU/Event category	Corresponding SMI-S class	Operational status values that would trigger alert conditions
Controller	HP_Controller	Down, Not Installed, OK
Hard Disk Drive	HP_DiskDrive	Unknown, Missing, Error, Degraded, OK
Fan	HP_PSUFan	Error, Stopped, OK
Power Supply	HP_PSU	Unknown, Error, Other, Stressed, Degraded, OK
Temperature Sensor	HP_OverallTempSensor	Unknown, Error, Other, Non-Recoverable Error, Degraded, OK
Battery/Super Cap	HP_SuperCap	Unknown, Error, OK
FC Port	HP_FCPort	Stopped, OK
SAS Port	HP_SASTargetPort	Stopped, OK
iSCSI Port	HP_ISCSIEthernetPort	Stopped, OK

Life cycle indications

The SMI-S interface provides CIM life cycle indications for changes in the physical and logical devices in the storage system. The SMI-S provider supports all mandatory elements and certain optional elements in SNIA SMI-S specification version 15.0. CIM Query Language (CQL) and Windows Management Instrumentation Query Language (WQL) are both supported, with some limitations to the CQL indication filter. The provider supports additional life cycle indications that the Windows Server 2016 or 2019 operating system requires.

Table 16 Life cycle indications

Profile or subprofile	Element description and name	WQL or CQL
Block Services	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_StoragePool Send life cycle indication when a disk group is created or deleted.	Both
Block Services	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_StorageVolume Send life cycle indication when a volume is created or deleted.	Both
Block Services	SELECT * FROM CIM_InstModification WHERE SourceInstance ISA CIM_LogicalDevice Send life cycle indication when disk drive (or any logical device) status changes.	Both
Copy Services	SELECT * FROM CIM_InstModification WHERE SourceInstance ISA CIM_StorageSynchronized AND SourceInstance.SyncState <> PreviousInstance.SyncState Send life cycle indication when the snapshot synchronization state changes.	CQL
Disk Drive Lite	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_DiskDrive Send life cycle indication when a disk drive is inserted or removed.	Both
Job Control	SELECT * FROM CIM_InstModification WHERE SourceInstance ISA CIM_ConcreteJob AND SourceInstance.OperationalStatus=17 AND SourceInstance.OperationalStatus=2 Send life cycle indication when a create or delete operation completes for a volume, LUN, or snapshot.	WQL

Table 16 Life cycle indications (continued)

Profile or subprofile	Element description and name	WQL or CQL
Masking and Mapping	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_authorizedSubject Send life cycle indication when a host privilege is created or deleted.	Both
Masking and Mapping	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_ProtocolController Send life cycle indication when storage hardware ID is created or deleted (add/remove hosts).	Both
Masking and Mapping	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_ProtocolControllerForUnit Send life cycle indication when a LUN is created, deleted, or modified.	Both
Multiple Computer System	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_ComputerSystem Send life cycle indication when a controller is powered on or off.	Both
Multiple Computer System	SELECT * FROM CIM_InstModification WHERE SourceInstance ISA CIM_ComputerSystem AND SourceInstance.OperationalStatus <> PreviousInstance.OperationalStatus Send life cycle indication when a logical component degrades or upgrades the system.	WQL
Multiple Computer System	SELECT * FROM CIM_InstModification WHERE SourceInstance ISA CIM_RedundancySet AND SourceInstance.RedundancyStatus <> PreviousInstance.RedundancyStatus Send life cycle indication when the controller active-active configuration changes.	WQL
Target Ports	SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_FCPort Send life cycle indication when a target port is created or deleted.	Both
Target Ports	SELECT * FROM CIM_InstModification WHERE SourceInstance ISA CIM_FCPort AND SourceInstance.OperationalStatus <> PreviousInstance.OperationalStatus Send life cycle indication when the status of a target port changes.	WQL

SMI-S configuration

In the default SMI-S configuration:

- The secure SMI-S protocol is enabled, which is the recommended protocol for SMI-S.
- The SMI-S interface is enabled for the manage user.

The following table lists the CLI commands relevant to the SMI-S protocol:

Table 17 CLI commands for SMI-S protocol configuration

Action	CLI command
Enable secure SMI-S port 5989 (and disable port 5988)	set protocols smis enabled
Disable secure SMI-S port 5989	set protocols smis disabled
Enable unsecured SMI-S port 5988 (and disable port 5989)	set protocols usmis disabled
Enable unsecured SMI-S port 5988	set protocol usmis enabled
See the current status	show protocols
Reset all configurations	reset smis-configurations

To configure the SMI-S interface for other users

1. Log in as manage.

- If the user does not already exist, create one using this command:

```
create user role manage username.
```

- Type this command:

```
set user username interfaces wbi,cli,smis,ftp,sftp
```

Listening for managed-logs notifications

For use with the storage system's managed logs feature, the SMI-S provider can be set up to listen for notifications that log files have filled to a point that are ready to be transferred to a log-collection system. For more information about the managed logs feature, see ["Managed logs" on page 35](#).

To set up SMI-S to listen for managed logs notifications

- In the CLI, enter this command:

```
set advanced-settings managed-logs enabled
```

- In an SMI-S client:

- Subscribe using the `SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_LogicalFile` filter.
- Subscribe using the `SELECT * FROM CIM_InstDeletion WHERE SourceInstance ISA CIM_LogicalFile` filter.

Testing SMI-S

Use an SMI-S certified client for SMI-S 1.5. Hewlett Packard Enterprise has clients such as HPE SIM and HPE Storage Essentials. Other common clients are Microsoft System Center, IBM Tivoli, EMC CommandCenter and CA Unicenter. Common WBEM CLI clients are Pegasus `cimcli` and Sblim's `wbemcli`.

To certify that the array provider is SMI-S 1.5 compliant, SNIA requires that the providers pass the Conformance Test Program (CTP) tests.

The `reset smis-configuration` command enables the restoration of your original SMI-S configuration.

Troubleshooting

The following table provides solutions to common SMI-S problems.

Table 18 Troubleshooting

Problem	Cause	Solution
Unable to connect to the embedded SMI-S Array provider.	SMI-S protocol is not enabled.	Log in to the array as <code>manage</code> and type: <code>set protocol smis enabled</code>
HTTP Error (Invalid username/password or 401 Unauthorized).	User preferences are configurable for each user on the storage system.	Check that the user has access to the <code>smis</code> interface and set the user preferences to support the <code>smis</code> interface, if necessary. See "User settings" on page 75 for instructions on how to add users. Also verify the supplied credentials.
Want to connect securely as <code>username my_XXXX</code> .	Need to add user.	Log in to the array as <code>manage</code> . Type: <code>create user level manage my_XXXuser</code> and then type: <code>set user my_XXXuser interfaces wbi,cli,smis</code>
Unable to discover via SLP.	SLP multicast has limited range (known as hops).	Move the client closer to the array or set up a SLP DA server or using unicast requests.
Unable to determine if SMI-S is running.	Initial troubleshooting.	Use a Common Information Model (CIM) client tool, such as <code>wbemcli</code> , to troubleshoot.
SMI-S is not responding to client requests.	SMI-S configuration may have become corrupted.	Use the CLI command <code>reset smis-configuration</code> . Refer to the CLI Reference Guide for further information.

Using SLP

HPE MSA 1060/2060/2062 Storage systems support Service Location Protocol (SLP, `srvloc`), which is a service discovery protocol that allows computers and other devices to find services in a LAN without prior configuration. SLP is open for use on all operating systems, and does not require formal licensing.

SLP is based on User Datagram Protocol (UDP) and can use Transmission Control Protocol (TCP) if needed. SLP listens on port 427. When a client, or User Agent (UA), connects to a network, the client queries for Directory Agents (DA) on the network. If no DA responds, the client assumes a DA-less network and sends a multicast UDP query. All Service Agents (SA) that contain query matches will send a UDP answer to the client. If the answer message is too large, the client can repeat the query using TCP.

In a network with DAs, each SA must register all services with a DA. Then the clients will query the DAs, who will respond to the query with its cached SA information.

Through use of DAs, SLP can also scale beyond the local area network to large enterprise, which is an enterprise IT issue. Consult the IETF RFC2165.

When SLP is enabled, the storage system will advertise the interfaces shown in [Table 19](#) and populate the configuration attributes shown in [Table 20](#).

Table 19 Interfaces advertised by SLP

Interface (protocol) description	Advertisement string
HTTP	<code>service:api:http</code>
HTTPS	<code>service:api:https</code>
Telnet	<code>service:ui:telnet</code>
SSH	<code>service:ui:ssh</code>
FTP/SFTP (firmware upgrade)	<code>service:firmware-update:ftp/sftp</code>
SNMP	<code>service:api:snmp</code>

Table 20 SLP attributes shown for a storage system

SLP attribute	Corresponding property shown by the CLI <code>show system detail</code> command in XML API mode
<code>x-system-name</code>	<code>system-name</code>
<code>x-system-contact</code>	<code>system-contact</code>
<code>x-system-location</code>	<code>system-location</code>
<code>x-system-information</code>	<code>system-information</code>
<code>x-midplane-serial-number</code>	<code>midplane-serial-number</code>
<code>x-vendor-name</code>	<code>vendor-name</code>
<code>x-product-id</code>	<code>product-id</code>
<code>x-product-brand</code>	<code>product-brand</code>
<code>x-wwnn</code>	<code>current-node-wwn</code>
<code>x-platform-type</code>	<code>platform-type</code>
<code>x-bundle-version</code>	no corresponding property
<code>x-build-date</code>	no corresponding property
<code>x-mac-address</code>	no corresponding property
<code>x-top-level-assembly-part-number</code>	no corresponding property
<code>x-top-level-assembly-serial-number</code>	no corresponding property

You can enable or disable the SLP service in the SMU, as described in ["Enabling or disabling system-management services" on page 74](#), or by using the CLI `set protocols` command as described in the CLI Reference Guide. If the SLP service is enabled, you can test it by using an open source tool, such as `slptool` from openSLP.org.

B Administering a log-collection system

A log-collection system receives log data that is incrementally transferred from a storage system for which the managed logs feature is enabled, and is used to integrate that data for display and analysis. For information about the managed logs feature, see ["Managed logs" on page 35](#).

Over time, a log-collection system can receive many log files from one or more storage systems. The administrator organizes and stores these log files on the log-collection system. Then, if a storage system experiences a problem that needs analysis, that system's current log data can be collected and combined with the stored historical log data to provide a long-term view of the system's operation for analysis.

The managed logs feature monitors the following controller-specific log files:

- Expander Controller (EC) log, which includes EC debug data, EC revisions, and PHY statistics
- Storage Controller (SC) debug log and controller event log
- SC crash logs, which include the SC boot log
- Management Controller (MC) log

Each log-file type also contains system-configuration information.

How log files are transferred and identified

Log files can be transferred to the log-collection system in two ways, depending on whether the managed logs feature is configured to operate in *push mode* or *pull mode*:

- In push mode, when log data has accumulated to a significant size, the storage system sends notification events with attached log files through email to the log-collection system. The notification specifies the storage-system name, location, contact, and IP address, and contains a single log segment in a compressed zip file. The log segment will be uniquely named to indicate the log-file type, the date/time of creation, and the storage system. This information will also be in the email subject line. The file name format is `logtype_yyyy_mm_dd__hh_mm_ss.zip`.
- In pull mode, when log data has accumulated to a significant size, the system sends notification events via email, SMI-S, or SNMP traps, to the log-collection system. The notification will specify the storage-system name, location, contact, and IP address and the log-file type (region) that needs to be transferred. The storage system's FTP/SFTP interface can be used to transfer the appropriate logs to the log-collection system, as described in ["Transferring log data to a log-collection system" on page 110](#).

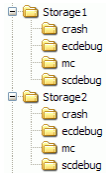
Log file details

- SC debug-log records contain date/time stamps of the form `mm/dd hh:mm:ss`.
- SC crash logs (diagnostic dumps) are produced if the firmware fails. Upon restart, such logs are available, and the restart boot log is also included. The four most recent crash logs are retained in the storage system.
- When EC debug logs are obtained, EC revision data and SAS PHY statistics are also provided.
- MC debug logs transferred by the managed logs feature are for five internal components: `appsv`, `mccli`, `logc`, `web`, and `snmpd`. The contained files are log-file segments for these internal components and are numbered sequentially.

Storing log files

It is recommended to store log files hierarchically by storage-system name, log-file type, and date/time. Then, if historical analysis is required, the appropriate log-file segments can easily be located and can be concatenated into a complete record.

For example, assume that the administrator of a log-collection system has created the following hierarchy for logs from two storage systems named Storage1 and Storage2:



In push mode, when the administrator receives an email with an attached ecdebug file from Storage1, the administrator would open the attachment and unzip it into the ecdebug subdirectory of the Storage1 directory.

In pull mode, when the administrator receives notification that an SC debug log needs to be transferred from Storage2, the administrator would use the storage system's FTP/SFTP interface to get the log and save it into the scdebug subdirectory of the Storage2 directory.

C Settings changed by restoring defaults

This page summarizes the system settings that result from using the CLI `restore defaults` command.

Table 21 Settings changed by restore defaults

Setting	Value
System information settings:	
System name	Uninitialized Name
System contact	Uninitialized Contact
System location	Uninitialized Location
System information	Uninitialized Info
Management protocols settings:	
CLI/Telnet	Disabled
CLI/SSH	Enabled
SLP	Enabled
FTP	Disabled
SFTP	Enabled
SNMP	Disabled
WBI/HTTP	Disabled
WBI/HTTPS	Enabled
SMI-S	Disabled
Unsecure SMI-S	Disabled
Debug	Disabled
Ciphers setting	Default cipher strings
Users	All configured users are deleted and replaced with default user definitions and default settings: User: <code>setup</code> ; Password: press Enter
CLI session timeout	Preserved
Tasks and schedules	Preserved
Management Controller debug logs	Preserved
Management Controller event logs	Preserved
Storage Controller debug logs	Preserved
Storage Controller event logs	Preserved
Time/date and NTP settings	Preserved
Network IP settings	Preserved
IPv6 network settings	Preserved
DNS management hostname	Preserved
DNS name servers	Preserved
DNS search domains	Preserved
SNMP settings:	
SNMP trap notification level	None
SNMP trap host IPs	0.0.0.0

Table 21 Settings changed by restore defaults (continued)

Setting	Value
SNMP read community	public
SNMP write community	private
SMTP settings:	
Email notification	Disabled
Email notify filter	None
Email addresses	None
Email server	None
Email domain	None
Email sender	None
Log destination	None
Include logs	Disabled
Persistent alerts	Enabled
Alert notification	All
Proxy setting	Cleared
LDAP:	
LDAP parameters	Cleared
LDAP settings	Disabled
User groups	Cleared
Audit log	Preserved
Alert condition history	Preserved
Alerts	Preserved
SSL/SSH certificates	Preserved
Licenses	Preserved
Disk group metadata	Preserved
Host port settings:	
FC link speed	Auto
FC topology	Point-to-point
SAS fanout (Y cable) support	Enabled
Host and initiator nicknames and profiles	Preserved
Disk spin down	Disabled
Advanced settings:	
Disk group background scrub	Enabled
Disk group background scrub interval	24 hours
Partner firmware upgrade	Enabled
Utility priority	High
SMART	Enabled

Table 21 Settings changed by restore defaults (continued)

Setting	Value
Dynamic spare configuration	Enabled
Enclosure polling rate	5 seconds
Host control of caching	Disabled
Sync cache mode	Immediate
Missing LUN response	Illegal Request
Controller failure	Disabled
Supercap failure	Enabled
Power supply failure	Disabled
Fan failure	Disabled
Temperature exceeded	Disabled
Partner notify	Disabled
Auto write back	Enabled
Inactive drive spin down	Disabled
Inactive drive spin down delay	15 minutes
Disk background scrub	Enabled
Managed logs	Disabled
Auto stall recovery	Enabled (for failover/failback, not I/O)
Restart on CAPI fail	Enabled
FDE settings	Preserved
Replication settings:	
Peer connections	Preserved
Replication sets	Preserved
CHAP records	Preserved
Enclosure settings:	
Name	Cleared
Location	Cleared
Rack number	0
Rack position	0
Host groups	Preserved
iSCSI port settings:	
IP	Preserved
IP version	Preserved
Netmask	Preserved
Gateway	Preserved
Router (IPv6 only)	Preserved
Other iSCSI settings:	
CHAP enabled	Preserved

Table 21 Settings changed by restore defaults (continued)

Setting	Value
iSNS	Preserved
Jumbo frames	Preserved
Volume identifying information	
Preserved	
Pool settings:	
Thresholds	Preserved
Overcommit	Preserved
Limits and policy	Preserved
Snapshot space thresholds	Preserved
CLI parameters	CLI parameters are kept on a per-user basis. All configured users are deleted and replaced with default user definitions and default settings as detailed in the Users section of this table.
Debug log parameters	Each parameter is reset to its default as documented in <code>set debug-log-parameters</code> .
Volume snapshot retention priority	Preserved
Volume cache settings	Preserved
Expander PHY settings	Cleared.
Volume tier affinity	Preserved
Device identification LED status	Cleared

D System configuration limits

Table 22 System configuration limits

Feature	Value
Enclosures and disks	
Maximum enclosures and disks per system	Supported configurations:
1060	One 2U24 controller enclosure + three 2U12 expansion enclosures = 60 One 2U24 controller enclosure + three 2U24 expansion enclosures = 96
2060/2062	One 2U12 controller enclosure + nine 2U12 expansion enclosures = 120 One 2U12 controller enclosure + nine 2U24 expansion enclosures = 228 One 2U24 controller enclosure + nine 2U12 expansion enclosures = 132 One 2U24 controller enclosure + nine 2U24 expansion enclosures = 240
Disk groups and pools	
Storage model	Virtual
Maximum virtual pools per controller module	1
Maximum usable virtual pool size	1004 TiB (1 PB)
Maximum disk-group size	1060: 128 TiB 2060/2062: 1004 TiB
Maximum disk groups per pool	16
Minimum/maximum disks per virtual disk group	NRAID (non-RAID): 1/1 (read cache only) RAID 0: 2/2 (read cache only) RAID 1: 2/2 RAID 5: 3/16 RAID 6: 4/16 RAID 10: 4/16 MSA-DP+: 12/128
Maximum global spares per system	64
Maximum MSA-DP+ disk groups per pool	4
Maximum MSA-DP+ single disk size	64 TiB
MSA-DP+ stripe width (total, data+parity)	10, 8+2
Volumes, initiators, hosts, and mapping	
Maximum virtual volumes per system	1024
Maximum volume (LUN) size	128 TiB (approximately 140 TB)
Maximum mappable virtual volumes (LUNs) per pool	512
Maximum virtual volumes per pool	1024 (512 base volumes and 512 snapshots)
Maximum volumes per replication volume group	16
Maximum initiators per host port	1024
Maximum initiators per controller module	4096
Maximum initiators per system	8192
Maximum initiators per volume	128
Maximum initiators per host	128
Maximum hosts per host group	128

Table 22 System configuration limits (continued)

Feature	Value
Maximum host groups per system	32
Maximum queue depth per host port	1024
Maximum host-port link speed	16 Gb FC 10 Gb iSCSI 12 Gb SAS
Virtual volume snapshots	
Maximum snapshots per system, without a license	64
Maximum snapshots per system, with a license	512
Maximum snapshots per pool (net usable)	512
Maximum base volumes per system	1024
Maximum snapshots per base volume	254 in the volume's snapshot tree (with a license)
Maximum mappable snapshots per system	1024
Virtual volume replication	
Maximum number of peer connections per system	1060: 1 2060/2062: 4
Maximum number of replicated volumes per system	32
Maximum number of replication sets for a volume	1
Maximum number of volumes for a replicated volume group	16, if no other volumes belong to a replication set
Minimum replication schedule interval	30 minutes
Embedded SMI-S provider	
Maximum mapping paths (where a path is a volume presented through a host port to an initiator)	250
Miscellaneous	
Maximum SCSI reservations	Per system: 1024 Per LUN: 1
Maximum SCSI registrations	Per system: 32768 Per LUN: 4096

Glossary

2U12

An enclosure that is two rack units in height and can contain 12 disks.

2U24

An enclosure that is two rack units in height and can contain 24 disks.

AES

Advanced Encryption Standard.

AFA

All-flash array. A storage system that uses only SSDs, without tiering.

all-flash array

See AFA.

allocated page

A page of virtual pool space that has been allocated to a volume to store data.

allocation rate

The rate, in pages per minute, at which a virtual pool is allocating pages to its volumes because they need more space to store data.

array

See storage system.

ASC/ASCQ

Additional Sense Code/Additional Sense Code Qualifier. Information on sense data returned by a SCSI device.

auto-write-through

See AWT.

automated tiered storage

Automated tiered storage. A virtual-storage feature that automatically uses the appropriate tier of disks to store data based on how frequently the data is accessed. This enables higher-cost, higher-speed disks to be used only for frequently needed data, while infrequently needed data can reside in lower-cost, lower-speed disks.

available disk

A disk that is not a member of a disk group, is not configured as a spare, and is not in the leftover state. It is available to be configured as a part of a disk group or as a spare.

AWT

Auto-write-through. A setting that specifies when the RAID controller cache mode automatically changes from write-back to write-through.

base volume

A virtual volume that is not a snapshot of any other volume, and is the root of a snapshot tree.

canister

See IOM.

CAPI

Configuration Application Programming Interface. A proprietary protocol used for communication between the Storage Controller and the Management Controller in a controller module. CAPI is always enabled.

CHAP

Challenge Handshake Authentication Protocol.

chassis

The sheetmetal housing of an enclosure.

child volume

The snapshot of a parent volume in a snapshot tree.

chunk size

The amount of contiguous data that is written to a disk group member before moving to the next member of the disk group.

CIM

Common Information Model. The data model for WBEM. It provides a common definition of management information for systems, networks, applications and services, and allows for vendor extensions.

CIMOM

Common Information Model Object Manager. A component in CIM that handles the interactions between management applications and providers.

compatible disk

A disk that can be used to replace a failed member disk of a disk group because it has at least the same capacity as, and is of the same type (enterprise SAS, for example) as, the disk that failed.

controller A (or B)

A short way of referring to controller module A (or B).

controller enclosure

An enclosure that contains two controller modules.

controller module

A FRU that contains the following subsystems and devices: a Storage Controller processor; a Management Controller processor; a SAS expander and Expander Controller processor; management interfaces; cache protected by a supercapacitor pack and nonvolatile memory; host, expansion, network, and service ports; and midplane connectivity.

CPLD

Complex programmable logic device.

CQL

CIM Query Language.

CRC

Cyclic Redundancy Check.

CRU

customer-replaceable unit. See customer FRU.

CSV

Comma-separated values. A format to store tabular data in plain-text form.

customer FRU

A product module that can be ordered as a SKU and replaced in an enclosure by customers or by qualified service personnel, without having to send the enclosure to a repair facility.

DAS

Direct Attached Storage. A dedicated storage device that connects directly to a host without the use of a switch.

deallocation rate

The rate, in pages per minute, at which a pool is deallocating pages from its volumes because they no longer need the space to store data.

DES

Data Encryption Standard.

DHCP

Dynamic Host Configuration Protocol. A network configuration protocol for hosts on IP networks.

disk group

A group of disks that is configured to use a specific RAID level and that provides storage capacity. The number of disks that a disk group can contain is determined by its RAID level.

disk spin down

See DSD.

DNS

Domain Name System.

drain

The automatic movement of active volume data from a virtual disk group to other disk-group members within the same pool.

drive enclosure

See expansion enclosure. See also EBOD, JBOD.

DSD

Disk spin down. A power-saving feature for spinning disks that monitors disk activity and spins down inactive disks based on user-selectable policies.

DSP

Digital signal processor.

dual-port disk

A disk that is connected to both controllers so it has two data paths, achieving fault tolerance.

dynamic spare

An available compatible disk that is automatically assigned, if the dynamic spares option is enabled, to replace a failed disk in a disk group with a fault-tolerant RAID level.

EBOD

Expanded Bunch of Disks. Expansion enclosure attached to a controller enclosure.

EC

Expander Controller. A processor (located in the SAS expander in each controller module and expansion module) that controls the SAS expander and provides SES functionality. See also EMP.

EEPROM

Electrically erasable programmable ROM.

eMMC

Electro-magnetic memory card. Also referred to as memory card, non-volatile memory.

EMP

Enclosure management processor. An Expander Controller subsystem that provides SES data such as temperature, power supply and fan status, and the presence or absence of disks.

enclosure

A physical storage device that contains I/O modules, disk drives, and other FRUs. See also controller enclosure, expansion enclosure.

enclosure management processor

See EMP.

ESD

Electrostatic discharge.

ESM

Environmental Service Module. See IOM.

Expander Controller

See EC.

expansion enclosure

An enclosure that contains two expansion modules. Expansion enclosures can be connected to a controller enclosure to provide additional storage capacity. See also EBOD, JBOD.

expansion module

A FRU that contains the following subsystems and devices: a SAS expander and Expander Controller processor; host, expansion, and service ports; and midplane connectivity. In a drive enclosure, the upper expansion module is designated A and the lower one is designated B.

fallback

See recovery.

failover

In an active-active configuration, failover is the act of temporarily transferring ownership of controller resources from an offline controller to its partner controller, which remains operational. The resources include pools, volumes, cache data, host ID information, and LUNs and WWNs. See also recovery.

FC

Fibre Channel interface protocol.

FC-AL

Fibre Channel Arbitrated Loop. The FC topology in which devices are connected in a one-way loop.

FDE

Full Disk Encryption. A feature that secures all the user data on a storage system. See also lock key, passphrase, repurpose, SED.

FPGA

Field-programmable gate array. An integrated circuit designed to be configured after manufacturing.

FQDN

Fully qualified domain name.

FRU

field-replaceable unit. See service FRU.

Full Disk Encryption

See FDE.

GEM

Generic Enclosure Management. The firmware responsible for managing enclosure electronics and environmental parameters. GEM is used by the Expander Controller.

global spare

A compatible disk that is reserved for use by any disk group with a fault-tolerant RAID level to replace a failed disk.

HBA

Host bus adapter. A device that facilitates I/O processing and physical connectivity between a host and the storage system.

host

A user-defined object that represents a server to which the storage system is attached, and is used to define a mapping relationship to storage.

host group

A user-defined set of hosts for ease of management, such as for volume-attachment operations.

host port

A port on a controller module that interfaces to a server, either directly or through a network switch.

I/O Manager

An SNMP MIB term for a controller module.

I/O module

See IOM.

initiator

An external port to which the storage system is connected. The external port may be a port in an I/O adapter in a server, or a port in a network switch.

IOM

Input/output module, or I/O module. An IOM can be either a controller module or an expansion module.

IOPS

I/O operations per second.

IQN

iSCSI Qualified Name.

iSCSI

Internet SCSI interface protocol.

iSNS

Internet Storage Name Service.

JBOD

"Just a bunch of disks." An expansion enclosure attached to a server.

LBA

Logical block address. The address used for specifying the location of a block of data.

LDAP

Local directory access protocol.

LDAPS

LDAP over SSL.

leftover

The state of a disk that the system has excluded from a disk group because the timestamp in the disk's metadata is older than the timestamp of other disks in the disk group, or because the disk was not detected during a rescan. A leftover disk cannot be used in another disk group until the disk's metadata is cleared. For information and cautions about doing so, see documentation topics about clearing disk metadata.

LFF

Large form factor.

LIP

Loop Initialization Primitive. An FC primitive used to determine the loop ID for a controller.

lock key

A system-generated value that manages the encryption and decryption of data on FDE-capable disks. See also FDE, passphrase.

loop

See FC-AL.

LUN

Logical Unit Number. A number that identifies a mapped volume to a host system.

MAC address

Media Access Control Address. A unique identifier assigned to network interfaces for communication on a network.

Management Controller

See MC.

map/mapping

Settings that specify whether a volume is presented as a storage device to a host, and how the host can access the volume. Mapping settings include an access type and a LUN that identifies the volume to the host.

MC

Management Controller. A processor (located in a controller module) that is responsible for human-computer interfaces, such as a WBI, and computer-computer interfaces, such as SNMP, and interacts with the Storage Controller.

metadata

Data in the first sectors of a disk that stores disk-, disk-group-, and volume-specific information including disk group membership or spare identification, disk group ownership, volumes and snapshots in the disk group, host mapping of volumes, and results of the last media scrub.

MIB

Management Information Base. A database used for managing the entities in SNMP.

midplane

The printed circuit board to which components connect in the middle of an enclosure.

mount

To enable access to a volume from a host OS. Synonyms for this action include present and map.

MSA-DP+

A RAID-based data protection level that maximizes flexibility, provides built in spare capacity, and allows for very fast rebuilds, large storage pools, and simplified expansion.

network port

The Ethernet port on a controller module through which its Management Controller is connected to the network.

NRAID

Non-RAID, nonstriped mapping to a single disk.

NTP

Network time protocol.

OID

Object Identifier. In SNMP, an identifier for an object in a MIB.

orphan data

See unwritable cache data.

overcommit

A setting that controls whether a pool is allowed to have volumes whose total size exceeds the physical capacity of the pool.

overcommitted

The amount of storage capacity that is allocated to virtual volumes exceeds the physical capacity of the storage system.

page

A range of contiguous LBAs in a virtual disk group.

paged storage

A method of mapping logical host requests to physical storage that maps the requests to virtualized “pages” of storage that are in turn mapped to physical storage. This provides more flexibility for expanding capacity and automatically moving data than the traditional, linear method in which requests are directly mapped to storage devices. Paged storage is also called virtual storage.

parent volume

A virtual volume that has snapshots (can be either a base volume or a base snapshot volume). The parent of a snapshot is its immediate ancestor in the snapshot tree.

partner firmware update

See PFU.

passphrase

A user-created password that allows users to manage lock keys in an FDE-capable system. See also FDE, lock key.

PCB

Printed circuit board.

PCBA

Printed circuit board assembly.

PCM

Power and cooling module FRU. A power supply module that includes an integrated fan. See also PSU.

PDU

Power distribution unit. The rack power-distribution source to which a PCM or PSU connects.

peer connection

The configurable entity defining a peer-to-peer relationship between two systems for the purpose of establishing an asynchronous replication relationship. See also peer system.

peer system

A remote storage system that can be accessed by the local system and is a candidate for asynchronous replications. Both systems in a peer connection are considered peer systems to each other, and they both maintain a peer connection with the other. Asynchronous replication of volumes may occur in either direction between peer systems configured in a peer connection.

PFU

Partner firmware update. The automatic update of the partner controller when the user updates firmware on one controller.

PGR

Persistent group reservations.

PHY

One of two hardware components that form a physical link between devices in a SAS network that enables transmission of data.

point-to-point

Fibre Channel Point-to-Point topology in which two ports are directly connected.

pool

A container for volumes that is composed of one or more virtual disk groups.

POST

Power-on self test. Tests that run immediately after a device is powered on.

primary system

The storage system that contains a replication set's primary volume.

primary volume

The volume that is the source of data in a replication set and that can be mapped to hosts. The primary volume exists in the primary storage system.

PSU

Power supply unit FRU.

RAID head

See controller enclosure.

RBOD

"RAID bunch of disks." See controller enclosure.

read cache

A special virtual disk group, comprised of SSDs, that can be added to a pool for the purpose of speeding up read access to data stored on spinning disks elsewhere in the pool.

recovery

In an active-active configuration, recovery is the act of returning ownership of controller resources to a controller (which was offline) from its partner controller. The resources include volumes, cache data, host ID information, and LUNs and WWNs. See also failover.

remote syslog support

See syslog.

replication

Asynchronous replication of block-level data from a volume in a primary system to a volume in a secondary system by creating an internal snapshot of the primary volume and copying the snapshot data to the secondary system via FC or iSCSI links.

replication set

A container that houses the infrastructure upon which replications are performed. It defines a relationship between a primary and secondary volume for the purposes of maintaining a remote copy of the primary volume on a peer system. See primary volume, secondary volume.

replication set failover

The replication set's secondary system has allowed direct access to the secondary volume or volume group because the primary system is not operational. In this state no replications will occur, even if the primary system becomes operational and communication is restored. The secondary volume can be mapped and accessed for use, including rollback to the contents of any manually created or snapshot-history snapshot.

replication snapshot history

As part of handling a replication, the replication set will automatically take a snapshot of the primary and/or secondary volume, thereby creating a history of data that has been replicated over time. This feature can be enabled for a secondary volume or for a primary volume and its secondary volume.

repurpose

A method by which all data in a storage system or disk is erased in an FDE-capable system. Repurposing unsecures the system and disks without needing the correct passphrase. See also FDE, passphrase.

SAS

Serial Attached SCSI.

SATA

Serial ATA.

- SC**
Storage Controller. A processor (located in a controller module) that is responsible for RAID controller functions. The SC is also referred to as the RAID controller. See also EC, MC.
- secondary system**
The storage system that contains a replication set's secondary volume. See also primary system.
- secondary volume**
The volume that is the destination for data in a replication set and that is not accessible to hosts. The secondary volume exists in a secondary storage system.
- secret**
For use with CHAP, a password that is shared between an initiator and a target to enable authentication.
- SED**
Self-encrypting drive. A disk drive that provides hardware-based data encryption and supports use of the storage system's Full Disk Encryption feature. See also FDE.
- SEEPRAM**
Serial electrically erasable programmable ROM. A type of nonvolatile (persistent if power removed) computer memory used as FRU ID devices.
- service FRU**
A product module that can be replaced in an enclosure by qualified service personnel only, without having to send the enclosure to a repair facility.
- SES**
SCSI Enclosure Services. The protocol that allows the initiator to communicate with the enclosure using SCSI commands.
- SFCB**
Small Footprint CIM Broker.
- SFF**
Small form factor.
- SFTP**
SSH File Transfer Protocol. A secure secondary interface for installing firmware updates, downloading logs, installing a license, and installing security certificates and keys. All data sent between the client and server will be encrypted.
- SHA**
Secure Hash Algorithm.
- shelf**
See enclosure.
- SLAAC**
Stateless address autoconfiguration.
- SLP**
Service Location Protocol. Enables computers and other devices to find services in a local area network without prior configuration.
- SMART**
Self-Monitoring Analysis and Reporting Technology. A monitoring system for disk drives that monitors reliability indicators for the purpose of anticipating disk failures and reporting those potential failures.
- SMI-S**
Storage Management Initiative Specification. The SNIA standard that enables interoperable management of storage networks and storage devices. It is the interpretation of CIM for storage, and provides a consistent definition and structure of data, using object-oriented techniques.

SMU

Storage Management Utility. The web application that is embedded in each controller module and is the primary management interface for the storage system.

snapshot

A point-in-time copy of the data in a source volume that preserves the state of the data as it existed when the snapshot was created. Data associated with a snapshot is recorded in the source volume. A snapshot can be mapped and written to. Snapshots that can be mapped to hosts are counted against the snapshot-license limit, whereas transient and unmappable snapshots are not.

snapshot tree

A group of virtual volumes that are interrelated due to creation of snapshots. Since snapshots can be taken of existing snapshots, volume inter-relationships can be thought of as a "tree" of volumes. A tree can be 254 levels deep. See also base volume, child volume, parent volume, source volume.

source volume

A volume that has snapshots. Used as a synonym for parent volume.

SSD

Solid state drive.

SSH

Secure Shell. A network protocol for secure data communication.

SSL

Secure Sockets Layer. A cryptographic protocol that provides security over the internet.

standard volume

A volume that can be mapped to initiators and presented as a storage device to a host system, but is not enabled for snapshots.

Storage Controller

See SC.

Storage Management Utility

See SMU.

storage system

A controller enclosure, optionally with connected expansion enclosures. Product documentation and interfaces use the terms storage system and system interchangeably.

syslog

A protocol for sending event messages across an IP network to a logging server. This feature supports User Datagram Protocol (UDP) but not Transmission Control Protocol (TCP).

TCP

Transmission control protocol.

thin provisioning

A virtual-storage feature that allows actual storage for a volume to be assigned as data is written, rather than storage being assigned immediately for the eventual size of the volume. This allows the storage administrator to overcommit physical storage, which in turn allows the connected host system to operate as though it has more physical storage available than is actually allocated to it. When physical resources fill up, the storage administrator can add storage capacity on demand.

tier

A homogeneous group of disks, typically of the same capacity and performance level, that comprise one or more virtual disk groups in the same pool. Tiers differ in their performance, capacity, and cost characteristics, which forms the basis for the choices that are made with respect to which data is placed in which tier. The predefined tiers are: Performance, which uses

SSDs (high speed); Standard, which uses enterprise-class spinning SAS disks (10k/15k RPM, higher capacity); Archive, which uses midline spinning SAS disks (<10k RPM, high capacity).

tier migration

The automatic movement of blocks of data, associated with a single virtual volume, between tiers based on the access patterns that are detected for the data on that volume.

tray

See enclosure.

UDP

User datagram protocol.

ULP

Unified LUN Presentation. A RAID controller feature that enables a host system to access mapped volumes through any controller host port. ULP incorporates ALUA extensions.

undercommitted

The amount of storage capacity that is allocated to volumes is less than the physical capacity of the storage system.

unmount

To remove access to a volume from a host OS. Synonyms include unpresent and unmap.

unwritable cache data

Cache data that has not been written to disk and is associated with a volume that no longer exists or whose disks are not online. If the data is needed, the volume's disks must be brought online. If the data is not needed it can be cleared, in which case it will be lost and data will differ between the host system and disk. Unwritable cache data is also called orphan data.

UPS

Uninterruptible power supply.

UTC

Coordinated Universal Time.

UTF-8

UCS transformation format - 8-bit. A variable-width encoding that can represent every character in the Unicode character set used for the SMU and CLI interfaces.

virtual

The storage-class designation for logical components such as volumes that use paged-storage technology to virtualize data storage. See paged storage.

volume

A logical representation of a fixed-size, contiguous span of storage that is presented to host systems for the purpose of storing data.

volume copy

An independent copy (clone) of the data in a virtual volume. The capability to copy volumes makes use of snapshot functionality.

VPD

Vital Product Data. Data held on an EEPROM in an enclosure or FRU that is used by GEM to identify and control the component.

WBEM

Web-Based Enterprise Management.

WBI

Web-browser interface, called Storage Management Utility. The primary interface for managing the storage system. See SMU.

WWN

World Wide Name. A globally unique 64-bit number that identifies a device used in storage technology.

WWNN

World Wide Node Name. A globally unique 64-bit number that identifies a device.

WWPN

World Wide Port Name. A globally unique 64-bit number that identifies a port.

Index

A

- all-flash array 23
- audit logs 52
- automated tiered storage 28

B

- base for size representations 14
- bytes versus characters 14

C

- cache
 - configuring volume settings 26
 - optimization modes 27
 - write-back or write-through 27
- CHAP
 - about 29
 - configuring for iSCSI hosts 82
 - using with peer connections 83
 - using with replication 47

- characters versus bytes 14

- configuration
 - first-time 10
 - web browser requirements 10

- configuration limits 134

- CSV file
 - exporting data to 14

D

- data protection
 - adding to volumes 60
 - creating a remote replication set 65
 - creating snapshots 65
- data protection with a single controller 50
- date and time
 - setting manually 78
 - setting with NTP 78
- debug logs
 - downloading 109
- disk groups
 - about 16
 - about virtual 17
 - adding to a pool 86
 - deleting 86
 - expanding 87
 - expansion 20
 - read-cache 18, 28
 - removing from pools 18
 - renaming 86
 - scrub utility 21

- scrubbing 87
- verify utility 21
- verifying 87
- viewing in a pool 86
- virtual 17

disks

- about spares 24
- clearing metadata 49
- repurposing 79
- rescanning 49
- setting properties 80
- using FTP/SFTP to retrieve performance statistics 111
- using FTP/SFTP to update firmware 116

DNS

- about 39
- configuring 73

- dynamic spares 24

E

- events
 - history 51
 - severity meanings 51
- exporting data to a CSV file 14

F

FDE

- about 48
- using 79

- features 9

firmware

- best practices for updating 92
- configuring automatic updates 91
- update overview 35
- updating disk 91
- updating expansion module 90
- updating system 89
- updating through FTP/SFTP 112
- using an updating server 91
- using FTP/SFTP to update controller module firmware 113
- using FTP/SFTP to update disk drive firmware 116
- using FTP/SFTP to update expansion module firmware 114
- viewing information about 88

FTP

- about updating firmware 112
- downloading heat map data 117
- downloading system logs 109
- overview 109
- retrieving disk-performance statistics 111
- updating controller module firmware 113
- updating disk drive firmware 116
- updating expansion module firmware 114
- using to install a security certificate 116
- using with the log-management feature 110

full disk encryption
See FDE 48

G

global spares 24

H

hardware
viewing configuration 87

heat map data
downloading 117

host groups
about 29
adding hosts to 70
deleting 71
removing hosts from 70
renaming 71

host ports
about 30
supported protocols 30

hosts
about 29
adding initiators to 71
attaching 70
changing a profile 71
creating 69
deleting 70
detaching 70
removing initiators from 70
renaming 71
renaming initiator nicknames 71
working with 69

I

icons used in the SMU 11

initiators
about 29
assigning nicknames 29

iSCSI
changing configuration settings 83
configuring host port settings 82

L

LDAP
about 37
managing users 76

licensed features
using FTP/SFTP to install license files 116

log-collection
about 128
log file details 128
storing log files 128
transferring data using FTP/SFTP 110
transferring log files 128

log data
managing 35
saving 36

M

maintenance
about 93
firmware 88
hardware 87
storage system 85
support 93

managed logs
about 35
setting 81

metadata
clearing 49

metrics
about 52

MIB
See SNMP 97

MSA-DP+ RAID level 20

N

network settings
about 72
CLI 74
configuring DNS 73
configuring IPv4 and IPv6 72
FTP, SFTP, SMI-S, SNMP, SLP 74
system-management services 74
web and API 74

notifications
email 81
SNMP 81
syslog 81

O

overcommitting
about 28
volumes 28

P

peer connections
creating 40
deleting 83
modifying 83
querying 83
settings 83

performance
alerts 53
collecting data 56
displaying data 56
metrics 54
monitoring 54
system usage trends 54

- pools
 - about 24
 - about removing 25
 - and disk groups 25
 - changing threshold settings 25
 - removing disk groups from 18
 - resolving conflicts 25
 - virtual 25
 - volume allocation 25
- provisioning
 - first-time 10
 - hosts 69
 - volumes 59

Q

- quick rebuild
 - about 35

R

- RAID levels
 - about 18
 - MSA-DP+ 20
- read-cache
 - about 23
 - advantages 23
 - disk groups 18, 28
 - optimizing 27
- reconstruction
 - about 33
 - using MSA-DP+ 34
- regulatory/safety compliance 95
- replication
 - aborting a replication set 68
 - about 41
 - between current and legacy systems 47
 - creating a replication set 45, 65
 - creating a virtual pool 44
 - deleting a replication set 66
 - disaster recovery 45
 - initiating a replication set 67
 - internal snapshots 44
 - maintaining snapshot history 46
 - managing sechedules 69
 - managing snapshot space 44
 - modifying a replication set 66
 - prerequisites 41
 - primary volumes 45
 - process 42
 - queuing 45
 - reclaiming unallocated pages 45
 - resuming a replication set 68
 - scheduling a replication set 67
 - secondary volumes 45
 - suspending a replication set 68
- requirements
 - web browser 10

S

- SAS cabling
 - about 51
- security certificate
 - about 75
 - using FTP/SFTP to install 116
- settings
 - managing LDAP users 76
 - managing local users 75
 - managing SNMP users 77
 - network 72
 - user 75
- SFTP
 - about updating firmware 112
 - downloading heat map data 117
 - downloading system logs 109
 - overview 109
 - retrieving disk-performance statistics 111
 - updating controller module firmware 113
 - updating disk drive firmware 116
 - updating expansion module firmware 114
 - using to install a security certificate 116
 - using with the log-management feature 110
- signing in to the SMU 14
- size representations
 - about 14
- SLP
 - attributes 126
 - interfaces 126
 - overview 126
- SMI-S
 - about 118
 - architecture 120
 - Array profile supported profiles and subprofiles 119
 - block server performance subprofile 122
 - CIM alerts 122
 - components 118
 - configuring 124
 - embedded array provider 119
 - implementation 120
 - life cycle indications 123
 - managed-logs notifications 125
 - profile descriptions 121
 - provider 120
 - supported CIM operations 122
 - testing 125
 - troubleshooting 125
- SMU
 - about 9
 - alerts 53
 - dashboard 53
 - features 9
 - first-time setup 10
 - health 53
 - icon list 11
 - interface 11
 - performance issues 53
 - performance metrics 55
 - signing in 14

- statistics 54
- storage trends 54
- system activity 57
- tips for using 13
- snapshots
 - about 32
 - copying 33, 64
 - creating 64
 - deleting 62
 - heirarchy 32
 - reset feature 33
 - resetting 64
 - rollback feature 33
- SNMP
 - configuring traps 105
 - differences between FA MIB 2.2 and 4.0 108
 - enterprise trap MIB 106
 - enterprise traps 97
 - external details for connUnitPortTable 105
 - external details for connUnitRevsTable 103
 - FA MIB 2.2 behavior 98
 - management 105
 - managing users 77
 - MIB-II behavior 97
 - notifications 81
 - overview 97
 - setting event notification 105
- spare disks
 - about 24
- SSD read cache
 - about 23
- SSDs
 - about 22
 - all-flash array 23
 - cost/benefit analysis 22
 - disk management 23
 - DWPD (drive writes per day) 23
 - gauging percentage of life remaining 22
 - overprovisioning 23
 - rules for using 22
 - SSD Life Left disk property 22
- system
 - about metrics 52
 - adding disk groups to a pool 86
 - changing pool settings 85
 - data protection with a single controller 50
 - downloading debug logs 109
 - viewing disk groups in a pool 86
 - viewing pool information 85
- system settings 72
 - cache properties 80
 - configuration limits 134
 - configuring iSCSI host ports 82
 - date and time 78
 - disk properties 80
 - FDE 79
 - identification information 78
 - managed logs 81
 - network 72
 - notifications 81
 - partner firmware update 81

- peer connections 83
- properties 79
- restoring defaults 130
- scrub properties 80
- user settings 75

T

- tables
 - tips for using 13
- technical support 94
- tips
 - SMU 13
 - tables 13

U

- units for size representations 14
- updating firmware
 - about 35
- user interface
 - about 11
 - icons used 11

V

- virtual storage
 - about 16
- volume cache options
 - about 26
- volume copy
 - about 33
- volume tier affinity 29
- volumes
 - aborting a copy operation 65
 - about 26
 - about adding to pools 25
 - about cache options 26
 - adding data protection 60
 - attaching to hosts 31, 63
 - copying 33, 64
 - creating 61
 - deleting 62
 - detaching from hosts 63
 - expanding 63
 - modifying 62
 - overcommitting 28
 - rolling back 64
 - working with 59

W

- web browser requirements 10
- write-back caching 27
- write-through caching 27