Lenovo Storage Manager Guide

For firmware release G221

Abstract

This guide is for use by storage administrators to manage an Lenovo Storage S3200/S2200 storage system by using its web interface, Storage Management Console (SMC).

P/N 00WE607-03

Third Edition, January 2016

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About this guide

This guide provides information about managing a Lenovo Storage™ system by using its web interface, Storage Management Console.

Product information specific to Lenovo Storage S3200 or S2200 is called out by the product name in bold at the beginning of each relevant paragraph (for instance, "**For Lenovo Storage S3200**:"). If there is a mention within a sentence, there will be a callout within the sentence. If there are several paragraphs for a product, a preceding note will indicate the relevant content. If an entire section is specific to a product, the section heading will include a call out, which will apply to all sub-sections.

Otherwise, the content of this guide applies to both systems.

Intended audience

This guide is intended for storage administrators.

Prerequisites

Prerequisites for using this product include knowledge of:

- Network administration
- Storage system configuration
- Storage area network (SAN) management and server-attached storage
- Fibre Channel, Serial Attached SCSI (SAS), Internet SCSI (iSCSI), and Ethernet protocols

Related documentation

For information about	See
Environmental notices, basic troubleshooting, rack safety, safety, and safety labels	Lenovo Documentation CD*, which includes: • Environmental and Notices Guide • Basic Troubleshooting Guide • Rack Safety Information • Safety Information • Safety Labels
Overview of product shipkit contents and setup tasks	Lenovo Storage Getting Started*
Multilingual warranty, service and support information and safety notices	Lenovo Safety, Support and Warranty*
Information about the safety, electronic emission, and environmental notices for your Lenovo product	Lenovo Important Notices*
Regulatory compliance and safety and disposal information	Lenovo Storage Product Regulatory Compliance and Safety*
Using a rackmount bracket kit to install an enclosure into a rack	Lenovo Storage Rackmount Bracket Kit Installation
Product hardware setup and related troubleshooting	Lenovo Storage S3200/S2200 Setup Guide
Using the command-line interface (CLI) to configure and manage the product	Lenovo Storage CLI Reference Guide
Event codes and recommended actions	Lenovo Storage Event Descriptions Reference Guide
Identifying and installing or replacing customer-replaceable units (CRUs), also referred to in this guide as field-replaceable units (FRUs)	Lenovo Storage CRU Installation and Replacement Guide

For information about	See
Installation and usage instructions for the VSS hardware provider that works with Microsoft Windows Server, and the CAPI Proxy required by the hardware provider	Lenovo Storage VSS Hardware Provider Installation Guide
Enhancements, known issues, and late-breaking information not included in product documentation	Lenovo Storage S3200/S2200 Release Notes

* Printed document included in product shipkit.

To obtain PDF versions of product documentation, visit http://support.lenovo.com.

Document conventions and symbols

Table 1 Document conventions

Convention	Element
Blue text	Cross-reference links and e-mail addresses
Blue, underlined text	Web site addresses
Bold font	• Key names • Text typed into a GUI element, such as into a box • GUI elements that are clicked or selected, such as menu and list items, buttons, and check boxes • Text pointers to product information specific to Lenovo Storage S3200 or S2200
Italics font	Text emphasis
`Monospace font`	• File and directory names • System output • Code • Text typed at the command-line
`Monospace, italic font`	• Code variables • Command-line variables
`Monospace, bold font`	Emphasis of file and directory names, system output, code, and text typed at the command line

△ **CAUTION:** Indicates that failure to follow directions could result in damage to equipment or data.

IMPORTANT: Provides clarifying information or specific instructions.

NOTE: Provides additional information.

TIP: Provides helpful hints and shortcuts.

1 Getting started

The Lenovo Storage Management Console (also called SMC) is a web-based application for configuring, monitoring, and managing the storage system. It is a web-based interface (WBI).

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

In addition to the SMC, each controller module in the storage system has a CLI and an FTP interface, and SNMP and SMI-S interfaces. For information about using the SMC, FTP, SNMP, and SMI-S, see this guide. For information about using the CLI, see the CLI Reference Guide.

Configuring and provisioning a new storage system

To configure and provision a storage system for the first time

1. Configure your web browser to use the SMC as described in "Web browser requirements and setup" (page 11).
2. Sign in to the SMC; the default user for management is `manage` and the default password is `!manage`. For more information about signing in, see "Signing in and signing out" (page 16).
3. Verify that controller modules and expansion modules have the latest firmware as described in "Updating firmware" (page 56).
4. Use the Configuration Wizard as described in "Using the Configuration Wizard" (page 35).
5. Create virtual disk groups and pools, and read-cache disk groups, as described in "Adding a disk group" (page 73).
6. Create volumes and map them to initiators, as described in "The Schedules table shows the following schedule information. By default, the table shows 10 entries at a time." (page 80).
7. From hosts, verify volume mappings by mounting the volumes and performing read/write tests to the volumes.
8. Optionally, for replication of virtual volumes and snapshots, create peer connections and replication sets, as described in "Creating a peer connection" (page 95), "Creating a replication set from the Replications topic" (page 97), and "Creating a replication set from the Volumes topic" (page 86).

Using the interface

Web browser requirements and setup

- Use Mozilla Firefox 11 and newer, Google Chrome 17 and newer, Microsoft Internet Explorer 10 and 11, or Apple Safari 5.1 and newer.
- To see the help window, you must 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):
  - For Internet Explorer, set the browser's local-intranet security option to medium or medium-low.
  - Verify that the browser is set to allow cookies at least for the IP addresses of the storage-system network ports.
  - For Internet Explorer, add each controller's network IP address as a trusted site.
  - If the SMC is configured to use HTTPS, ensure that Internet Explorer is set to use either TLS 1.0, TLS 1.1 or TLS 1.2.

Areas of the interface

The main areas of the SMC interface are the banner, topic tabs, topic pane, and footer, as represented by the following table. For information about a topic tab or an item in the banner or footer, click its link in the table.

The topic pane shows information that relates to the selected topic tab. This area also contains an Action menu that provides access to configuration, provisioning, and other actions. The contents of the Action menu are determined by the user's role, the selected topic, and what (if anything) is selected in the topic pane.

Table 2 Areas of the SMC interface

<table>
<tr><td>Banner:</td><td>Product ID</td><td>System panel (page 110)</td><td>Connection panel (page 111)</td><td>Date/time panel (page 111)</td><td>User panel (page 112)</td><td>Sign Out button (page 16)</td><td>Help button (page 13)</td></tr>
<tr><td rowspan="7">Topic tabs:</td><td>Home (page 32)</td><td colspan="6" rowspan="7">Topic pane</td></tr>
<tr><td>System (page 48)</td></tr>
<tr><td>Hosts (page 65)</td></tr>
<tr><td>Pools (page 71)</td></tr>
<tr><td>Volumes (page 78)</td></tr>
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<tr><td>Footer:</td><td>Health panel (page 112)</td><td>Event panel (page 113)</td><td>Capacity panel (page 114)</td><td>Host I/O panel (page 115)</td><td>Tier I/O panel (page 115)</td><td colspan="2">Activity panel (page 115)</td></tr>
</table>

Tips for using the SMC

- Do not use the browser's Back, Forward, Reload, or Refresh buttons. The SMC has a single page for which content changes as you perform tasks and automatically updates to show current data.
- A red asterisk (*) identifies a required setting.
- As you set options in action panels, the SMC informs you whether a value is invalid or a required option is not set. If the **Apply** or **OK** button remains inactive after you set all required options, either press **Tab** or click in an empty area of the panel to activate the button.
- If an action panel has an **Apply** button and an **OK** button, click **Apply** to apply any changes and keep the panel open or click **OK** to apply any changes and close the panel. After clicking **Apply,** you can click **Close** to close the panel without losing changes already applied.
- You can move an action panel or a confirmation panel by dragging its top border.
- If you are signed in to the SMC 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 SMC session.
- 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 SMC.
- If you start to perform an action in a panel (such as adding a new entry to a table) and then select an item or button that interrupts the action, a confirmation panel will ask if you want to navigate away and lose any changes made. If you want to continue performing the original action, click **No**. If you want to stop performing the original action, click **Yes**.
- In the banner or footer, or indicates that a panel has a menu. Click anywhere in the panel to display the menu.

Tips for using tables

Items such as initiators, hosts, volumes, and mappings are listed in tables. Use the following methods singly or together to quickly locate items that you want to work with.

Selecting items

- To select an item, click in its row.
- To select a range of adjacent items, click the first item in the range and **Shift**+click the last item in the range.
- To select or deselect one or more items, **Ctrl**+click each one.

Sorting items

To sort items by a specific column, click the column heading to reorder items from low to high (▲). Click again to reorder items from high to low (▼).

To sort items by multiple columns

1. In the first column to sort by, click its heading once or twice to reorder items.
2. In the second column to sort by, **Shift**+click its heading once or twice to reorder items. If you **Shift**+click a third time, the column is deselected.
3. Continue for each additional column to sort by.

Using filters to find items with specified text

To filter a multicolumn table, in the filter field above the table, enter the text to find. As you type, only items that contain the specified text remain shown. Filters are not case sensitive.

To use a column filter

1. In the column heading click the filter icon ( ). The filter menu appears.
2. Do one of the following:
   - In the filter field, enter the text to find. As you type, only items that contain the specified text remain shown. Because a filter is active, the icon changes ( ). Previous search terms are listed below the field. Previous search terms that match displayed values are shown in bold.
   - If the filter list has an entry for the text you want to find, select that entry.
   - To show all items in the column, click the filter icon and select **All**.

To clear all filters and show all items, click **Clear Filters**.

Limiting the number of items shown

To show a specific number of items at a time in a multicolumn table, select a value from the **Show** menu. If more items exist, you can page through them by using the following buttons:


Show next set of items.


Reached end of list.


Show previous set of items.


Reached start of list.

Tips for using help

- To display help for the content in the topic pane, click the help icon ? in the banner.
- In the help window, click the table of contents icon to show or hide the Contents pane.
- As the context in the main panel is changed, the corresponding help topic is displayed in the help window. To prevent this automatic context-switching, click the pin icon . When a help window is pinned ( ), you can still browse to other topics within the help window and you can open a new help window. You cannot unpin a help window. You can only close it.
- If you have viewed more than one help topic, you can click the arrow icons to display the previous or next topic.
- To close the help window, click the close icon .

Color codes

The interface uses the following color codes to distinguish performance statistics and types of capacity utilization.

Home topic

Table 3 Home topic storage space color codes

Color	Meaning
System performance statistics	
	IOPS
	Data throughput (MB/s)
Capacity graph, bottom bar	
	System physical space available
	System physical space used by global spares
	System physical space used by virtual disk groups
Capacity graph, top bar	
	Pool reserved space (RAID parity and metadata)
	Pool allocated space
	Pool unallocated space
Storage A/B, virtual capacity graph, bottom bar	
	Pool usable space (excludes reserved space)
Storage A/B, virtual capacity graph, top bar	
	Pool allocated space
	Pool unallocated space
Storage A/B, virtual disk group utilization graph	
	Performance tier unallocated space
	Performance tier allocated space
	Standard tier unallocated space
	Standard tier allocated space
	Archive tier unallocated space
	Archive tier allocated space
Storage A/B, read cache utilization graph	
	Read cache unallocated space
	Read cache allocated space

Table 3 Home topic storage space color codes

Color	Meaning
Spares	
	Standard tier global spares
	Archive tier global spares

Create Volumes panel

Table 4 Create Volumes panel storage space color codes

Color	Meaning
Virtual capacity graph, top bar	
	Pool allocated space
	Pool unallocated space
	Pool space that would be used by the volumes being created
Virtual capacity graph, bottom bar	
	Pool usable space (excludes reserved space)

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. Standard US-ASCII characters require 1 byte; most Latin (Western European), Cyrillic, and Arabic characters are encoded with 2 bytes; most Asian characters are 3 bytes.

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 SMC, 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 5 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 6 Decimal (radix) point character by locale

Language	Character	Examples
Arabic, English, Chinese, Japanese, Korean, Russian	Period (.)	146.81 GB 3.0 Gbit/s
Dutch, French, German, Italian, Portuguese, 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 SMC 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 SMC session, but all instances of Firefox, Chrome, and Safari share the same SMC session.

To sign in

1. In the web browser address field, type `https://`*<IP address of a controller network port>* and press **Enter**. (Do not include a leading zero in an IP address. For example, enter 10.1.4.33 and not 10.1.4.**0**33.) The Storage Management Console Sign In page is displayed. If the Sign In page does not display, verify that you have entered the correct IP address.
2. On the sign-in page, enter the name and password of a configured user. The default user name and password are `manage` and `!manage`. To display the interface in a language other than the user setting, select the language from the Language list.

   Language preferences can be configured for the system and for individual users.
3. Click **Sign In**. If the system is available, the Home page is displayed. Otherwise, a message indicates that the system is unavailable.

When you are ready to end your session, sign out as described below. Do not simply close the browser window.

To sign out

1. Click **Sign Out** near the top of the Storage Management Console window.
2. In the confirmation panel, click **Sign Out**.

System concepts

About 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 RAID sets 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.

Virtual storage provides the foundation for data-management features such as thin provisioning on page 23, automated tiered storage on page 24, read cache on page 23, and the quick rebuild feature on page 28.

About disk groups

A disk group is an aggregation of disks of the same type, using a specific RAID type that is incorporated as a component of a pool, for the purpose of storing volume data. You can add virtual and read-cache disk groups to a pool.

All disks in a disk group must be the same type (SAS SSD, enterprise SAS, or midline SAS). A disk group can contain different models of disks, and disks with different capacities and sector formats. 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 level. For example, the capacity of a disk group composed of one 500 GB disk and one 750 GB disk is equivalent to a disk group composed of two 500 GB disks. To maximize capacity, use disks of similar size.

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.

You can provision storage by adding a disk group to a pool. Volumes then can be created in the pool.

Virtual disk groups

A virtual disk group requires the specification of a set of disks, RAID level, disk group type, pool target (A or B), and a name. 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 pool. Virtual disk groups that contain SSDs can only be created with a Performance tier license. This restriction does not apply to read-cache disk groups.

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

When a virtual disk group is removed that contains active volume data, that volume data will drain (or be moved) to other disk group members within the pool (if they exist). Disk groups should only be removed when all volume data can cleanly be drained from the disk group. Otherwise, the data will be lost. When the last disk group is removed, the pool ceases to exist, and will be deleted from the system automatically.

The RAID type for a virtual disk group must be fault tolerant. The supported RAID types for virtual disk groups are: RAID 1, RAID 5, RAID 6, RAID 10. If RAID 10 is specified, the disk group must have at least two sub-groups.

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. 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.

If your system uses SSDs, you can create read-cache disk groups for virtual pools if you do not have any virtual disk groups for the pool that are comprised of SSDs (virtual disk pools cannot contain both read cache and a performance tier).

Only a single read-cache disk group may exist within a pool. Increasing the size of read cache within a pool requires the user to 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 a single disk in an NRAID configuration. For more information on read cache, see "About SSD read cache" (page 23).

About RAID levels

The RAID 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 RAID 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.

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

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 7 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

Table 8 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

Table 9 Number of disks per RAID level to optimize virtual disk group performance

RAID level	Number of disks (data and parity)
1	N/A. 2 total.
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	16 total (8 RAID-1 subgroups)

About pools

A *pool* is an aggregation of one or more drives in the form 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 type that is incorporated as a component of a pool, that stores volume data. Volumes are added to a pool and the data is distributed across the pool's disk groups.

If the owning controller fails, the partner controller assumes temporary ownership of disk groups and resources owned by the failed controller. If a fault-tolerant cabling configuration and 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 provision disks into disk groups. For information about how provisioning disks works, see "Adding a disk group" (page 73).

Pools and disk groups

The volumes within a pool are allocated virtually (separated into fixed size pages, with each page allocated randomly from somewhere 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).

If you would like to create a virtual pool that is larger than 300 TiB on each controller, you can enable the large pools feature by using the `large-pools` parameter of the `set advanced-settings` CLI command. When the large pools feature is disabled, which is the default, the maximum size for a virtual pool is 300 TiB and the maximum number of volumes per snapshot tree is 255 (base volume plus 254 snapshots). Enabling the large pools feature will increase the maximum size for a virtual pool to 512 TiB and decrease the maximum number of volumes per snapshot tree to 9 (base volume plus 8 snapshots). The maximum number of volumes per snapshot will decrease to fewer than 9 if more than 3 replication sets are defined for volumes in the snapshot tree. For more information about the `large-pools` parameter of the `set advanced-settings` CLI command, see the CLI documentation.

You can remove one or more disk groups, but not all, from a pool without losing data if there is enough space available in the remaining disk groups to which to move the data. 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.

If a system has at least one SSD, each 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.

About SSDs

The use of SSDs can 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. If you have the Performance tier license, you can use SSDs for virtual disk groups for improved read and write performance. You can also use one or two SSDs in read-cache disk groups to increase performance for pools without a performance tier. For more information about automated tiered storage, see "About automated tiered storage" (page 24). For more information on read-cache disk groups, see "Read-cache disk groups" (page 17).

The application workload of a system determines the percentage of SSDs of the total disk capacity that is needed for best performance.

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 values decreases to 5% of life remaining.

You can view the value of the SSD Life Left property through the Disk Information panel. In the front view of the enclosure in the System topic, hover the cursor over any disk to view its properties. You can also view the Disk Information panel through the Pools topic. Select the pool for the disk group in the pools table, select the disk group in the Related Disk Groups table, and then hover the cursor over the disk in the Related Disks table.

Internal disk management

SSDs use multiple algorithms to manage SSD endurance features. These include wear leveling, over-provisioning to minimize write amplification, and support for Unmap commands.

Wear leveling

Wear leveling is a technique for prolonging the service life of some kinds of erasable computer storage media, such as the flash memory used in SSDs. It attempts to ensure that all flash cells are written to or exercised as evenly as possible to avoid any hot spots where some cells are used up faster than other locations. There are several different wear leveling mechanisms used in flash memory systems, each with different levels of success.

Vendors have different algorithms to achieve optimum wear leveling. Wear leveling management occurs internal to the SSD. The SSD automatically manages wear leveling, which does not require any user interaction.

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. This is used to account for the user data and activities like wear leveling. This affects wear leveling calculations and is influenced by the characteristics of data written to and read from SSDs. Data that is written in sequential LBAs that are 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 that are less than 4KB and that originate on LBA's that are not on 4KB boundaries. Try to align your data on 4KB boundaries.

TRIM and UNMAP commands

A command (known as TRIM in the ATA command set and UNMAP in the SCSI command set) allows an operating system to inform an SSD of the blocks of data that are no longer considered in use and can be wiped internally. The autonomic nature of Lenovo Storage real-time tiering does not support static use of the TRIM or UNMAP commands. Lenovo Storage firmware does not issue TRIM or UNMAP commands to SSDs.

Data retention

Data retention is another major characteristic of SSDs that all SSD algorithms take into account while running. While powered up, the data retention of SSD cells are monitored and rewritten if the cell levels decay to an unexpected level. Data retention when the drive is powered off is affected by Program and Erase (PE) cycles and the temperature of the drive when stored.

Drive Writes per Day (DWD)

DWD or DWPD refers to Drive Writes Per Day. 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 of which SSDs to use is highly dependent on your applications and I/O workload. So also is the ratio of SSDs to conventional drives. In some environments, a ratio of 10% SSDs to 90% conventional drives, when combined with Lenovo Storage real-time tiering, can yield dramatic performance improvements.

Since Lenovo Storage real-time tiering 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, as well as the use of higher DWPD SSDs (such as 8 DWPD or 10 DWPD). For less demanding application environments, the cost savings of upcoming 3 DWPD SSDs may be more attractive.

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.

About volumes and volume groups

A volume is a logical subdivision of a pool, and can be mapped to host-based applications. A mapped volume provides the storage for a file system partition you create with your operating system or third-party tools. For more information about mapping, see “About volume mapping” (page 25).

Volumes

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

Because volumes and snapshots share the same underlying structure, it is possible to create snapshots of other snapshots, not just of volumes.

Volume groups

For ease of management related to virtual storage, you can group 1–20 volumes (standard volumes, snapshots, or both) into a volume group. Doing so enables you to perform mapping operations for all volumes in a group at once, instead of for each volume individually. A volume can be a member of only one group. All volumes in a group must be in the same pool. A volume group cannot have the same name as another volume group, but can have the same name as any volume. A maximum of 256 volume groups can exist per system.

About volume cache options

You can set options that optimize reads and writes performed for each volume.

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.

You can change the write-back cache setting for a volume when modifying it. 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 mirrors all of the data from one controller module cache to the other. 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 operation and 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.

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 corruption or loss. Before changing this setting, quiesce I/O from all initiators.

You can also change the optimization mode.

- **Standard**. This controller cache mode of operation is optimized for sequential and random I/O and is the optimization of choice for most workloads. In this mode, the cache is kept coherent with the partner controller. This mode gives you high performance and high redundancy.
- **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.

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.
- The **Stripe** option sets the read-ahead size to one stripe. The controllers treat NRAID and 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.
- 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.

About SSD read cache

Unlike tiering, where a single copy of specific blocks of data resides in either spinning disks or SSDs, the Read Flash Cache (RFC) 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 capacity of 4TB. A separate copy of the data is also kept in spinning disks. Read- cache contents are lost when a controller restart or failover occurs. 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.
- SSDs do not need to be 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 NRAID. When a read-cache group consists of two SSDs, it automatically uses RAID 0.

For more information in SSDs, see "About SSDs" (page 20).

About thin provisioning

Thin provisioning 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 on demand.

Paged mapping allows physical resources to be disparate and noncontiguous, making it much easy to add storage on the fly. For example, contrast the methods for creating a volume for Microsoft Exchange Server data:

- Typically, administrators create a storage-side volume for Exchange and map that volume with an assigned LUN to hosts, and then create a Microsoft Windows volume for that LUN. Each volume has a fixed size. There are ways to increase the size of a storage-side volume and its associated Windows volume, but they are often cumbersome. The administrator must make a trade-off between initial disk costs and a volume size that provides capacity for future growth.
- With thin provisioning, the administrator can create a very large volume, up to the maximum size allowed by Windows. The administrator can begin with only a small number of disks, and add more as physical storage needs grow. The process of expanding the Windows volume is eliminated.

NOTE: For a thin-provisioned volume mapped to a host, when data is deleted from the volume not all of the pages (space) associated with that data will be deallocated (released). This is especially true for smaller files. To deallocate the pages, in Windows, select the mapped volume and do either of the following:

- Perform a quick format.
- View its properties, select the **Tools** tab, and under **Defragmentation**, click **Optimize**.

About automated tiered storage

Automated Tiered Storage (ATS) 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:

- Frequently accessed, "hot" data can move to disks with higher performance, lower capacity, and higher costs.
- Infrequently accessed, "cool" data can move to disks with higher capacity, 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 SAS SSDs, which provide the best performance but also the highest cost. For more information on SSDs, see "About SSDs" (page 20).
- 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.

Some advantages of using ATS are:

- Because a pool can have multiple disk groups, each belonging to a different tier, it can provide multiple tiers of storage.
- The I/O load is automatically balanced between components in a tier.
- Virtual disk groups can be added or removed without disrupting I/O. Data in virtual disk groups that are being removed is automatically migrated to other disk groups as long as the other disk groups have enough storage space for it. If they do not have the space, the system will not delete the disk groups until enough data is removed.

Volume tier affinity feature

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 available performing tiers 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.
- Archive—This setting prioritizes the volume data to the least 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.

About 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 a FC HBA) in a server, or a port in a network switch.

The controllers automatically discover initiators that have sent an `inquiry` command or a `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. For example, you might want to define an initiator before a controller port is physically connected through a switch to a host.

You can assign a nickname to an initiator to make it easy to recognize for volume mapping. A maximum of 512 names can be assigned.

For ease of management, you can group 1–128 initiators that represent a server or switch into a host. Further, you can group 1–256 hosts into a host group. Doing so enables you to perform mapping operations for all initiators in a host, or all initiators and hosts in a group, instead of for each initiator or host individually. 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.

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. Steps involved in enabling CHAP include:

- Decide on host node names (identifiers) and secrets. The host node name is its IQN. A secret must have 12–16 characters.
- Define CHAP entries in the storage system.
- Enable CHAP on the storage system. 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 CHAP secret in the host iSCSI initiator.
- Establish a new connection to the storage system using CHAP. The host should be displayable by the system, as well as the ports through which connections were made.

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. This information 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 move to the full feature phase.

About volume mapping

Mappings between a volume and one or more initiators, hosts, or host groups (hereafter called “hosts”) enable the hosts to view and access the volume. There are two types of maps that can be created: default maps and explicit maps. Default maps enable all hosts to see the volume using a specified LUN and access permissions. Default mapping applies to any host that has not been explicitly mapped using different settings. Explicit maps override a volume's default map for specific hosts.

Default mapping is expected by some operating systems, such as Microsoft Windows, which can immediately discover the volume. The advantage of a default mapping is that all connected hosts can discover the volume with no additional work by the administrator. The disadvantage is that all connected hosts can discover the volume with no restrictions. Therefore, this process is not recommended for specialized volumes that require restricted access.

If multiple hosts mount a volume without being cooperatively managed, volume data is at risk for corruption. To control access by specific initiators, you can create an explicit mapping. An explicit mapping can use a different access mode, LUN, and port settings to allow or prevent access by an initiator to a volume. If there is a default mapping, the explicit mapping overrides it.

When a volume is created, it is not mapped by default. You can create default or explicit mappings for it.

You can change the default mapping of a volume, and create, modify, or delete explicit mappings. A mapping can specify read-write, read-only, or no access through one or more controller host ports to a volume. When a mapping specifies no access, the volume is masked.

For example, a payroll volume could be mapped with read-write access for the Human Resources host and be masked for all other hosts. An engineering volume could be mapped with read-write access for the Engineering host and read-only access for other departments' hosts.

A LUN identifies a mapped volume to a host. Both controllers share a set of LUNs, and any unused LUN can be assigned to a mapping. However, each LUN can only be used once as a default LUN. For example, if LUN 5 is the default for Volume1, no other volume in the storage system can use LUN 5 as its default LUN. For explicit mappings, the rules differ: LUNs used in default mappings can be reused in explicit mappings for other volumes and other hosts.

TIP: When an explicit mapping is deleted, the volume's default mapping takes effect. Therefore, it is recommended to use the same LUN for explicit mappings as for the default mapping.

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 in 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 disk group ownership. When ULP is in use, 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.

About snapshots

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.

For Lenovo Storage S3200: A base of 128 snapshots is included with all systems without an additional license.

For Lenovo Storage S2200: A base of 64 snapshots is included with all systems without an additional license.

With a license, you can create additional snapshots. When you reach the maximum number of base snapshots, before you can create a new snapshot you must either delete an existing snapshot or purchase and install a license that increases the maximum number of snapshots. For the maximum number of snapshots for your system, see the System configuration limits topic of the Storage Management Console online help for your system.

The system treats a snapshot like any other volume. The snapshot can be mapped to hosts with read-only access, read-write 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 also use the reset snapshot feature, which enables you to replace the data in a snapshot with the current data in the source volume. You can use it to update an existing snapshot with the data contained in the current source volume or snapshot. When you reset a snapshot, the snapshot name and mappings 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 the event log 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.

Snapshot creation and levels

The process of 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. (Since snapshots reference volumes, they take up no space unless they or the source volume or snapshot is modified.) There are no intermediate steps needed like designating the volume for snapshot capability. Space does not have to be reserved for snapshots because all space in the pool is available for them. 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.

Because a snapshot can be the source of other snapshots, a single virtual 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 existing snapshots from the tree. You can only delete snapshots that do not have any child snapshots.

You cannot expand the base volume of a snapshot tree or 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, they 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.

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.

About copying volumes

The volume copy feature enables you to copy a virtual base volume or snapshot to a new virtual volume through the CLI. The volume copy feature creates a complete "physical" copy of a virtual base volume or snapshot within a storage system. It is an exact copy 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 an 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.

For more information about using the CLI to create a copy of a virtual base volume or snapshot, see the CLI Reference Guide.

About reconstruction

If one or more disks fail in a disk group and spares of the appropriate size (same or larger) and type (same as the failed disks) are available, the storage system automatically uses the spares to reconstruct the component. Component reconstruction does not require I/O to be stopped, so volumes can continue to be used while reconstruction is in progress.

If no spares are available, reconstruction does not start automatically. To start reconstruction manually, replace each failed disk and designate each replacement disk as a spare. If you have configured the dynamic spares feature through the CLI, reconstruction will automatically start for disk groups. With dynamic spares enabled, if a disk fails and you replace it with a compatible disk, the storage system rescans the bus, finds the new disk, automatically designates it a spare, and starts reconstructing the disk group.

Reconstruction of all disk groups uses a quick-rebuild feature. For more information on quick rebuild, see "About quick rebuild" (page 28).

When a disk fails, its fault LED illuminates amber. When a spare is used as a reconstruction target, its activity LED blinks green. During reconstruction, the fault and activity LEDs for all disks in the disk group blink. For descriptions of LED states, see the Setup Guide.

NOTE: Reconstruction can take hours or days to complete, depending on the disk group RAID level and size, disk speed, utility priority, and other processes running on the storage system.

When reconstruction is complete, you can remove the failed disk and replace it with a new disk of the same type in the same slot.

About quick rebuild

Quick rebuild 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 only 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 RAID rebuild. Data stripes that have not been allocated to user data are scrubbed in the background, using a lightweight process that allows future data allocations to be more efficient.

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

About performance statistics

You can view current or historical performance statistics for components of the storage system.

Current performance statistics for disks, disk groups, pools, tiers, host ports, controllers, and volumes are displayed in tabular format. Current statistics show the current performance from host to disk, and are sampled immediately upon request.

Historical performance statistics for disks, pools, and tiers are displayed in graphs for ease of analysis. Historical statistics focus on disk workload. You can view historical statistics to determine whether I/O is balanced across pools and to identify disks that are experiencing errors or are performing poorly.

The system samples historical statistics for disks every quarter hour and retains these samples for 6 months. It samples statistics for pools and tiers every 5 minutes and retains this data for one week but does not persist it across failover or power cycling. By default, the graphs show the latest 100 data samples, but you can specify either a time range of samples to display or a count of samples to display. The graphs can show a maximum of 100 samples.

If you specify a time range of samples to display, the system determines whether the number of samples in the time range exceeds the number of samples that can be displayed (100), requiring aggregation. To determine this, the system divides the number of samples in the specified time range by 100, giving a quotient and a remainder. If the quotient is 1, the 100 newest samples will be displayed. If the quotient exceeds 1, each “quotient” number of newest samples will be aggregated into one sample for display. The remainder is the number of oldest samples that will be excluded from display.

- Example 1: A 1-hour range includes 4 samples. 4 is less than 100 so all 4 samples are displayed.
- Example 2: A 30-hour range includes 120 samples. 120 divided by 100 gives a quotient of 1 and a remainder of 20. Therefore, the newest 100 samples will be displayed and the oldest 20 samples will be excluded.
- Example 3: A 60-hour range includes 240 samples. 240 divided by 100 gives a quotient of 2 and a remainder of 40. Therefore, each two newest samples will be aggregated into one sample for display and the oldest 40 samples will be excluded.

If aggregation is required, the system calculates values for the aggregated samples. For a count statistic (total data transferred, data read, data written, total I/Os, number of reads, number of writes), the samples' values are added to produce the value of the aggregated sample. For a rate statistic (total data throughput, read throughput, write throughput, total IOPS, read IOPS, write IOPS), the samples' values are added and then are divided by their combined interval. The base unit for data throughput is bytes per second.

- Example 1: Two samples' number-of-reads values must be aggregated into one sample. If the value for sample 1 is 1060 and the value for sample 2 is 2000 then the value of the aggregated sample is 3060.
- Example 2: Continuing from example 1, each sample's interval is 900 seconds so their combined interval is 1800 seconds. Their aggregate read-IOPs value is their aggregate number of reads (3060) divided by their combined interval (1800 seconds), which is 1.7.

You can export historical performance statistics in CSV format to a file on the network for import into a spreadsheet or other application. You can also reset current or historical statistics, which clears the retained data and continues to gather new samples.

For more information about performance statistics, see "Viewing performance statistics" (page 106), "Updating historical statistics" (page 108), "Exporting historical performance statistics" (page 108), and "Resetting performance statistics" (page 109).

About firmware update

Controller modules, expansion modules, and disk drives contain firmware that operate them. As newer firmware versions become available, they may be installed at the factory or at a customer maintenance depot or they may be installed by storage-system administrators at customer sites. For a system with two controller modules, the following firmware-update scenarios are supported:

- The administrator installs a new firmware version in one controller and wants that version to be transferred to the partner controller.
- In a system that has been qualified with a specific firmware version, the administrator replaces one controller module and wants the firmware version in the remaining controller to be transferred to the new controller (which might contain older or newer firmware).

When a controller module is installed into an enclosure at the factory, the enclosure midplane serial number and firmware-update timestamp are recorded for each firmware component in controller flash memory, and will not be erased when the configuration is changed or is reset to defaults. These two pieces of data are not present in controller modules that are not factory-installed and are used as replacements.

When you update controller firmware, the Partner Firmware Update (PFU) option, which is enabled by default, ensures that the same firmware version is installed in both controller modules. 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.
- If the firmware in only one controller has the proper midplane serial number then the firmware, midplane serial number, and attributes of that controller are transferred to the partner controller. Subsequently, the firmware update behavior for both controllers depends on the system settings.
- If the firmware in both controllers has the proper midplane serial number then the firmware having the latest firmware-update timestamp is transferred to the partner controller.
- If the firmware in neither controller has the proper midplane serial number, then the firmware in controller A is transferred to controller B.

For information about the procedures to update firmware in controller modules, expansion modules, and disk drives, see "Updating firmware" (page 56). That topic also describes how to use the activity progress interface to view detailed information about the progress of a firmware-update operation.

About 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. The managed logs feature allows log data to be transferred to a log-collection system before any data is lost. The transfer does not remove any data from the logs in the storage system. This feature is disabled by default.

The *log-collection system* is a host computer that is designated to receive the log data transferred from the storage system. Because log data is transferred incrementally, the log-collection system is responsible for integrating the log data for display and analysis.

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, 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 notifications via email, SNMP, or SMI-S to the log-collection system, which can then use FTP 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.

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 its partner will send the logs from both controllers.

Alternative methods for obtaining log data are to use the Save Logs action in the SMC or the `get logs` command in the FTP interface. These methods will transfer the entire contents of a log file without changing its capacity-status level. Use of Save Logs or get logs is expected as part of providing information for a technical support request. For information about using the Save Logs action, see "Saving log data to a file" (page 112). For information about using the FTP interface, see "Using FTP" (page 129).

About replicating virtual volumes

See "Working with Asynchronous Replication" (page 89).

About the Full Disk Encryption feature

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. A lock key is generated by the system 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.

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.

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

Secured disks and systems can be repurposed without needing the correct passphrase. Repurposing erases all data and unsecures the system and disks.

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. For information on setting up FDE and modifying FDE options, see "Changing FDE settings" (page 60).

About 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.

The default caching mode for a volume is write back, as opposed to write through. In write-back mode, data is held in controller cache until it is written to disk. In write-through mode, data is written directly 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. This can result in data becoming unavailable or, in some cases, volume unavailability.

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

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 significant 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 "Modifying a volume" (page 81).

2 Working in the Home topic

Viewing overall system status

The Home topic provides an overview of the storage managed by the system. Information is shown about hosts, host ports, storage capacity and usage, global spares, and logical storage components (like volumes, snapshots, disk groups, and pools).

Host information

The Hosts block shows how many host groups, hosts, and initiators are defined in the system. An *initiator* identifies 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. A *host* is a user-defined set of initiators that represents a server or switch. A *host group* is a user-defined set of hosts for ease of management.

NOTE: If the external port is a switch and there is no connection from the switch to an I/O adapter, then no host information will be shown.

Port information

The Ports A block shows the name and type (protocol) of each host port in controller A. The port icon indicates whether the port is active or inactive:

	FC port is active.
	FC port is connected.
	FC port is disconnected.
	iSCSI port is active.
	iSCSI port is connected.
	iSCSI port is disconnected.
	SAS port is active.
	SAS port is connected.
	SAS port is disconnected

The Ports B block shows similar information for controller B.

Hover the cursor over a port to see the following information in the Port Information panel. If the health is not OK, the health reason and recommended action are shown to help you resolve problems.

Port Information	FC port: Name, type, ID (WWN), status, configured speed, actual speed, topology, and health. iSCSI IPv4 port: Name, type, ID (IQN), status, actual speed, IP version, IP address, gateway, netmask, and health iSCSI IPv6 port: Name, type, ID (IQN), status, actual speed, IP version, IP address, default router, link-local address, and health SAS port: Name, type, ID (WWN), status, configured speed, actual speed, cable type, health

The area between the blocks displays the following statistics, which show the current performance from all hosts to the system:

- Current IOPS for all ports, calculated over the interval since these statistics were last requested (every 30 seconds unless more than one SMC session is active or if the CLI command `show host-port-statistics` is issued) or reset.
- Current data throughput (MB/s) for all ports, calculated over the interval since these statistics were last requested or reset.

Capacity information

The Capacity block shows two color-coded bars. The lower bar represents the physical capacity of the system, showing the capacity of disk groups, global spares, and unused disk space, if any. The upper bar identifies how the capacity is allocated and used. For color-code descriptions, see "Color codes" (page 14).

The upper bar shows the reserved, allocated, and unallocated space for the system. Reserved space refers to space that is unavailable for host use. It consists of RAID parity and the metadata needed for internal management of data structures.

The terms allocated space and unallocated space have the following meanings for virtual storage:

- Allocated space is the amount of space that the data written to the pools takes.
- Unallocated space is space that is designated for a pool but has not yet been allocated by a volume within that pool.
- Uncommitted space is the overall space minus the allocated and unallocated space.

If virtual storage is *overcommitted*, which means that the amount of storage capacity that is designated for use by volumes exceeds the physical capacity of the storage system, the right upper bar will be longer than the lower bar.

Hover the cursor over a segment of a bar to see the storage size represented by that segment. Point anywhere in this block to see the following information about capacity utilization in the Capacity Utilization panel:

- Total Disk Capacity. The total physical capacity of the system
- Unused. The total unused disk capacity of the system
- Global Spares. The total global spare capacity of the system
- Virtual Disk Groups. The capacity of disk groups, both total and by pool
- Reserved. The reserved space for disk groups, both total and by pool
- Allocated. The allocated space for disk groups, both total and by pool
- Unallocated. The unallocated space for disk groups, both total and by pool
- Uncommitted. The uncommitted space in each pool (total space minus the allocated and unallocated space) and total uncommitted space

Storage information

The Storage A and Storage B blocks provide more detailed information about the logical storage of the system. Storage A block shows information for pool A, which is owned by controller A. The Storage B block shows the same types of information about pool B. In a single-controller system, only the storage block relevant to that controller will be shown (for example, only the Storage A block will be shown if controller A is the sole operating controller).

Each storage block contains color-coded graphs. For color-code descriptions, see "Color codes" (page 14).

The block contains a pool capacity graph disk group utilization graph, and—if read cache is configured—a cache utilization graph. The pool capacity graph consists of two horizontal bars. The top bar represents the allocated and unallocated storage for the pool with the same information as the capacity top bar graph, but for the pool instead of the system. The bottom horizontal bar represents the size of the pool.

The disk group utilization graph consists of a graph with vertical measurements. The size of each disk group in the pool is proportionally represented by a horizontal section of the graph. Vertical shading for each disk group section represents the relative space allocated in that disk group. A tool tip for each section shows the disk group name, size, and amount of unallocated space. The color for each disk group represents the tier to which it belongs.

The cache utilization graph also consists of a graph with vertical measurements. However, since read cache does not cache pool capacity, it is represented independently.

The number of volumes and snapshots for the pool(s) owned by the controller displays above the top horizontal bar.

Hover the cursor anywhere in a storage block to display the Storage Information panel.

Storage Information	Owner, storage type, total size, allocated size, snapshot size, available size, allocation rate, and deallocation rate For each tier: Pool percentage, number of disks, total size, allocated size, unallocated size, number of reclaimed pages, and health If the pool health is not OK, an explanation and recommendations for resolving problems with unhealthy components is available. If the overall storage health is not OK, the health reason, recommended action, and unhealthy subcomponents are shown to help you resolve problems.

System health information

The health icon between the storage blocks indicates the health of the system. Hover the cursor over this icon to display the System Health panel, which shows more information about the health state. If the system health is not OK, the System Health panel also shows information about resolving problems with unhealthy components.

Spares information

The Spares block between the storage blocks and below the event icon shows the number of disks that are designated as global spares to automatically replace a failed disk in the system. Hover the cursor over the Spares block to see the disk types of the available global spares in the Global Spares Information panel.

Resolving a pool conflict caused by inserting a foreign disk group

If you insert 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 pool A on `OldSystem`, the imported pool A from `OldSystem` will be offline.

To avoid this, do either of the following:

- Physically remove all disks for the existing pool, which will remove the pool, and then insert the imported disks.

  △ **CAUTION:** This is an offline operation. Removing a virtual disk group or pool while the system is online may result in RAID corruption and possible data loss. Power off the system before removing the existing pool.

- Delete the existing pool and then insert the imported disks.

  △ **CAUTION:** Deleting a pool will delete all the data it contains

Either method will allow the system to create pool A for the new disk group without conflict, allowing the imported disk group's data to be accessible. 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.

Using the Configuration Wizard

The Configuration Wizard helps you initially configure the system or change system configuration settings.

When you complete this wizard you are given the option to start creating disk groups.

Using the Configuration Wizard: Introduction

You can use the Configuration Wizard to perform the following:

- Change the system date and time settings
- Change passwords for the default users, providing they still exist
- Configure each controller's network port
- Enable or disable system-management services
- Enter information to identify the system
- Configure event notification
- Configure controller host ports (if applicable)

The wizard guides you through each step. As you complete a step, it is highlighted at the bottom of the panel. For each step, you can view help by clicking the help icon. At any point, you can cancel the wizard and discard changes.

To use the Configuration Wizard, perform one of the following:

- Point to the Home tab, and select **Configuration Wizard**.
- In the Home topic, select **Action > Configuration Wizard**.

When the Configuration Wizard panel opens, click **Next** to proceed to the next step.

Using the Configuration Wizard: Set Date and Time

You can change the storage system date and time, which appear in the date/time panel in the banner. It is important to set the date and time so that entries in system logs and notifications have correct time stamps.

You can set the date and time manually or configure the system to use NTP to obtain them from a network-attached server. When NTP is enabled, and if an NTP server is available, the system time and date can be obtained from the NTP server. This allows multiple storage devices, hosts, log files, and so forth to be synchronized. 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 options:

- 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.

Whether NTP is enabled or disabled, the storage system does not automatically make time adjustments, such as for Daylight Saving Time. You must make such adjustments manually.

NOTE: If you make changes in this step, they will be applied when you click **Next**. Changes made in other steps will be applied when you complete the wizard.

To use manual date and time settings

1. Clear the **Network Time Protocol (NTP)** check box.
2. To set the Date value, either enter the current date in the format *YYYY-MM-DD*.
3. To set the Time value, enter two-digit values for the hour and minutes and select either **AM**, **PM**, or **24H** (24-hour clock).
4. Click **Next** to proceed to the next step.

To obtain the date and time from an NTP server

1. Select the **Network Time Protocol (NTP)** check box.
2. Perform one of the following:
   - To have the system retrieve time values from a specific NTP server, enter its address in the NTP Server Address field.
   - To have the system listen for time messages sent by an NTP server in broadcast mode, clear the NTP Server Address field.
3. In the NTP Time Zone Offset field, enter the time zone as an offset in hours, and optionally minutes, from UTC. For example: the Pacific Time Zone offset is -8 during Pacific Standard Time or -7 during Pacific Daylight Time and the offset for Bangalore, India is +5:30.
4. Click **Next** to proceed to the next step.

Using the Configuration Wizard: Password Setup

The system provides the default users `manage` and `monitor`.

1. To secure the storage system, enter and confirm a new password for each default user.

   A 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, and one non-alphabetic character. A password can include printable UTF-8 characters except for the following: a space or " , < > \
2. Click **Next** to proceed to the next step.

Using the Configuration Wizard: Network configuration

You can change addressing parameters for the network port in each controller module. You can set static IP values or use DHCP (enabled by default). When setting static IP values, you can use either IPv4 or IPv6 format.

In 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, current addressing is unchanged. You must have some means of determining what addresses have been assigned, such as the list of bindings on the DHCP server.

Each controller has the following factory-default IP settings:

- IP address source: DHCP
- 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: 10.0.0.1

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: 0.0.0.0

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

To use DHCP

1. Set IP address source to DHCP. The new IP values will not appear until the Configuration Wizard is completed and you have logged in again to the new IP addresses.
2. Record the new addresses.
3. Click **Next** to proceed to the next step.

To use static IP values:

1. Determine the IP address, subnet mask, and gateway values to use for each network port.
2. Set IP address source to manual.
3. To specify addresses in IPv6 format instead of the default format, IPv4, select the **IPv6** check box. IPv4 uses 32-bit addresses. IPv6 uses 128-bit addresses.

   NOTE: IPv6 for controller module network ports is not supported in this release.

4. Enter IP address, subnet mask, and gateway values for each controller. You must set a unique IP address for each controller.

   NOTE: The following IP addresses are reserved for internal use by the storage system: 192.168.200.253, 192.168.200.254, 172.22.255.253, 172.22.255.254, and 127.0.0.1

5. Record the IP values you assign.
6. Click **Next** to proceed to the next step.

Using the Configuration Wizard: Enable system-management services

You can enable or disable management 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. In-band services operate through the data path and can slightly reduce I/O performance.

If a service is disabled, it continues to run but cannot be accessed. To allow specific users to access the SMC (the web browser interface otherwise known as the WBI), CLI, FTP, or SMI-S, see "Adding, modifying, and deleting users" (page 43).

To change system services settings

1. Enable the services that you want to use to manage the storage system, and disable the others.
   - Web Browser Interface (WBI). The web application that is the primary interface for managing the system.

     You can enable use of HTTP, HTTPS for increased security, or of both. Also, if you choose to disable the SMC, the change does not take effect until the Configuration Wizard has finished and you have logged in again. If you disable both, you will lose access to this interface.
   - Command Line Interface (CLI). An advanced-user interface that is used to manage the system and can be used to write scripts. You can enable use of SSH (secure shell) for increased security, Telnet, or both.
   - Storage Management Initiative Specification (SMI-S). Used for remote management of the system through your network. You can enable use of secure (encrypted) or unsecure (unencrypted) SMI-S:
     - **Enable**. Select this check box to enable unencrypted communication between SMI-S clients and the embedded SMI-S provider in each controller module via HTTP port 5988. Clear this check box to disable the active port and use of SMI-S.
     - **Encrypted**. Select this check box to enable encrypted communication, which disables HTTP port 5988 and enables HTTPS port 5989 instead. Clear this check box to disable port 5989 and enable port 5988.
   - File Transfer Protocol (FTP). A secondary interface for installing firmware updates, downloading logs, and installing a license.
   - Simple Network Management Protocol (SNMP). Used for remote monitoring of the system through your network.
   - Service Debug. Used for technical support only. Enables or disables debug capabilities, including Telnet debug ports and privileged diagnostic user IDs.

- Activity Progress Reporting. Provides access to the activity progress interface via HTTP port 8081. This mechanism reports whether a firmware update or partner firmware update operation is active and shows the progress through each step of the operation. In addition, when the update operation completes, status is presented indicating either the successful completion, or an error indication if the operation failed.
- In-band SES Capability. Used for in-band monitoring of system status based on SCSI Enclosure Services (SES) data. This service operates through the data path and can slightly reduce I/O performance.

2. Click **Next** to proceed to the next step.

Using the Configuration Wizard: System information

To change system information settings

1. Set the system name, contact, location, and information (description) values. The name is shown in the browser title bar or tab. The name, location, and contact are included in event notifications. All four values are recorded in system debug logs for reference by service personnel. Each value can include a maximum of 79 bytes, using all characters except the following: " < > \
2. Click **Next** to proceed to the next step.

Using the Configuration Wizard: Configure event notification

You can enable the system to send notifications to SNMP trap hosts and email addresses when events occur in the system. You can also enable the managed logs feature, which transfers log data to a log-collection system. For more information about the managed logs feature, see "About managed logs" (page 29).

To change SNMP notification settings

1. Select one of the following Notification Level options:
   - **none** (disabled). All events are excluded from trap notification and traps are disabled.

     However, Critical events and managed-logs events are sent regardless of the notification setting.
   - **Critical**. Notifications are sent for Critical events only.
   - **Error**. Notifications are sent for Error and Critical events only.
   - **Warning**. Notifications are sent for Warning, Error, and Critical events only.
   - **Informational**. Notifications are sent for all events.
2. In the Read community field, enter the SNMP read password for your network. This password is included in traps that are sent. The value is case sensitive and can have a maximum of 31 bytes. It can include any character except for the following: " < >
3. In the Write community field, enter the SNMP write password for your network. The value is case sensitive and can have a maximum of 31 bytes. It can include any character except for the following: " ' < >
4. If SNMP notification is enabled, in the Trap Host Address fields enter the IP addresses of hosts that are configured to receive SNMP traps.

To change email notification settings

1. If the mail server is not on the local network, make sure that the gateway IP address was set in "Using the Configuration Wizard: Network configuration" (page 36).
2. Select the **Email** tab.
3. In the SMTP Server address field, enter the IP address of the SMTP mail server to use for the email messages.
4. In the Sender Domain field, enter a domain name, which will be joined with an @ symbol to the sender name to form the "from" address for remote notification. The domain name can have a maximum of 255 bytes. Because this name is used as part of an email address, do not include spaces or the following: \ " : ; < > ( )

   The default is `mydomain.com`. If the domain name is not valid, some email servers will not process the mail.
5. In the Sender Name field, enter a sender name, which will be joined with an @ symbol to the domain name to form the "from" address for remote notification. This name provides a way to identify the system that is sending the notification. The sender name can have a maximum of 64 bytes. Because this name is used as part of an email address, do not include spaces or the following: \ " : ; < > ( ) [ ]

   For example: `Storage-1`.

6. Perform one of the following:
   - To enable email notifications, select the **Enable Email Notifications** check box. This enables the notification level and email address fields.
   - To disable email notifications, clear the **Enable Email Notifications** check box. This disables the notification level and email address fields.
7. If email notification is enabled, select one of the following Notification Level options:
   - **Critical**. Notifications are sent for Critical events only.
   - **Error**. Notifications are sent for Error and Critical events only.
   - **Warning**. Notifications are sent for Warning, Error, and Critical events only.
   - **Informational**. Notifications are sent for all events.
8. If email notification is enabled, in one or more of the Email Address fields enter an email address to which the system should send notifications. Each email address must use the *format user-name@domain-name*. Each email address can have a maximum of 320 bytes. For example: `Admin@mydomain.com` or **IT-team@mydomain.com**.

To change managed logs settings

1. Select the **Managed Logs** tab.
2. Perform one of the following:
   - To enable managed logs, select the **Enable Managed Logs** check box.
   - To disable managed logs, clear the **Enable Managed Logs** check box.
3. If the managed logs option is enabled, in the Email destination address field, enter the email address of the log-collection system. The email address must use the format user-name@domain-name and can have a maximum of 320 bytes. For example: `LogCollector@mydomain.com`.
4. Perform one of the following:
   - To use push mode, which automatically attaches system log files to managed-logs email notifications that are sent to the log-collection system, select the **Include logs as an email attachment** check box.
   - To use pull mode, clear the **Include logs as an email attachment** check box.
5. Click **Next** to proceed to the next step.

Using the Configuration Wizard: Port configuration

NOTE: The Port configuration panel does not appear for systems with SAS controller modules since it does not have SAS host-interface configuration options.

For Lenovo Storage S2200: Host ports can be configured through the Host Ports Settings panel to use fan-out cables or standard cables (see "Changing host-interface settings" (page 53) for more information).

To enable the system to communicate with hosts having FC or iSCSI interfaces, you can configure the system's host-interface options. If the current settings are correct, port configuration is optional.

For Lenovo Storage S3200: Host ports can be configured as a combination of FC and iSCSI ports.

For Lenovo Storage S2200: Host ports can only be configured as either FC or iSCSI ports.

NOTE: For information about setting advanced host-port parameters, such as FC port topology, see the CLI Reference Guide.

To configure FC ports

1. Set the Speed option to the proper value to communicate with the host. The speed can be set to **auto**, which auto-negotiates the proper link speed with the host, or to **4 Gbit/s**, **8 Gbit/s**, or **16 Gbit/s**. Because a speed mismatch prevents communication between the port and host, set a speed only if you need to force the port to use a known speed.
2. The FC Connection Mode can be point-to-point or auto:
   - **point-to-point**: Fibre Channel point-to-point.
   - **auto**: Automatically sets the mode based on the detected connection type.
3. Click **Next** to proceed to the next step.

To configure iSCSI ports

1. Set the port-specific options:
   - 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 2: 10.10.10.100
     - Controller A port 3: 10.11.10.120
     - Controller B port 2: 10.10.10.110
     - Controller B port 3: 10.11.10.130
   - Netmask. For IPv4, subnet mask for assigned port IP address.
   - Gateway. For IPv4, gateway IP address for assigned port IP address.
   - Default Router. For IPv6, default router for assigned port IP address.
2. In the Advanced Settings section of the panel, set the options that apply to all iSCSI ports:
   - Enable Authentication) (CHAP). Enables or disables use of Challenge Handshake Authentication Protocol.

     NOTE: CHAP records for iSCSI login authentication must be defined if CHAP is enabled. To create CHAP records, see "Configuring CHAP" (page 69).

   - Link Speed.
     - auto—Auto-negotiates the proper speed.
     - 1 Gbit/s—Forces the speed to 1 Gbit/sec, overriding a downshift that can occur during auto-negotiation with 1-Gbit/sec HBAs. This setting does not apply to 10-Gbit/sec HBAs.
   - Enable Jumbo Frames. Enables or disables support for jumbo frames. Allowing for 100 bytes of overhead, a normal frame can contain a 1400-byte payload whereas a jumbo frame can contain a maximum 8900-byte payload for larger data transfers.

     NOTE: Use of jumbo frames can succeed only if jumbo-frame support is enabled on all network components in the data path.

   - iSCSI IP Version. Specifies whether IP values use Internet Protocol version 4 (IPv4) or version 6 (IPv6) format. IPv4 uses 32-bit addresses. IPv6 uses 128-bit addresses.
   - Enable iSNS. Enables or disables registration with a specified Internet Storage Name Service server, which provides name-to-IP-address mapping.
   - iSNS Address. Specifies the IP address of an iSNS server.
   - Alternate iSNS Address. Specifies the IP address of an alternate iSNS server, which can be on a different subnet.

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

3. Click **Next** to proceed to the next step.

Using the Configuration Wizard: Confirm the configuration changes

NOTE: For systems with SAS controller modules, this panel appears after the Configure event notification panel since the Port configuration panel is skipped.

Confirm that the changes listed in the wizard panel are correct.

- If they are not correct, click **Previous** to return to previous steps and make necessary changes.
- If they are correct, click **Finish** to apply the settings and finish the wizard. If the changes might disrupt access, confirm the changes.

  When processing is complete, you are prompted to add storage. Click **Yes** to open the Add Disk Group panel. Otherwise, click **No**.

Changing system information settings

To change system information settings

1. Perform one of the following:
   - In the Home topic, select **Action > Set System Information**.
   - In the banner, click the system panel and select **Set System Information**.

     The Set System Information panel opens.
2. Set the System Name, System Contact person, System Location, and System Information (description) values. The name is shown in the browser title bar or tab. The name, contact, and location are included in event notifications. All four values are recorded in system debug logs for reference by service personnel. Each value can include a maximum of 79 bytes, using all characters except the following: " < > \
3. Click **OK**.

Managing users

The system provides three default users and nine additional users can be created. The default users are "standard users," which can access one or more of the following standard management interfaces: SMC (otherwise known as WBI), CLI, SMI-S, or FTP. You can also create SNMPv3 users, which can either access the Management Information Base (MIB) or receive trap notifications. SNMPv3 users support SNMPv3 security features, such as authentication and encryption. For information about configuring trap notifications, see "Changing notification settings" (page 44). For information about the MIB, see "SNMP reference" (page 117).

As a user with the `manage` role, you can modify or delete any user other than your current user. Users with the `monitor` role can change all settings for their own user except for user type and role but can only view the settings for other users.

Table 10 Settings for the default users

User Name	Password	User Type	Roles	Interfaces	Base	Precision	Unit	Temperature	Timeout (minutes)	Locale
`monitor`	`!monitor`	Standard	monitor	WBI, CLI	Base 10	1	Auto	Celsius	30	English
`manage`	`!manage`		monitor, manage	WBI, CLI, SMI-S, FTP						
`ftp`	`!ftp`		monitor, manage	FTP						

IMPORTANT: To secure the storage system, set a new password for each default user.

User options

The following options apply to standard and SNMPv3 users:

- User Name. A user name is case sensitive and can have a maximum of 29 bytes. It cannot already exist in the system or include the following: a space or " , < \
- Password. A 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, and one non-alphabetic character. A password can include printable UTF-8 characters except for the following: a space or " ' , < > \
- Confirm Password. Re-enter the new password.
- User Type. When creating a new user, select **Standard** to show options for a standard user, or **SNMPv3** to show options for an SNMPv3 user.

The following options apply only to a standard user:

- Roles. Select one or more of the following roles:
  - **Monitor**. Enables the user to view but not change system status and settings. This is enabled by default and cannot be disabled.
  - **Manage**. Enables the user to change system settings.
- Interfaces. Select one or more of the following interfaces:
  - **WBI**. Enables access to the SMC.
  - **CLI**. Enables access to the command-line interface.
  - **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, which can be used instead of the SMC to install firmware updates and to download logs.
- Base Preference. Select the base for entry and display of storage-space sizes:
  - Base 2. Sizes are shown as powers of 2, using 1024 as a divisor for each magnitude.
  - Base 10. Sizes are shown as powers of 10, using 1000 as a divisor for each magnitude.
- Precision Preference. Select the number of decimal places (1–10) for display of storage-space sizes.
- Unit Preference. Select one of the following options for display of storage-space sizes:
  - **Auto**. Enables the system to determine the proper unit for a size. Based on the precision setting, if the selected unit is too large to meaningfully display a size, the system uses a smaller unit for that size. For example, if the unit is set to TB and the precision is set to 1, the size 0.11709 TB is shown as 117.1 GB.
  - **TB**. Display all sizes in terabytes.
  - **GB**. Display all sizes in gigabytes.
  - **MB**. Display all sizes in megabytes.
- Temperature Preference. Select whether to use the Celsius or Fahrenheit scale for display of temperatures.
- Timeout. Select the amount of time that the user's session can be idle before the user is automatically signed out (2–720 minutes).
- Locale. Select a display language for the user. Installed language sets include Arabic, Chinese-Simplified, Chinese-Traditional, Dutch, English, French, German, Italian, Japanese, Korean, Portuguese, Russian, and Spanish. The locale determines the character used for the decimal (radix) point, as shown in "Size representations" (page 15).

The following options apply only to an SNMPv3 user:

- SNMPv3 Account Type. Select one of the following types:
  - **User Access**. Enables the user to view the SNMP MIB.
  - **Trap Target**. Enables the user to receive SNMP trap notifications.
- SNMPv3 Authentication Type. Select whether to use **MD5** or **SHA** authentication, or no authentication. 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.

- SNMPv3 Privacy Type. Select whether to use **DES** or **AES** encryption, or no encryption. To use encryption you must also set a privacy password and enable authentication.
- SNMPv3 Privacy Password. If the privacy type is set to use encryption, specify an encryption password. This 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, and one non-alphabetic character. A password can include printable UTF-8 characters except for the following: a space or " , < > \
- Trap Host Address. If the account type is **Trap Target**, specify the IP address of the host system that will receive SNMP traps.

Adding, modifying, and deleting users

To add a new user

1. Perform one of the following:
   - In the Home topic, select **Action > Manage Users**.
   - In the banner, click the user panel and select **Manage users**.

     The User Management panel opens and shows a table of existing users. For information about using tables, see "Tips for using help" (page 13).
2. Below the table, click **New**.
3. Set the options.
4. Click **Apply**. The user is added and the table is updated.

To create a user from an existing user

1. Perform one of the following:
   - In the Home topic, select **Action > Manage Users**.
   - In the banner, click the user panel and select **Manage users**.

     The User Management panel opens and shows a table of existing users. For information about using tables, see "Tips for using help" (page 13).
2. Select the user to copy.
3. Click **Copy**. A user named `copy_of_`*selected-user* appears in the table.
4. Set a new user name and password and optionally change other settings.
5. Click **Apply**. The user is added and the table is updated.

To modify a user

1. Perform one of the following:
   - In the Home topic, select **Action > Manage Users**.
   - In the banner, click the user panel and select **Manage users**.

     The User Management panel opens and shows a table of existing users. For information about using tables, see "Tips for using help" (page 13).
2. Select the user to modify.
3. Change the settings. You cannot change the user name. Users with the `monitor` role can change their own settings except for their role and interface settings.
4. Click **Apply**. A confirmation panel appears.
5. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the user is modified.

To delete a user (other than your current user)

1. Perform one of the following:
   - In the Home topic, select **Action > Manage Users**.
   - In the banner, click the user panel and select **Manage users**.

     The User Management panel opens and shows a table of existing users. For information about using tables, see "Tips for using help" (page 13).
2. Select the user to delete.
3. Click **Delete**. A confirmation panel appears.
4. Click **Remove** to continue. Otherwise, click **Cancel**. If you clicked Remove, the user is removed and the table is updated.

Changing notification settings

You can enable the system to send notifications to SNMP trap hosts and to email addresses when events occur in the system. You can also enable the managed logs feature, which transfers log data to a log-collection system. For more information about the managed logs feature, see "About managed logs" (page 29).

To change notification settings

1. Open the Notification Settings panel through either method:
   - In the footer, click the events panel and select **Set Up Notifications**.
   - In the Home topic, select **Action > Set Up Notifications**.
2. Change SNMP, email, and managed logs settings, as described in the first three procedures below.
3. Test the notification settings, as described in "To test notification settings" (page 45).

To change SNMP notification settings

1. Select the **SNMP** tab.
2. If a message near the top of the panel informs you that the SNMP service is disabled, enable it, as described in "Changing system services settings" (page 51).
3. Select one of the following Notification Level options:
   - **none (disabled)**. All events are excluded from trap notification and traps are disabled.

     However, Critical events and managed-logs events are sent regardless of the notification setting.
   - **Critical**. Notifications are sent for Critical events only.
   - **Error**. Notifications are sent for Error and Critical events only.
   - **Warning**. Notifications are sent for Warning, Error, and Critical events only.
   - **Informational**. Notifications are sent for all events.
4. In the Read Community field, enter the SNMP read password for your network. This password is included in traps that are sent. The value is case sensitive and can have a maximum of 31 bytes. It can include any character except for the following: " < >
5. In the Write Community field, enter the SNMP write password for your network. The value is case sensitive and can have a maximum of 31 bytes. It can include any character except for the following: " < >
6. If SNMP notification is enabled, in the Trap Host Address fields, enter the IP addresses of hosts that are configured to receive SNMP traps.
7. Click **Apply**.

To change email notification settings

1. If the mail server is not on the local network, make sure that the gateway IP address is set in the System IP Network Configuration panel, as described in "Changing network interface settings" (page 52).
2. Select the **Email** tab.
3. In the SMTP Server address field, enter the IP address of the SMTP mail server to use for the email messages.
4. In the Sender Domain field, enter a domain name, which will be joined with an @ symbol to the sender name to form the "from" address for remote notification. The domain name can have a maximum of 255 bytes. Because this name is used as part of an email address, do not include spaces or the following: \ " : ; < > ( ).

   The default is `mydomain.com` If the domain name is not valid, some email servers will not process the mail.
5. In the Sender Name field, enter a sender name, which will be joined with an @ symbol to the domain name to form the "from" address for remote notification. This name provides a way to identify the system that is sending the notification. The sender name can have a maximum of 64 bytes. Because this name is used as part of an email address, do not include spaces or the following: \ " : ; < > ( ) [ ]

   For example: `Storage-1`
6. Set the email notification option:
   - To enable email notifications, select the **Enable Email Notifications** check box. This enables the notification level and email address fields.
   - To disable email notifications, clear the **Enable Email Notifications** check box. This disables the notification level and email address fields.
7. If email notification is enabled, select one of the following Notification Level options:
   - **Critical**. Notifications are sent for Critical events only.
   - **Error**. Notifications are sent for Error and Critical events only.
   - **Warning**. Notifications are sent for Warning, Error, and Critical events only.
   - **Informational**. Notifications are sent for all events.
8. If email notification is enabled, in one or more of the Email Address fields enter an email address to which the system should send notifications. Each email address must use the format *user-name@domain-name*. Each email address can have a maximum of 320 bytes. For example: `Admin@mydomain.com` or `IT-team@mydomain.com`
9. Click **Apply**.

To change managed logs settings

1. Select the **Email** tab and ensure that the SMTP Server Address and Sender Domain options are set, as described above.
2. Select the **Managed Logs** tab.
3. Set the managed log option:
   - To enable managed logs, select the **Enable Managed Logs** check box.
   - To disable managed logs, clear the **Enable Managed Logs** check box.
4. If the managed logs option is enabled, in the Email destination address field, enter the email address of the log-collection system. The email address must use the format *user-name@domain-name* and can have a maximum of 320 bytes. For example: `LogCollector@mydomain.com`.
5. Select one of the following options:
   - To use the push mode, which automatically attaches system log files to managed-logs email notifications that are sent to the log-collection system, select the **Include logs as an email attachment** check box.
   - To use the pull mode, clear the **Include logs as an email attachment** check box.
6. Click **Apply**.

To test notification settings

1. Click **Send Test Event**. A test notification is sent to each configured trap host and email address.
2. Verify that the test notification reached each configured trap host and email address.
3. If the managed logs option is enabled, click **Send Log Test**. A test notification is sent to the log-collection system.
4. Verify that the test notification reached the log-collection system.

Managing scheduled tasks

You can modify or delete scheduled tasks to create snapshots, reset snapshots, and run replications.

To modify a schedule

1. In the Home topic, select **Action > Manage Schedules**. The Manage Schedules panel opens.
2. Select the schedule to modify. The schedule's settings appear at the bottom of the panel.
3. Modify the settings.
4. Click **Apply**. A confirmation panel appears.
5. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the schedule is modified.
6. Click **OK**.

To delete a schedule

1. In the Home topic, select **Action > Manage Schedules**. The Manage Schedules Action panel opens.
2. Select the schedule to delete.
3. Click **Delete**. A confirmation panel appears.
4. Click **Apply** to continue. Otherwise, click **No**. If you clicked Apply, the schedule was deleted.
5. Click **OK**.

Installing a license

A license is required to use the Performance tier, expand the maximum number of snapshots, and use the replication feature and VSS. The license is specific to a controller enclosure serial number and firmware version.

Viewing the status of licensed feature

1. In the Home topic, select **Action > Install License**. The License Settings panel opens and shows the following information about each licensed feature:
   - Feature. The feature name.
   - Base. One of the following:
     - The number of standard snapshots that users can create without a license.
     - `N/A`. Not applicable.
   - License. One of the following:
     - The number of standard snapshots that the installed license supports.
     - `Enabled`. The feature is enabled.
     - `Disabled`. The feature is disabled.
   - In Use. One of the following:
     - The number of standard snapshots that exist.
     - `N/A`. Not applicable.
   - Max Licensable. One of the following:
     - The number of standard snapshots that the maximum license supports.
     - `N/A`. Not applicable.
   - Expiration. One of the following:
     - `Never`. License does not expire.
     - `N/A`. Not applicable.

The panel also shows the licensing serial number and the licensing version number (both required for generating a license).

Installing a permanent license

1. Verify the following:
   - The license file is saved to a network location that you can access from the SMC.
   - You are signed into the controller enclosure for which the file is generated.
2. In the Home topic, select **Action > Install License**. The License Settings panel opens.
3. On the **Permanent License** tab, click **Choose File** to locate and select the license file.
4. Click **OK**. The license settings table is updated and, for each feature included in the license, the `Expiration` value changes to `Never`.

3 Working in the System topic

Viewing system components

The System topic enables you to see information about each enclosure and its physical components in front, rear, and tabular views. Components vary by enclosure model.

Front view

The Front tab shows the front of all enclosures in a graphical view. For each enclosure, the front view shows the enclosure ID and other information. If installed disks are part of a virtual disk group or are global spares, unique color codes identify them as such. For information on the specific colors used, see "Color codes" (page 14).

To see more information about an enclosure or disks, hover the cursor over an enclosure ear or a disk:

Table 11 Additional information for front view of enclosure

Enclosure Information	ID, status, vendor, model, disk count, WWN, midplane serial number, revision, health
Disk Information	Location, serial number, usage, type, size, status, RPM (spinning disk only), SSD life left, manufacturer, model, revision, power on hours, FDE state, FDE lock key, job running, sector format, health

If a component's health is not OK, the health reason, recommended action, and unhealthy subcomponents are shown to help you resolve problems.

NOTE: Following is more information for selected Disk Information panel items:

- *Power On Hours* refers to the total number of hours that the disk has been powered on since it was manufactured. This value is updated in 30-minute increments.
- *FDE State* refers to the FDE state of the disk. For more information about FDE states, see the CLI Reference Guide.
- *FDE lock keys* are generated from the FDE 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 data on the disks.

Rear view

The Rear tab shows the rear of all enclosures in a graphical view. The rear view shows enclosure IDs and the presence or absence of power supplies, controller modules, and expansion modules. It also shows controller module IDs, host port types and names, network port IP addresses, and expansion port names. To see more information, hover the cursor over an enclosure ear or a component:

Table 12 Additional information for rear view of enclosure

Enclosure	ID, status, vendor, model, disk count, WWN, midplane serial number, revision, health
Power supply	Status, vendor, model, serial number, revision, health
Controller module	ID, network-port IP address, description, status, model, serial number, hardware version, system cache memory (MB), hardware revision, health
FC host port	Name, type, ID (WWN), status, configured speed, actual speed, topology, health
iSCSI host port	Name, type, ID (IQN), status, actual speed, IP version, address, gateway, network mask, health
SAS host port	Name, type, ID (WWN), status, configured speed, actual speed, cable type, health
Network port	Name, mode, IP address, network mask, gateway, health
Expansion port	Enclosure ID, controller ID, name, status, health
Expansion module (IOM)	ID, description, serial number, hardware revision, health

If a component's health is not OK, the health reason, recommended action, and unhealthy subcomponents are shown to help you resolve problems.

Table view

The Table tab shows a tabular view of information about physical components in the system. By default, the table shows 20 entries at a time. For information about using tables, see "Tips for using help" (page 13).

For each component, the table shows the following information:

- Health. Shows the health of the component:
  - OK
  - Degraded
  - Fault
  - N/A
  - Unknown
- Type. Shows the component type: enclosure, disk, power supply, controller module, network port, host port, expansion port, CompactFlash card, or I/O module (expansion module).
- Enclosure. Shows the enclosure ID.
- Location. Shows the location of the component.
  - For an enclosure, the location is shown in the format *Rack rack-ID.shelf-ID*. You can set the location through the CLI `set enclosure` command.
  - For a disk, the location is shown in the format *enclosure-ID.disk-slot*.
  - For a power supply or I/O module, the locations Left and Right are as viewed from the rear of the enclosure.
  - For a host port, the location is shown as controller ID and port number.
- Information. Shows additional, component-specific information:
  - For an enclosure: its FRU description and current disk count.
  - For a disk: its type, capacity, and usage.
  - Type is shown as either:
    - `MDL`. Spinning midline SAS disk.
    - `SAS`. Spinning enterprise-class SAS disk.
    - `SSD`. Solid-state SAS disk.
  - Usage is shown as either:
    - `AVAIL`. The disk is available.
    - `SPARE`. The disk is configured as a spare.
    - *pool-ID:tier name*. The disk is part of a disk group.
    - `FAILED`. The disk is unusable and must be replaced. Reasons for this status include: excessive media errors, SMART error, disk hardware failure, or unsupported disk.
    - `LEFTOVR`. The disk is part of a disk group that is not found in the system.
    - `UNUSABLE`. The disk cannot be used in a disk group because the system is secured, or the disk is locked to data access, or the disk is from an unsupported vendor.
  - For a power supply: its FRU description.
  - For a controller module: its ID.
  - For a network port: its IP address.
  - For a host port: one of the following values:
    - `FC(L)`. Fibre Channel-Arbitrated Loop (public or private)
    - `FC(P)`. Fibre Channel Point-to-Point
    - `FC(-)`. Fibre Channel disconnected
    - `SAS`. Serial Attached SCSI
    - `iSCSI`. Internet SCSI

    - For an expansion port: either `Out Port` or `In Port`.
    - For an I/O module: its ID.
- Status. Shows the component status:
    - For an enclosure: `Up`.
    - For a disk:
        - `Up`. The disk is present and is properly communicating with the expander.
        - `Spun Down`. The disk is present and has been spun down by the DSD feature.
        - `Warning`. The disk is present but the system is having communication problems with the disk LED processor. For disk and midplane types where this processor also controls power to the disk, power-on failure will result in the Error status.
        - `Error`. The disk is present but not detected by the expander.
        - `Unknown`. Initial status when the disk is first detected or powered on.
        - `Not Present`. The disk slot indicates that no disk is present.
        - `Unrecoverable`. The disk is present but has unrecoverable errors.
        - `Unavailable`. The disk is present but cannot communicate with the expander.
        - `Unsupported`. The disk is present but is an unsupported type.
    - For a power supply: `Up`, `Warning`, `Error`, `Not Present`, or `Unknown`.
    - For a controller module or I/O module: `Operational`, `Down`, `Not Installed`, or `Unknown`.
    - For a network port: `N/A`.
    - For a host port:
        - `Up`. The port is cabled and has an I/O link.
        - `Warning`. Not all of the port's PHYs are up.
        - `Error`. The port is reporting an error condition.
        - `Not Present`. The controller module is not installed or is down.
        - `Disconnected`. Either no I/O link is detected or the port is not cabled.
    - For an expansion port: `Up`, `Disconnected`, or `Unknown`.
    - For a CompactFlash card: `Installed`, `Not Installed`, or `Unknown`.

Managing global spares

You can designate a maximum of 16 global spares for the system. 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 parity or mirror data is completely written to the spare, at which time the disk group will return to fault-tolerant status.

The Change Global Spares panel contains a single disk set, which consists of the disks selected as global spares. The Disk Sets summary includes a row that shows the total space of the disk set and amount of space allocated for spares. Also, a table is located below the row that contains several fields, including the Disks and Size fields. The total space and Size field values reflect the cumulative amount of storage for the selected disks. The Disks field shows the number of spares selected.

Underneath the Disk Sets summary are one or more disk tables depending on how many enclosures your system has. Each table represents an enclosure and all of its disks. To see more information about an enclosure or disks, such as the disk type, capacity, and sector format, hover the cursor over an enclosure ear or disk. The Enclosure Information or Disk Information panel appears. "Viewing pools" (page 71) contains more details about the Disk Information panel.

If installed disks are part of a disk group or are global spares, unique color codes identify them as such. For information on the specific colors used, see "Color codes" (page 14).

NOTE: Disk groups support a mix of 512n and 512e disks. 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 "About disk groups" (page 17).

To change the system's global spares

1. In the System topic, select **Action > Change Global Spares**. The Change Global Spares panel shows information about available disks in the system. Existing spares are labeled GLOBAL SP.
   - In the Disk Sets summary, the number of white slots in the Disks field shows how many spares you can add. The colored slots show how many disks you have selected to become spares or have already added as spares.
   - In each disk table, which visually represents the disks for an enclosure, only existing global spares and suitable available disks are selectable.
2. Select spares to remove, disks to add as spares, or both.
3. Click **Change**. If the task succeeds, the panel is updated to show which disks are now global spares.

Changing system services settings

You can enable or disable management 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.

If a service is disabled, it continues to run but cannot be accessed. To allow specific users to access the SMC (the web browser interface also known as the WBI), CLI, FTP, or SMI-S interfaces, see "Managing users" (page 41).

To change system services settings

1. Perform one of the following:
   - In the banner, click the system panel and select **Set Up System Services**.
   - In the System topic, select **Action > Set Up System Services**.

   The System Services panel opens.
2. Enable the services that you want to use to manage the storage system, and disable the others.
   - Web Browser Interface (WBI). The web application that is the primary interface for managing the system.

     You can enable use of HTTP, HTTPS for increased security, or of both. If you disable both, you will lose access to this interface.
   - Command Line Interface (CLI). An advanced-user interface that is used to write scripts to manage the system. You can enable use of SSH (secure shell) for increased security, Telnet, or both.
   - Storage Management Initiative Specification (SMI-S). Used for remote management of the system through your network. You can enable use of secure (encrypted) or unsecure (unencrypted) SMI-S:
     - **Enable**. Select this check box to enable unencrypted communication between SMI-S clients and the embedded SMI-S provider in each controller module via HTTP port 5988. Clear this check box to disable the active port and use of SMI-S.
     - **Encrypted**. Select this check box to enable encrypted communication, which disables HTTP port 5988 and enables HTTPS port 5989 instead. Clear this check box to disable port 5989 and enable port 5988.
   - File Transfer Protocol (FTP). A secondary interface for installing firmware updates, downloading logs, and installing a license.
   - Simple Network Management Protocol (SNMP). Used for remote monitoring of the system through your network.
   - Service Debug. Used for technical support only. Enables or disables debug capabilities, including Telnet debug ports and privileged diagnostic user IDs.

- Activity Progress Reporting. Provides access to the activity progress interface via HTTP port 8081. This mechanism reports whether a firmware update or partner firmware update operation is active and shows the progress through each step of the operation. In addition, when the update operation completes, status is presented indicating either the successful completion, or an error indication if the operation failed.
- In-band SES Capability. Used for in-band monitoring of system status based on SCSI Enclosure Services (SES) data. This service operates through the data path and can slightly reduce I/O performance.

3. Click **OK**. If any unsecure interfaces are enabled, a confirmation panel will appear.
4. Click **Yes** to confirm use of unsecure interfaces. Otherwise, click **No**.

Changing network interface settings

You can change addressing parameters for the network port in each controller module. You can set static IP values or use DHCP. When setting static IP values, you can use either IPv4 or IPv6 format.

In 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, current addressing is unchanged. You must have some means of determining what addresses have been assigned, such as the list of bindings on the DHCP server.

Each controller has the following factory-default IP settings:

- IP address source: DHCP
- 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: 10.0.0.1

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: 0.0.0.0

△ **CAUTION:** Changing IP settings can cause management hosts to lose access to the storage system.

To use DHCP to obtain IP values for network ports

1. In the System topic, select **Action > Set Up Network**. The System IP Network Configuration panel opens.
2. Set IP address source to **DHCP** and click **OK**. If the controllers successfully obtain IP values from the DHCP server, the new IP values appear.
3. Record the new addresses.
4. Sign out and try to access the SMC using the new IP addresses.

To set static IP values for network ports:

1. Determine the IP address, subnet mask, and gateway values to use for each network port.
2. In the System topic, select **Action > Set Up Network**. The System IP Network Configuration panel opens.
3. Set IP address source to **manual**.
4. To specify addresses in IPv6 format instead of the default format, IPv4, select the **IPv6** check box. IPv4 uses 32-bit addresses. IPv6 uses 128-bit addresses.

NOTE: IPv6 for controller module network ports is not supported in this release.

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5. Enter IP address, subnet mask, and gateway values for each controller. You must set a unique IP address for each controller.

   NOTE: The following IP addresses are reserved for internal use by the storage system: 192.168.200.253, 192.168.200.254, 172.22.255.253, 172.22.255.254, and 127.0.0.1

6. Record the IP values you assign.
7. Click **OK**.
8. Sign out and try to access the SMC using the new IP addresses.

Changing host-interface settings

To enable the system to communicate with hosts having FC or iSCSI interfaces, you can configure the system's host-interface options. If the current settings are correct, port configuration is optional.

For Lenovo Storage S3200: Host ports can be configured as a combination of FC and iSCSI ports. For a system with a 4-port SAS controller module, there are no host-interface options.

For Lenovo Storage S2200: Host ports can only be configured as either FC or iSCSI ports. For a 2-port SAS controller module, host ports can be configured to use fan-out cables or standard cables.

NOTE: For information about setting `advanced host-port` parameters, such as FC port topology, see the CLI Reference Guide.

To change FC host interface settings

1. In the System topic, select **Action > Set Up Host Ports**. The Host Ports Settings panel opens.
2. Set the Speed option to the proper value to communicate with the host. The speed can be set to **auto**, which auto-negotiates the proper link speed with the host, or to **4 Gbit/s**, **8 Gbit/s**, or **16 Gbit/s**. Because a speed mismatch prevents communication between the port and host, set a speed only if you need to force the port to use a known speed.
3. The FC Connection Mode can be point-to-point or auto:
   - **point-to-point**: Fibre Channel point-to-point.
   - **auto**: Automatically sets the mode based on the detected connection type.
4. Click **OK**.
5. Click **Apply**. Otherwise, click **Cancel**. If you clicked Apply, the ports are configured.
6. Click **OK**.

To configure iSCSI ports

1. In the System topic, select **Action > Set Up Host Ports**. The Host Ports Settings panel opens.
2. Set the port-specific options:
   - 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 2: 10.10.10.100
     - Controller A port 3: 10.11.10.120
     - Controller B port 2: 10.10.10.110
     - Controller B port 3: 10.11.10.130
   - Netmask. For IPv4, subnet mask for assigned port IP address.
   - Gateway. For IPv4, gateway IP address for assigned port IP address.
   - Default Router. For IPv6, default router for assigned port IP address.

3. In the Advanced Settings section of the panel, set the options that apply to all iSCSI ports:
   - Enable Authentication (CHAP). Enables or disables use of Challenge Handshake Authentication Protocol.

     NOTE: CHAP records for iSCSI login authentication must be defined if CHAP is enabled. To create CHAP records, see "Configuring CHAP" (page 69).

   - Link Speed.
     - auto—Auto-negotiates the proper speed.
     - 1 Gbit/s—Forces the speed to 1 Gbit/sec, overriding a downshift that can occur during auto-negotiation with 1-Gbit/sec HBAs. This setting does not apply to 10-Gbit/sec HBAs.
   - Enable Jumbo Frames. Enables or disables support for jumbo frames. Allowing for 100 bytes of overhead, a normal frame can contain a 1400-byte payload whereas a jumbo frame can contain a maximum 8900-byte payload for larger data transfers.

     NOTE: Use of jumbo frames can succeed only if jumbo-frame support is enabled on all network components in the data path.

   - iSCSI IP Version. Specifies whether IP values use Internet Protocol version 4 (IPv4) or version 6 (IPv6) format. IPv4 uses 32-bit addresses. IPv6 uses 128-bit addresses.
   - Enable iSNS. Enables or disables registration with a specified Internet Storage Name Service server, which provides name-to-IP-address mapping.
   - iSNS Address. Specifies the IP address of an iSNS server.
   - Alternate iSNS Address. Specifies the IP address of an alternate iSNS server, which can be on a different subnet.

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

4. Click **OK**.
5. Click **Apply**. Otherwise, click **Cancel**. If you clicked Apply, the ports are configured.
6. Click **OK**.

Rescanning disk channels

A rescan 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,

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 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.

To rescan disk channels

1. Verify that both controllers are operating normally.
2. Perform one of the following:
   - Point to the **System** tab and select **Rescan Disk Channels**.
   - In the System topic, select **Action > Rescan Disk Channels**.

     The Rescan Disk Channels panel opens.
3. Click **Rescan**.

Clearing disk metadata

You can clear metadata from a leftover disk to make it available for use.

△ **CAUTION:**

- Only use this command when all disk groups are online and leftover disks exist. Improper use of this command may result in data loss.
- Do not use this command when a disk group is offline and one or more leftover disks exist.
- If you are uncertain whether to use this command, 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 pool. The following situations cause a disk to become a *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 that is a member of a disk group in another system is moved into this system without the other members of its group.

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 spare is available, and the health of the disk group is Degraded or Critical, the disk group will use them to start reconstruction. When reconstruction is complete, you can clear the leftover disk's metadata. Clearing the metadata will 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.

This command clears metadata from leftover disks only. If you specify disks that are not leftovers, the disks are not changed.

To clear metadata from leftover disks

1. In the System topic, select **Action > Clear Metadata**. The Clear Metadata panel opens.
2. Select the leftover disks from which to clear metadata.
3. Click **OK**.
4. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the metadata is cleared.
5. Click **OK**.

Updating firmware

You can view the current versions of firmware in controller modules, expansion modules, and disk drives. You can also install new versions. For information about supported releases for firmware update, see the Release Notes for your product. For information about which controller module will update the other when a controller module is replaced, see "About firmware update" (page 29). For information about how to enable PFU, using the `set advanced-settings` CLI command, see the CLI Reference Guide.

To monitor the progress of a firmware-update operation by using the activity progress interface, see "Using the activity progress interface" (page 59).

Best practices for firmware update

- In the health panel in the footer, verify that the system health is OK. If the system health is not OK, view the Health Reason value in the health panel in the footer and resolve all problems before you update firmware. For information about the health panel, see "Viewing health information" (page 112).
- 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 need to 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.
- If a disk group is quarantined, resolve the problem that is causing the component 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 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.

Updating controller module firmware

In a dual-controller system, both controller modules should run the same firmware version. Storage systems that are used by 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 Lenovo web download site at support.lenovo.com.

To prepare to update controller module firmware

1. Follow the best practices in Best practices for firmware update (above).
2. Obtain the appropriate firmware file and download it to your computer or network.
3. If the storage system has a single controller, stop I/O to the storage system before you start the firmware update.

To update controller module firmware

1. Perform one of the following:
   - In the banner, click the system panel and select **Update Firmware**.
   - In the System topic, select **Action > Update Firmware**.

     The Update Firmware panel opens. The Update Controller Modules tab shows versions of firmware components that are currently installed in each controller.
2. Click **Browse** and select the firmware file to install.
3. Click **OK**. A panel shows firmware-update progress.

   The process starts by validating the firmware file:
   - If the file is invalid, verify that you specified the correct firmware file. If you did, try downloading it again from the source location.
   - If the file is valid, the process continues.

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.

Firmware update typically takes 10 minutes for a controller with current CPLD firmware, or 20 minutes for a controller with downlevel CPLD 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 each EMP in a drive 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. If this problem persists, contact technical support.

When firmware update on the local controller is complete, users are automatically signed out and the MC 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, allow 10–20 minutes for the partner controller to be updated.

4. Clear your web browser cache, then sign in to the SMC. If PFU is running on the controller you sign in to, a panel shows PFU progress and prevents you from performing other tasks until PFU is complete.

NOTE: If PFU is enabled for the system through the `partner-firmware-upgrade` parameter of the `set advanced-settings` CLI command, 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 can contain one or two expansion modules. Each expansion module contains an enclosure management processor (EMP). All modules of the same model should run the same firmware version.

When you update controller-module firmware, all expansion modules are automatically updated to a compatible firmware version.

If necessary, you can update the firmware in each expansion module by loading a firmware file available only from Lenovo at support.lenovo.com and following the steps below.

To prepare to update expansion module firmware

1. Follow the best practices in "Best practices for firmware update" (page 56).
2. Obtain the appropriate firmware file and download it to your computer or network.
3. If the storage system has a single controller, stop I/O to the storage system before starting the firmware update.

To update expansion module firmware

1. Perform one of the following:
   - In the banner, click the system panel and select **Update Firmware**.
   - In the System topic, select **Action > Update Firmware**.

   The Update Firmware panel opens.
2. Select the **Update Expansion Modules** tab. This tab shows information about each expansion module in the system.
3. Select the expansion modules to update.
4. Click **File** and select the firmware file to install.

5. Click **OK**. Messages show firmware update progress.

△ **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 3 minutes to update each EMP in an expansion enclosure. Wait for a message that the code load has completed.

6. Verify that each updated expansion module has the new firmware version.

Updating disk-drive firmware

You can update disk-drive firmware by loading a firmware file obtained from your reseller.

A dual-ported disk drive can be updated from either controller.

To prepare to update disk-drive firmware

1. Follow the best practices in "Best practices for firmware update" (page 56).
2. Obtain the appropriate firmware file and download it to your computer or network.
3. Read documentation from the disk-drive manufacturer to determine whether the disk drives must be power cycled after firmware update.
4. 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.

To update disk-drive firmware

1. Perform one of the following:
   - In the banner, click the system panel and select **Update Firmware**.
   - In the System topic, select **Action > Update Firmware**.

   The Update Firmware panel opens.
2. Select the **Update Disk Drives** tab. This tab shows information about each disk drive in the system.
3. Select the disk drives to update.
4. Click **File** and select the firmware file to install.
5. Click **OK**.

△ **CAUTION:** Do not power cycle enclosures or restart a controller during the firmware update. If the update is interrupted or there is a power failure, the disk drive might become inoperative. If this occurs, contact technical support.

It typically takes several minutes for the firmware to load. Wait for a message that the update has completed.

6. Verify that each disk drive has the new firmware revision.

Using the activity progress interface

The activity progress interface reports whether a firmware update or partner firmware update operation is active and shows the progress through each step of the operation. In addition, when the update operation completes, status is presented indicating either the successful completion, or an error indication if the operation failed.

To use the activity progress interface

1. Enable the Activity Progress Monitor service. See "Changing system services settings" (page 51).
2. In a new tab in your web browser, enter the URL for the form:

   `http://`*`controller-address`*`:8081/cgi-bin/content.cgi?mc=`*`MC-identifier`*`&refresh=true`

   where:

   - *`controller-address`* is required and specifies the IP address of a controller network port.
   - `mc=`*`MC-identifier`* is an optional parameter that specifies the controller for which to report progress/status:
     - `mc=A` shows output for controller A only.
     - `mc=B` shows output for controller B only.
     - `mc=both` shows output for both controllers.
     - `mc=self` shows output for the controller whose IP address is specified.
   - `refresh=true` is an optional parameter that causes automatic refresh of the displayed output every second. This will continue until either:
     - The parameter is removed.
     - The controller whose IP address is specified is restarted and communication is lost.

When activity is in progress, the interface will display an MC-specific Activity Progress table with the following properties and values.

Table 13 Activity progress properties and values

Property	Value
Time	The date and time of the latest status update.
Seconds	The number of seconds this component has been active.
Component	The name of the object being processed.
Status	The status of the component representing its progress/completion state. • ACTIVE: The operation for this component is currently active and in progress. • OK: The operation for this component completed successfully and is now inactive. • N/A: The operation for this component was not completed because it was not applicable. • ERROR: The operation for this component failed with an error (see code and message).
Code	A numeric code indicating the status. • `0`: The operation for this component completed with a "completed successfully" status. • `1`: The operation for this component was not attempted because it is not applicable (the component doesn't exist or doesn't need updating). • `2`: The operation is in progress. The other properties will indicate the progress item (message, current, total, percent). • `10` or higher: The operation for this component completed with a failure. The code and message indicate the reason for the error.
Message	A textual message indicating the progress status or error condition.

Changing FDE settings

In the Full Disk Encryption panel, you can change settings for these options:

- FDE general configuration
  - Set the passphrase
  - Clear lock keys
  - Secure the system
  - Repurpose the system
- Repurpose disks
- FDE import lock key IDs

Changing FDE general configuration

CAUTION: Do not change FDE configuration settings while running I/O. Temporary data unavailability may result. Also, the intended configuration change might not take effect.

Setting the passphrase

You can set the FDE passphrase the system uses to write to and read from FDE-capable disks. From the passphrase, the system generates the lock key ID that is used to secure the FDE-capable disks. If the passphrase for a system is different from the passphrase associated with a disk, the system cannot access data on the disks.

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

To set or change the passphrase

1. In the System topic, select **Action > Full Disk Encryption**.
   The Full Disk Encryption panel opens with the **FDE General Configuration** tab selected.
2. Enter a passphrase in the Passphrase field of the **Set/Create Passphrase** section. A passphrase is case sensitive and can include 8–32 printable UTF-8 characters except for the following: ", < > \
3. Re-enter the passphrase.
4. Click **Set**. A dialog box will confirm the passphrase was changed successfully.

Clearing lock keys

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 data on the disks. Use this procedure 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. The disks will still be in the secured, unlocked state. Once the system has been transported and powered back up, the system and disks will both be in the secured, locked state. Set the system's lock key to restore access to data.

To clear lock keys

NOTE: The FDE tabs are dynamic, and the **Clear All FDE Keys** option is not available until the current passphrase is entered in the Current Passphrase field. (If you do not have a passphrase, the **Clear All FDE Keys** option will not appear. If you have a passphrase but have not entered it, you can view but will be unable to access this option.) If there is no passphrase, set one using the procedure in "Setting the passphrase," above.

1. In the System topic, select **Action > Full Disk Encryption**.
   The Full Disk Encryption panel opens with the **FDE General Configuration** tab selected.
2. Enter the passphrase in the Current Passphrase field.
3. Click **Clear**. A dialog box displays.
4. Perform one of the following:
   - To clear the keys, click **Yes**.
   - To cancel the request, click **No**.

Securing the system

An FDE-capable system must be secured to enable FDE protection.

To secure the system

NOTE: The FDE tabs are dynamic, and the **Secure** option is not available until the current passphrase is entered in the Current Passphrase field. (If you do not have a passphrase, the Secure option will not appear. If you have a passphrase but have not entered it, you can view but will be unable to access this option.) If there is no passphrase, set one using the procedure in "Setting the passphrase" (page 60).

1. In the System topic, select **Action > Full Disk Encryption**.
   The Full Disk Encryption panel opens with the **FDE General Configuration** tab selected.
2. Enter the passphrase in the Current Passphrase field.
3. Click **Secure**. A dialog box displays.
4. Perform one of the following:
   - To secure the system, click **Yes**.
   - To cancel the request, click **No**.

Repurposing the system

You can repurpose a system to erase all data on the system and return its FDE state to unsecure.

△ **CAUTION:** Repurposing a system erases all disks in the system and restores the FDE state to unsecure.

To repurpose the system

NOTE: The FDE tabs are dynamic, and the **Repurpose System** option is not available until the system is secure and all disk groups have been removed from the system.

1. Delete all disk groups in the system. To delete disk groups, see "Removing disk groups" (page 75). Removing disk groups effectively deletes all data on the disks but does not secure erase them.
2. Click the System tab.
3. In the System topic, select **Action > Full Disk Encryption**.
   The Full Disk Encryption panel opens with the **FDE General Configuration** tab selected.
4. Click **Repurpose**. A dialog box displays.

5. Perform one of the following:
   - To repurpose the system, click **Yes**.
   - To cancel the request, click **No**.

Repurposing disks

You can 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.

△ **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.

To repurpose a disk

1. In the System topic, select **Action > Full Disk Encryption**.
   The Full Disk Encryption panel opens with the **FDE General Configuration** tab selected.
2. Select **Repurpose Disks** tab.
3. Select the disk to repurpose.
4. Click **Repurpose**. A dialog box displays.
5. Perform one of the following:
   - To repurpose the selected disk, click **Yes**.
   - To cancel the request, click **No**.

Setting FDE import lock key IDs

You can set the passphrase associated with an import lock key to unlock FDE-secured disks that are inserted into the system from a different secure system. If the correct passphrase is not entered, the system cannot access data on the disk.

After importing disks into the system, the disks will now be associated with the system lock key ID and data will no longer be accessible using the import lock key. This effectively transfers security to the local system passphrase.

To set or change the import passphrase

1. In the System topic, select **Action > Full Disk Encryption**.
   The Full Disk Encryption panel opens with the **FDE General Configuration** tab selected.
2. Select the **Set Import Lock Key ID** tab.
3. In the Passphrase field, enter the passphrase associated with the displayed lock key.
4. Re-enter the passphrase.
5. Click **Set**. A dialog box will confirm the passphrase was changed successfully.

Restarting or shutting down controllers

Each controller module contains a Management Controller processor and a Storage Controller processor. When necessary, you can restart or shut down these processors for one controller or both controllers.

Restarting controllers

Perform a restart when the SMC informs you that you have changed a configuration setting that requires a restart or when the controller is not working properly.

When you restart a Management Controller, communication with it is lost until it successfully restarts. If the restart fails, the Management Controller in the partner controller module remains active with full ownership of operations and configuration information.

When you restart a Storage Controller, it attempts to shut down with a proper failover sequence. This sequence includes stopping all I/O operations and flushing the write cache to disk. At the end, the controller restarts. Restarting a Storage Controller restarts the corresponding Management Controller.

△ **CAUTION:** If you restart both controller modules, all users will lose access to the system and its data until the restart is complete.

NOTE: When a Storage Controller is restarted, current performance statistics that it recorded are reset to zero, but historical performance statistics are not affected. In a dual-controller system, disk statistics may be reduced but are not reset to zero, because disk statistics are shared between the two controllers. For more information, see "Viewing performance statistics" (page 106).

To perform a restart

1. Perform one of the following:
   - In the banner, click the system panel and select **Restart System**.
   - In the System topic, select **Action > Restart System**.

     The Controller Restart and Shut Down panel opens.
2. Select the **Restart** operation.
3. Select the controller type to restart: **Management** or **Storage**.
4. Select the controller module to restart: **Controller A**, **Controller B**, or both.
5. Click **OK**. A confirmation panel appears.
6. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, a message describes restart activity.

Shutting down controllers

Perform a shut down before you remove a controller module from an enclosure, or before you power off its enclosure for maintenance, repair, or a move. Shutting down the Storage Controller in a controller module ensures that a proper failover sequence is used, which includes stopping all I/O operations and writing any data in write cache to disk. If you shut down the Storage Controller in both controller modules, hosts cannot access system data.

△ **CAUTION:** You can continue to use the CLI when either or both Storage Controllers are shut down, but information shown might be invalid.

To perform a shut down

1. Perform one of the following:
   - In the banner, click the system panel and select **Restart System**.
   - In the System topic, select **Action > Restart System**.

   The Controller Restart and Shut Down panel opens.
2. Select the **Shut Down** operation, which automatically selects the Storage controller type.
3. Select the controller module to shut down: **Controller A**, **Controller B**, or both.
4. Click **OK**. A confirmation panel appears.
5. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, a message describes shutdown activity.

4 Working in the Hosts topic

Viewing hosts

The Hosts topic shows a tabular view of information about initiators, hosts, and host groups that are defined in the system. For information about using tables, see "Tips for using help" (page 13). For more information about hosts, see "About initiators, hosts, and host groups" (page 25). The Hosts topic also enables users to map initiators (see page 102) and view map details (see page 105).

Hosts table

The hosts table shows the following information. By default, the table shows 10 entries at a time.

- Group. Shows the group name if the initiator is grouped into a host group; otherwise, `-ungrouped-`.
- Host. Shows the host name if the initiator is grouped into a host; otherwise, `-nohost-`.
- Nickname. Shows the nickname assigned to the initiator.
- ID. Shows the initiator ID, which is the WWN of an FC or SAS initiator or the IQN of an iSCSI initiator.
- Profile. Shows profile settings:
  - `Standard`. Default profile.
  - `HP-UX`. The host uses Flat Space Addressing.
- Discovered. Shows `Yes` for a discovered initiator, or `No` for a manually created initiator.
- Mapped. Shows `Yes` for an initiator that is mapped to volumes, or `No` for an initiator that is not mapped.

Related Maps table

For selected initiators, the Related Maps table shows the following information. By default, the table shows 20 entries at a time.

- Group.Host.Nickname. Identifies the initiators to which the mapping applies:
  - *initiator-name*—The mapping applies to this initiator only.
  - *initiator-ID*—The mapping applies to this initiator only, and the initiator has no nickname.
  - *host-name.**—The mapping applies to all initiators in this host.
  - *host-group-name.*.**—The mapping applies to all hosts in this group.
- Volume. Identifies the volumes to which the mapping applies:
  - *volume-name*—The mapping applies to this volume only.
  - *volume-group-name.**—The mapping applies to all volumes in this volume group.
- Access. Shows the type of access assigned to the mapping:
  - `read-write`—The mapping permits read and write access.
  - `read-only`—The mapping permits read access.
  - `no-access`—The mapping prevents access.
- LUN. Shows whether the mapping uses a single LUN or a range of LUNs (indicated by *).
- Ports. Lists the controller host ports to which the mapping applies. Each number represents corresponding ports on both controllers.

To display more information about a mapping, see "Viewing map details" (page 105).

Creating an initiator

You can manually create initiators. For example, you might want to define an initiator before a controller port is physically connected through a switch to a host.

To create an initiator

1. Determine the FC or SAS WWN or iSCSI IQN to use for the initiator.
2. In the Hosts topic, select **Action > Create Initiator**. The Create Initiator panel opens.
3. In the Initiator ID field, enter the WWN or IQN. A WWN value can include a colon between each pair of digits but the colons will be discarded.
4. In the Initiator Name field, enter a nickname that helps you easily identify the initiator. For example, you could use `MailServer_FCp1`. An initiator name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , . < \

   If the name is used by another initiator, you are prompted to enter a different name.
5. In the Profile list, select the appropriate option:
   - **Standard**. Default profile.
   - **HP-UX**. The host uses Flat Space Addressing.
6. Click **OK**. The initiator is created and the hosts table is updated.

Modifying an initiator

You can modify the nickname of any initiator.

To modify an initiator

1. In the Hosts topic, select one initiator to modify.
2. Select **Action > Modify Initiator**. The Modify Initiator panel opens.
3. In the Initiator Name field, enter a new nickname to help you identify the initiator. For example, you could use `MailServer_FCp2`. An initiator name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , . < \

   If the name is used by another initiator, you are prompted to enter a different name.
4. In the Profile list, select the appropriate option:
   - **Standard**. Default profile.
   - **HP-UX**. The host uses Flat Space Addressing.
5. Click **OK**. The hosts table is updated.

Deleting initiators

You can delete manually created initiators that are not grouped or are not mapped. You cannot delete manually created initiators that are mapped. You also cannot delete a discovered initiator but you can remove its nickname through the delete operation.

To delete initiators

1. In the Hosts topic, select 1–1024 ungrouped, undiscovered initiators to delete.
2. Select **Action > Delete Initiators**. The Delete Initiators panel opens and lists the initiators to be deleted.
3. Click **OK**. The initiators are deleted and the hosts table is updated.

Adding initiators to a host

You can add existing named initiators to an existing host or to a new host.

To add an initiator to a host, the initiator must have the same mappings as all other initiators in the host. This means that the initiator must be mapped with the same access, port, and LUN settings to the same volumes or volume groups.

To add initiators to a host

1. In the Hosts topic, select 1–128 named initiators to add to a host.
2. Select **Action > Add to Host**. The Add to Host panel opens.
3. Perform one of the following:
   - To use an existing host, select its name in the Host Select list.
   - To create a host, enter a name for the host in the Host Select field. An host name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , . < \
4. Click **OK**. For the selected initiators, the Host value changes from `-nohost-` to the specified host name.

Removing initiators from hosts

You can remove all except the last initiator from a host. Removing an initiator from a host will ungroup the initiator but will not delete it. To remove all initiators, remove the host.

To remove initiators from hosts:

1. In the Hosts topic, select 1–1024 initiators to remove from their hosts.
2. Select **Action > Remove from Host**. The Remove from Host panel opens and lists the initiators to be removed.
3. Click **OK**. For the selected initiators, the Host value changes to `-nohost-`.

Removing hosts

You can remove hosts that are not grouped. Removing a host will ungroup its initiators but will not delete them.

To remove hosts

1. In the Hosts topic, select 1–512 ungrouped hosts to remove.
2. Select **Action > Remove Host**. The Remove Host panel opens and lists the hosts to be removed.
3. Click **OK**. For initiators that were in the selected hosts, the Host value changes to `-nohost-`.

Renaming a host

You can rename a host.

To rename a host

1. In the Hosts topic, select an initiator that belongs to the host that you want to rename.
2. Select **Action > Rename Host**. The Rename Host panel opens.
3. In the New Host Name field, enter a new name for the host. A host name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , . < \
   If the name is used by another host, you are prompted to enter a different name.
4. Click **OK**. The hosts table is updated.

Adding hosts to a host group

You can add existing hosts to an existing host group or new host group.

To add a host to a host group, the host must have the same mappings as all other members of the group. This means that the host must be mapped with the same access, port, and LUN settings to the same volumes or volume groups.

To add hosts to a host group

1. In the Hosts topic, select 1–256 initiators that belong to a host that you want to add to a host group.
2. Select **Action > Add to Host Group**. The Add to Host Group panel opens.
3. Perform one of the following:
   - To use an existing host group, select its name in the Host Group Select list.
   - To create a host group, enter a name for the host group in the Host Group Select field. A host group name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , . < \
4. Click **OK**. For the selected hosts, the Group value changes from `-ungrouped-` to the specified host group name.

Removing hosts from a host group

You can remove all except the last host from a host group. Removing a host from a host group will ungroup the host but will not delete it. To delete a host group, see "Removing host groups" (page 68).

To remove hosts from a host group

1. In the Hosts topic, select 1–256 hosts to remove from their host group.
2. Select **Action > Remove from Host Group**. The Remove from Host Group panel opens and lists the hosts to be removed.
3. Click **OK**. For the selected hosts, the Group value changes to `-ungrouped-`.

Renaming a host group

You can rename a host group.

To rename a host group

1. In the Hosts topic, select a host group to rename.
2. Select **Action > Rename Host Group**. The Rename Host Group panel opens.
3. In the New Host Group Name field, enter a new name for the host group. A host group name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , . < \
   If the name is used by another host group, you are prompted to enter a different name.
4. Click **OK**. The hosts table is updated.

Removing host groups

You can remove host groups. Removing a host group will ungroup its hosts but will not delete them.

To remove host groups

1. In the Hosts topic, select 1–32 host groups to remove.
2. Select **Action > Remove Host Group**. The Remove Host Group panel opens and lists the host groups to be removed.
3. Click **OK**. For hosts that were in the selected host groups, the Group value changes to `-ungrouped-`.

Configuring CHAP

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 identification, 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.

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 for all iSCSI nodes, see "Changing host-interface settings" (page 53).

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. As the originator, with a valid CHAP record it can authenticate CHAP even if CHAP is disabled. This is possible because the system will supply the CHAP secret requested by its peer and the connection will be allowed. For information about setting up CHAP for use in a peer connection, see "Creating a peer connection" (page 95).

To add or modify a CHAP record

1. If you intend to use mutual CHAP and need to determine the IQN of a controller iSCSI port, perform the following:
   - Select the System topic.
   - Select the Rear view.
   - Hover the cursor over the iSCSI host port that you intend to use. In the Port Information panel that appears, note the IQN in the ID field value.
2. In the Hosts topic, select **Action > Configure CHAP**. The Configure CHAP panel opens with existing CHAP records listed.
3. Perform one of the following:
   - To modify an existing record, select it. The record values appear in the fields below the CHAP records list for editing. You cannot edit the IQN.
   - To add a new record, click **New**.
4. For a new record, in the Node Name (IQN) field, enter the IQN of the initiator. The value is case sensitive and can include a maximum of 223 bytes, including 0–9, lowercase a–z, hyphen, colon, and period.
5. In the Secret field, enter a secret for the target to use to authenticate the initiator. The secret is case sensitive and can include 12–16 bytes. The value can include spaces and printable UTF-8 characters except for the following: " <
6. To use mutual CHAP:
   - Select the **Mutual CHAP** check box.
   - In the Mutual CHAP Name field, enter the IQN obtained in step 1. The value is case sensitive and can include a maximum of 223 bytes and the following: 0–9, lowercase a–z, hyphen, colon, and period.
   - In the Mutual CHAP Secret field, enter a secret for the initiator to use to authenticate the target. The secret is case sensitive, can include 12–16 bytes, and must differ from the initiator secret. The value can include spaces and printable UTF-8 characters except for the following: " <
     A storage system secret is shared by both controllers.
7. Click **Apply** or **OK**. The CHAP records table is updated.

To delete a CHAP record

△ **CAUTION:** Deleting CHAP records may make volumes inaccessible and the data in those volumes unavailable.

1. In the Hosts topic, select **Action > Configure CHAP.** The Configure CHAP panel opens with existing CHAP records listed.
2. Select the record to delete.
3. Click **Delete**. A confirmation panel appears.
4. Click **Remove** to continue. Otherwise, click **Cancel**. If you clicked Remove, the CHAP record is deleted.

5 Working in the Pools topic

Viewing pools

The Pools topic shows a tabular view of information about the pools and disk groups that are defined in this system. It shows information about pools and disk groups. There is another type of disk group, the read-cache disk group, which is also related to virtual storage. Read-cache disk groups consist of SSDs. If your system does not use SSDs, you will not be able to create read-cache disk groups.

It also shows information for the disks that each disk group contains. For information about using tables, see "Tips for using tables" (page 13). For more information about pools, see "About pools" (page 19). For more information about disk groups, see "About disk groups" (page 17).

Pools table

The pools table shows the following information. The system is limited to two pools, which are named A and B.

- Name. Shows the name of the pool.
- Health. Shows the health of the pool: OK, Degraded, Fault, N/A, or Unknown.
- Total Size. Shows the storage capacity defined for the pool when it was created.
- Avail. Shows the storage capacity presently available for the pool.
- Volumes. Shows the number of volumes defined for the disk groups of the pool.
- Disk Groups. Shows the number of disk groups that the pool has.

To see more information about a pool, hover the cursor over the pool in the table. The **Pool Information** panel that appears contains the following information:

Pool Information	Name, serial number, size, available, overcommit, pool overcommitted, low threshold, mid threshold, high threshold, allocated pages, snapshot pages, available pages, sector format, health.

For more information about and to manage the above overcommit, low threshold, mid threshold, and high threshold settings, see "Changing pool settings" (page 76).

Related Disk Groups table

When you select a pool in the pools table, the disk groups for it appear in the Related Disk Groups table.

For selected pools, the Related Disk Groups table shows the following information.

- Name. Shows the name of the disk group.
- Health. Shows the health of the disk group: OK, Degraded, Fault, N/A, or Unknown.
- Pool. Shows the name of the pool to which the disk group belongs.
- RAID. Shows the RAID level for the disk group.
- Disk Type. Shows the disk type. For virtual disk groups, the disk group's tier appears in parentheses after its disk type. For read-cache disk groups, `Read Cache` appears in parentheses after the disk type.
- Size. Shows the storage capacity defined for the disk group when it was created.
- Free. Shows the available storage capacity for the disk group.
- Current Job. Shows the following current system operations for the disk group, if any are occurring:
  - `DRSC`: Disks in the disk group are being scrubbed.
  - `INIT`: The disk group is being initialized.
  - `RCON`: The disk group is being reconstructed.
  - `VDRAIN`: The disk group is being removed and its data is being drained to another disk group.
  - `VPREP`: The disk group is being prepared for use in a pool.
  - `VRECV`: The disk group is being recovered to restore its membership in the pool.
  - `VREMV`: The disk group and its data are being removed.

    - VRFY: The disk group is being verified.
    - VRSC: The disk group is being scrubbed.
- Status. Shows the status for the disk group:
    - CRIT: Critical. The disk group is online but isn't fault tolerant because some of its disks are down.
    - DMGD: Damaged. The disk group is online and fault tolerant, but some of its disks are damaged.
    - FTDN: Fault tolerant with a down disk. The disk group is online and fault tolerant, but some of its disks are down.
    - FTOL: Fault tolerant and online. The disk group is online and fault tolerant.
    - MSNG: Missing. The disk group is online and fault tolerant, but some of its disks are missing.
    - OFFL: Offline. Either the disk group is using offline initialization, or its disks are down and data may be lost.
    - QTCR: Quarantined critical. The disk group is critical with at least one inaccessible disk. For example, two disks are inaccessible in a RAID-6 disk group or one disk is inaccessible for other fault-tolerant RAID levels. If the inaccessible disks come online or if after 60 seconds from being quarantined the disk group is QTCR or QTDN, the disk group is automatically dequarantined.
    - QTDN: Quarantined with a down disk. For example, the RAID-6 disk group has one inaccessible disk. The disk group is fault tolerant but degraded. If the inaccessible disks come online or if after 60 seconds from being quarantined the disk group is QTCR or QTDN, the disk group is automatically dequarantined.
    - QTOF: Quarantined offline. The disk group is offline with multiple inaccessible disks causing user data to be incomplete.
    - STOP: The disk group is stopped.
    - UNKN: Unknown.
    - UP: Up. The disk group is online and does not have fault-tolerant attributes.
- Disks. Shows the number of disks in the disk group.

To see more information about a disk group, select the pool for the disk group in the pools table, then hover the cursor over the disk group in the Related Disk Groups table:

Disk Group Information	Virtual: Name, serial number, pool, tier, % of pool, allocated pages, available pages, sector format, health. Read cache: Name, serial number, pool, tier, allocated pages, available pages, sector format, health.

Related Disks table

When you select a disk group in the Related Disk Groups table, the disks for it appear in the Related Disks table.

- Location. Shows the location of the disk.
- Health. Shows the health of the disk: OK, Degraded, Fault, N/A, or Unknown.
- Description. Shows the disk type:
    - SAS: Enterprise SAS.
    - SAS MDL: Midline SAS.
    - sSAS: SAS SSD.
- Size. Shows the storage capacity of the disk.
- Usage. Shows how the disk is being used:
    - VIRTUAL POOL: The disk is part of a pool.
    - LEFTOVR: The disk is leftover.
    - FAILED: The disk is unusable and must be replaced. Reasons for this status include: excessive media errors, SMART error, disk hardware failure, or unsupported disk.
- Disk Group. Shows the disk group that contains the disk.
- Status. Shows the status of the disk:
    - Up: The disk is present and is properly communicating with the expander.
    - Spun Down: The disk is present and has been spun down by the DSD feature.

- Warning: The disk is present but the system is having communication problems with the disk LED processor. For disk and midplane types where this processor also controls power to the disk, power-on failure will result in Error status.
- Unrecoverable: The disk is present but has unrecoverable errors.

To see more information about a disk in a disk group, select the pool for the disk group in the pools table, select the disk group in the Related Disk Groups table, and then hover the cursor over the disk in the Related Disks table:

Disk Information	Location, serial number, usage, type, size, status, revolutions per minute (spinning disk only), SSD life left, manufacturer, model, firmware revision, power on hours, FDE state, FDE lock key, job running, sector format, health.

NOTE: Following is more information for selected Disk Information panel items:

- *Power On Hours* refers to the total number of hours that the disk has been powered on since it was manufactured. This value is updated in 30-minute increments.
- *FDE State* refers to the FDE state of the disk. For more information about FDE states, see the CLI Reference Guide.
- *FDE lock keys* are generated from the FDE 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 data on the disks.

Adding a disk group

You can create virtual disk groups using specified disks through the Add Disk Group panel. You can also create read-cache disk groups through this panel. When creating a disk group, you explicitly select the RAID type and individual disks and incorporate them into a pool. You cannot create virtual disk groups that contain SSDs without the Performance tier license. All disks in a disk group must be the same type (enterprise SAS, for example). 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). For more information about disk groups, see “About disk groups” (page 17).

Add Disk Group panel overview

There are three sections that comprise the Add Disk Group panel. The top section provides options for the disk group, such as the type, name, and RAID level of the disk group. The options that appear vary depending on the type of disk group selected.

The middle section contains the disk selection sets summary, which presents cumulative data for the disks selected for the disk group. The amount of disk space (total, available, and overhead) appears, as do the RAID and disk types that have been selected for the disk group.

The summary also contains the Disks bar, which shows the number of disks selected, and the **Complete** check box. The Disks bar appears for disks intended for use in a RAID configuration or in a read-cache disk group. The **Complete** check box indicates if the minimum number of disks needed for the configuration have been selected. It automatically changes from ☒ to ☑ when the minimum has been selected. The options that appear in the middle section vary depending on the type of disk group selected.

In the bottom section are one or more disk tables depending on the number of enclosures that your system has. Each table represents an enclosure and all of its disks. Open check boxes appear on available disks. To see more information about an enclosure or disks, such as the disk type, capacity, and sector format, hover the cursor over an enclosure ear or disk. The Enclosure Information or Disk Information panel appears. “Viewing pools” (page 71) contains more details about the Disk Information panel.

If installed disks are part of a virtual disk group or are global spares, unique color codes identify them as such. For information on the specific colors used, see “Color codes” (page 14).

Using SSDs in a disk group

For the best performance for virtual disk groups with SSDs, use at least a minimum of four SSDs with one mirrored pair of drives (RAID 1) per controller. RAID 5 and RAID 6 are also preferable for SSDs. However, they require more drives if you are following the best practice of having one disk group owned by each controller. In this configuration, six SSDs for RAID 5 and eight SSDs for RAID 6 are required. For data integrity, use a fault-tolerant RAID level for a disk group of SSDs.

For more information on SSDs, see "About SSDs" (page 20).

Virtual disk groups

The system supports a maximum of two pools, one per controller module: A and B. You can add up to 16 virtual disk groups for each pool. If a virtual pool does not exist, the system will automatically add it when creating the disk group. Once a virtual pool and disk group exist, volumes can be added to the pool. Once you add a virtual disk group, you cannot modify it. If your organization's needs change, you can modify your storage amount by adding new virtual disk groups or deleting existing ones.

Depending on the type of disks selected and license installed, virtual disk groups belong to one of the following tiers:

- Enterprise SAS disks: Standard tier.
- Midline SAS disks: Archive tier.
- SAS SSD disks: Requires the Performance tier license to be used in virtual disk groups, which automatically use the Performance tier for SSDs. Does not require the license to be used in read-cache disk groups, which do not use tiers.

TIP: All virtual groups in the same tier within a pool should have the same RAID level. This will provide consistent performance across the tier.

NOTE: If a virtual pool contains a single virtual disk group, and it has been quarantined, you cannot add a new virtual disk group to the pool until you have dequarantined the existing disk group. For information on quarantining and dequaranting disk groups, see the CLI documentation.

Read-cache disk groups

If your system has SSDs, you can also add read-cache disk groups. Read cache is a special type of virtual disk group that can be added to a virtual pool. It is used for the purpose of caching virtual pages for improving read performance. A virtual pool can contain only one read-cache disk group. A virtual pool cannot contain both read cache and a Performance tier. At least one virtual disk group must exist before a read-cache disk group can be added. NRAID is automatically used for a read-cache disk group with a single disk. RAID 0 is automatically used for a read-cache disk group with the maximum of two disks. When you create a read-cache disk group, the system automatically creates a read-cache tier, if one does not already exist. Unlike the other tiers, it is not used in tiered migration of data.

Disk group options

The following options appear in the top section of the Add Disk Group panel:

- Type. When creating a disk group, select **Virtual** to show options for a virtual disk group or **Read Cache** to show options for a read cache disk group.
- Name. A disk group name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \
- RAID Level. Select one of the following RAID levels when creating a virtual disk group:
  - **RAID 1**. Requires 2 disks.
  - **RAID 5**. Requires 3-16 disks.
  - **RAID 6**. Requires 4-16 disks.
  - **RAID 10**. Requires 4-16 disks, with a minimum of two RAID-1 subgroups, each having two disks.

- Pool. Select the name of the pool (A or B) to contain the group.
- Number of Sub-groups (options only appear when RAID-10 is selected). Changes the number of sub-groups that the disk group should contain.

To add a disk group

1. In the Pools topic, select **Action > Add Disk Group**.
   The Add Disk Group panel opens.
2. Set the options.
3. Select the disks.
4. Click **Add**.
   If your disk group contains a mix of 512n and 512e disks, a dialog box displays. Perform one of the following:
   - To create the disk group, click **Yes**.
   - To cancel the request, click **No**.

   If the task succeeds, the new disk group appears in the Related Disk Groups table in the Pools topic when you select the pool for it in the pools table.

Modifying disk groups

You can rename virtual and read-cache disk groups.

To modify a disk group

1. In the Pools topic, select the linear pool for the disk group that you are modifying in the pools table. Then, select the disk group in the Related Disk Groups table.

   NOTE: To see more information about a pool, hover the cursor over the pool in the table. "Viewing pools" (page 71) contains more details about the Pool Information panel that appears.

2. Select **Action > Modify Disk Group**. The Modify Disk Group panel opens.
3. To change the disk group name, replace the existing name in the New Name field. A disk group name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \
4. Click **Modify**.
5. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the disk group modification has started.
6. To close the confirmation panel, click **OK**.

Removing disk groups

You can remove disk groups. It is possible to delete a single disk group or select multiple disk groups and delete them in a single operation. By removing disk groups, you can also remove pools.

If all disk groups for a pool have volumes assigned and are selected for removal, a confirmation panel will warn the user that the pool and all its volumes will be removed.

If a pool has more than one disk group and at least one volume that contains data, the system attempts to drain the disk group to be deleted by moving the volume data that it contains to other disk groups in the pool. When removing one or more, but not all, disk groups from a pool, the following possible results can occur:

- If the other disk groups do not have room for the data of the selected disk group, the delete operation will fail immediately and a message will be displayed.
- If there is room to drain the volume data to other disk groups, a message will appear that draining has commenced and an event will be generated upon completion (progress will also be shown in the Current Job column of the Related Disk Groups table).
  - When the disk group draining completes, an event will be generated, the disk group disappears, and the drives for it becomes available.

- If a host writes during the disk group draining, which results in there not being enough room to finish the draining, an event will be generated, the draining terminates, and the disk group will remain in the pool.

NOTE: If the disk group is the last disk group for a pool that is used in a peer connection or it contains a volume that is used in a replication set, the **Remove Disk Groups** menu option will be unavailable.

To remove a disk group

1. In the Pools topic, select the pool for the disk group(s) that you are deleting in the pools table. Then, select the disk group(s) in the Related Disk Groups table.

   NOTE: To see more information about a pool, hover the cursor over the pool in the table. "Viewing pools" (page 71) contains more details about the Pool Information panel that appears.

2. Select **Action > Remove Disk Groups**. The Remove Disk Groups panel opens.
3. Click **OK**.
4. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the disk group(s) and their volumes are deleted, the pool for the disk group(s) might be deleted, the disks for the disk group(s) become available, and the Related Disk Groups table is updated.

Creating a volume

You can add volumes to pools. The Create Virtual Volumes panel enables you to create volumes. You can access these panels from both the Pools and Volumes topics.

To create volumes through the Pools topic

1. In the Pools topic, select a pool in the pools table. Then, select a disk group in the Related Disk Groups table.

   NOTE: To see more information about a pool, hover the cursor over the pool in the table. "Viewing pools" (page 71) contains more details about the Pool Information panel that appears.

2. Select **Action > Create Virtual Volumes**. The Create Virtual Volumes panel opens.
3. For more information about creating volumes, see "The Schedules table shows the following schedule information. By default, the table shows 10 entries at a time." (page 80).

Changing pool settings

Each 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.

NOTE: If the pool size is 500 GB or smaller, and/or the middle threshold is relatively high, the high threshold may not guarantee 200 GB of reserved space in the pool. The controller will not automatically adjust the low and middle thresholds in such cases.

You can view and change settings that govern the operation of each pool:

- Low Threshold. When this percentage of pool capacity has been used, informational event 462 will be generated to notify the administrator. This value must be less than the Mid Threshold value. The default is 25%.
- Mid Threshold. When this percentage of pool capacity has been used, event 462 will be generated 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 50%. If the pool is not overcommitted, the event will have Informational severity. If the pool is overcommitted, the event will have Warning severity.

- High Threshold. When this percentage of pool capacity has been used, event 462 will be generated 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 event will have Informational severity. If the pool is overcommitted, the event will have Warning severity and the system will use write-through cache mode until pool usage drops back below this threshold.
- **Enable overcommitment of pool?**. This check box controls whether thin provisioning is enabled, and whether storage-pool capacity may exceed the physical capacity of disks in the system. For information about thin provisioning, see "About thin provisioning" (page 23).

NOTE: 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. 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.

To check if the pool is overcommitted, in the Pools topic, display the Pool Information panel by hovering the cursor over the pool in the pools table. In that panel, if the Pool Overcommitted value is `True`, the pool is overcommitted. If the value is `False`, the pool is not overcommitted.

To change pool settings

1. In the **Pools** topic, select a pool in the pools table.

   NOTE: To see more information about a pool, hover the cursor over the pool in the table. "Viewing pools" (page 71) contains more details about the Pool Information panel that appears.

   ---

2. Select **Action > Change Pool Settings**. The Pool Settings panel opens.
3. To change the low and mid thresholds for each pool, enter new values.
4. To enable thin provisioning, select the **Enable overcommitment of pool?** check box.
5. Click **OK**. The changes are saved.

6 Working in the Volumes topic

Viewing volumes

The Volumes topic shows a tabular view of information about volumes, replication sets, and snapshots that are defined in the system. For more information about volumes, see "About volumes and volume groups" (page 21). For more information about replication, see "Asynchronous replication of virtual volumes" (page 89). For more information about snapshots, see "About snapshots" (page 26). For information about using tables, see "Tips for using tables" (page 13).

Volumes table

To see more information about a volume or snapshot, hover the cursor over an item in the volumes table. The Volume Information panel opens with more detailed information about the item. The following table displays the categories of information while descriptions for selected terms follow.

Volume Information	Name, type, pool, group, class, size, allocated size, serial number, write policy, read-ahead size, health

For more information about write policy and read-ahead size, see "Modifying a volume" (page 81).

The volumes table shows the following information. By default, the table shows 10 entries at a time.

- Group. Shows the group name if the volume is grouped into a volume group; otherwise, `-ungrouped-`.
- Name. Shows the name of the volume.
- Pool. Shows whether the volume is in pool A or B.
- Type. Shows whether the volume is a base volume or a snapshot.
- Size. Shows the storage capacity defined for the volume when it was created (minus 60 KB for internal use).
- Allocated. Shows the storage capacity allocated to the volume for written data.

TIP: When selecting one or more volumes or snapshots in the volumes table, the Snapshots, Maps, Replication Sets, and Schedules tabs will be enabled if they have associated information for the selected items. They will be grey and disabled if they do not.

Snapshots table

To see more information about a snapshot and any child snapshots taken of it, select the snapshot or volume that is associated with it in the volumes table. If it is not already selected, select the **Snapshots** tab. The snapshots appear in the Snapshots table. Then, hover the cursor over the item in the Snapshots table:

Snapshot Information	Name, serial number, status, status reason, retention priority, snapshot data, unique data, shared data, pool, class, health

The Snapshots table shows the following snapshot information. By default, the table shows10 entries at a time.

- Name. Shows the name of the snapshot.
- Base Volume. Shows the name of the virtual volume from which the snapshot was created. All virtual volumes are base volumes when created and are volumes from which virtual snapshots can be created.
- Parent Volume. Shows the name of the volume from which the snapshot was created.
- Creation Date/Time. Shows the date and time when the snapshot was created.
- Status. Shows whether the snapshot is available or unavailable. A snapshot can be unavailable for one of the following reasons:
  - The source volume is not accessible or is not found.
  - The snapshot is pending.
  - A rollback with modified data is in progress.

- Snap Data. Shows the total amount of data associated with the specific snapshot (data copied from a source volume to a snapshot and data written directly to a snapshot).
- Type. Shows the following snapshot type:
  - Standard snapshot. Snapshot of a standard volume.

Maps table

To see information about the maps for a snapshot or volume, select the snapshot or volume in the volumes table. Then, select the **Map** tab. The maps appear in the **Maps** table.

The Maps table shows the following information. By default, the table shows 10 entries at a time.

- Group.Host.Nickname. Identifies the initiators to which the mapping applies:
  - *initiator-name*. The mapping applies to this initiator only.
  - *initiator-ID*. The mapping applies to this initiator only, and the initiator has no nickname.
  - *host-name.**. The mapping applies to all initiators in this host.
  - *host-group-name.*.**. The mapping applies to all hosts in this group.
- Volume. Identifies the volumes to which the mapping applies:
  - *volume-name*. The mapping applies to this volume only.
  - *volume-group-name.**. The mapping applies to all volumes in this volume group.
- Access. Shows the type of access assigned to the mapping:
  - read-write. The mapping permits read and write access.
  - read-only. The mapping permits read access.
  - no-access. The mapping prevents access.
- LUN. Shows the LUN number or `'*'` if the map is to a volume group.
- Ports. Lists the controller host ports to which the mapping applies. Each number represents corresponding ports on both controllers.

To display more information about a mapping, see "Viewing map details" (page 105).

Replication Sets table

To see information about the replication set for a volume or volume group, select a volume in the volumes table. If it is not already selected, select the Replication Sets tab. The replication appears in the Replication Sets table.

The Replication Sets table shows the following information. By default, the table shows 10 entries at a time.

- Name. Shows the replication set name.
- Primary Volume. Shows the primary volume name. For replication sets that use volume groups, the primary volume name is `volume-group-name.*` where `.*` signifies that the replication set contains more than one volume. If the volume is on the local system, the icon appears.
- Secondary Volume. Shows the secondary volume name. For replication sets that use volume groups, the secondary volume name is `volume-group-name.*` where `.*` signifies that the replication set contains more than one volume. If the volume is on the local system, the icon appears.
- Status. Shows the status of the replication set:
  - `Not Ready`. The replication set is not ready for replications because the system is still preparing the replication set.
  - `Unsynchronized`. The primary and secondary volumes are unsynchronized because the system has prepared the replication set, but the initial replication has not run.
  - `Running`. A replication is in progress.
  - `Ready`. The replication set is ready for a replication.
  - `Suspended`. Replications have been suspended.
  - `Unknown`: This system cannot communicate with the primary system and thus cannot be sure of the current state of the replication set. Check the state of the primary system.
- Last Successful Run. Shows the date and time of the last successful replication.
- Estimated Completion. Shows the estimated date and time for the replication in progress to complete.

Schedules table

For information about the schedules for a snapshot, select the snapshot in the volumes table. For information about the schedules for copy operations for a volume, select the volume in the volumes table. For information about the schedules for a replication set, select a volume for the replication set in the volumes table. If it is not already selected, select the **Schedules** tab. The schedules appear in the Schedules table. Then, hover the cursor over the item in the Schedules table.

Schedule Information	Name, schedule specification, schedule status, next time, task name, task type, task status, task state, error message

The Schedules table shows the following schedule information. By default, the table shows 10 entries at a time.

- Schedule Name. Shows the name of the schedule.
- Schedule Specification. Shows the schedule settings for running the associated task.
- Status. Shows the status for the schedule:
  - `Uninitialized`. The schedule is not yet ready to run.
  - `Ready`. The schedule is ready to run at the next scheduled time.
  - `Suspended`. The schedule had an error and is holding in its current state.
  - `Expired`. The schedule exceeded a constraint and will not run again.
  - `Invalid`. The schedule is invalid.
  - `Deleted`. The schedule has been deleted
- Task Type. Shows the type of schedule:
  - `TakeSnapshot`. The schedule creates a snapshot of a source volume.
  - `ResetSnapshot`. The schedule deletes the data in the snapshot and resets it to the current data in the volume from which the snapshot was created. The snapshot's name and other volume characteristics are not changed.
  - `VolumeCopy`. The schedule copies a source volume to a new volume. It creates the destination volume you specify, which must be in a disk group owned by the same controller as the source volume. The source volume can be a base volume or a snapshot.
  - `Replicate`. The schedule replicates a virtual replication set to a remote system.

Creating a volume

You can add volumes to a pool. You can create an individual volume, multiple volumes with different settings, or multiple copies of a volume with the same settings. In the latter case, the copies will have the same base name with a numeric suffix (starting at 0000) to make each name unique. You can also select a volume tier affinity setting to specify a tier for the volume data.

The Create Virtual Volumes panel contains a graphical representation of storage capacity for pools A and B. Each graph provides the number of existing volumes, free space, allocated and unallocated space, and committed and overcommitted space for pool A or B. The graph for the specified pool of the prospective new volume also shows the impact of storage space and the prospective new volume on the pool.

The volumes table in the Volumes topic lists all volumes, volume groups, and snapshots. To see more information about a volume, hover the cursor over the volume in the table. "Viewing volumes" (page 78) contains more details about the Volume Information panel that appears.

To create volumes

1. Perform one of the following:
   - In the Pools topic, select a pool in the pools table and select **Action > Create Volumes**.
   - In the Volumes topic, select **Action > Create Virtual Volumes**.

   The Create Virtual Volumes panel opens and shows the current capacity usage of each pool.

   NOTE: If a pool does not exist, the option to create volumes will be unavailable.

2. Optional: Change the volume name. The default is `Voln`, where *n* starts at 0001 and increments by one for each volume that has a default name. A volume name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \

   If the name is used by another volume, the name is automatically changed to be unique. For example, `MyVolume` would change to `MyVolume0001`, or `Volume2` would change to `Volume3`.
3. Optional: Change the volume size, including unit of measurement. You can use any of the following units: MiB, GiB, TiB, MB, GB, TB. The default size is 100 GB. For the maximum volume size that the system supports, see the system configuration limits topic in the Storage Management Console online help.

   Volume sizes are aligned to 4-MB boundaries. When a volume is created or expanded, if the resulting size would be less than 4 MB, it will be increased to 4 MB. If the resulting size would be greater than 4 MB, it will be decreased to the nearest 4-MB boundary.
4. Optional: Change the number of volumes to create. The default is 1. See the system configuration limits topic in Storage Management Console online help for the maximum number of volumes supported per pool.
5. Optional: Specify a volume tier affinity setting to automatically associate the volume data with a specific tier, moving all volume data to that tier whenever possible. For more information on the volume tier affinity feature, see "About automated tiered storage" (page 24).
6. Optional: Select the pool in which to create the volume. The system load-balances volumes between the pools so the default may be A or B, whichever contains fewer volumes.
7. Optional: To create another volume with different settings, click **Add Row** and then change the settings. To remove the row that the cursor is in, click **Remove Row**.
8. Click **OK**.

   If creating the volume will overcommit the pool capacity, the system will prompt you to configure event notification to be warned before the pool runs out of physical storage.
9. If the volume exceeds the capacity:
   a. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the volumes are created and the volumes table is updated.
   b. To close the confirmation panel, click **OK**.

Modifying a volume

You can change the name and cache settings for a volume. You can also expand a volume. If a virtual volume is not a secondary volume involved in replication, you can expand the size of the volume but not make it smaller. Because volume expansion does not require I/O to be stopped, the volume can continue to be used during expansion.

The volume cache settings consist of the write policy, cache optimization mode, and read-ahead size.

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

To see more information about a volume, hover the cursor over the volume in the table. "Viewing volumes" (page 78) contains more details about the Volume Information panel that appears.

To modify a volume

1. In the Volumes topic, select a volume in the volumes table.
2. Select **Action > Modify Volume**. The Modify Volume panel opens.
3. Optional: In the New Name field, enter a new name for the volume. A volume name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \
4. Optional: In the Expand By field, enter the size by which to expand the volume. If overcommitting the physical capacity of the system is not allowed, the value cannot exceed the amount of free space in the storage pool. You can use any of the following units: MiB, GiB, TiB, MB, GB, TB.

   Volume sizes are aligned to 4-MB boundaries. When a volume is created or expanded, if the resulting size would be less than 4 MB, it will be increased to 4 MB. If the resulting size would be greater than 4 MB, it will be decreased to the nearest 4-MB boundary.
5. Optional: In the Write Policy list, select **Write-back** or **Write-through**.

6. Optional: In the Write Optimization list, select **Standard** or **No-mirror**.
7. Optional: In the Read Ahead Size list, select **Adaptive**, **Disabled**, **Stripe**, or a specific size (512 KB; 1, 2, 4, 8, 16, or 32 MB).
8. Optional: In the Tier Affinity field, select **No Affinity**, **Archive**, or **Performance**. The default is **No Affinity**.
9. Click **OK**.

   If a change to the volume size will overcommit the pool capacity, the system will prompt you to configure event notification to be warned before the pool runs out of physical storage.
10. If the volume exceeds the capacity:
    a. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the volumes table is updated.
    b. To close the confirmation panel, click **OK**.

Adding volumes to a volume group

You can add volumes to a new or existing volume group.

To add a volume to a volume group, the volume must have the same mappings as all other members of the group. This means that the volume must be mapped with the same access, port, and LUN settings to the same initiators, hosts, or host groups.

If the volume group is part of a replication set, you cannot add or remove volumes to or from it.

To add volumes to a volume group

1. In the Volumes topic, select 1–20 volumes to add to a volume group.
2. Select **Action > Add to Volume Group**. The Add to Volume Group panel opens.
3. Perform one of the following:
   - To use an existing volume group, select its name in the Volume Groups list.
   - To create a volume group, enter a name for the volume group in the Volume Groups field. A volume group name is case sensitive and can have a maximum of 32 bytes. It cannot include the following: " , < \
4. Click **OK**. For the selected volumes, the Volume Groups value changes from `-ungrouped-` to the specified host group name.

Removing volumes from a volume group

You can remove volumes from a volume group. You cannot remove all volumes from a group. At least one volume must remain. Removing a volume from a volume group will ungroup the volumes but will not delete them. To remove all volumes from a volume group, see “Removing volume groups” (page 83).

To see more information about a volume, hover the cursor over the volume in the table. “Viewing volumes” (page 78) contains more details about the Volume Information panel that appears.

To remove volumes from a volume group

1. In the Volumes topic, select the volumes to remove from a volume group.
2. Select **Action > Remove from Volume Group**. The Remove from Volume Group panel opens and lists the volumes to be removed.
3. Click **OK**. For the selected volumes, the Group value changes to `-ungrouped-`.

Renaming a volume group

You can rename a volume group unless it is part of a replication set. Renaming a volume group will delete the volume group and then create one with the new name.

To see more information about a volume, hover the cursor over the volume in the table. "Viewing volumes" (page 78) contains more details about the Volume Information panel that appears, including how to view volumes and volume groups which are part of a replications set.

To rename a volume group

1. In the Volumes topic, select a volume that belongs to the volume group that you want to rename.
2. Select **Action > Rename Volume Group**. The Rename Volume Group panel opens.
3. In the New Group Name field, enter a new name for the volume group. A volume group name is case sensitive and can have a maximum of 32 bytes. It cannot include the following: " , < \
   If the name is used by another volume group, you are prompted to enter a different name.
4. Click **OK**. The volumes table is updated.

Removing volume groups

You can remove volume groups. When you remove a volume group, you can optionally delete its volumes. Otherwise, removing a volume group will ungroup its volumes but will not delete them.

△ **CAUTION:** Deleting a volume removes its mappings and deletes its data.

To see more information about a volume, hover the cursor over the volume in the table. "Viewing volumes" (page 78) contains more details about the Volume Information panel that appears.

To remove volume groups only

1. In the Volumes topic, select a volume that belongs to each volume group that you want to remove. You can remove 1–32 volume groups at a time.
2. Select **Action > Remove Volume Group**. The Remove Volume Group panel opens and lists the volume groups to be removed.
3. Click **OK**. For volumes that were in the selected volume groups, the Volume Groups value changes to `-ungrouped-`.

To remove volume groups and their volumes

1. Verify that hosts are not accessing the volumes that you want to delete.
2. In the **Volumes** topic, select a volume that belongs to each volume group that you want to remove. You can remove 1–32 volume groups at a time.
3. Select **Action > Remove Volume Group**. The Remove Volume Group panel opens and lists the volume groups to be removed.
4. Select the **Delete Volumes** check box.
5. Click **OK**. A confirmation panel appears.
6. Click Yes to continue. Otherwise, click **No**.
   If you clicked **Yes**, the volume groups and their volumes are deleted and the volumes table is updated.

Rolling back a volume

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

△ **CAUTION:** When you perform a rollback, the data that existed on the volume is replaced by the data on the snapshot. All data on the volume written since the snapshot was created is lost. As a precaution, create a snapshot of the volume before starting a rollback.

Only one rollback is allowed on the same volume at one time. Additional rollbacks are queued until the current rollback is complete. However, after the rollback is requested, the volume is available for use as if the rollback has already completed.

For volumes and snapshots, 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 the rollback. Since snapshots are copies of a point in time, they 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.

You cannot roll back a volume that is part of a replication set.

To see more information about a volume, hover the cursor over the volume in the table. "Viewing volumes" (page 78) contains more details about the Volume Information panel that appears.

To roll back a volume

1. Unmount the volume from hosts.
2. In the Volumes topic, select the volume to roll back.
3. Select **Action > Rollback Volume**. The Rollback Volume panel opens and lists snapshots of the volume.
4. Select the snapshot to roll back to.
5. Click **OK**. A confirmation panel appears.
6. Click **Yes** to continue. Otherwise, click **No**. The rollback starts. You can now remount the volume.

Deleting volumes and snapshots

You can delete volumes and snapshots. You can delete a volume that has no child snapshots. You cannot delete a virtual volume that is part of a replication set.

△ **CAUTION:** Deleting a volume or snapshot removes its mappings and schedules and deletes its data.

NOTE: You can only delete a volume with one or more snapshots, or a snapshot with child snapshots, by deleting all of the snapshots or child snapshots first.

To see more information about a volume or snapshot, hover the cursor over the item in the volumes table.

You can view additional snapshot information by hovering the cursor over the snapshot in the Related Snapshots table. "Viewing volumes" (page 78) contains more details about the Volume Information and Snapshot Information panels that appear.

To delete volumes and snapshots

1. Verify that hosts are not accessing the volumes and snapshots that you want to delete.
2. In the Volumes topic, select 1–100 items (volumes, snapshots, or both) to delete.
3. Select **Action > Delete Volumes**. The Delete Volumes panel opens with a list of the items to be deleted.
4. Click **Delete**. The items are deleted and the volumes table is updated.

Creating snapshots

You can create snapshots of selected volumes or snapshots. You can create more snapshots with an upgrade license. You can create snapshots immediately or schedule snapshot creation.

For Lenovo Storage S3200: A base of 128 snapshots is included with all systems without an additional license.

For Lenovo Storage S2200: A base of 64 snapshots is included with all systems without an additional license.

If the large pools feature is enabled, through use of the `large-pools` parameter of the `set advanced-settings` CLI command, the maximum number of volumes in a snapshot tree is limited to 9 (base volume plus 8 snapshots). The maximum number of volumes per snapshot will decrease to fewer than 9 if more than 3 replication sets are defined for volumes in the snapshot tree. If creating a snapshot will exceed that limit, you will be unable to create the snapshot unless you delete a snapshot first.

To see more information about a volume or snapshot, hover the cursor over the item in the volumes table.

You can view additional snapshot information by hovering the cursor over the snapshot in the Related Snapshots table. "Viewing volumes" (page 78) contains more details about the Volume Information and Snapshot Information panels that appear.

To create snapshots

1. In the Volumes topic, select from1 to 16 volumes or snapshots.

   NOTE: You can also select a combination of volumes and snapshots.

2. Select **Action > Create Snapshot**. The Create Snapshots panel opens.
3. Optional: In the Snapshot Name field, change the name for the snapshot. The default is *`volume-name_sn`*, where *`n`* starts at 0001. A snapshot name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \

   If the name is used by another snapshot, you are prompted to enter a different name.
4. Optional: If you want to schedule a create-snapshot task, perform the following:
   - Select the **Scheduled** check box.
   - Optional: Change the default prefix to identify snapshots created by this task. The default is *volume* **s** *n*, where *n* starts at 01. The prefix is case sensitive and can have a maximum of 26 bytes. It cannot already exist in the system or include the following: " , < \

     Scheduled snapshots are named *`prefix _S n`*, where *`n`* starts at 0001.
   - Optional: Select the number of snapshots to retain, from 1–32. The default is 1. When the task runs, the retention count is compared with the number of existing snapshots:
     - If the retention count has not been reached, the snapshot is created.
     - If the retention count has been reached, the oldest snapshot for the volume is unmapped, reset, and renamed to the next name in the sequence.
   - Specify a date and a time at least five minutes in the future to run the task. The date must use the format *yyyy-mm-dd*. The time must use the format *hh :mm* followed by either AM, PM, or 24H (24-hour clock). For example, 13:00 24H is the same as 1:00 PM.
   - Optional: If you want the task to run more than once, perform the following:
     - Select the **Repeat** check box and specify how often the task should run.
     - Optional: Specify when the task should stop running.
     - Optional: Specify a time range within which the task should run.
     - Optional: Specify days when the task should run. Ensure that this constraint includes the start date.
5. Click **OK**.
   - If **Scheduled** is not selected, the snapshot is created.
   - If **Scheduled** is selected, the schedule is created and can be viewed in the Manage Schedules panel. For information on modifying or deleting schedules through this panel, see "Managing scheduled tasks" (page 46)

Resetting a snapshot

As an alternative to taking a new snapshot of a volume, you can replace the data in a base snapshot with the current data in the source volume. The snapshot name and mappings are not changed. This action is not allowed for a replication snapshot.

This feature is supported for all snapshots in a tree hierarchy. However, a snapshot can only be reset to the parent volume or snapshot from which it was created.

△ **CAUTION:** To avoid data corruption, unmount a snapshot from hosts before resetting the snapshot.

You can reset a snapshot immediately.

To see more information about a snapshot, hover the cursor over the item in the volumes table. You can view different snapshot information by hovering the cursor over the snapshot in the Snapshots table. "Viewing volumes" (page 78) contains more details about the Volume Information and Snapshot Information panels that appear.

To reset a snapshot

1. Unmount the snapshot from hosts.
2. In the Volumes topic, select a snapshot.
3. Select **Action > Reset Snapshot**. The Reset Snapshot panel opens.
4. Optional: To schedule a reset task, perform the following:
   - Select the **Schedule** check box.
   - Specify a date and a time at least five minutes in the future to run the task. The date must use the format *yyyy-mm-dd*. The time must use the format *hh :mm* followed by either AM, PM, or 24H (24-hour clock). For example, 13:00 24H is the same as 1:00 PM.
   - Optional: If you want the task to run more than once:
     - Select the **Repeat** check box and specify how often the task should run.
     - Optional: Specify when the task should stop running.
     - Optional: Specify a time range within which the task should run.
     - Optional: Specify days when the task should run. Ensure that this constraint includes the start date.
5. Click **OK**. A confirmation panel appears.
6. Click **Yes** to continue. Otherwise, click **No**.

   If you clicked Yes:
   - If the **Schedule** check box was not selected, the snapshot is created. You can remount the snapshot.
   - If **Schedule** is selected, the schedule is created and can be viewed in the Manage Schedules panel. Make a reminder to unmount the snapshot before the scheduled task runs.

Creating a replication set from the Volumes topic

You can create a replication set, which specifies the components of a replication. The Create Replication Set panel enables you to create replication sets. You can access this panel from both the Replications and Volumes topics.

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

A peer connection must be defined to create and use a replication set. 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 volume group is part of a replication set, volumes cannot be added to or deleted from the volume group.

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 or volume groups.

Primary volumes and volume groups

The volume, volume group, or snapshot that will be replicated is called the primary volume or volume group. It can belong to only one replication set. If the volume group is already in a replication set, individual volumes may not be included in separate replication sets. Conversely, if a volume that is a member of a volume group is already in a replication set, its volume group cannot be included in a separate replication set.

The maximum number of individual volumes and snapshots that can be replicated is 32 in total. If a volume group is being replicated, the maximum number of volumes that can exist in the group is 16.

Using a volume group for a replication set enables you to make sure that the contents of multiple volumes are synchronized at the same time. When a volume group is replicated, snapshots of all of the volumes are created simultaneously. In doing so, it functions as a consistency group, ensuring consistent copies of a group of volumes. The snapshots are then replicated as a group. Though the snapshots may differ in size, replication of the volume group is not complete until all of the snapshots are replicated.

Secondary volumes and volume groups

When the replication set is created—either through the CLI or the SMC—secondary volumes and volume groups are created automatically. Secondary volumes and volume groups cannot be mapped, moved, expanded, deleted, or participate in a rollback operation. Create a snapshot of the secondary volume or volume group and use the snapshot for mapping and accessing data.

To create a replication set

1. In the volumes table, select a volume or snapshot to use as the primary volume.
2. Select **Action > Create Replication Set**. The Create Replication Set panel displays.
3. If the selected volume is in a volume group, source options appear
   - To replicate the selected volume only, select **Single Volume**.
   - To replicate all volumes in the volume group, select **Volume Group**.
4. Enter a name for the replication set. The name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \
5. Optional: Select a peer system to use as the secondary system for the replication set.
6. Optional: Select a pool on the secondary system. By default, the pool that corresponds with the pool in which the primary volume resides is selected. The selected pool must exist on the remote system.
7. Optional: If **Single Volume** is selected, enter a name for the secondary volume. The default name is the name of the primary volume. The name is case sensitive and can have a maximum of 32 bytes. It cannot already exist on the secondary system or include the following: " , < \
8. Optional: Select the **Scheduled** check box to schedule recurring replications.
9. Click **OK**.
10. In the success dialog box, click **OK**.
    - If you selected the **Scheduled** check box, click **OK**. The Schedule Replications panel opens and you can set the options to create a schedule for replications. For more information on scheduling replications, see “Scheduling replications” (page 100).
    - Otherwise, you have the option to perform the first replication. Click **Yes** to begin the first replication, or click **No** to initiate the first replication later.

Initiating replication from the Volumes topic

After you have created a replication set, you can copy the selected volume or volume group on the primary system to the secondary system by initiating replication. The first time that you initiate replication, a full copy of the allocated pages for the volume or volume group 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 or create a scheduled task to initiate it automatically. You can initiate replications from a replication set's primary system only. For information on scheduling replications, see "Scheduling replications" (page 100).

You can initiate a replication from both the Replications and Volumes topics. For information on how to initiate a replication, see "Initiating replication" (page 99).

If a replication fails, 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.

7 Working with Asynchronous Replication

Asynchronous replication of virtual volumes

Asynchronous replication for virtual storage is a licensed feature that provides a remote copy of a volume, volume group, or snapshot (thereafter known as *volume*) 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 using all pages of data from the source.) This feature can be used for disaster recovery, to preserve data, and back data up to off-site locations. It can also be used to distribute data.

Replication prerequisites

To replicate a volume, you must first create a peer connection and replication set. A peer connection establishes bi-directional communication between a local and remote system, both of which must have iSCSI ports, a virtual pool, and a replication license for virtual storage. 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 port address is available before creating a peer connection, use the `query port-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 documentation. For more information on peer connections, see "Creating a peer connection" (page 95), "Deleting a peer connection" (page 97), and "Modifying a peer connection" (page 97).

After you create a peer connection, you can create a replication set. A replication set specifies a volume, snapshot, or multiple volumes in a volume group (hereafter known as *volume*) 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, a corresponding volume is 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 two internal snapshots for each volume, which are created on both the primary and secondary systems. These snapshots are used internally for replication operations.

Using a volume group for a replication set enables you to make sure that multiple volumes are synchronized at the same time. When a volume group is replicated, snapshots of all of the volumes are created simultaneously. In doing so, it functions as a consistency group, ensuring consistent copies of a group of volumes. The snapshots are then replicated as a group. Even though the snapshots may differ in size, replication is not complete until all of the snapshots are replicated.

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 (write permission is unavailable), rolled back, or modified except through replication. To prevent problems with host systems, which do not handle well volumes whose contents change automatically, the secondary volume also cannot be mapped with read permission.

While you cannot modify the secondary volume, you can create a snapshot of the secondary volume that you can map, 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. These snapshots also can be used in disaster recovery. For more information on replication sets, see "Creating a replication set from the Replications topic" (page 97), "Modifying a replication set" (page 98), and "Deleting a replication set" (page 99).

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.

Subsequent replications are completed by resetting one of the hidden snapshots to contain the contents last replicated and then resetting the other hidden snapshot to the current primary volume contents and comparing the changes. The system writes any changes it finds on the hidden primary snapshot to the hidden secondary snapshot, after which the secondary volume is updated to contain the contents of the secondary volume.

The progress and status of both the initial and subsequent replications is 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" (page 101), "Initiating replication" (page 99), "Resuming a replication" (page 101), and "Suspending a replication" (page 101).

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, see "Scheduling replications" (page 100).

Initial replication

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

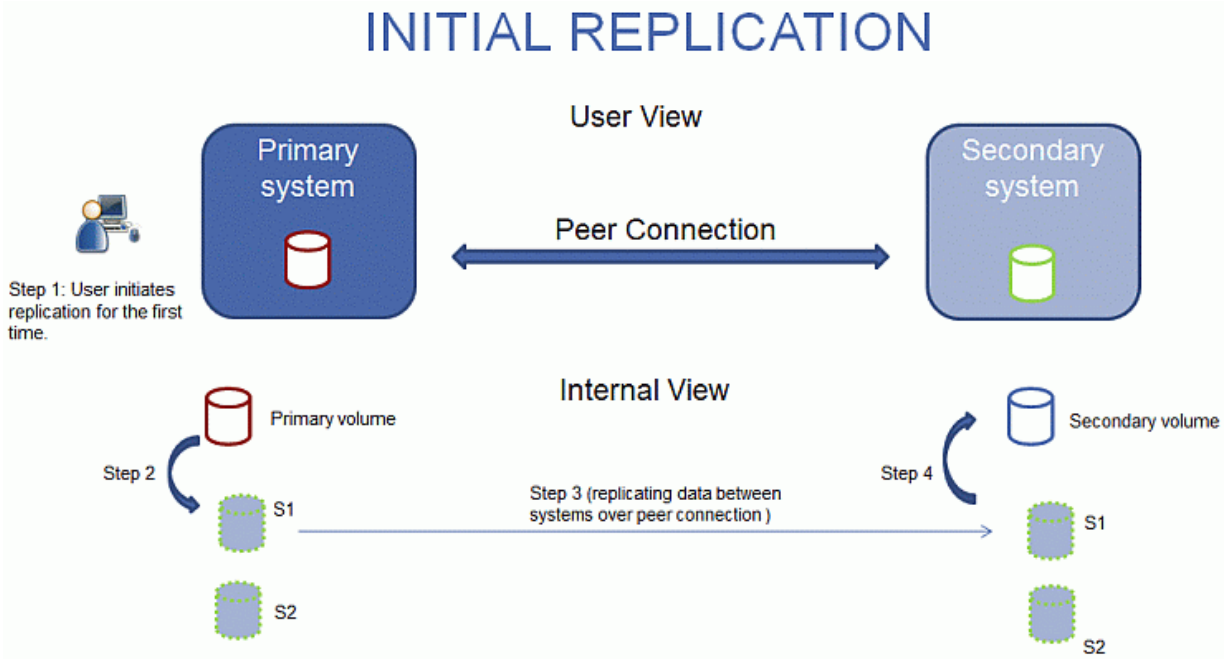

Figure 1 Replication process for initial replication

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 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 initiates replication on the primary system (step 1). The current primary volume contents, which might be different than when the replication set was created, replace the contents of S1 on the primary system (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 take place in replications subsequent to the initial replication of a single volume.

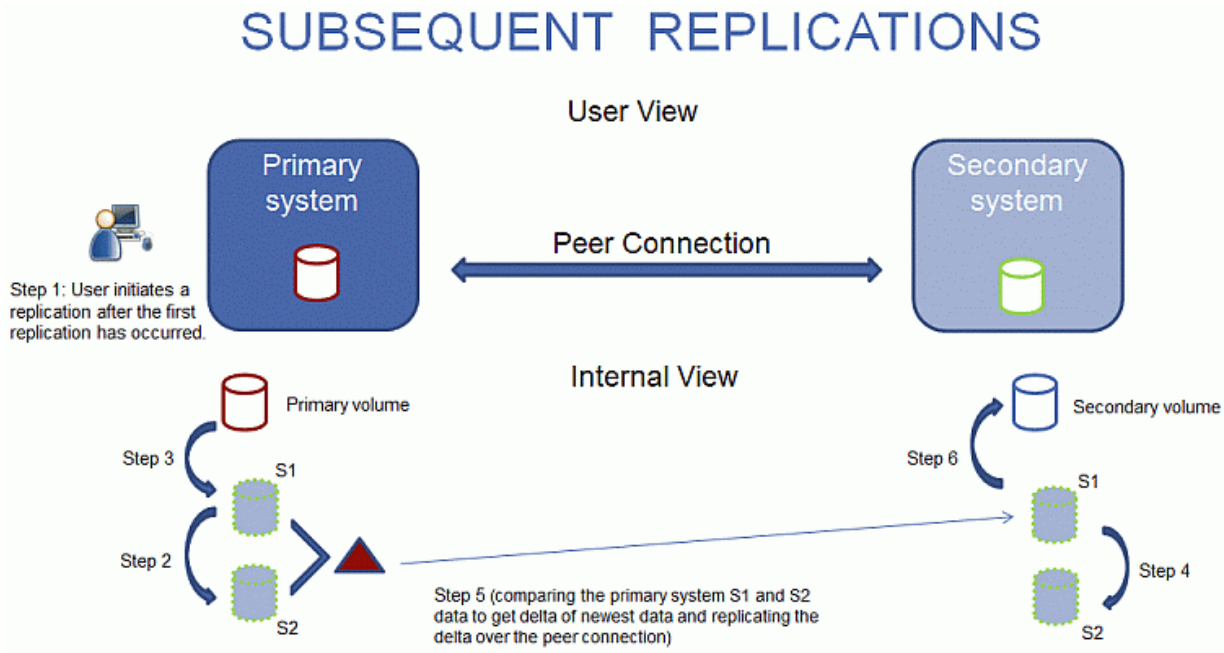

Figure 2 Replication process for replications subsequent to the initial replication.

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 initiates replication on the primary system (step 1). On the primary system, the S1 contents replace the S2 contents (step 2). (The S2 contents can then be used for comparison during step 5.) The current primary volume contents replace the contents of S1 on the primary system (step 3). On the secondary system, the S1 contents replace the S2 contents (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 do not count against the maximum number of licensed snapshots for the system.

Creating a virtual pool for replication

When you create a virtual pool, specify that it has enough space for three 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). 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

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. The policy will either notify you via the event log that the percentage has been reached (in which case the system continues to take snapshots, using the general pool space), or notify you and trigger automatic deletion of snapshots. If automatic deletion is triggered, snapshots are deleted according to their configured retention priority.

When you create virtual volumes through the `create volume` and `create volume-set` CLI commands, you can set the retention priority for snapshots of the volume. If automatic deletion of snapshots is enabled, the system uses the retention priority of snapshots to determine which, if any, snapshots to delete. Snapshots are considered to be eligible for deletion if they have any retention priority other than `never-delete`. Snapshots are configured to be eligible for deletion by priority and age. The oldest, lowest priority snapshots are deleted first. Internal replication snapshots and snapshots that are mapped or are not leaves of a volume's snapshot tree are ineligible for deletion. For more information on the `create volume` and `create volume-set` CLI commands, see the CLI documentation.

If you are using the replication feature and snapshot space management, there are specific 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 snapshot space to accommodate the maximum anticipated size of the two internal snapshots, which cannot be deleted, and any other snapshots that you would like to retain.
- 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 documentation.
- You can later create more snapshot space by adding disks to the pool to increase its size.

If the internal snapshots are larger than anticipated and take up a lot of snapshot space, you can adjust the snapshot space thresholds or increase the snapshot space to prevent unintentional automatic deletion of snapshots that you want to retain. 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 documentation.

Replication and empty allocated pages

Deleting data from a volume can result in deallocation of pages on that volume. 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.

Disaster recovery

The replication feature supports manual disaster recovery only. It is not integrated with third-party disaster recovery software. Since replication sets of virtual volumes cannot reverse the direction of the replication, carefully consider how the replicated data will be accessed at the secondary backup site when a disaster occurs.

NOTE: Using a volume group in a replication set ensures consistent simultaneous copies of the volumes in the volume group. This means that the state of all replicated volumes can be known when a disaster occurs since the volumes are synchronized to the same point in time.

Accessing the data while keeping the replication set intact

If you want to continue replicating changed data from the primary data center system, you will need to keep the replication set intact. While the data center system is down, you can access the data at the secondary backup system by creating a snapshot of the secondary volume. The snapshot can be mapped either read-only or read-write (but you cannot replicate the changes written to it back to the data center system using the existing replication set).

NOTE: If a system goes down but recovers, the data, peer connection, and replication sets should be intact and replication can resume normally.

To temporarily access data at the backup site

1. Create a snapshot of the secondary volume.
2. Map the snapshot to hosts.
3. When the data center system has recovered, delete the snapshot.

Accessing the data from the backup system as if it were the primary system

If you do not think the data center system can be recovered in time or at all, then you will want to temporarily access the data from the backup system as if it were the primary system. You can again create a snapshot of the secondary volume and map that to hosts, or delete the replication set to allow mapping the secondary volume directly to hosts. Deleting the replication set means the secondary volume becomes a base volume and is no longer the target of a replication. Should the primary volume become available and you want to use it as is in preparation for another disaster, a new replication set with a new secondary volume must be created. Deleting the replication set also enables cleaning up any leftover artifacts of the replication set.

In an emergency situation where no connection is available to the peer system and you do not expect to be able to reconnect the primary and secondary systems, use the `local-only` parameter of the `delete replication-set` and `delete peer-connection` CLI commands on both systems to delete the replication set and peer connection. Do not use this parameter in normal operating conditions. For more information, see the CLI documentation. Other methods for deleting replication sets and peer connections will most likely be ineffective in this situation.

NOTE: While deleting the peer connection for the replication set is unnecessary for making the secondary volume mappable, if you think that it will no longer be operable in the future, delete it when deleting the replication set.

Disaster recovery procedures

In a disaster recovery situation, you might typically:

1. Transfer operations from the data center system to the backup system (failover).
2. Restore operations to the data center system when it becomes available (failback).
3. Prepare the secondary system for disaster recovery.

To transfer operations from the data center system to the backup system

1. Create a snapshot of the secondary volume, or delete the replication set.
2. Map the snapshot or the secondary volume, depending on the option that you choose in step 1, to hosts.

To restore operations to the data center system

1. If the old primary volume still exists on the data center system, delete it. The volume cannot be used as the target (a new “secondary” volume will be created) and deleting it will free up available space.
2. Create a peer connection between the backup system and the data center system, if necessary.
3. Create a replication set using the backup system’s volume as the primary volume and the data center system as the secondary system.
4. Replicate the volume from the backup system to the data center system.

To prepare the backup system for disaster recovery after the replication is complete

1. Delete the replication set.
2. Delete the volume on the backup system. The volume cannot be used as the target of a replication and deleting it will free up space.
3. Create a replication set using the data center system's volume as the primary volume and the backup system as the secondary system.
4. Replicate the volume from the data center system to the backup system.

Replication licensing

For information about viewing the status of licensed features in your system, see "Installing a license" (page 46).

Viewing replications

The Replications topic shows a tabular view of information about peer connections and replication sets that are defined in the system. For information about using tables, see "Tips for using tables" (page 13). For more information about replication, see "Asynchronous replication of virtual volumes" (page 89).

Peer Connections table

The Peer Connections table shows the following information. By default, the table shows 10 entries at a time.

- Name. Shows the specified peer connection name.
- Status. Shows the status of the peer connection:
  - `Online`: The systems have a valid connection.
  - `Offline`: No connection is available to the remote system.
- Health. Shows the health of the component: OK, Fault, or Unknown.
- Type. Shows the type of ports being used for the peer connection: iSCSI.
- Local Ports. Shows the IDs of ports in the local system.
- Remote Ports. Shows the IDs of ports in the remote system.

To see more information about a peer connection, hover the cursor over the peer connection in the table. The Peer Connections panel that appears contains the following information. If the health is not OK, the health reason and recommended action are shown to help you resolve problems.

Peer Connections	Name, serial number, connection type, connection status, local host port name and IP address, remote host port name and IP address, health

Replication Sets table

The Replication Sets table shows the following information. By default, the table shows 10 entries at a time.

- Name. Shows the replication set name.
- Primary Volume. Shows the primary volume name. For replication sets that use volume groups, the primary volume name is volume-group-name.* where .* signifies that the replication set contains more than one volume. If the volume is on the local system, the icon appears.
- Secondary Volume. Shows the secondary volume name. For replication sets that use volume groups, the secondary volume name is volume-group-name.* where .* signifies that the replication set contains more than one volume. If the volume is on the local system, the icon appears.
- Status. Shows the status of the replication set.
  - `Not Ready`: The replication set is not ready for replications because the system is still preparing the replication set.
  - `Unsynchronized`: The primary and secondary volumes are unsynchronized because the system has prepared the replication set, but the initial replication has not run.
  - `Running`: A replication is in progress.
  - `Ready`: The replication set is ready for a replication.

- `Suspended`: Replications have been suspended.
- `Unknown`: This system cannot communicate with the primary system and thus cannot be sure of the current state of the replication set. Check the state of the primary system.

- Last Successful Run. Shows the date and time of the last successful replication.
- Estimated Completion Time—Shows the estimated date and time for the replication in progress to complete.

To see more information about a replication set, hover the cursor over a replication set in the Replication Sets table. The Replication Sets panel that appears contains the following information.

Replication Sets	Replication set name and serial number; primary volume or volume group name and serial number; secondary volume or volume group name and serial number; peer connection name; replication schedule name, current run progress, current run start time, current run estimated time to completion, current run transferred data, last success time, last run start time, last run end time, last run transferred data, last run status, and last run error status

Creating a peer connection

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 an IP address of a single available iSCSI host port on the remote system. Only iSCSI host ports are used for the peer connection. FC or SAS ports are not used for 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 virtual replication.
- Both systems must have iSCSI ports.
- Each system must have a virtual pool.
- Neither system can have a linear replication set.
- If iSCSI CHAP is configured for the peer connection, the authentication must be valid.

The limit is one peer connection per storage system.

While creating the peer connection, the local system receives information about all host ports and IPs on the remote system as well as the remote system's licensing and host port health. (Both systems must be licensed to use the replication feature for virtual storage.) It also links host ports of the select host port type on the local system to those 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 the bi-directional communication path between the systems when exchanging information and transferring replicated data. Once you create a peer connection, you can use it when creating any replication set. Because the peer connection is bi-directional, replication sets can be created from both systems with replication occurring from either direction.

NOTE: You can use the `query peer-connection` CLI command to determine if the remote system is compatible with your system. This command provides information about the remote system, such as ports, licensing, and pools. You can run it before creating the peer connection to determine if either system needs to be reconfigured first. You can also run it to diagnose problems if creating a peer connection fails.

To create a peer connection

1. In the Replications topic, select **Action > Create Peer Connection**. The Create Peer Connection panel opens.
2. Enter a name for the peer connection. The name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \
3. Enter the destination address (IP) for the remote system.
4. Click **OK**.
5. If the task succeeds, click **OK** in the confirmation dialog. The peer connection is created and the Peer Connections table is updated.
6. If the task does not succeed, the Create Peer Connection panel displays with errors in red text. Correct the errors, then click **OK**

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. Peer connections support one-way CHAP only.

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, 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 (see below procedure).

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 enabled on neither system, 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 procedure below to set up 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 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.

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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.

Modifying a peer connection

You can change the name of a current peer connection or the port address of the remote system without changing the peer connection configurations.

You can only modify a peer connection if there are no replications currently running or suspended from a running state. Abort all running replications and replications suspended from a running state before modifying a peer connection. Also, before modifying your peer connection, suspend your replication set to prevent any scheduled replications from running during the operation. After you have modified the peer connection, you can resume the replication set.

To modify a peer connection

1. In the Replications topic, select the peer connection to be modified in the Peer Connections table.
2. Select **Action > Modify Peer Connection**. The Modify Peer Connection panel displays.
3. Enter a new name for the peer connection or a new address (IP) for the remote system. (You cannot change both.) The name is case sensitive and can have a maximum of 80 bytes. It cannot already exist in the system or include the following: " , < \
4. Click **OK**. The peer connection is modified and the Peer Connections table is updated.

Deleting a peer connection

You can 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" (page 99).

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.

To delete a peer connection

1. In the Replications topic, select the peer connection to be deleted in the Peer Connections table.
2. Select **Action > Delete Peer Connection**.
3. Click **OK**. The peer connection is deleted and the Peer Connections table is updated.

Creating a replication set from the Replications topic

You can create a replication set, which specifies the components of a replication. The Create Replication Set panel enables you to create replication sets. You can access this panel from both the Replications and Volumes topics.

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

A peer connection must be defined to create and use a replication set. 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 volume group is part of a replication set, volumes cannot be added to or deleted from the volume group.

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 or volume groups.

Primary volumes and volume groups

The volume, volume group, or snapshot that will be replicated is called the primary volume or volume group. It can belong to only one replication set. If the volume group is already in a replication set, individual volumes may not be included in separate replication sets. Conversely, if a volume that is a member of a volume group is already in a replication set, its volume group cannot be included in a separate replication set.

The maximum number of individual volumes and snapshots that can be replicated is 32 in total. If a volume group is being replicated, the maximum number of volumes that can exist in the group is 16.

Using a volume group for a replication set enables you to make sure that the contents of multiple volumes are synchronized at the same time. When a volume group is replicated, snapshots of all of the volumes are created simultaneously. In doing so, it functions as a consistency group, ensuring consistent copies of a group of volumes. The snapshots are then replicated as a group. Though the snapshots may differ in size, replication of the volume group is not complete until all of the snapshots are replicated.

Secondary volumes and volume groups

When the replication set is created—either through the CLI or the SMC—secondary volumes and volume groups are created automatically. Secondary volumes and volume groups cannot be mapped, moved, expanded, deleted, or participate in a rollback operation. Create a snapshot of the secondary volume or volume group and use the snapshot for mapping and accessing data.

To create a replication set

1. In the Peer Connections table, select the peer connection to use for the replication set.
2. Select **Action > Create Replication Set**. The Create Replication Set panel displays.
3. Enter a name for the replication set. The name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \
4. Select whether you want to use a single volume or a volume group, which will filter the entries in the adjacent table.
5. In the table, select the volume or volume group to replicate. This will be the primary volume or volume group.
6. Optional: If **Single Volume** is selected, enter a name for the secondary volume. The default name is the name of the primary volume. The name is case sensitive and can have a maximum of 32 bytes. It cannot already exist on the secondary system or include the following: " , < \
7. Optional: Select a pool on the secondary system. By default, the pool that corresponds with the pool in which the primary volume resides is selected. The selected pool must exist on the remote system.
8. Optional: Select the **Scheduled** check box to schedule recurring replications.
9. Click **OK**.
10. In the success dialog box:
    - If you selected the **Scheduled** check box, click **OK**. The Schedule Replications panel opens and you can set the options to create a schedule for replications. For more information on scheduling replications, see "Scheduling replications" (page 100).
    - Otherwise, you have the option to perform the first replication. Click **Yes** to begin the first replication, or click **No** to initiate the first replication later.

Modifying a replication set

You can change the name of a replication set. Volume membership of a replication cannot change for the life of the replication set.

To modify a replication set

1. In the Replications topic, select the replication set in the Replications Sets table that you want to modify.
2. Select **Action > Modify Replication Set**.
3. Enter a new name for the replication set. The name is case sensitive and can have a maximum of 32 bytes. It cannot already exist in the system or include the following: " , < \
4. Click **OK**. The name of the replication set is deleted and the Replications Sets table is updated.

Deleting a replication set

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

If you want to delete a replication set that has a replication in progress, you must first suspend and then abort replication for that replication set. For more information, see "Aborting a replication" (page 101) or "Suspending a replication" (page 101).

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.

To delete a replication set

1. In the Replications topic, select the replication set to be deleted in the Replication Sets table.
2. Select **Action > Delete Replication Set**.
3. Click **OK**. The replication set is deleted and the Replication Sets table is updated.

Initiating replication

After you have created a replication set, you can copy the selected volume or volume group on the primary system to the secondary system by initiating replication. The first time that you initiate replication, a full copy of the allocated pages for the volume or volume group 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 or create a scheduled task to initiate it automatically. You can initiate replications from a replication set's primary system only. For information on scheduling replications, see "Scheduling replications" (page 100).

You can initiate a replication from both the Replications and Volumes topics.

If a replication fails, 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.
- The replication will not use another available port until all currently used ports become unavailable.

To manually initiate replication

1. In the either the Replications or Volumes topic, select a replication set in the Replication Sets table.
2. Select **Action > Initiate Replication**.
3. Click **OK**. The local system begins replicating the contents of the replication set volume to the remote system and the status of the replication set changes to `Running`.

Scheduling replications

After you have created a replication set, you can schedule replication. You can schedule replications from a replication set's primary system only. For more information on replications, see "Initiating replication" (page 99).

NOTE: Virtual storage replication tasks are not queued. If a replication task is running and the time comes for that replication task to start again, that task will be skipped, though it will be counted against the schedule's count constraint (if set). Instead of an open-ended schedule, you can specify the number of replications that can occur for the replication task as part of the procedure for scheduling a replication.

To schedule a replication

1. In the Replications topic, select a replication set in the Replication Sets table.
2. Select **Action > Schedule Replications**. The Schedule Replications panel opens.
3. Select the **Schedule** check box.
4. Specify a date and a time in the future to be the first instance when the scheduled task will run, and to be the starting point for any specified recurrence.
   - To set the **Date** value, enter the current date in the format *YYYY-MM-DD*.
   - To set the **Time** value, enter two-digit values for the hour and minutes and select either AM, PM, or 24H (24-hour clock).
5. Optional: If you want the task to run more than once, select the **Schedule** check box.
   - Specify how often the task should repeat. Enter a number and select the appropriate time unit. Replications can recur no less than 60 minutes apart.
   - Either make sure the **End** check box is cleared, which allows the schedule to run indefinitely, or select the check box to specify when the schedule ends. To then specify an end date and time, select the **On** option, and specify when the schedule should stop running. Or, select the **After** option, and specify the number of replications that can occur before the schedule stops running.
   - Either make sure the **Time Constraint** check box is cleared, which allows the schedule to run at any time, or select the check box to specify a time range within which the schedule should run.
   - Either make sure the **Date Constraint** check box is cleared, which allows the schedule to run on any day, or select the check box to specify the days when the schedule should run.
6. Click **OK**. The schedule is created.

To manage a replication schedule

1. In the Replications topic, select a replication set in the Replication Sets table.
2. Select **Action > Manage Schedules**.
3. Set the options:
   - Specify a date and a time in the future to be the first instance when the scheduled task will run, and to be the starting point for any specified recurrence.
   - To set the **Date** value, enter the current date in the format YYYY-MM-DD.
   - To set the **Time** value, enter two-digit values for the hour and minutes and select either AM, PM, or 24H (24-hour clock).
4. Optional: If you want the task to run more than once, select the **Repeat** check box.
   - Specify how often the task should repeat. Enter a number and select the appropriate time unit. Replications can recur no less than 60 minutes apart.
   - Either make sure the **End** check box is cleared, which allows the schedule to run without an end date, or select the check box and specify when the schedule should stop running.
   - Either make sure the **Time Constraint** check box is cleared, which allows the schedule to run at any time, or select the check box to specify a time range within which the schedule should run.
   - Either make sure the **Date Constraint** check box is cleared, which allows the schedule to run on any day, or select the check box to specify the days when the schedule should run.
5. Click **OK**. The schedule is modified.

Aborting a replication

You can abort running or suspended replication operations for a specified replication set only from its primary system. Aborting a replication for a replication set that is in a Ready or Unsynchronized state will generate an error.

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.

To abort a replication

1. In the Replications topic, select a replication set that is currently being replicated in the Replication Sets table.
2. Select **Action > Abort Replication**.
3. Click **OK**. The replication is aborted.

Suspending a replication

You can suspend replication operations for a specified replication set from its primary system. You can suspend replications from a replication set's primary system only.

When you suspend a replication set, all replications in progress are paused and no new replications are allowed to occur. You can abort suspended replications. After you suspend replication, you must resume it to allow the replication set to resume replications that were in progress and allow new replications to occur. For more information, see "Aborting a replication" (page 101) or "Resuming a replication" (page 101).

If replications are attempted during the suspended period (including scheduled replications), the replications will fail.

To suspend a replication

1. In the Replications topic, select a replication set that is currently being replicated in the Replication Sets table.
2. Select **Action > Suspend Replication**.
3. Click **OK**. The replications on the replication set are suspended and the status of the replication set changes to `Suspended`.

Resuming a replication

You can resume the replication operations of a specified suspended replication set. You can resume replications from a replication set's primary system only.

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. If you aborted a replication while the replication set was suspended, the aborted replication does not resume.

To resume a replication

1. In the Replications topic, select a replication set for which replications were suspended in the Replication Sets table.
2. Select **Action > Resume Replication**.
3. Click **OK**. Replications on the replication set are resumed and the status of the replication set changes to `Running`.

8 Working in the Mappings topic

Viewing mappings

The Mapping topic shows a tabular view of information about mappings that are defined in the system. By default, the table shows 20 entries at a time and is sorted first by host and second by volume. For information about using tables, see "Tips for using tables" (page 13).

The mapping table shows the following information:

- Group.Host.Nickname. Identifies the initiators to which the mapping applies:
  - All Other Initiators. The mapping applies to all initiators that are not explicitly mapped with different settings.
  - *initiator-name*. The mapping applies to the initiator only.
  - *initiator-ID*. The mapping applies to the initiator only, and the initiator has no nickname.
  - *host-name*.*. The mapping applies to all initiators in the host.
  - *host-group-name*.*.*. The mapping applies to all hosts in this group.
- Volume. Identifies the volumes to which the mapping applies:
  - *volume-name*. The mapping applies to the volume only.
  - *volume-group-name*.*. The mapping applies to all volumes in the volume group.
- Access. Shows the type of access assigned to the mapping:
  - read-write. The mapping permits read and write access to volumes.
  - read-only. The mapping permits read access to volumes.
  - no-access. The mapping prevents access to volumes.
- LUN. Shows whether the mapping uses a single LUN or a range of LUNs (indicated by *).
- Ports. Lists the controller host ports to which the mapping applies. Each number represents corresponding ports on both controllers.

To display more information about a mapping, see "Viewing map details" (page 105).

Mapping initiators and volumes

You can map initiators and volumes to control host access to volumes unless the volume is the secondary volume of a replication set. (Mapping also applies to hosts and host groups as well as initiators, and snapshots and volume groups as well as volumes. For the purposes of brevity, the terms *initiator* and *volumes* will stand in for all possibilities, unless otherwise stated.) By default, volumes are not mapped.

If a volume is mapped to All Other Initiators, this is its default mapping. The *default mapping* enables all connected initiators to see the volume using the specified access mode, LUN, and port settings. The advantage of a default mapping is that all connected initiators can discover the volume with no additional work by the administrator. This behavior is expected by some operating systems, such as Microsoft Windows, which can immediately discover the volume. The disadvantage is that all connected initiators can discover the volume with no restrictions. Therefore, this process is not recommended for specialized volumes that require restricted access. Also, to avoid multiple hosts mounting the volume and causing corruption, the hosts 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 corruption. To control access by specific initiators, you can create an *explicit mapping*. An explicit mapping can use different access mode, LUN, and port settings to allow or prevent access by an initiator to a volume, overriding the default mapping. When an explicit mapping is deleted, the volume's default mapping takes effect.

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 in 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 disk group ownership. When ULP is in use, 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.

If a group (host group or host) is mapped to a volume or volume group, all of the initiators within that group will have an individual map to each volume that makes up the request. As long as the group entity is mapped consistently, that set of individual maps will be represented as a grouped mapping. If any individual map within that group is modified, the grouped mapping will no longer be consistent, and it will no longer appear in the SMC. It will be replaced in the SMC with all of the individual maps.

△ **CAUTION:** Volume mapping changes take effect immediately. Make changes that limit access to volumes when the volumes are not in use. Before changing a LUN, be sure to unmount the volume.

NOTE: The secondary volume of a replication set cannot be mapped. Create a snapshot of the secondary volume or volume group and use the snapshot for mapping and accessing data.

To map initiators and volumes

1. Perform one of the following:
   - In the Hosts topic, select the initiators to map and select **Action > Map Initiators**.
   - In the Volumes topic, select the volumes to map and select **Action > Map Volumes**.
   - In the Mapping topic, select **Map** to create a new mapping.
   - In the Mapping topic, select one or more mappings to modify or delete and select **Action > Map**. You can also create a new mapping.

   The Map panel opens and shows two tables side-by-side that list available initiators and volumes. You can use these tables to create mappings. There is also a table underneath the host and volume tables that lists mappings. After you create a mapping and before you save it, the mapping appears in the mappings table and you can modify its settings or delete it.

   The Available Host Groups, Hosts, and Initiators table shows one or more of the following rows:

Table 14 Available host groups, hosts, and initiators

Row description	Group	Host	Nickname	ID
A row with these values always appears. Select this row to apply map settings to all initiators and create a default mapping.	–	–	(blank)	All Other Initiators
A row with these values appears for an initiator that is grouped into a host. Select this row to apply map settings to all initiators in this host.	–	*host-name*	*	*
A row with these values appears for an initiator that is grouped into a host group. Select this row to apply map settings to all initiators in this host group.	*host-group-name*	*	*	*
A row with these values appears for each initiator. Select this row to apply map settings to this initiator.	– or *host* – *host-group-name*	– or *host-name*	(blank) or *initiator-nickname*	*initiator-ID*

The Available Volume Groups and Volumes table shows one or more of the following rows:

Table 15 Available volume groups and volumes

Row description	Group	Name	Type
A row with these values appears for a volume/snapshot that is grouped into a volume group. Select this row to apply map settings to all volumes/snapshots in this volume group.	*volume-group-name*	*	Group
A row with these values appears for each volume/snapshot. Select this row to apply map settings to this volume/snapshot	–	*volume-name*	*volume-type*

NOTE:

- When you select one or more host groups, hosts, or initiators in the Hosts topic, the item(s) appears in the Available Host Groups, Hosts, and Initiators table while all available volumes, volume groups, and snapshots appear in the Available Volume Groups and Volumes table.
- The converse is true when you select one or more volumes, volume groups, or snapshots in the Available Volume Groups and Volumes table.
- When you open the Map panel through the Mapping topic without selecting a mapping, both tables are fully populated with all available items.
- When you select a mapping in the mapping table, it appears in the list of mappings below the above two tables. Also, both tables are fully populated.

2. Perform one of the following:

- If nothing was pre-selected, select one or more initiators and one or more volumes to map and click the **Map** button.
- If initiators were pre-selected, select volumes to map to those initiators and click the **Map** button.
- If volumes were pre-selected, select initiators to map to those volumes and click the **Map** button.
- If maps were pre-selected, they already appear in the mapping table and a **Map** button will be displayed.

For each pairing of selected initiators and volumes, a row appears in the mapping table at the bottom of the panel. At this time, no further mappings can be added to the list. Mappings in the list can be modified--including the mapping's mode, LUN, or ports, or they can be deleted.

NOTE: Once a set of mappings between initiators and volumes have been defined using the **Map** button, the button changes from **Map** to **Reset**. If mappings have been pre-selected, the **Reset** button, not the **Map** button, appears.

3. Perform any of the following:

- To immediately remove a row from the table, in the Action column, select **Remove Row**.
- To delete an existing mapping, in the Action column, select **Delete**.
- To edit a mapping, set the following options:
  - **Mode**. The access mode can specify read-write access, read-only access, or no access to a volume. The default is read-write. When a mapping specifies no access, the volume is masked, which means it is not visible to associated initiators. Masking is useful to override an existing default map that allows open access so that access is denied only to specific initiators. To allow access to specific host(s) and deny access to all other hosts, create explicit map(s) to those hosts. For example, an engineering volume could be mapped with read-write access for the Engineering server and read-only access for servers used by other departments.
  - **LUN**. The LUN identifies the volume to a host. The default is the lowest available LUN. Both controllers share one set of LUNs, and any unused LUN can be assigned to a mapping. However, each LUN can only be used once as a default LUN. For example, if LUN 5 is the default for Volume1, no other volume in the storage system can use LUN 5 as its default LUN. For explicit mappings, the rules differ: LUNs used in default mappings can be reused in explicit mappings for other volumes and other hosts.

TIP: When mapping a volume to a host with the Linux ext3 file system, specify read-write access. Otherwise, the file system will be unable to mount the volume and will report an error such as “unknown partition table.”

  - **Ports**. Port selections specify controller host ports through which initiators are permitted to access, or are prevented from accessing, the volume. Selecting a port number automatically selects the corresponding port in each controller.
- To save a new mapping or edits to an existing mapping, in the Action column, select **Save**.
- To clear the mapping table and discard any changes, click **Reset**.

4. Once the list is correct, to apply changes, click **Apply** or **OK**. A confirmation panel appears.
   To discard the changes instead of applying them, click **Reset**
5. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the mapping changes are processed.
6. To close the panel, click **Cancel**.

Viewing map details

In the Hosts, Volumes, and Mapping topics, you can see basic information about mappings between hosts and volumes.

To view additional details

1. Perform one of the following:
   - In the Hosts or Volumes topic, in the Related Maps table, select at least one mapping.
   - In the Mapping topic, in the mapping table, select at least one mapping.
2. Select **Action > View Map Details**. The Map Details panel opens and shows the following information. For information about using tables, see "Tips for using tables" (page 13).
   - Host Group. Identifies the host group to which the mapping applies:
     - `-`. The mapping does not apply to a host group.
     - *`host-group-name`*. The mapping applies to all hosts in this host group.
   - Host. Identifies the host to which the mapping applies:
     - `-`. The mapping does not apply to a host.
     - *`host-name`*. The mapping applies to all initiators in this host.
   - Nickname. Shows the nickname of the initiator, if a nickname is assigned. Otherwise, this field is blank.
   - Initiator ID. Shows the WWN of an FC or SAS initiator or the IQN of an iSCSI initiator.
   - Volume Group. Identifies the volumes to which the mapping applies:
     - `-`. The mapping does not apply to a volume group.
     - *`volume-group-name`*. The mapping applies to all volumes in this volume group.
   - Volume. Identifies the volume to which the mapping applies.
   - Access. Shows the type of access assigned to the mapping:
     - read-write. The mapping permits read and write access to volumes.
     - read-only. The mapping permits read access to volumes.
     - no-access. The mapping prevents access to volumes.
   - LUN. Shows whether the mapping uses a single LUN or a range of LUNs (indicated by *). By default, the table is sorted by this column.
   - Ports. Lists the controller host ports to which the mapping applies. Each number represents corresponding ports on both controllers.
3. Click **OK**.

9 Working in the Performance topic

Viewing performance statistics

The Performance topic shows performance statistics for the following types of components: disks, disk groups, virtual pools, virtual tiers, host ports, controllers, and volumes. For more information about performance statistics, see "About performance statistics" (page 28).

You can view current statistics in tabular format for all component types, and historical statistics in graphical format for disks, disk groups, and pools and tiers.

To view performance statistics

1. In the Performance topic, select a component type from the Show list. The components table shows information about each component of that type in the system. For information about using tables, see "Tips for using tables" (page 13).
2. Select one or more components in the list.
3. Click **Show Data**. The Current Data area shows the sample time, which is the date and time when the data sample was collected. It also shows the total duration of all data samples, which is the time period between collection and display of the current sample, the previous sample (if any), and a table of current performance statistics for each selected component.
4. To view graphs of historical data for the selected disks, disk groups, pools, or virtual tiers, select the **Historical Data** check box. The Historical Data area shows the time range of samples whose data is represented by the graphs, and the Total IOPS graph by default.
5. To specify either a time range or a count of historical statistics samples to display, perform the following:
   - Click **Set time range**. The Update Historical Statistics panel opens and shows the default count value of 100.
   - To specify a count, in the Count field, enter a value in the range of 5–100 and click **OK**.
   - To specify a time range, perform the following:
     - Select the **Time Range** check box.
     - Set date/time values for the starting and ending samples. The values must be between the current date/time and 6 months in the past. The ending values must be more recent than the starting values.

   TIP: If you specify a time range, it is recommended to specify a range of 24 hours or less.

   - Click **OK**. In the Historical Data area, the Time Range values are updated to show the times of the oldest and newest samples displayed, and the graph for the selected components is updated.
6. To view different historical statistics, select a graph from the Statistics list. For a description of each graph, see "Historical performance graphs," below.
7. To hide the legend in the upper right corner of a historical statistics graph, clear the **Show Legend** check box.

Historical performance graphs

The following table describes the graphs of historical statistics that are available for each component type. In the graphs, measurement units are automatically scaled to best represent the sample data within the page space.

Table 16 Historical performance graphs

System component	Graph	Description
Disk, group, pool, tier	Total IOPS	Shows the total number of read and write operations per second since the last sampling time.
Disk, group, pool, tier	Read IOPS	Shows the number of read operations per second since the last sampling time.
Disk, group, pool, tier	Write IOPS	Shows the number of write operations per second since the last sampling time.

Table 16 Historical performance graphs

System component	Graph	Description
Disk, group, pool, tier	Data Throughput	Shows the overall rate at which data was read and written since the last sampling time.
Disk, group, pool, tier	Read Throughput	Shows the rate at which data was read since the last sampling time.
Disk, group, pool, tier	Write Throughput	Shows the rate at which data was written since the last sampling time.
Disk, group, pool, tier	Total I/Os	Shows the number of read and write operations since the last sampling time.
Disk, group, pool, tier	Number of Reads	Shows the number of read operations since the last sampling time.
Disk, group, pool, tier	Number of Writes	Shows the number of write operations since the last sampling time.
Disk, group, pool, tier	Data Transferred	Shows the total amount of data read and written since the last sampling time.
Disk, group, pool, tier	Data Read	Shows the amount of data read since the last sampling time.
Disk, group, pool, tier	Data Written	Shows the amount of data written since the last sampling time.
Disk, group	Average Response Time	Shows the average response time for reads and writes since the last sampling time.
Disk, group	Average Read Response Time	Shows the average response time for reads since the last sampling time.
Disk, group	Average Write Response Time	Shows the average response time for writes since the last sampling time.
Disk, group	Average I/O Size	Shows the average size of reads and writes since the last sampling time.
Disk, group	Average Read I/O Size	Shows the average size of reads since the last sampling time.
Disk, group	Average Write I/O Size	Shows the average size of writes since the last sampling time.
Disk, group	Number of Disk Errors	Shows the number of disk errors since the last sampling time.
Disk, group	Queue Depth	Shows the average number of pending I/O operations being serviced since the last sampling time. This value represents periods of activity only and excludes periods of inactivity.
Pool, tier	Number of Allocated Pages	Shows the number of 4-MB pages allocated to volumes, based on writes to those volumes. Creating a volume does not cause any allocations. Pages are allocated as data is written.
Tier	Number of Page Moves In	Shows the number of pages moved into this tier from a different tier.
Tier	Number of Page Moves Out	Shows the number of pages moved out of this tier to other tiers.
Tier	Number of Page Rebalances	Shows the number of pages moved between disk groups in this tier to automatically load balance.

Table 16 Historical performance graphs

System component	Graph	Description
Tier	Number of Initial Allocations	Shows the number of pages that are allocated as a result of host writes. This number does not include pages allocated as a result of background tiering page movement. (Tiering moves pages from one tier to another, so one tier will see a page deallocated while another tier will show pages allocated; these background moves are not considered "initial allocations.")
Tier	Number of Unmaps	Shows the number of 4-MB pages that are automatically reclaimed and deallocated because they are empty (they contain only zeroes for data).
Tier	Number of RFC Copies	Shows the number of 4-MB pages copied from spinning disks to SSD read cache (read flash cache).
Tier	Number of Zero-Pages Reclaimed	Shows the number of empty (zero-filled) pages that were reclaimed during this sample period.

Updating historical statistics

The Performance topic can show historical performance statistics for the following types of components: disks, disk groups, and pools and tiers. By default, the newest 100 samples are shown. For more information about performance statistics, see "About performance statistics" (page 28).

You can update historical statistics.

To update displayed historical statistics

1. Display a historical statistics graph as described in "Viewing performance statistics" (page 106).
2. Select **Action > Update Historical Statistics**. The Update Historical Statistics panel opens and shows the default count value of 100.
3. To specify a count, in the Count field enter a value in the range of 5–100 and click **OK**.
4. To specify a time range, perform the following:
   - Select the **Time Range** check box.
   - Set date/time values for the starting and ending samples. The values must be between the current date/time and 6 months in the past. The ending values must be more recent than the starting values.

   TIP: If you specify a time range, it is recommended to specify a range of 24 hours or less.

   - Click **OK**.

   In the Historical Data area of the Performance topic, the Time Range values are updated to show the times of the oldest and newest samples displayed. The graph for the selected components is updated.

Exporting historical performance statistics

You can export historical performance statistics in CSV format to a file on the network. You can then import the data 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.

To export historical performance statistics

1. In the Performance topic, from the Show list, select **Disks**, **Disk Groups**, **Virtual Pools**, or **Virtual Tiers**.
2. Select at least one component.

   NOTE: Statistics are exported for all disks, regardless of which components are selected.

3. Select **Action > Export Historical Statistics**. The Export Historical Statistics panel opens.
4. To specify a time range, perform the following:
   - Select the **Time Range** check box.
   - Set date/time values for the starting and ending samples. The values must be between the current date/time and 6 months in the past. The ending values must be more recent than the starting values.

   TIP: If you specify a time range, it is recommended to specify a range of 24 hours or less.

5. Click **OK**.

   NOTE: In Microsoft Internet Explorer, if the download is blocked by a security bar, select its **Download File** option. If the download does not succeed the first time, return to the Export Historical Statistics panel and retry the export operation.

6. When prompted to open or save the file, click **Save**.
   - If you are using Firefox or Chrome and have a download directory set, the file `Disk_Performance.csv` is saved there.
   - Otherwise, you are prompted to specify the file location and name. The default file name is `Disk_Performance.csv`. Change the name to identify the system, controller, and date.
7. Click **OK**.

Resetting performance statistics

You can reset (clear) the current or historical performance statistics for all components. When you reset statistics, an event is logged and new data samples will continue to be stored every quarter hour.

To reset performance statistics

1. In the Performance topic, select **Action > Reset All Statistics**. The Reset All Statistics panel opens.
2. Perform one of the following:
   - To reset current statistics, select **Current Data**.
   - To reset historical statistics, select **Historical Data**.
3. Click **OK**. A confirmation panel appears.
4. Click **Yes** to continue. Otherwise, click **No**. If you clicked Yes, the statistics are cleared.

10 Working in the banner and footer

Banner and footer overview

The banner of the SMC interface contains four panels that are next to each other:

- The system panel shows system and firmware information.
- The connection information panel shows information about the link between the SMC and the storage system.
- The system date/time panel shows system date and time information.
- The user information panel shows the name of the logged-in user.

The footer of the SMC interface contains six panels that are next to each other:

- The system health panel shows the current health of the system and each controller.
- The event panel shows the last 1,000 or fewer events (organized by event type) that the system has logged.
- The capacity utilization panel shows a pair of color-coded bars that represent the physical capacity of the system and how the capacity is allocated and used.
- The host I/O panel shows a pair of color-coded bars for each controller that has active I/O, which represent the current IOPS for all ports and the current data throughput (MB/s) for all ports.
- The tier I/O panel shows a color-coded bar for each pool (A, B, or both) that has active I/O.
- The activity panel shows notifications of recent system activities.

If you hover your cursor over any of these panels except for the activity panel, an additional panel with more detailed information displays. Some of these panels have menus that enable you to perform related tasks. There are two icons for panels that have a menu: for the banner and for the footer. Click anywhere in the panel to display the menu.

Viewing system information

The system panel in the banner shows the system name and the firmware bundle version installed for the controller that you are accessing.

Hover the cursor over this panel to display the System Information panel, which shows the system name, vendor, location, contact, and description. It also shows the firmware bundle version for each controller (A and B).

The icon indicates that the panel has a menu. Click anywhere in the panel to display a menu to change system information settings (page 41) and system services settings (page 51), update firmware (page 56), restart or shut down controllers (page 63), and view SSL certificate information (see below).

Viewing certificate information

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 Certificate Information panel shows information for the active SSL certificates that are stored on the system for each controller. Tabs A and B 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 most often occurs when a controller is restarting, the certificate replacement process is still in process, or you have selected the tab for a partner controller in a single-controller system.

You can use your own certificates by uploading them through FTP 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 first restart the controller for it. For information on how to restart a controller, see "Restarting controllers" (page 63).

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.

To view certificate information

1. In the banner, click the system panel and select **Show Certificate Info**. The Certificate Information panel opens.
2. After you have finished viewing certificate information, click **Close**.

Viewing connection information

The icon in the connection panel in the banner shows the current state of the management link between the SMC and the storage system. The connection information table show the icon that displays for each state.

Table 17 Connection information

Icon	Meaning
	The management link is connected and the system is up. Animation shows when data is being transferred.
	The management link is connected but the system is down.
	The management link is not connected.

Hover the cursor over this panel to display the Connection Information panel, which shows the connection and system states.

Viewing system date and time information

The date/time panel in the banner shows the system date and time in the format *year-month-day hour:minutes:seconds*.

Hover the cursor over this panel to display the System Date/Time panel, which shows NTP settings.

The icon indicates that the panel has a menu. Click anywhere in the panel to display a menu to change date and time settings.

Changing date and time settings

You can change the storage system date and time, which appear in the date/time panel in the banner. It is important to set the date and time so that entries in system logs and notifications have correct time stamps.

You can set the date and time manually or configure the system to use NTP to obtain them from a network-attached server. When NTP is enabled, and if an NTP server is available, the system time and date can be obtained from the NTP server. This allows multiple storage devices, hosts, log files, and so forth to be synchronized. 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 options:

- 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.

Whether NTP is enabled or disabled, the storage system does not automatically make time adjustments, such as for Daylight Saving Time. You must make such adjustments manually.

To use manual date and time settings

1. In the banner, click the date/time panel and select **Set Date and Time**. The Set Date and Time panel opens.
2. Clear the **Network Time Protocol (NTP)** check box.
3. To set the Date value, enter the current date in the format *YYYY-MM-DD*.
4. To set the Time value, enter two-digit values for the hour and minutes and select either **AM**, **PM**, or **24H** (24-hour clock).
5. Click **OK**.

To obtain the date and time from an NTP server

1. In the banner, click the date/time panel and select **Set Date and Time**. The Set Date and Time panel opens.
2. Select the **Network Time Protocol (NTP)** check box.
3. Perform one of the following:
   - To have the system retrieve time values from a specific NTP server, enter its address in the NTP Server Address field.
   - To have the system listen for time messages sent by an NTP server in broadcast mode, clear the NTP Server Address field.
4. In the NTP Time Zone Offset field, enter the time zone as an offset in hours, and optionally, minutes, from UTC. For example, the Pacific Time Zone offset is -8 during Pacific Standard Time or -7 during Pacific Daylight Time. The offset for Bangalore, India is +5:30.
5. Click **OK**.

Viewing user information

The user panel in the banner shows the name of the signed-in user.

Hover the cursor over this panel to display the User Information panel, which shows the roles, accessible interfaces, and session timeout for this user.

The icon indicates that the panel has a menu. Click anywhere in the panel to change settings for the signed-in user (`monitor` role) or to manage all users (`manage` role). For more information on user roles and settings, see "Managing users" (page 41).

Viewing health information

The health panel in the footer shows the current health of the system and each controller.

Hover the cursor over this panel to display the System Health panel, which shows the health state. If the system health is not OK, the System Health panel also shows information about resolving problems with unhealthy components.

The icon indicates that the panel has a menu. Click anywhere in the panel to display a menu to change notification settings (page 44), save log data (page 112), and view system information (page 48).

Saving log data to a file

To help service personnel diagnose a system problem, you might be asked to provide system log data. Using the SMC, you can save the following log data to a compressed zip file:

- 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
- CAPI traces from each controller

NOTE: The controllers share one memory buffer for gathering log data and for loading firmware. Do not try to perform more than one log saving operation at a time, or to perform a firmware update operation while performing a log saving operation.

To save log data from the storage system to a network location

1. In the footer, click the health panel and select **Save Logs**. The Save Logs panel opens.
2. Enter your name, email address, and phone number so support personnel will know who provided the data. The value for your name and phone number can include a maximum of 100 bytes while your email address can include a maximum of 100 characters. All three values can use all characters except the following: " < > \
3. Enter comments describing the problem and specifying the date and time when the problem occurred. This information helps service personnel when they analyze the log data. Comment text can include a maximum of 500 bytes.
4. Click **OK**. Log data is collected, which takes several minutes.

   NOTE: In Microsoft Internet Explorer, if the download is blocked by a security bar, select its **Download File** option. If the download does not succeed the first time, return to the Save Logs panel and retry the save operation.

5. When prompted to open or save the file, click **Save**.
   - If you are using Chrome, `store.zip` is saved to the downloads folder.
   - If you are using Firefox and have a download folder set, `store.zip` is saved to that folder.
   - Otherwise, you are prompted to specify the file location and name. The default file name is `store.zip`. Change the name to identify the system, controller, and date.

   NOTE: The file must be uncompressed before the files it contains can be examined. The first file to examine for diagnostic data is `store_yyyy_mm_dd__hh_mm_ss.logs`.

Viewing event information

The event panel in the footer shows the numbers of the following types of events that the system has logged:

- Critical. A failure occurred that may 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.
- 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.

Hover the cursor over this area to display the Critical & Error Event Information panel, which shows:

- The number of events with Critical and Error severity that have occurred in the past 24 hours or in the last 1000 events
- The date and time when the last most-severe event occurred

The icon indicates that the panel has a menu. Click anywhere in the panel to display a menu to view the most recent 1000 events on "Viewing the event log" (page 114) and change notification settings on "Changing notification settings" (page 44).

Viewing the event log

If you are having a problem with the system, review the event log before calling technical support. Information shown in the event log might enable you to resolve the problem.

To view the event log, in the footer, click the events panel and select **Show Event List**. The Event Log Viewer panel opens. The panel shows a tabular view of the 1000 most recent events logged by either controller. All events are logged, regardless of notification settings. For information about notification settings, see "Changing notification settings" (page 44). For information about using tables, see "Tips for using tables" (page 13).

For each event, the panel shows the following information:

- Sev. One of the following severity icons:
  - Critical. A failure occurred that may 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.
  - 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.
- Date/Time. The date and time when the event occurred, shown in the format *year-month-day hour:minutes:seconds*. Time stamps have one-second granularity.
- ID. The event ID. The prefix A or B identifies the controller that logged the event.
- Code. An event code that helps you and support personnel diagnose problems.
- Message. Brief information about the event. Click the message to show or hide additional information and recommended actions.
- Ctrl. The ID of the controller that logged the event.

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

Resources for diagnosing and resolving problems

- The troubleshooting chapter and LED descriptions appendix in your product's Setup Guide
- The topics about verifying component failure in your product's CRU Installation and Replacement Guide
- The full list of event codes, descriptions, and recommended actions in your product's event documentation

Viewing capacity information

The capacity panel in the footer shows a pair of color-coded bars. The lower bar represents the physical capacity of the system and the upper bar identifies how the capacity is allocated and used. For color-code descriptions, see "Color codes" (page 14).

Hover the cursor over a segment to see the storage type and size represented by that segment. For instance, in a system where storage is being used, the bottom bar has color-coded segments that show the total unused disk space and space used by virtual disk groups. The total of these segments is equal to the total disk capacity of the system.

In this same system, the top bar has color-coded segments for reserved, allocated, and unallocated space for virtual disk groups. If very little disk group space is used for any of these categories, it will not be visually represented.

Reserved space refers to space that is unavailable for host use. It consists of RAID parity and the metadata needed for internal management of data structures. Allocated space refers to the amount of space that the data written to the pool takes. Unallocated space is the difference between the space designated for all volumes and the allocated space.

Hover the cursor over a segment of a bar to see the storage size represented by that segment. Point anywhere in this panel to see the following information about capacity utilization in the Capacity Utilization panel:

- Total Disk Capacity. The total physical capacity of the system
- Unused. The total unused disk capacity of the system
- Global Spares. The total global spare capacity of the system

- Virtual Disk Groups. The capacity of disk groups, both total and by pool
- Reserved. The reserved space for disk groups, both total and by pool
- Allocated. The allocated space for disk groups, both total and by pool
- Unallocated. The unallocated space for disk groups, both total and by pool
- Uncommitted. The uncommitted space in each pool (total space minus the allocated and unallocated space) and total uncommitted space

Viewing host I/O information

The host I/O panel in the footer shows a pair of color-coded bars for each controller that has active I/O. In each pair, the upper bar represents the current IOPS for all ports, which is calculated over the interval since these statistics were last requested or reset, and the lower bar represents the current data throughput (MB/s) for all ports, which is calculated over the interval since these statistics were last requested or reset. The pairs of bars are sized to represent the relative values for each controller. For color-code descriptions, see "Color codes" (page 14).

Hover the cursor over a bar to see the value represented by that bar.

Hover the cursor anywhere in the panel to display the Host I/O Information panel, which shows the current port IOPS and data throughput (MB/s) values for each controller.

Viewing tier I/O information

The tier I/O panel in the footer shows a color-coded bar for each pool (A, B, or both) that has active I/O. The bars are sized to represent the relative IOPS for each pool. Each bar contains a segment for each tier that has active I/O. The segments are sized to represent the relative IOPS for each tier. For color-code descriptions, see "Color codes" (page 14).

Hover the cursor over a segment to see the value represented by that segment.

Hover the cursor anywhere in this panel to display the Tier I/O Information panel, which shows the following details for each tier in each pool:

- Current IOPS for the pool, calculated over the interval since these statistics were last requested or reset.
- Current data throughput (MB/s) for the pool, calculated over the interval since these statistics were last requested or reset.

The panel also contains combined total percentages of IOPS and current data throughput (MB/s) for both pools.

Viewing recent system activity

The activity panel in the footer shows notifications of recent system activities, such as the loading of configuration data upon sign-in and events with the Resolved status.

To view past notifications for this SMC session, click the activity panel in the footer and select **Notification History**. For more information, see Viewing the notification history (below).

Viewing the notification history

The Notification History panel shows past activity notifications for this SMC session. You can page through listed items by using the following buttons:

 Show next set of items.

 Reached end of list.

 Show previous set of items.

 Reached start of list.

When you sign out, the list is cleared.

To view notification history

1. Click the activity panel in the footer and select **Notification History**. The Notification History panel opens.
2. View activity notifications, using the navigation buttons.
3. Click **Close** when you are finished.

A SNMP reference

This appendix describes the Simple Network Management Protocol (SNMP) capabilities that Lenovo Storage S3200/S2200 storage systems support. This includes standard MIB-II, the FibreAlliance SNMP Management Information Base (MIB) version 2.2 objects, and enterprise traps.

Lenovo Storage S3200/S2200 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, etc.).

Supported SNMP versions

Lenovo Storage S3200/S2200 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 only have access to the MIB-II common system information. This allows device discovery.

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`) is based on the vendor name followed by ".2." and the identifier for the particular product model. For example, the object identifier for Lenovo Storage S3200/S2200 storage systems is 1.3.6.1.4.1.19046. 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 occurring in the storage system. These events can be selected by severity and by individual event type. A maximum of three SNMP trap destinations can be configured by IP address.

Enterprise event severities are 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, `lstraps.mib`. Information included is the event ID, the event code type, and a text description generated from the internal event. Equivalent information can also be sent using email or popup alerts to users who are logged in to the SMC.

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 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 SMC. The statistics section is not implemented.

The following table lists the MIB objects, their descriptions and the value set in a Lenovo Storage S3200/S2200 storage system. Unless specified otherwise, objects are *not* settable.

Table 18 FA MIB 2.2 objects, descriptions, and values

Object	Description	Value
`RevisionNumber`	Revision number for this MIB	0220
`UNumber`	Number of connectivity units present	1
`SystemURL`	Top-level URL of the device. For example, `http://10.1.2.3`. If a web server is not present on the device, this string is empty in accordance with the FA MIB2.2 Spec.	Default: `http://10.0.0.1`
`StatusChangeTime`	`sysuptime` timestamp of the last status change event, in centiseconds. `sysuptime` starts at 0 when the Storage Controller boots and keeps track of the up time. `statusChangeTime` is updated each time an event occurs.	0 at startup
`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`)

Table 18 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
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
connUnitConfiguration ChangeTime	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
connUnitControl	Not supported	invalid(2) for an SNMP GET operation and not settable through an SNMP SET operation.

Table 18 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
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 SMC.	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" (page 123)
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" (page 123)
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" (page 124)
connUnitSensorName	Display string containing textual identification of the sensor intended primarily for operator use	See "External details for connUnitSensorTable" (page 124)
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" (page 124)

Table 18 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
connUnitSensor Characteristic	Characteristics being monitored by this sensor	See "External details for connUnitSensorTable" (page 124)
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" (page 126)
connUnitPortPhysical Number	Port number represented on the hardware	Port number represented on the hardware

Table 18 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
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
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
connUnitPortStatFabric Table	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)

Table 18 FA MIB 2.2 objects, descriptions, and values (continued)

Object	Description	Value
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**	
SiSysSerialNum	System serial number	For example, 3CL8Y40991
SiSysProductId	System product ID	For example, 481321-001
SiProductName	System product name	For example, Lenovo 2200
HoMibStatusArray	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)
HoGUID	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 section specify values for certain objects described in Table 18.

External details for connUnitRevsTable

Table 19 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	CAPI 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)

Table 19 connUnitRevsTable index and description values (continued)

connUnitRevsIndex	connUnitRevsDescription
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)
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 20 connUnitSensorTable index, name, type, and characteristic values

connUnitSensorIndex	connUnitSensorName	connUnitSensorType	connUnitSensor Characteristic
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)

Table 20 connUnitSensorTable index, name, type, and characteristic values (continued)

connUnitSensorIndex	connUnitSensorName	connUnitSensorType	connUnitSensor Characteristic
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)
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 21 connUnitPortTable index and name values

connUnitPortIndex	connUnitPortName
0	Host Port 0 (Controller A), Host Port 0 (Controller B)
1	Host Port 1 (Controller A), Host Port 1 (Controller B)
2	Host Port 2 (Controller A), Host Port 2 (Controller B)
3	Host Port 3 (Controller A, Host Port 3 (Controller B)

Configuring SNMP event notification in the SMC

1. Verify that the storage system's SNMP service is enabled. See "Changing system services settings" (page 51).
2. Configure and enable SNMP traps. See "Changing notification settings" (page 44).
3. Optionally, configure a user account to receive SNMP traps. See "Managing users" (page 41).

SNMP management

You can manage storage devices using SNMP with a network management system. See your network management system's 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. See "Changing system services settings" (page 51). 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 "Managing users" (page 41). 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 Lenovo enterprise traps MIB, `lstraps.mib`. This MIB defines the content of the SNMP traps that Lenovo Storage S3200/S2200 storage systems generate.

```
-- ------------------------------------------------------
-- Lenovo Low Cost Array MIB for SNMP Traps
--
--
-- Copyright 2015 Lenovo
-- All rights reserved. Use is subject to license terms.
--
-- ------------------------------------------------------

LSTRAPS-MIB
-- Last edit date: April 29th, 2015
DEFINITIONS ::= BEGIN
  IMPORTS
    enterprises
        FROM RFC1155-SMI
    TRAP-TYPE
        FROM RFC-1215
    connUnitEventId, connUnitEventType, connUnitEventDescr
        FROM FCMGMT-MIB;


    --Textual conventions for this MIB

-------------------------------------------------------------------------
lenovo    OBJECT IDENTIFIER ::= { enterprises 19046 }


-- Related traps

   lsEventInfoTrap TRAP-TYPE
        ENTERPRISE lenovo
        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
        ::= 1

   lsEventWarningTrap TRAP-TYPE
        ENTERPRISE lenovo
        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
        ::= 2

    lsEventErrorTrap TRAP-TYPE
        ENTERPRISE lenovo
        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
        ::= 3

    lsEventCriticalTrap TRAP-TYPE
        ENTERPRISE lenovo
        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
        ::= 4

END
```

B Using FTP

Although the SMC is the preferred interface for downloading log data and historical disk-performance statistics, updating firmware, installing a license, and installing a security certificate, you can also use FTP to do these tasks.

IMPORTANT: Do not attempt to do more than one of the operations in this appendix 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 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 client. A GUI-based FTP client might not work.

To download system logs

1. In the SMC, prepare to use FTP:
   a. Determine the network-port IP addresses of the system's controllers. See "Changing network interface settings" (page 52).
   b. Verify that the system's FTP service is enabled. See "Changing system services settings" (page 51).
   c. Verify that the user you will log in as has permission to use the FTP interface. See "To modify a user" (page 43).
2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the destination directory for the log file.
3. Enter:

   `ftp` *`controller-network-address`*

   For example:

   `ftp 10.1.0.9`
4. Log in as a user that has permission to use the FTP interface.
5. 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`

   Wait for the message `Operation Complete` to appear.
6. Quit the FTP session.
7. If the problem to diagnose seems specific to user-interface behavior, repeat step 3 through step 6 on the partner controller to collect its unique MC log data.

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 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 indicate that there is no untransferred data. Log data is controller specific.

For an overview of the log-management feature, see "About managed logs" (page 29).

Use a command-line-based FTP client. A GUI-based FTP client might not work.

To transfer log data to a log-collection system

1. In the SMC, prepare to use FTP:
   a. Determine the network-port IP addresses of the system's controllers. See "Changing network interface settings" (page 52).
   b. Verify that the system's FTP service is enabled. See "Changing system services settings" (page 51).
   c. Verify that the user you will log in as has permission to use the FTP interface. See "To modify a user" (page 43).
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:

   `ftp` *`controller-network-address`*

   For example:

   `ftp 10.1.0.9`
4. Log in as a user that has permission to use the FTP interface.
5. 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`

   Wait for the message `Operation Complete` to appear.
6. Quit the FTP 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 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 client. A GUI-based FTP client might not work.

To retrieve historical disk-performance statistics

1. In the SMC, prepare to use FTP:
   a. Determine the network-port IP addresses of the system's controllers. See "Changing network interface settings" (page 52).
   b. Verify that the system's FTP service is enabled. See "Changing system services settings" (page 51).
   c. Verify that the user you will log in as has permission to use the FTP interface. See "To modify a user" (page 43).
2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the destination directory for the log file.
3. Enter:

   `ftp` *`controller-network-address`*

   For example:

   `ftp 10.1.0.9`
4. Log in as a user that has permission to use the FTP interface.
5. 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`

   Wait for the message `Operation Complete` to appear.
6. Quit the FTP session.

Updating firmware

You can update the versions of firmware in controller modules, expansion modules (in drive enclosures), and disks.

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 through the CLI. See information about events 172 and 485 in the Event Descriptions Reference Guide, and de-quarantining disk groups in 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.
- 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 information on the System Health hover panel (page 112).

Updating controller-module firmware

A controller enclosure can contain one or two controller modules. In a dual-controller system, both controllers should run the same firmware version. You can update the firmware in each controller module by loading a firmware file obtained from the Lenovo web download site at support.lenovo.com.

If you have a dual-controller system and the Partner Firmware Update (PFU) option is enabled (PFU is enabled by default), 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, the storage system should be 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 SMC, prepare to use FTP:
   a. Determine the network-port IP addresses of the system's controllers.
   b. Verify that the system's FTP service is enabled.
   c. Verify that the user you will log in as has permission to use the FTP interface.
3. If the storage system has a single controller, stop I/O to disk groups before starting the firmware update.
4. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory containing the firmware file to load.
5. Enter:

   `ftp` *`controller-network-address`*

   For example:

   `ftp 10.1.0.9`
6. Log in as an FTP user.

7. Enter:

   put *firmware-file* **flash**

   For example:

   put T230R01-01.bin 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 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 a Lenovo Storage S3200/S2200 drive enclosure.

   NOTE: If you are using a Windows FTP client, during firmware update a client-side FTP application issue can cause the FTP session to be aborted. If this issue persists try using the SMC to perform the update, use another client, or use another FTP application.

   If the Storage Controller cannot be updated, the update operation is cancelled. If the FTP prompt does not return, quit the FTP 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 message `Operation Complete` is printed, the FTP session returns to the `ftp>` prompt, and the FTP session to the local MC is closed.

   If PFU is enabled, allow an additional 10–20 minutes for the partner controller to be updated.
8. Quit the FTP session.
9. Clear your web browser's cache, then sign in to the SMC. 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: 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 disk firmware

You can update disk firmware by loading a firmware file obtained from your reseller.

A dual-ported disk can be updated from either controller.

NOTE: Disks of the same model in the storage system must have the same firmware revision.

You can specify to update all disks or only specific disks. If you specify to update all disks and the system contains more than one type of disk, the update will be attempted on all disks in the system. The update will only succeed for disks whose type matches the file, and will fail for disks of other types.

To prepare for update

1. Obtain the appropriate firmware file and download it to your computer or network.
2. Check the disk manufacturer's documentation to determine whether disks must be power cycled after firmware update.
3. If you want to update all disks of the type that the firmware applies to, continue with the next step. Otherwise, in the SMC, for each disk to update:
   a. Determine the enclosure number and slot number of the disk.
   b. If the disk is associated with a disk group and is single ported, determine which controller owns the disk group.
4. In the SMC, prepare to use FTP:
   a. Determine the network-port IP addresses of the system's controllers.
   b. Verify that the system's FTP service is enabled.
   c. Verify that the user you will log in as has permission to use the FTP interface.
5. 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.

To update disk firmware

1. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory containing the firmware file to load.
2. Enter:

   ftp *controller-network-address*

   For example:

   ftp 10.1.0.9
3. Log in as an FTP user.
4. Either:
   - To update all disks of the type that the firmware applies to, enter:

     put *firmware-file* **disk**
   - To update specific disks, enter:

     put *firmware-file* **disk:***enclosure-ID***:***slot-number*

     For example:

     put *firmware-file* **disk:1:11**

   △ **CAUTION:** Do not power cycle enclosures or restart a controller during the firmware update. If the update is interrupted or there is a power failure, the disk might become inoperative. If this occurs, contact technical support.

   It typically takes several minutes for the firmware to load. Wait for a message that the update has succeeded.

   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.
5. If you are updating specific disks, repeat step 4 for each remaining disk to update.
6. Quit the FTP session.
7. If the updated disks must be power cycled:
   a. Shut down both controllers by using the SMC.
   b. Power cycle all enclosures as described in your product's Setup Guide.
8. Verify that each disk has the correct firmware revision.

Installing a license file

1. Ensure that the license file is saved to a network location that the storage system can access.
2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory containing the license file to load.
3. Log in to the controller enclosure that the file was generated for:

   ftp *controller-network-address*

   For example:

   ftp 10.1.0.9
4. Log in as an FTP user.
5. Enter:

   put *license-file* **license**

   For example:

   put certificate.txt license

   A message confirms whether installation succeeded or failed. If installation succeeds, licensing changes take effect immediately.

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 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 SMC, prepare to use FTP:
   a. Determine the network-port IP addresses of the system's controllers. See "Changing network interface settings" (page 52).
   b. Verify that the system's FTP service is enabled. See "Changing system services settings" (page 51).
   c. Verify that the user you will log in as has permission to use the FTP interface. See "To modify a user" (page 43).
2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the directory that contains the certificate files.
3. Enter:

   ftp *controller-network-address*

   For example:

   ftp 10.1.0.9
4. Log in as a user that has permission to use the FTP interface.
5. Enter:

   put *certificate-file-name* **cert-file**

   where *certificate-file-name* is the name of the certificate file for your specific system.
6. Enter:

   put *key-file-name* **cert-key-file**

   where *key-file-name* is the name of the security key file for your specific system.
7. Restart both Management Controllers to have the new security certificate take 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 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 SMC, prepare to use FTP:
   a. Determine the network-port IP addresses of the system's controllers. See "Changing network interface settings" (page 52).
   b. Verify that the system's FTP service is enabled. See "Changing system services settings" (page 51).
   c. Verify that the user you will log in as has permission to use the FTP interface. See "To modify a user" (page 43).
2. Open a Command Prompt (Windows) or a terminal window (UNIX) and navigate to the destination directory for the log file.
3. Enter:

   `ftp` *`controller-network-address`*

   For example:

   `ftp 10.1.0.9`
4. Log in as a user that has permission to use the FTP interface.
5. Enter:

   `get logs:heatmap` *`filename`***`.csv`**

   where: *`filename`* is the file that will contain the data.

   For example:

   `get logs:heatmap IO_density.csv`

   Wait for the message `Operation Complete` to appear.
6. Quit the FTP session.

C Using SMI-S

This appendix 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.

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 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 Target Ports subprofile
- SAS Target Ports subprofile
- iSCSI Target Ports subprofile
- 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:

- HTTP/HTTPS using SSL encryption on the default port 5989, or standard HTTP/HTTPS on the default port 5988. Both ports cannot be enabled at the same time.
- SLPv2
- CIM Alert and Lifecycle indications
- Microsoft Windows Server 2012 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, Lenovo Storage S3200/S2200 storage systems), and provides the CIMOM with information about them. In theory, providers for multiple types of devices (for example, Lenovo Storage S3200/S2200 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 CIMPLE (www.simplewbem.org) is used. For more information on SFCB go to http://sourceforge.net/projects/sblim/files/sblim-sfcb.

About the Lenovo Storage S3200/S2200 SMI-S provider

The Lenovo Storage S3200/S2200 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.

Lenovo Storage S3200/S2200 CNC and SAS systems are supported. The classes for Lenovo are `smi_XXXX`. The device namespace for Lenovo 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 unsecure 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/smis`
- 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.

Table 22 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 Target Ports profile	Models the Fibre Channel-specific aspects of a target storage system.
SAS Target Ports subprofile	Models the SAS-specific aspects of a target storage system.
iSCSI Target Ports subprofile	Models the iSCSI-specific aspects of a target storage system.
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.

Table 22 Supported SMI-S profiles (continued)

Profile/subprofile/package	Description
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.

CIM

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, iSCSI, and SAS 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" (page 143).

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 23 pertain to FRU assemblies and certain FRU components.

Table 23 CIM Alert indication events

FRU/Event category	Corresponding SMI-S class	Operational status values that would trigger alert conditions
Controller	`SMI_Controller`	`Down, Not Installed, OK`
Hard Disk Drive	`SMI_DiskDrive`	`Unknown, Missing, Error, Degraded, OK`
Fan	`SMI_PSUFan`	`Error, Stopped, OK`
Power Supply	`SMI_PSU`	`Unknown, Error, Other, Stressed, Degraded, OK`
Temperature Sensor	`SMI_OverallTempSensor`	`Unknown, Error, Other, Non-Recoverable Error, Degraded, OK`
Battery/Super Cap	`SMI_SuperCap`	`Unknown, Error, OK`
FC Port	`SMI_FCPort`	`Stopped, OK`
SAS Port	`SMI_SASTargetPort`	`Stopped, OK`
iSCSI Port	`SMI_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 1.5.0. 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 2012 operating system requires.

Table 24 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
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 create/delete storage hardware ID (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

Table 24 Life cycle indications (continued)

Profile or subprofile	Element description and name	WQL or CQL
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.

Table 25 lists the CLI commands relevant to the SMI-S protocol:

Table 25 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 unsecure SMI-S port 5988 (and disable port 5989)	`set protocols usmis disabled`
Enable unsecure 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`
2. If the user does not already exist, create one using this command:
   `create user level manage` *`username`*
3. Type this command:
   `set user` *`username`* `interfaces wbi,cli,smis,ftp`

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 "About managed logs" (page 29).

To set up SMI-S to listen for managed logs notifications:

1. In the CLI, enter this command:
   `set advanced-settings managed-logs enabled`
2. In an SMI-S client:
   a. Subscribe using the `SELECT * FROM CIM_InstCreation WHERE SourceInstance ISA CIM_LogicalFile` filter.
   b. 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. Common clients include 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.

The implementation of the Masking and Mapping subprofile's extrinsic methods allows CIM clients to create LUNs by mapping volumes to logical ports. The `ExposePaths` method is fully implemented and simplifies this operation to one step. The `CreateStorageHardwareID` and `DeleteStorageHardwareID` methods all CIM clients to create and remove hosts.

Troubleshooting

Table 26 provides solutions to common SMI-S problems.

Table 26 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 `manage` and type: `set protocol smis enabled`
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 `smis` interface and set the user preferences to support the `smis` interface, if necessary. See "To add a new user" (page 43) for instructions on how to add users. Also verify the supplied credentials.
Want to connect securely as user name `my_xxxx`.	Need to add user.	Log in to the array as `manage`. Type: `create user level manage my_xxxuser` and then type: `set user my_xxxuser interfaces wbi,cli,smis`
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.	Install wbemcli on a Linux system by typing: `apt-get install wbemcli` Type: `wbemcli -nl -t -noverify ein 'https://manage:!manage@:5989/root/smis:cim_computersystem'`
SMI-S is not responding to client requests.	SMI-S configuration may have become corrupted.	Use the CLI command `reset smis-configuration`. Refer to the CLI Reference Guide for further information.

D 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 "About managed logs" (page 29).

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, SNMP traps, or SMI-S 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 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" (page 130).

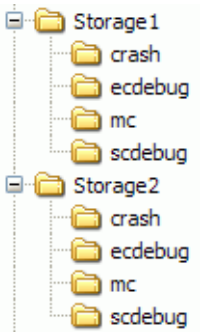
Log-file details

- 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 interface to get the log and save it into the `scdebug` subdirectory of the `Storage2` directory.

E Best practices

This appendix describes best practices for configuring and provisioning a storage system.

Pool setup

In a storage system with two controller modules, try to balance the workload of the controllers. Each controller can own one virtual pool. Having the same number of disk groups and volumes in each pool will help balance the workload, increasing performance.

RAID selection

A pool is created by adding disk groups to it. Disk groups are based on RAID technology. Table 27 describes the characteristics and use cases of each RAID level.

Table 27 RAID level characteristics and use cases

RAID level	Protection	Performance	Capacity	Application use cases	Suggested disk speed
RAID 1/ RAID 10	Protects against up to one disk failure per mirror set	Great random I/O performance	Poor: 50% fault tolerance capacity loss	Databases, OLTP, Exchange Server, booting from SAN	10K, 15K, 7K
RAID 5	Protects against up to one disk failure per RAID set	Good sequential I/O performance, moderate random I/O performance	Great: One-disk fault tolerance capacity loss	Big data, media and entertainment (ingest, broadcast, and past production)	10K, 15K, lower capacity 7K
RAID 6	Protects against up to two disk failures per RAID set	Moderate sequential I/O performance, poor random I/O performance	Moderate: Two-disk fault tolerance capacity loss	Archive, parallel distributed file system	High capacity 7K

Disk count per RAID

The controller breaks virtual volumes into 4-MB pages, which are referenced paged tables in memory. The 4-MB page is a fixed unit of allocation. Therefore, 4-MB units of data are pushed to a disk group. A write performance penalty is introduced in RAID-5 or RAID-6 disk groups when the stripe size of the disk group isn't a multiple of the 4-MB page.

- Example 1: Consider a RAID-5 disk group with five disks. The equivalent of four disks provide usable capacity, and the equivalent of one disk is used for parity (parity is distributed among disks). The four disks providing usable capacity are the *data disks* and the one disk providing parity is the *parity disk*. In reality, the parity is distributed among all the disks, but conceiving of it in this way helps with the example.

  Note that the number of data disks is a power of two (2, 4, and 8). The controller will use a 512-KB stripe unit size when the data disks are a power of two. This results in a 4-MB page being evenly distributed across two stripes. This is ideal for performance.
- Example 2: Consider a RAID-5 disk group with six disks. The equivalent of five disks now provide usable capacity. Assume the controller again uses a stripe unit of 512-KB. When a 4-MB page is pushed to the disk group, one stripe will contain a full page, but the controller must read old data and old parity from two of the disks in combination with the new data in order to calculate new parity. This is known as a read-modify-write, and it's a performance killer with sequential workloads. In essence, every page push to a disk group would result in a read-modify-write.

  To mitigate this issue, the controllers use a stripe unit of 64-KB when a RAID-5 or RAID-6 disk group isn't created with a power-of-two data disks. This results in many more full-stripe writes, but at the cost of many more I/O transactions per disk to push the same 4-MB page.

Table 28 shows recommended disk counts for RAID-6 and RAID-5 disk groups. Each entry specifies the total number of disks and the equivalent numbers of data and parity disks in the disk group. Note that parity is actually distributed among all the disks.

Table 28 Recommended disk group sizes

RAID level	Total disks	Data disks (equivalent)	Parity disks (equivalent)
RAID 6	4	2	2
	6	4	2
	10	8	2
RAID 5	3	2	1
	5	4	1
	9	8	1

To ensure best performance with sequential workloads and RAID-5 and RAID-6 disk groups, use a power-of-two data disks.

Disk groups in a pool

For better efficiency and performance, use similar disk groups in a pool.

- Disk count balance: For example, with 20 disks, it is better to have two 8+2 RAID-6 disk groups than one 10+2 RAID-6 disk group and one 6+2 RAID-6 disk group.
- RAID balance: It is better to have two RAID-5 disk groups than one RAID-5 disk group and one RAID-6 disk group.
- In terms of the write rate, due to wide striping, tiers and pools are as slow as their slowest disk groups.
- All disks in a tier should be the same type. For example, use all 10K disks or all 15K disks in the Standard tier.

Create more small disk groups instead of fewer large disk groups.

- Each disk group has a write queue depth limit of 100. This means that in write-intensive applications this architecture will sustain bigger queue depths within latency requirements.
- Using smaller disk groups will cost more raw capacity. For less performance-sensitive applications, such as archiving, bigger disk groups are desirable.

Tier setup

In general, it is best to have two tiers instead of three tiers. The highest tier will nearly fill before using the lowest tier. The highest tier must be 95% full before the controller will evict cold pages to a lower tier to make room for incoming writes.

Typically, you should use tiers with SSDs and 10K/15K disks, or tiers with SSDs and 7K disks. An exception may be if you need to use both SSDs and faster spinning disks to hit a combination of price for performance, but you cannot hit your capacity needs without the 7K disks; this should be rare.

VMware missing LUN response

For VMware environments, the missing LUN response setting should be set to *Illegal Request*. You can do this in the CLI by running the following command:

```
set advanced-settings missing-lun-response illegal
```

Multipath configuration

Lenovo Storage systems comply with the SCSI-3 standard for Asymmetrical Logical Unit Access (ALUA). ALUA compliant storage systems will provide optimal and non-optimal path information to the host during device discovery, but the operating system must be directed to use ALUA. You can use the following procedures to direct Windows and Linux systems to use ALUA.

To direct a Windows 2012 system to use ALUA

1. Verify that MPIO is enabled on the host by starting Server Manager.
   a. Select **Local Server**.
   b. Select **Add Roles and Features**.
   c. Select **Role-based** or **Feature Based Installation**.
   d. Select the server from the pool.
   e. Click **Next** to navigate to the feature selection screen.
   f. Verify that Multipath IO is installed. If it is not installed, click the box and then select **Install**.
2. When MPIO is installed, navigate to Server Manager, then Tools.
3. Select **MPIO** from the menu.
4. Select **Discover Multi-Paths**.
5. Your storage system model should be listed. Select the device and then **Add**.
6. When prompted, reboot the system. When the reboot is complete, the system is ready to use.

To direct a Linux system to use ALUA

1. Ensure that the multipath daemon is installed and set to start at run-time. Linux command:
   `chkconfig multipathd on`
2. Ensure the correct entries exist in the `/etc/multipath.conf` file on each OSS/MDS host. Create a separate device entry for the Lenovo Storage system. The following table specifies four attributes that should be set. To obtain the exact vendor and product ID values, run the Linux command: `multipath -v3`

Attribute	Value
`prio`	`alua`
`failback`	`immediate`
`vendor`	`Lenovo`
`product`	*`product-ID`*

3. Instruct the multipath daemon to reload the `multipath.conf` file or reboot the server. Linux command:
   `service multipathd reload`
4. Determine if the multipath daemon used ALUA to obtain the optimal/non-optimal paths. Linux command:
   `multipath -v3 | grep alua`
   You should see output stating that ALUA was used to configure the path priorities. For example:
   `Oct 01 14:28:43 | sdb: prio = alua (controller setting) Oct 01 14:28:43 | sdb: alua prio = 130`

Physical port selection

In an S3200 system configured to use either all FC or all iSCSI ports, use the ports in the following order:

1. A0,B0
2. A2,B2
3. A1,B1
4. A3,B3

The reason for doing so is that each pair of ports (A0,A1 or A2,A3) are connected to a dedicated CNC chip. If you are not using all four ports on a controller, it is best to use one port from each pair (A0,A2) to ensure better I/O balance on the front end.

Boot from SAN

- Use RAID 10 to boot from SAN environments.
- Use faster disks (10K and 15K) to deliver the required performance.
- Data LUNs should be separate from boot LUNs.
- Data LUNs can be used for heavy I/O but boot LUNs should only be used for operating systems.
- As a rule of thumb, use 12 disks in a RAID-10 configuration to run 7 operating systems (7 BFS LUNs + 7 data LUNs).

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.
Additional Sense Code/Additional Sense Code Qualifier	*See* ASC/ASCQ.
Advanced Encryption Standard	*See* AES.
AES	Advanced Encryption Standard. A specification for the encryption of data using a symmetric-key algorithm.
Air Management Sled	*See* AMS.
allocated page	A page of storage-pool space that has been allocated to a volume to store data.
allocation rate	The rate, in pages per minute, at which a pool is allocating pages to its volumes because they need more space to store data.
ALUA	Asymmetric Logical Unit Access.
AMS	For a 2U12 or 2U24 enclosure, Air Management Sled. A drive blank designed to fill an empty disk slot in an enclosure to maintain optimum airflow through the chassis.
array	*See* storage system.
ASC/ASCQ	Additional Sense Code/Additional Sense Code Qualifier. Information on sense data returned by a SCSI device.
ATS	Automated tiered storage. A paged-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.
automated tiered storage	*See* ATS.
auto-write-through	*See* AWT.
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. *See also* compatible disk, dynamic spare, and global 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	For virtual storage, a volume that is not a snapshot of any other volume, and is the root of a snapshot tree.
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	For virtual storage, a 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.
CIM Query Language	*See* CQL.

CIMOM Common Information Model Object Manager. A component in CIM that handles the interactions between management applications and providers.

comma separated values *See* CSV.

Common Information Model *See* CIM.

Common Information Model Object Manager *See* CIMOM.

compatible disk A disk that can be used to replace a failed member disk of a disk group because it both has enough capacity and is of the same type (enterprise SAS, for example) as the disk that failed. *See also* available disk, dynamic spare, and global spare.

complex programmable logic device *See* CPLD.

Configuration Application Programming Interface *See* CAPI.

controller A (or B) A short way of referring to controller module A (or B).

controller enclosure An enclosure that contains one or 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 (CompactFlash); host, expansion, network, and service ports; and midplane connectivity.

converged network controller

Coordinated Universal Time *See* UTC.

CPLD Complex programmable logic device. An electronic component used to build reconfigurable digital circuits. It can replace large numbers of logic gates.

CQL CIM Query Language.

CRC Cyclic Redundancy Check. A mathematical algorithm that, when implemented in software or hardware, can be used to detect errors in data.

CRU Customer-replaceable unit. A part that can be removed and replaced by a customer or a support technician without having to send the product to a repair facility.

CSV Comma separated values. A format to store tabular data in plain-text form.

Cyclic Redundancy Check *See* CRC.

Data Encryption Standard *See* DES.

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.

default mapping Host-access settings that apply to all initiators that are not explicitly mapped to that volume using different settings. *See also* explicit mapping and masking.

DES Data Encryption Standard. An algorithm for the encryption of electronic data.

DHCP Dynamic Host Configuration Protocol. A network configuration protocol for hosts on IP networks.

disk group A set of disk drives that is configured to use a specific RAID type and provides storage capacity for a pool. *See also* virtual disk group.

Distributed Management Task Force	*See* DMTF.
DMTF	Distributed Management Task Force. An industry organization that develops and maintains standards for system management.
drain	Moving active volume data from a virtual disk group to other disk-group members within the same pool.
drive enclosure	*See* expansion enclosure. *See also* JBOD.
drive spin down	*See* DSD.
DSD	Drive spin down. A power-saving feature that monitors disk activity in the storage system and spins down inactive disks based on user-selectable policies. Drive spin down is not applicable to disks in virtual pools.
dual-port disk	A disk that is connected to both controllers so it has two data paths, achieving fault tolerance.
Dynamic Host Configuration Protocol	*See* DHCP.
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. *See also* available disk, compatible disk, and global spare.
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, MC, and SC.
EMP	Enclosure management processor. An EC 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.
enclosure management processor	*See* EMP.
Expander Controller	*See* EC.
expansion enclosure	An enclosure that contains one or two expansion modules. Expansion enclosures can be connected to a controller enclosure to provide additional storage capacity. *See also* JBOD.
expansion module	A FRU that contains the following subsystems and devices: a SAS expander and EC processor; host, expansion, and service ports; and midplane connectivity.
explicit mapping	Access settings for an initiator to a volume that override the volume's default mapping. *See also* default mapping and masking.
failback	*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* 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 method by which you can secure the data residing on a system. *See also* lock key, passphrase, repurpose, and SED.
Fibre Channel Arbitrated Loop	*See* FC-AL.
field-programmable gate array	*See* FPGA.
field-replaceable unit	*See* FRU.

FPGA Field-programmable gate array. An integrated circuit designed to be configured after manufacturing.

FRU Field-replaceable unit. A part that can be removed and replaced by the user or support technician without having to send the product to a repair facility. *See also* CRU.

full disk encryption *See* FDE.

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. *See also* available disk, compatible disk, and dynamic spare.

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 group of initiators that represents a server or switch.

host bus adapter *See* HBA.

host group A user-defined group of hosts for ease of management, such as for mapping operations.

host port A port on a controller module that interfaces to a host computer, either directly or through a network switch.

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.

I/O Manager A MIB-specific term for a controller module.

I/O module *See* IOM.

IOM Input/output module. An IOM can be either a controller module or an expansion module.

IQN iSCSI Qualified Name.

iSCSI Internet SCSI interface protocol.

iSNS Internet Storage Name Service.

JBOD "Just a bunch of disks." *See* drive enclosure.

large form factor *See* LFF.

LBA Logical Block Address. The address used for specifying the location of a block of data.

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 and passphrase.

logical block address *See* LBA.

Logical Unit Number *See* LUN.

loop *See* FC-AL.

Loop Initialization Primitive *See* LIP.

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.

Management Information Base *See* MIB.

map/mapping Settings that specify whether a volume is presented as a storage device to a host system, and how the host system can access the volume. Mapping settings include an access type (read-write, read-only, or no access), controller host ports through which initiators may access the volume, and a LUN that identifies the volume to the host system. *See also* default mapping, explicit mapping, and masking.

masking A volume-mapping setting that specifies no access to that volume by hosts. *See also* default mapping and explicit mapping.

MC Management Controller. A processor (located in a controller module) that is responsible for human-computer interfaces, such as the SMC, and computer-computer interfaces, such as SNMP, and interacts with the Storage Controller. *See also* EC and SC.

Media Access Control Address *See* MAC address.

metadata Data in the first sectors of a disk drive that stores all 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.

mount To enable access to a volume from a host OS. *See also* host, map/mapping, and volume.

network port The Ethernet port on a controller module through which its Management Controller is connected to the network.

network time protocol *See* NTP.

NTP Network time protocol.

object identifier *See* OID.

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 virtual 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 volumes exceeds the physical capacity of the storage system.

page For virtual storage, 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 For virtual storage, 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 and lock key.

PCBA Printed circuit board assembly.

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 connection between devices in a SAS network that enables transmission of data.

physical layer *See* PHY.

point-to-point Fibre Channel Point-to-Point topology in which two ports are directly connected.

pool *See* virtual pool.

POST Power-on self test. Tests that run immediately after a device is powered on.

Power-On Self Test *See* POST.

power supply unit *See* PSU.

primary system For virtual replication, the storage system that contains a replication set's primary volume. See also replication set, secondary system.

primary volume For virtual replication, the source volume in a replication set. This volume's data will be replicated to the secondary volume in the secondary system. *See also* replication set, secondary volume.

PSU Power supply unit. The power supply FRU.

quick rebuild A feature that reduces the time that user data is less than fully fault-tolerant after a disk failure in a disk group. The quick-rebuild process rebuilds only data stripes that contain user data. Data stripes that have not been allocated to user data are rebuilt in the background.

RAID head *See* controller enclosure.

read cache For virtual storage, a special disk group using SSDs that can be added to a virtual pool for the purpose of speeding up read access to data stored on spinning disks elsewhere in the pool. Read cache is also referred to as read flash cache.

read flash cache *See* read cache.

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 iSCSI links. The capability to replicate volumes is a licensed feature.

replication set For virtual replication, 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 and secondary volume.

repurpose A method by which all data on a system or disk is erased in an FDE-capable system. Repurposing unsecures the system and disks without needing the correct passphrase. *See also* FDE and passphrase.

RFC Read flash cache. *See* read cache.

SAS Serial Attached SCSI interface protocol or disk-drive architecture.

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 and MC.

SCSI Enclosure Services *See* SES.

secondary system The storage system that contains a replication set's secondary volume. *See also* replication set, 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 pool (virtual storage) in a secondary storage system.

secret For use with CHAP, a password that is shared between an initiator and a target to enable authentication.

secure hash algorithm *See* SHA.

secure shell *See* SSH.

Secure Sockets Layer *See* SSL.

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.

SEEPROM	Serial electrically erasable programmable ROM. A type of nonvolatile (persistent if power removed) computer memory used as FRU ID devices.
Self-Monitoring Analysis and Reporting Technology	*See* SMART.
serial electrically erasable programmable ROM	*See* SEEPROM.
Service Location Protocol	*See* SLP.
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. A type of disk drive.
SHA	Secure Hash Algorithm. A cryptographic hash function.
SLP	Service Location Protocol. Enables computers and other devices to find services in a local area network without prior configuration.
Small Footprint CIM Broker	*See* SFCB.
small form factor	*See* SFF.
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.
SMC	The web application that is embedded in each controller module and is the primary management interface for the storage system.
SMI-S	Storage Management Initiative - Specification. The SNIA standard that enables interoperable management of storage networks and storage devices. The interpretation of CIM for storage. It provides a consistent definition and structure of data, using object-oriented techniques.
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 both the source volume and in its pool. A snapshot can be mapped and written to. The capability to create snapshots is a licensed feature. 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 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, and source volume.
SNIA	Storage Networking Industry Association. An association regarding storage networking technology and applications.
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 Console	*See* SMC.

Storage Management Initiative - Specification *See* SMI-S.

Storage Networking Industry Association *See* SNIA.

storage system A controller enclosure with at least one connected drive enclosure. 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.

thin provisioning A 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 For virtual storage, a homogeneous set of disk drives, typically of the same capacity and performance level, that comprise one or more 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 SAS SSDs (high speed)
- Standard, which uses enterprise-class spinning SAS disks (lower speed, higher capacity)
- Archive, which uses midline spinning SAS disks (low speed, high capacity).

tier migration For virtual storage, the automatic movement of blocks of data, associated with a single volume, between tiers based on the access patterns that are detected for the data on that volume.

tray *See* enclosure.

UCS Transformation Format - 8-bit *See* UTF-8.

ULP Unified LUN Presentation. A RAID controller feature that enables a host system to access mapped volumes through any controller host port. ULP incorporates Asymmetric Logical Unit Access (ALUA) extensions.

undercommitted The amount of storage capacity that is allocated to volumes is less than the physical capacity of the storage system.

Unified LUN Presentation *See* ULP.

unmount To remove access to a volume from a host OS.

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.

UTC Coordinated Universal Time. The primary time standard by which the world regulates clocks and time. It replaces Greenwich Mean 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 CLI and SMC interfaces.

virtual The storage-class designation for logical components such as volumes that use paged-storage technology to virtualize data storage. *See* paged storage.

virtual disk group For virtual storage, a set of disk drives that is configured to use a specific RAID type. A virtual disk group can use RAID 1, 5, 6, or 10. A virtual disk group can be added to a new or existing virtual pool. *See also* virtual pool.

virtual pool For virtual storage, a container for volumes that is composed of one or more virtual disk groups.

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 group	A user-defined group of volumes for ease of management, such as for mapping operations.
WBEM	Web-Based Enterprise Management. A set of management and internet standard technologies developed to unify the management of enterprise computing environments.
web-based interface/web-browser interface	*See* WBI.
WBI	Web-browser interface, called Storage Management Console. The primary interface for managing the system. A user can enable the use of HTTP, HTTPS for increased security, or both.
Web-Based Enterprise Management	*See* WBEM.
World Wide Name	*See* WWN.
World Wide Node Name	*See* WWNN.
World Wide Port Name	*See* WWPN.
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.

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