SGI InfiniteStorage 4000 Series and 5000 Series Concepts Guide for SANtricity ES Storage Manager

(ISSM 10.83)

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The information in this document supports the SGI InfiniteStorage 4000 series and 5000 series storage systems (ISSM 10.83). Refer to the table below to match your specific SGI InfiniteStorage product with the model numbers used in this document.

SGI Model #	Netapp Model	Netapp Compliance Model	Notes
TP9600H	6091	1500	
TP9700F	6091	1500	
IS4500F	6091	1500	
TP9600F	3994 and 3992	4600	
IS4000H	3994	4600	
IS350	3992	4600	
IS220	1932 1333 DE1300	3600	
IS4100	4900	4600	FC HICs only
IS-DMODULE16-Z	FC4600	4600	
IS-DMODULE60	DE6900	6900	
IS4600	7091	1550	4Gb FC, 8Gb FC, HICs only
IS5012	2600	3650	FC and SAS HICs only
IS5024	2600	5350	
IS5060	2600	6600	
IS-DMODULE12 & IS2212 (JBOD)	DE1600	3650	
IS-DMODULE24 & IS2224 (JBOD)	DE5600	5350	
IS-DMODULE60-SAS	DE6600	6600	
IS5512	5400	3650	
IS5524	5400	5350	
IS5560	5400	6600	

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Table of Contents

SANtricity ES Concepts for Version 10.83 1

The information in this guide provides the conceptual framework necessary to understand the features and functions of the SANtricity™ ES Storage Manager for Version 10.83.

NOTE The SANtricity ES Storage Manager software is also referred to as the storage management software.

New Features

This release of the SANtricity ES Storage Manager provides new software functionality. Some of the new prominent features include:

Enterprise Management Window (EMW) – The **Tools** menu on the EMW now contains options that let you automatically collect support data when the client monitor process detects an event or create a schedule for support data collection for one or several storage arrays.

Array Management Window (AMW) – Many features were added, moved or renamed in the current software release to make the AMW more visually appealing and intuitive. The first time you launch the AMW you'll notice the following changes:

- *Menu bar* contains new menus with additional menu options.
  - **Storage Array** menu options let you manage security and settings, and configure your storage array.
  - **Storage** menu provides commands to organize the drives in a storage array into a disk pool or a volume group and then into volumes.
  - **Copy Services** menu can contain tasks related to Volume Copy (premium feature), Snapshot Images (premium feature), Consistency Groups (premium feature), Snapshot (Legacy) Images (premium feature), and Mirroring options. The Copy Services menu contains the menu options that are premium features only when the features are enabled.
  - **Host Mappings** menu provides the options that let you configure the default host type and Port ID, and complete host mapping tasks.
  - **Hardware** menu options pertain to the controllers, drive trays, and drives that comprise your storage array.
  - **Monitor** menu provides the options to monitor the performance of your storage array, troubleshoot a problem, gather statistics, and generate reports. One of the important functions available from the Monitor menu is the ability to run configuration database diagnostics. For more information about using this function, refer to the topic *Running Configuration Database Diagnostics* in online help.
  - **Upgrade** menu provides the tasks related to firmware upgrades and collecting firmware inventory and drive tray configuration information.

- *Icons in the Toolbar* automatically appear when you access the AMW.
- *Tabs* have been renamed and reorganized to provide information, icons and links that make it easier to configure, maintain, and monitor your storage array, the storage, and the hardware components.
- *Premium Feature status area* shows the premium features that are available for your storage array and which features are enabled or disabled. The enabled features have color but the disabled features are gray. You place the pointer on the icon to see if the feature is enabled or disabled, or if the feature is included in the Try and Buy offering.

For more information about the AMW, see the topic *Learn About the Array Management Window* in online help.

Try and Buy – Try and Buy is a way for you to try a select group of the premium features for a pre-determined evaluation period before purchasing the feature. Unlike typical evaluation versions of software, the Try and Buy features do not have limited capability. You can use all aspects of the feature with the only imposed limit being the amount of time you are permitted to use the feature before purchasing it. The available Try and Buy features can vary by storage array. For more information about the Try and Buy features, see the topic *Using a Trial Version of a Premium Feature* in online help.

Disk Pools – Similar to a volume group, a disk pool is a set of drives that is logically grouped together from which you create volumes. Unlike a volume group, you do not need to select hot spare drives, RAID level, or segment size because the disk pool manages those attributes. A disk pool is made up of a minimum of 11 SAS hard disk drives (HDD) and can contain potentially hundreds of drives. Disk pools and volume groups can coexist in a storage array. Some of the benefits of creating a disk pool are simplified configuration, better utilization of drives, and reduced maintenance. Disk pools are available only on the E2600 controller and the E5400 controller. For more information about disk pools, see the topic *Learn About Disk Pools and Disk Pool Volumes* in online help.

Thin Volumes – Within a disk pool, you can create either standard volumes or thin volumes. For a standard volume, all of the capacity is allocated up front. For a thin volume, which requires that the Thin Provisioning premium feature is enabled for your storage array, the capacity is allocated as the data is being written. Thin provisioning eliminates the large amounts of unused capacity that can occur with standard volumes, thereby minimizing your up-front costs, floor space, energy costs, and administration time. You must create thin volumes from disk pools. Thin volumes are available only on the E2600 controller and the E5400 controller. For more information about thin volumes, see the topic *Thin Volumes* in online help.

Snapshot Images – A snapshot image is a logical point-in-time image of a volume. Both the Snapshot and Snapshot (Legacy) features are premium features and must be enabled for your storage array. The Snapshot image feature is similar to the snapshot (legacy) feature, with the following differences:

- When there are multiple point-in-time images for a base volume, the new snapshot image feature offers improved performance. The snapshot (legacy) feature uses one repository volume for each snapshot (legacy) volume. The new snapshot image feature uses one repository volume for all of the snapshot images associated with a snapshot group. Therefore, when a base volume is written to, the new snapshot image feature requires only one write operation for each snapshot group instead of multiple, sequential write operations.
- The new snapshot image feature adds the concept of a snapshot group. Because there is only one repository for multiple snapshot images, the repository is associated with the snapshot group instead of with the snapshot image as it is with the snapshot (legacy) feature.
- Unlike a snapshot (legacy) volume, a new snapshot image is not directly read/write accessible by hosts because the snapshot image is used only to save the changed data for a base volume. To provide hosts with read/write access to a snapshot image, you must first create a snapshot volume.
- When the Snapshot premium feature is enabled, you can create consistency groups to pool multiple volumes together so that a snapshot can be taken of all the volumes at the same point in time.

Snapshot images, snapshot groups, and snapshot volumes are available only on the E2600 controller and the E5400 controller. To learn more about snapshot images, snapshot groups, and snapshot volumes, see the topic *About Snapshot Operations* in online help.

Consistency Group – If you frequently want to perform the same snapshot image operations on multiple volumes, you can create a consistency group. A consistency group is a group of volumes that you treat as one entity. An operation that you perform on the consistency group is performed simultaneously on all of the volumes in the consistency group. Snapshot image operations that you can perform on a consistency group include creating a snapshot, scheduling snapshot images, and rolling back to a previous snapshot. The Consistency Group feature is available when the Snapshot premium feature is enabled for your storage array. Consistency groups are available only on the E2600 controller and the E5400 controller. For more information about consistency groups, see the topic *Creating Consistency Groups* in online help.

Asymmetric Logical Unit Access (ALUA) – ALUA is a new feature implemented in the controller firmware (CFW) that allows input/output (I/O) access to any controller port and manages volume ownership based on I/O access. When you create volumes using the SANtricity ES Storage Manager, you must assign a controller to own a volume. After the assignment is made, this volume is referred to as the *preferred owner*. In many cases, the preferred owner is selected to achieve load balancing across controllers.

In previous releases, if an I/O request was received by the non-owning controller, the I/O was either rejected or, if the Automatic Volume Transfer (AVT) feature was enabled, the controller would transfer ownership of the volume to the controller receiving the I/O. With the ALUA feature, if an I/O request is received by the non-owning controller, the controller uses an I/O Shipping model to transfer I/O internally to the owning controller for servicing, and the results/status are returned to the non-owning controller. Then the non-owning controller passes the results/status back to the host.

If the non-owning controller receives most of the I/O for a period of time, the controller transfers volume ownership to the controller receiving most of the I/O. If the condition which caused ownership of a volume to be transferred to the non-preferred controller is resolved, most host multipath drivers transfer the volume back to its preferred owner. ALUA is available only on the E2600 controller and the E5400 controller.

Storing Your Data

This section describes the basic storage concepts, methods for managing storage arrays (including data-protection strategies) and multi-path failover drivers.

For additional information and detailed procedures for the options described in this section, refer to the online help topics for your version of the storage management software.

Storage Arrays

A storage array configuration provides a secure and robust system that can store large amounts of data and offers different ways to backup and retrieve data. Administrators can set up the storage management software to maintain a specific level of security and configuration on the storage area network (SAN), so that the network requires little human interaction to perform its daily functions.

A storage array is a collection of both physical and logical components. Physical components can include drives, controller, fans, and other hardware. The physical drives are grouped into volume groups, disk pools, or both. The storage capacity of these volume groups or disk pools is organized into logical volumes.

Storage Area Networks

A storage area network (SAN) transfers data between computers and storage systems. A SAN is comprised of many hardware components. Each hardware component might have a device manager or third-party management software.

A SAN includes one or more storage arrays that are connected to I/O hosts to move I/O data.

The SAN can include storage management stations or use the I/O hosts to run the storage management software. A storage management station manages the storage arrays but does not send I/O data to them. Although physical storage array configurations vary, all SANs work using these basic principles.

You can use the storage management software to add, monitor, manage, and logically remove the storage arrays on your SAN.

Within the storage management software, you can configure the data to be stored in a particular configuration over a series of physical storage components and logical (virtual) storage components (that is physical drives, logical disk pools or volume groups, and logical volumes).

The I/O data and management instructions are sent from a host to the controllers in the storage array. The controllers distribute the data and instructions across a series of drives which are mounted in trays.

Drive Configuration

SANtricity ES Storage Manager enables you to configure a collection of drives into either a disk pool, a volume group, or both. A disk pool or a volume group contains drives with the same or similar characteristics. The characteristics used to determine similar drives are:

- **Drive type** – The types of drives supported for a volume group are Fibre Channel, SATA, or SAS. A disk pool can consist of only SAS drives.
- **Drive media type** – The drive media supported for a volume group is Hard Disk Drive (HDD) or Solid State Disk (SSD). A disk pool can have only SAS HDD drives.
- **Spindle speed** – The spindle speed of the drives in a disk pool or a volume group must be the same.
- **Security level** – The drive security must be the same for all the drives if an entire disk pool or a volume group is to be secured at a designated security level.

NOTE All security levels are not supported for all configurations.

- **Capacity** – To use the capacity of the drives in a disk pool or a volume group efficiently, the capacity should be the same. If the drives in a disk pool or a volume group have different capacities, the storage management software uses only the capacity equal to the capacity of the smallest drive in a disk pool or a volume group. For example, if your disk pool is comprised of several 4-GB drives and several 8-GB drives, the storage management software uses up to 4 GB on each drive; meaning 4 GB of the 8-GB drives remains unused.

Within a disk pool or a volume group the drives are further organized into volumes. A volume is a logical component that a host uses to organize data storage on a storage array. The host operating system sees a volume as a single drive even though data is written across several physical drives within a disk pool or a volume group. Each volume is mapped to a logical unit number (LUN) that a host uses to access a volume. A host attached to a storage array writes data to the volumes and reads data from the volumes.

Disk Pools and Volume Groups

When you have your storage array assembled, you use the storage management software to group a collection of drives into one or more disk pools, one or more volume groups, or a mix of one or more disk pools and one or more volume groups. A disk pool and a volume group can coexist on the same storage array.

Disk Pools

A disk pool is a collection of 11 or more SAS drives in a storage array that have the same spindle speed, the same security level, and preferably the same capacity to make the most efficient use of the drives. You cannot create a disk pool on solid state drives (SSD).

A storage array can contain one or more disk pools, although the benefits of using a disk pool increase as the number of drives in a disk pool increase. Creating a disk pool with the largest number of similar drives is the preferred approach. However, if not all drives in the storage array have the same characteristics or if you want certain drives to support different applications, you can create more than one disk pool on your storage array. There is no practical limit on the number of drives that can comprise a disk pool, although a disk pool cannot contain more drives than the maximum limit for each storage array.

Two differences between setting up a disk pool and a volume group are: with a disk pool the RAID level is preset to RAID 6, and there is no need to designate a hot spare drive. In a disk failure condition in a disk pool, instead of using hot spare technology all the operational drives in the disk pool participate in the reconstruction process. The reconstruction data space is used to reconstruct the data from the failed drive. With a volume group, hot spare technology is used to recover from a drive failure condition and you select the RAID level during the configuration process.

Volume Groups

A volume group is a collection of drives in a storage array that have the same type of drive (Fiber Channel, SATA or SAS) and have the same type of drive media (HDD or SSD). The minimum and maximum number of drives that can comprise a volume group depends on the RAID level you plan to assign to the volume group.

When you create a volume group, you can create a hot spare drive to support a volume group. The hot spare drive will not be part of the volume group but must be available for the volume group to use in the event of a disk failure. The hot spare drive must match the characteristics of the drives in the volume group otherwise some of the capacity of the hot spare is not used.

Advantages of using a volume group are the ability to have control over the RAID level and segment size of volumes in a volume group.

A storage array can contain one or more volume groups. You can create several volume groups if the drives in your storage array have different characteristics (Fibre Channel drives and SATA drives with different capacities), if you want to use different RAID levels, or if you want certain drives to support different applications. When you create a volume group, you assign a RAID level. This RAID level determines how redundancy or parity data is stored on the drives that comprise the volumes within the volume group.

When a host operating system writes data to the volumes within a volume group, the user data and redundancy or parity data is distributed across the drives in a volume group. Information about data locations is maintained by the controller. If a drive fails within a volume group, a hot spare drive takes over for the failed drive and is used in the data recovery process. To recover the data from the failed drive, the controller uses redundancy or parity data stored based on the RAID level assigned to a volume group.

Volumes

In your disk pool or volume group you need to create volumes for organizing your data. Volumes can be either standard volumes or thin volumes. You can create a standard volume in a disk pool or a volume group. You can create only a thin volume in a disk pool when the Thin Provisioning Premium Feature is enabled for your storage array.

When you create a standard volume you allocate the available storage up front, configuring the capacity of a standard volume to meet application needs for data availability and I/O performance. To increase the storage available for host I/O data writes, you need to add additional drives to the disk pool or volume group. Then you can create new volumes or expand volume capacity (if this feature is supported by your host operating system).

Thin volumes let you create large virtual volumes with small physical storage allocations that can grow over time to meet increased capacity demands. As storage demands increase, you can increase the amount of physical storage capacity as it is needed. Using thin volumes helps to reduce the possibility of having excess, unused capacity in the disk pool.

Thin volumes are volumes that have a large virtual capacity available for host I/O data writes, but not all of the virtual capacity is associated with the allocated physical capacity. When you configure a thin volume, you specify two types of capacity: the *virtual* capacity and the *preferred* capacity. The virtual capacity is the capacity that is reported to the host. The preferred capacity (also referred to as provisioned capacity and physical capacity) is the amount of physical drive space that is currently allocated for writing data. An administrator can increase the preferred capacity as capacity demands increase.

For thin volumes, an administrator can configure two attributes to help monitor capacity utilization of the volume and prevent a host write request from failing due to insufficient capacity. An administrator can set a *repository utilization warning threshold* percentage which causes the storage management software to generate an alert when the specified percentage of capacity is utilized. To permit the system to automatically expand the provisioned capacity by a specified amount when a repository utilization warning threshold is reached, an administrator can set an *automatic expansion policy* amount.

Some of the differences between a standard volume and a thin volume are:

- Supported volume types – You can create a standard volume from a disk pool or a volume group. You can create a thin volume from only a disk pool.
- Capacity allocation – With a standard volume you allocate the available storage capacity up front. With a thin volume you specify a virtual capacity and a preferred (or physical) capacity, and increase the preferred capacity to meet real capacity demands over time.
- Capacity increments – You can create the capacity of a standard volume in any increment. You must allocate capacity for a thin volume in increments of 4 GB.
- Premium feature – You can create a standard volume without enabling any premium features. You must enable the Thin Provisioning premium feature before you create a thin volume.

Management Methods

Depending on your system configuration, you can use an out-of-band management method, an in-band management method, or both to manage a storage array controller from a storage management station or host.

NOTE A maximum of eight storage management stations can concurrently monitor an out-of-band managed storage array. This limit does not apply to systems that manage the storage array through the in-band management method.

NOTE The out-of-band management method and the in-band management method are not supported on all controllers.

Out-of-Band Management

You can use the out-of-band management method to manage a storage array directly over the network through an Ethernet connection, from a storage management station to the ethernet port on the controllers. This management method lets you manage all of the functions in the storage array.

NOTE Storage management stations require Transmission Control Protocol/Internet Protocol (TCP/IP) to support the out-of-band management of storage arrays.

In-Band Management

You can use the in-band management method to manage a storage array in which the controllers are managed through an I/O connection from a storage management station to a host that is running host-agent software. The I/O connection can be Serial Attached SCSI (SAS), Fibre Channel (FC), or internet SCSI (iSCSI). The host-agent software receives communication from the storage management client software and passes it to the storage array controllers along an I/O connection. The controllers also use the I/O connections to send event information back to the storage management station through the host.

When you add storage arrays by using this management method, you must specify only the host name or IP address of the host. After you add the specific host name or the IP address, the host-agent software automatically detects any storage arrays that are connected to that host.

NOTE Systems running desktop (non-server) Windows operating systems and desktop Linux operating systems can be used only as storage management stations. You cannot use systems running desktop operating systems to perform I/O to the storage array and to run the host-agent software.

RAID Levels and Data Redundancy

Redundant Array of Independent Disks (RAID) is a storage function that allows data on a failed drive to be recovered. If a drive in a disk pool or a volume group fails, a controller uses the information stored as parity or redundant data to reconstruct data from a failed drive. The reconstructed data is saved to a hot spare drive configured for a volume group or the reserved reconstruction space on operational drives in a disk pool.

RAID has a series of configurations, called levels that determine how to manage data so it can be recovered in the event of a hard disk drive failure. Each RAID level provides different performance features and protection features. One difference between a volume group and a disk pool is that a volume group provides more RAID choices whereas disk pools are automatically based on RAID 6.

RAID for a Disk Pool

When you create a disk pool, the storage management software automatically configures RAID Level 6. This means that all volumes that comprise a disk pool have RAID Level 6. You cannot set or change the RAID level of a disk pool.

A volume group that coexists with a disk pool in a storage array can have a RAID level that is different from the RAID level auto-assigned for the disk pool. Because disk pools use 8+2 RAID 6 as the underlying data protection mechanism, two drives worth of capacity out of every 10 drives is dedicated to redundancy data.

The reserved reconstruction space allocated in a disk pool is in addition to the RAID 6 redundancy data. If a drive fails, the user data and redundancy data stored on the failed drive is reconstructed using the reserved reconstruction space on the remaining drives in the disk pool.

Recovery from a drive failure condition is faster in a disk pool as compared to a volume group because all the drives in a disk pool are used to recover the data and the reconstructed data is written to all the drives in the disk pool rather than to a single hot spare drive.

The reconstruction process runs in the background so there is minimal impact to the I/O processing. RAID 6 can tolerate the simultaneous failure of two drives before data availability is affected, regardless of whether the drives are in a volume group or a disk pool.

A disk pool uses distributed spare capacity rather than hot spare drives in the reconstruction process.

RAID for a Volume Group

In a volume group, the data is distributed across the volumes based on a RAID level. You can specify the RAID level when you create a volume group. The storage management software offers five RAID level configurations for a volume group: RAID Level 0, RAID Level 1, RAID Level 3, RAID Level 5, RAID Level 6. If available for your storage array, you also can select RAID Level 10. Select the RAID level that you want to apply to all volumes that comprise a volume group. You can configure only one RAID level for each volume group. If you need to use more than one RAID level, create multiple volume groups and select the appropriate RAID level for each volume group. If a volume group and a disk pool coexist in a storage array, the volume group and disk pool can have different RAID levels.

Each RAID level has a minimum number of drives required to perform the RAID functions. RAID 0 does not provide data redundancy so all drives are used for user data. RAID 1, RAID 3, RAID 5, RAID 6, and RAID 10 each require two or more drives, one drive for user data and another one or more drives for redundancy data or parity.

Parity is derived through a logical operation on the data. A controller uses the parity to recover data that was on the failed drive. Parity can exist on only one drive or can be distributed among all of the drives in a volume group. RAID 3, RAID 5, and RAID 6 write parity to the drive media for fault tolerance. The capacity needed to perform the recovery process depends on the selected RAID level. RAID 1 and RAID 10 are fully redundant.

RAID Level Configuration Table for Volume Groups

RAID Level	Short Description	Detailed Description
RAID Level 0	No protection against loss of a drive (non-redundant), striping mode	■ A minimum of one drive is required for RAID Level 0. ■ RAID Level 0 can use the maximum number of drives in a storage array. ■ You can use RAID Level 0 for high-performance needs, but it does not provide *data redundancy*. ■ Data is striped across all of the drives in the volume group. ■ Do not use this RAID level for high data-availability needs. RAID Level 0 is better for non-critical data. ■ A single drive failure in a volume group causes all of the volumes associated with the volume group to fail, and data loss occurs.

RAID Level	Short Description	Detailed Description
RAID Level 1 or RAID Level 10	Striping and mirroring mode	■ A minimum of two drives are required for RAID Level 1: one for the user data and one for the mirrored data. If you select four or more drives, RAID Level 10 is automatically configured across the volume group: two drives for the user data, and two drives for the mirrored data. ■ RAID Level 1 and RAID Level 10 can use the maximum number of drives in a storage array. ■ RAID Level 1 and RAID Level 10 typically provide the best write performance, but not in all cases. On a RAID Level 1 volume, data is written to a duplicate drive. On a RAID Level 10 volume, data is striped across mirrored pairs. ■ If one of the drives in a drive-pair fails, the system can instantly switch to the other drive without any loss of data or service. ■ RAID Level 1 and RAID Level 10 use drive mirroring to make an exact copy from one drive to another. ■ A single drive failure causes associated volumes to become degraded, but the mirror drive allows access to the data. ■ Two or more drive failures in a volume group causes the volumes associated with the volume group to fail, and data loss occurs.
RAID Level 3	High-bandwidth mode	■ A minimum of three drives is required for RAID Level 3. ■ RAID Level 3 is limited to a maximum of 30 drives in a volume group. ■ RAID Level 3 stripes user data across the drives. The redundancy data is stored on a drive dedicated to parity. ■ RAID Level 3 uses the equivalent of the capacity of one drive (in a volume group) for redundancy data. ■ RAID Level 3 is used for applications with large data transfers, such as multimedia or medical imaging that write and read large sequential chunks of data. ■ A single drive failure in a volume group causes the associated volumes to become degraded, but the redundancy data allows access to the data. ■ Two or more drive failures in a volume group causes the volumes associated with the volume group to fail, and data loss occurs.

RAID Level	Short Description	Detailed Description
RAID Level 5	High I/O mode	■ A minimum of three drives is required for RAID Level 5. ■ RAID Level 5 is limited to a maximum of 30 drives in a volume group. ■ RAID Level 5 stripes both user data and redundancy data (parity) across the drives. ■ RAID Level 5 uses the equivalent of the capacity of one drive (in a volume group) for redundancy data. ■ A single drive failure in a volume group causes associated volumes to become degraded, but the redundancy data allows access to the data. ■ Two or more drive failures in a volume group causes the volumes associated with the volume group to fail, and data loss occurs.
RAID Level 6 as it applies to volume groups	High I/O mode with simultaneous drive failure protection	■ A minimum of five drives is required for RAID Level 6. ■ RAID Level 6 is limited to a maximum of 30 drives in a volume group. ■ RAID Level 6 stripes both user data and redundancy data (parity) across the drives. ■ RAID Level 6 uses the equivalent of the capacity of two drives (in a volume group) for redundancy data.

Dynamic RAID-Level Migration

Dynamic RAID-Level Migration (DRM) is a modification operation that lets you change the RAID level on a selected volume group without impacting data I/O. Data I/O activity continues on volumes within the volume group during the migration process.

The volume group must contain sufficient free capacity and the required number of drives to support the new RAID level, or the DRM request is rejected. You cannot cancel the DRM operation after the process begins.

NOTE If RAID Level 6 is a premium feature on your storage array, you must enable RAID Level 6 with a feature key file before migrating a volume group to RAID Level 6.

NOTE Dynamic RAID-Level Migration (DRM) is not a supported feature in disk pools.

Hardware Redundancy

Data-protection strategies provided by the storage array hardware include controller cache memory, hot spare drives, background media scans, and channel protection.

NOTE With disk pools, a hot spare drive is not required.

Controller Cache Memory

Write caching, or caching a drive segment to a memory buffer before writing to the drive, can increase I/O performance during data transfers.

Write-cache mirroring protects data during a controller-memory failure or a cache-memory failure. When you enable write cache, cached data is mirrored across two redundant controllers with the same cache size. Therefore, if one controller fails, the alternate controller can complete all outstanding write operations.

To prevent data loss or corruption, the controller periodically writes cache data to a drive (flushes the cache) when the amount of unwritten data in the cache reaches a certain level, called a start percentage, or when data has been in the cache for a predetermined amount of time. The controller continues to write data to a drive until the amount of data in the cache drops to a stop percentage level. You can configure the start percentage and the stop percentage to suit your own storage requirements. For example, you can specify that the controller start flushing the cache when it reaches 80-percent full and stop flushing the cache when it reaches 16-percent full.

In case of power outages, data in the controller cache memory is protected. Controller trays and controller-drive trays contain batteries that protect the data in the cache by maintaining a level of power until the data can be written to the drive media or a flash memory card.

If the controller supports a flash memory card, the cache data can be written to the flash memory card when a power outage occurs. For example, the E2600 controller-drive tray supports a flash memory card to write the cache data. The battery is needed only to maintain power while the data in the cache is written to the flash memory card. The flash memory card provides nonvolatile backup of the cache data in case of long power outages. When power is restored to the controllers, the cache data can be read from the flash memory card by the controller.

If a power outage occurs when there is no UPS, and there is no battery or the battery is damaged, the data in the cache that has not been written to the drive media is lost. This situation occurs even if the data is mirrored to the cache memory of both controllers. Therefore, make sure that you change the batteries in the controller tray and the controller-drive tray at the recommended time intervals.

Tray Loss Protection

When you create a volume group using the tray loss protection feature, all of the drives in the volume group are found in different drive trays. Tray loss protection provides more data protection if access to the tray is lost. This feature is used by default when you choose the automatic configuration option for volume groups, if this feature is supported by your configuration.

Tray loss protection depends on the number of trays that are available, the value set for the Redundant Array of Independent Disks (RAID) level, and the number of drives in the volume group. For example, tray loss protection cannot be achieved if a RAID Level 5 volume group is comprised of eight drives, but there are only three trays. Configuring your volume groups to have tray loss protection is recommended. If your configuration supports the minimum number of drive trays for your RAID level, create your volume groups to have tray loss protection.

If a volume group already has a Degraded status due to a failed drive when a drawer fails, drawer loss protection may not protect the volume group. The data on the volumes might become inaccessible.

NOTE The Tray Loss Protection feature is used only with volume groups.

Table 1 Criteria for Using Tray Loss Protection for Your Volume Groups

RAID Level	Criteria for Tray Loss Protection
RAID Level 0	No tray loss protection (RAID Level 0 does *not* provide redundancy).
RAID Level 1 or RAID Level 10	For RAID Level 1, the volume group must use a minimum of two drives found in separate trays. For RAID Level 10, the volume group must use a minimum of four drives found in separate trays.
RAID Level 3	The volume group must use a minimum of three drives found in separate trays.
RAID Level 5	The volume group must use a minimum of three drives found in separate trays.
RAID Level 6 (as it applies to volume groups)	The volume group must use a minimum of five drives, with a maximum of two drives in any tray.

Drawer Loss Protection

Drawer loss protection is a characteristic of a volume group and is available only in the DE6900 drive tray and the DE6600 drive tray.

NOTE The Drawer Loss Protection feature is used only with volume groups.

In drive trays that contain drives in drawers, a drawer failure can lead to inaccessibility of data on the volumes in a volume group. A drawer might fail because of a loss of power, a failure of an environmental services module (ESM), or a failure of an internal component within the drawer.

The availability of drawer loss protection for a volume group is based on the location of the drives that comprise the volume group. In the event of a single drawer failure, data on the volumes in a volume group remains accessible if the volume group has drawer loss protection. If a drawer fails and the volume group is drawer loss protected, the data remains accessible.

To achieve drawer loss protection, make sure that the drives that comprise a volume group are located in different drawers with respect to their RAID levels as shown in Table 2.

Table 2 Crieria for Using Drawer Loss Protection with Volume Groups

RAID Level	Criteria for Drawer Loss Protection
RAID Level 3 and RAID Level 5	RAID Level 3 and RAID Level 5 require a minimum of three drives. Place all of the drives in different drawers for a RAID Level 3 volume group and for a RAID Level 5 volume group to achieve drawer loss protection. Drawer loss protection cannot be achieved for RAID Level 3 and RAID Level 5 if more than one drive is placed in the same drawer.
RAID Level 6	RAID Level 6 requires a minimum of five drives. Place all of the drives in different drawers or place a maximum of two drives in the same drawer and the remaining drives in different drawers to achieve drawer loss protection for a RAID Level 6 volume group.

RAID Level	Criteria for Drawer Loss Protection
RAID Level 1 and RAID Level 10	RAID Level 1 requires a minimum of two drives. Make sure that each drive in a mirrored pair is located in a different drawer. If you make sure that each drive in a mirrored pair is located in a different drawer, you can have more than two drives of the volume group within the same drawer. For example, if you create a RAID Level 1 volume group with six drives (three mirrored pairs), you can achieve the drawer loss protection for the volume group with only two drawers as shown in this example: Six-drive RAID Level 1 volume group: ■ Mirror pair 1 = Drive in tray 1, drawer 1, slot 1, and drive in tray 1, drawer 2, slot 1 ■ Mirror pair 2 = Drive in tray 1, drawer 1, slot 2, and drive in tray 1, drawer 2, slot 2 ■ Mirror pair 3 = Drive in tray 1, drawer 1, slot 3, and drive in tray 2, drawer 2, slot 3 RAID Level 10 requires a minimum of four drives. Make sure that each drive in a mirrored pair is located in a different drawer.
RAID Level 0	You cannot achieve drawer loss protection because the RAID Level 0 volume group does not have redundancy.

NOTE If you create a volume group by using the automatic drive selection method, the storage management software attempts to choose drives that provide drawer loss protection. If you create a volume group by using the manual drive selection method, you must use the criteria that are specified in Table 2. For more information about how to create volume groups, refer to the *Using the Create Volume Group Wizard* online help topic in the Array Management Window of SANtricity ES Storage Manager.

If a volume group already has a Degraded status due to a failed drive when a drawer fails, drawer loss protection might not protect the volume group. The data on the volumes might become inaccessible.

Hot Spare Drives

With volume groups, a valuable strategy to protect data is to assign available drives in the storage array as hot spare drives. A hot spare is a drive, containing no data, that acts as a standby in the storage array in case a drive fails in a RAID Level 1, RAID Level 3, RAID Level 5, RAID Level 6, or RAID Level 10 volume group. The hot spare adds another level of redundancy to the storage array. Generally, hot spare drives must have capacities that are equal to or greater than the used capacity on the drives that they are protecting. Hot spare drives must be of the same media type, the same interface type, and the same capacity as the drives that they are protecting.

If a drive fails in the storage array, the hot spare is normally substituted automatically for the failed drive without requiring your intervention. If a hot spare is available when a drive fails, the controller uses redundancy data/parity to reconstruct the data onto the hot spare. After the failed drive is physically replaced, you can use either of the following options to restore the data:

- When you have replaced the failed drive, the data from the hot spare is copied back to the replacement drive. This action is called *copyback*.
- You can assign the hot spare as a permanent member of the volume group. Performing the copyback function is not required for this option.

The availability of tray loss protection and drawer loss protection for a volume group depends on the location of the drives that comprise the volume group. Tray loss protection and drawer loss protection might be lost because of a failed drive and the location of the hot spare drive. To make sure that tray loss protection and drawer loss protection are not affected, you must replace a failed drive to initiate the copyback process.

The storage array automatically selects Data Assurance (DA) -capable drives for hot spare coverage of DA-enabled volumes. Make sure to have DA-capable drives in the storage array for hot spare coverage of DA-enabled volumes.

Security capable drives provide coverage for both security capable and non-security capable drives. Non-security capable drives can provide coverage only for other non-security capable drives.

If you do not have a hot spare, you can still replace a failed drive while the storage array is operating. If the drive is part of a RAID Level 1, RAID Level 3, RAID Level 5, RAID Level 6, or RAID Level 10 volume group, the controller uses redundancy data/parity to automatically reconstruct the data onto the replacement drive. This action is called *reconstruction*.

Channel Protection

In a Fibre Channel environment, channel protection is usually present for any storage array. When the storage array is cabled correctly, two redundant arbitrated loops (ALs) exist for each drive.

I/O Data Path Protection

When designing a storage area network (SAN), the duplication of host bus adapters (HBAs), cables, switches, controllers, and other components provides redundancy and can prevent loss of data access in the event of a component failure. This redundancy means the host has one or more paths to each controller.

When creating volumes, a controller must be assigned to own the volume and is referred to as the *preferred owner*. The preferred owner may be selected to achieve load balancing across controllers. Most host multi-path drivers will attempt to access each volume on a path to its preferred controller. However, if this preferred path becomes unavailable, the multi-path driver on the host will *failover* to an alternate path. This might cause the volume ownership to change to the alternate controller.

Target Port Group Support

Target Port Group Support (TPGS) is another multi-path driver that is available on specific combinations of operating systems and failover drivers that can be present on a host. TPGS provides failover for a storage array. Failover is an automatic operation that switches the data path for a volume from the preferred controller to the alternate controller in the case of a hardware failure.

TPGS is part of the ANSI T10 SPC-3 specification. It is implemented in the controller firmware. TPGS is similar to other multi-pathing options, such as Auto-Volume Transfer (AVT) and Redundant Dual Active Controller (RDAC), which were developed prior to defining a multi-pathing standard. The advantage of TPGS is that it is based on the current standard, which allows interoperability with multi-pathing solutions from other vendors. Interoperability with other multi-pathing solutions simplifies administration of the host.

Each host type uses only one of the multi-path methods: RDAC, AVT/ALUA (refer to the ALUA description in "New Features" on page 1), or TPGS.

Load Balancing

Load balancing is the redistribution of read/write requests to maximize throughput between the server and the storage array. Load balancing is very important in high workload settings or other settings where consistent service levels are critical. The multi-path driver transparently balances I/O workload without administrator intervention. Without multi-path software, a server sending I/O requests down several paths might operate with very heavy workloads on some paths, while other paths are not used efficiently.

The multi-path driver determines which paths to a device are in an active state and can be used for load balancing. The load-balancing policy uses one of three algorithms: round robin, least queue depth, or least path weight. Multiple options for setting the load-balancing policies let you optimize I/O performance when mixed host interfaces are configured. The load-balancing policies that you can choose depend on your operating system, fail-over solution, and configuration.

Round Robin with Subset

The round-robin with subset I/O load-balancing policy routes I/O requests, in rotation, to each available data path to the controller that owns the volumes. This policy treats all paths to the controller that owns the volume equally for I/O activity. Paths to the secondary controller are ignored until ownership changes. The basic assumption for the round-robin policy is that the data paths are equal. With mixed-host support, the data paths might have different bandwidths or different data transfer speeds.

Least Queue Depth with Subset

The least queue depth with subset policy is also known as the least I/Os policy or the least requests policy. This policy routes the next I/O request to the data path on the controller that owns the volume that has the least outstanding I/O requests queued. For this policy, an I/O request is a command in the queue. The type of command or the number of blocks that are associated with the command is not considered. The least queue depth with subset policy treats large block requests and small block requests equally. The data path selected is one of the paths in the path group of the controller that owns the volume.

Least Path Weight with Subset

The least path weight with subset policy assigns a weight factor to each data path to a volume. An I/O request is routed to the path with the lowest weight value to the controller that owns the volume. If more than one data path to the volume has the same weight value, the round-robin with subset path selection policy is used to route I/O requests between the paths with the same weight value.

Introducing the Storage Management Software 2

The topics in this section describe the basic layout of the SANtricity ES Storage Manager software. The SANtricity ES Storage Manager software has two windows that provide management functionality and a graphical representation of your storage array: the Enterprise Management Window (EMW) and the Array Management Window (AMW).

NOTE The SANtricity ES Storage Manager software is also referred to as the storage management software.

When you initiate the SANtricity ES Storage Manager, the EMW appears first. Use the EMW to add the storage arrays that you want to manage and monitor. Through the EMW, you also receive alert notifications of errors that affect the storage arrays. If you are notified in the EMW that a storage array has a non-Optimal status, you can start the AMW for the affected storage array to show detailed information about the storage array condition

The AMW provides summary views and detailed information about your storage arrays. Use the AMW to configure, maintain and manage a storage arrays and its components. In addition, use the AMW menus to enable, disable and use the premium features shipped with your storage management software, or use the Try and Buy feature to turn on a premium feature for an evaluation period.

NOTE Depending on your version of storage management software or controller firmware of the controller being managed, the views, menu options, and functionality might differ from the information presented in this section. For information about available functionality, refer to the online help topics that are supplied with your version of the storage management software.

Enterprise Management Window

The Enterprise Management Window (EMW) is the first window to appear when you start the storage management software. Some of the management tasks the EMW lets you perform include:

- Discover hosts and storage arrays automatically on your local sub-network.
- Manually add and remove hosts and storage arrays.
- Monitor the health of the storage arrays and report a high-level status by using the applicable icon.
- Configure alert notifications through email or Simple Network Management Protocol (SNMP) and report events to the configured alert destinations.
- Schedule or automatically save a copy of the support data when the client monitor process detects an event.

- Launch the applicable Array Management Window (AMW) for a selected storage array to perform detailed configuration and management operations.
- Run SMCLI scripts using the Script Editor to perform batch management tasks on a particular storage array. For example, scripts might be run to create new volumes or to download new controller firmware. For more information on running scripts, refer to the online help topics in the EMW.
- Upgrade the controller firmware.
- Collect support information on one or all of the storage arrays you are managing.
- Retrieve a firmware inventory for all storage arrays you are managing.

A local configuration file stores all of the information about storage arrays that you have added and any email destinations or SNMP traps that you have configured.

Parts of the Enterprise Management Window

The Enterprise Management Window (EMW) has these areas that provide options for managing your storage array.

Part	Description
Title bar	"Enterprise Management" in the title bar text indicates that this is the EMW.
Menu bar	The menu bar contains various options to manage the storage arrays. For more information about menu bar options, refer to the *EMW Menu Bar Options* online help topic.
Toolbar	The toolbar contains icons that are shortcuts to common commands. These icons let you: ■ Automatically discover new storage arrays ■ Rescan selected hosts for new storage arrays ■ Add or Remove a storage array from view ■ Launch the Array Management Window (AMW)
Tabs	The EMW contains two tabs: ■ **Devices** – Shows the discovered storage arrays and provides basic information about your storage arrays, such as the status of a storage array and type of configured management connection. ■ **Setup** – Allows you to perform initial setup tasks with the storage management software, such as adding, naming or managing a storage array or configuring alerts.
Status bar	The Status bar shows a summary of the health of your storage arrays, messages, and a progress bar.

EMW Devices Tab

The **Devices** tab in the Enterprise Management Window presents two views of the storage arrays that are managed by the storage management station:

- Tree view
- Table view

Tree View

The Tree view provides a tree-structured view of the nodes in the storage system. The Tree view shows two types of nodes:

- Discovered Storage Arrays
- Unidentified Storage Arrays (not common)

Both the Discovered Storage Arrays node and the Unidentified Storage Arrays node are child nodes of the storage management station node.

The Discovered Storage Arrays node has child nodes that represent the storage arrays that are currently managed by the storage management station. Each storage array is labeled with its machine name and is always present in the Tree view. When storage arrays and hosts with attached storage arrays are added to the EMW, the storage arrays become child nodes of the Discovered Storage Arrays node.

NOTE If you move the mouse over the storage array node with an out-of-band management connection, a tooltip shows the controller's IP address. For nodes with an in-band management connection, no information is displayed when you mouse over a storage array node.

The Unidentified Storage Arrays node shows storage arrays that the storage management station cannot access because the name or IP address does not exist.

You can perform these actions on the nodes in the Tree view:

- Double-click the storage management station node and the Discovered Storage Arrays node to expand or collapse the view of the child nodes.
- Double-click a storage array node to launch the Array Management Window for that storage array.
- Right-click a node to open a pop-up menu that contains the applicable actions for that node.

The right-click menu for the storage management station node contains these options:

- **Automatic Discovery**
- **Add Storage Array**
- **Configure Alerts**

The right-click menu for the Discovered Storage Arrays node contains these options:

- **Add Storage Array**
- **Automatic Discovery**
- **Collect Support Data**
- **Refresh**

Use the options on the **Edit** menu to add or rename a storage array, remove a storage array or management connection, configure alerts, enable remote status notification, or enter a comment that displays for a storage array node on the table view.

Use the options on the **Tools** menu to discover or manage storage arrays or hosts, upgrade firmware, load an existing configuration for a storage array, view a firmware inventory report, execute SMCLI scripts using the Script Editor, or collect support data.

Table View

Each managed storage array is represented by a single row in the Table view. The columns in the Table view show data about the managed storage array.

Column	Description
Name	The name of the managed storage array. If the managed storage array is unnamed, the default name is `Unnamed`.
Type	The type of device being managed. Currently, this column displays only an icon for a storage array.
Status	An icon and a text label that report the status of the managed storage array.
Management Connections	Displays the type of management connection configured for a storage array. Options are In-band, Out-of-Band, or Out-of-Band/In-band meaning your storage array uses both types of management connections. Click **Details** to see more information about any of these connections.
Comment	Any comments that you have entered about the specific managed storage array.

Sort the rows in the Table view in ascending order or descending order by either clicking a column heading or by selecting a command from the **View** menu.

Showing Managed Storage Arrays in the Table View

You can change the way that *managed storage arrays* appear in the Table view.

- Select the storage management station node to show all of the known managed storage arrays in the Table view.
- Select a Discovered Storage Array node in the Tree view to show any storage arrays that are attached to that specific host in the Table view.

NOTE If you have not added any storage arrays, the Table view is empty.

- Select a storage array node in the Tree view to show only that storage array in the Table view.

NOTE Selecting an Unidentified node in the Tree view shows an empty Table view.

Adding a Storage Array

The SANtricity ES Storage Manager provides several ways to add or remove a storage array to and from the Enterprise Management Window (EMW). Having more than one method available to add a storage array lets you choose the method that best suits your working style. Use one of the following methods to add or remove a storage array to or from the EMW:

- Menu bar – Select a menu option
- Toolbar – Click the appropriate icon
- Setup tab – Click one of the displayed links
- Tree view – Right-click a root node and select an option from a drop-down menu

When you add a storage array, you are actually adding an icon that represents a storage array to your view of the Enterprise Management Window (EMW).

Removing Multiple Storage Arrays Simultaneously

You can simultaneously manage one or more storage arrays from the EMW. As discussed in "Adding a Storage Array", there are several methods available to add or remove storage arrays from the EMW. Although you can manually add only one storage array to the EMW at a time, you can remove one or several storage arrays from the EMW at the same time.

- To remove a single storage array, from the Tree view click a node and then click the **Remove storage array from view** icon. Or you can select the appropriate option from the **Edit** menu.
- To remove several contiguous storage arrays, from the Tree view use the SHIFT key and click to select contiguous storage arrays. With the selected storage arrays highlighted in the Table view, right-click and select **Remove** from the pop-up menu.

- To remove several non-contiguous storage arrays, from the Tree view use the CTRL key and click to select contiguous storage arrays. With the selected storage arrays highlighted in the Table view, right-click and select **Remove** from the pop-up menu

Remember that when you remove a storage array, you are removing only the icon from the Tree and Table views. You are not physically deleting the storage array.

EMW Setup Tab

The EMW **Setup** tab is a gateway to tasks that you can perform when you set up a storage array. Using the EMW **Setup** tab, you can perform these tasks:

- Add a storage array
- Name or rename a storage array
- Configure an alert for one or all storage arrays
- Manage a storage array by launching the Array Management Window (AMW)
- Upgrade the controller firmware
- Open the **Inherit Systems Settings** window

Array Management Window

The Array Management Window (AMW) is a Java^{TM} technology-based software that you launch from the Enterprise Management Window (EMW). The AMW provides management functions for a single storage array. You can have more than one AMW open at the same time to manage different storage arrays. The AMW includes these management functions for a *storage array*:

- Provides storage array options, such as locating a storage array, configuring a storage array, renaming a storage array, or changing a password.
- Provides the ability to configure *volumes* from your storage array capacity, define *hosts* and *host groups*, and grant host or host group access to sets of volumes called *storage partitions*.
- Monitors the health of storage array components and reports a detailed status using applicable icons.
- Provides you with the applicable recovery procedures for a failed logical component or a failed hardware component.
- Presents a view of the *Event Log* for the storage array.
- Presents profile information about hardware components, such as *controllers* and *drive*s.
- Provides controller management options, such as changing ownership of volumes or placing a controller online or offline.
- Provides drive management options, such as assigning hot spares and locating the drive.
- Monitors storage array performance.

The format and options displayed on the AMW is dependent on the version of controller firmware running on your controller. When you launch the AMW for a storage array, the version of the AMW displayed depends on the version of controller firmware running on the controller assigned to that storage array. The information in this document describes the functions of the AMW for the current release. Refer to previous versions of this document for information about how to use the AMW with earlier releases.

Starting the Array Management Window

To start the Array Management Window (AMW) from the Enterprise Management Window (EMW), perform one of these tasks:

- Click the **Devices** tab, and double-click the name of the storage array that you want to manage.
- Click the **Devices** tab, right-click the name of the storage array you want to manage, and select **Manage Storage Array**.
- Click the **Devices** tab, and select **Tools >> Manage Storage Array**.
- Click the **Setup** tab, and select **Manage a Storage Array**. In the **Select Storage Array** dialog, select the name of the storage array that you want to manage, and click **OK**.

Parts of the Array Management Window

The Array Management Window (AMW) has these areas that provide options for managing your storage array.

Part	Description
Title bar	"Array Management" in the title bar text indicates that this is the AMW.
Menu bar	The menu bar contains various options to configure and manage the capacity of the drives in a storage array. For more information about menu bar options, refer to the *Learn About the Array Management Window* online help topic.
Toolbar	The toolbar contains icons that are shortcuts to common commands. Use these icons to: ■ Create a new volume ■ View an Event Log ■ Run the Performance Monitor ■ View which operations are in progress ■ Initiate the Recovery Guru to help recover from a failure condition ■ Manage the drive tray alarms ■ Launch the copy manager

Part	Description
Tabs	The AMW contains five tabs: ■ **Summary** – Provides links and displays information that helps you manage and monitor your storage array. The Summary tab also houses the Information Center which contains links to the available online help and online tutorials. ■ **Storage & Copy Service** – Shows the organization of the storage array by total unconfigured capacity, disk pools, volume groups, consistency groups (premium feature), and asynchronous mirroring groups. Additional features available from this tab include a search field that lets you locate objects by Name in the Tree view, and an Object Type search field that lets you display storage array objects and related information by type in the Table view. ■ **Host Mappings** – Shows the topology of the logical nodes related to the storage partitions in the storage array and the defined mappings associated with a selected logical node. ■ **Hardware** – Provides information about the controllers and drives in a storage array. ■ **Setup** – Provides the links to tasks that you can perform when setting up a storage array, such as configuring the storage array, setting the storage array password, provisioning drives, and configuring the Ethernet management port in the storage array.
Status bar	The Status bar shows which premium features are available and enabled/disabled for your storage array. If a feature icon is gray, the feature is available but disabled. If a feature icon has color the feature is available and enabled. The tool tip also indicates if the premium feature is a Try and Buy feature.

Summary Tab

The **Summary** tab in the AMW shows information about the storage array. Links to the **Storage Array Profile** dialog, relevant online help topics, and the storage concepts tutorial also appear. Additionally, the link to the **Recovery Guru** dialog appears when the storage array needs attention.

In the **Summary** tab, you can view this information:

- The status of the storage array
- Version information for storage management software and controller
- The capacity of the storage array
- A list of the number of disk pools and volume groups, volumes, snapshot image elements (premium feature), consistency groups (premium feature), snapshot (legacy) image elements (premium feature), and asynchronous mirror groups (premium feature) in the storage array
- The hosts, the mappings, and the storage partitions in the storage array
- A list of the number of Try and Buy premium features shipped (available) for your storage array, the number of Try and Buy premium features you are evaluating (active), and the number of purchased premium features enabled or disabled for your storage array
- A list of the hardware components in the storage array
- Links to online documentation available for learning about your storage array

Monitor and Capacity Panes

The Monitor pane provides information about the software and firmware running on the components of your storage array. Use the links available on the Monitor pane to view:

- The firmware versions in your storage array
- The components and properties of the storage array
- The events that occur on your storage array
- Inventory, status, and performance data that can help troubleshoot any problems with your storage array.

The Capacity pane shows the total amount of unconfigured capacity, free capacity, and configured capacity in your storage array, as well as the total capacity of your storage array. Table 3 describes the links available in the Monitor pane and Capacity pane.

Table 3 Links Available from the Monitor and Capacity Panes

Link	Status
View Firmware Inventory	Use this link to generate a report that provides version, model, location, and manufacturer information about the controllers, drives, power supplies, and environmental services module components of your storage array.

Link	Status
View Storage Array Profile	The Storage Array Profile dialog contains six tabs: ▪ **Storage Array** – This tab displays summary information about storage, hardware, features, firmware, and environmental services modules used in your storage array. ▪ **Storage** – This tab displays attribute settings and capacity information for the disk pools, volume groups, volumes, missing volumes, and the logical hierarchy of the components in your storage array. ▪ **Copy Services** – This tab displays information about the logical components created using the Snapshot (Legacy), and Snapshot, Consistency Group, and Asynchronous Mirroring premium features. ▪ **Host Mappings** – This tab displays information about the hosts, the mappings, and the storage partitions in your storage array. ▪ **Hardware** – This tab displays information about the controllers, drives, drive channels, and drive trays in your storage array. ▪ **All** – This tab displays a detailed summary for all the components of your storage array.
View Event Log	Use this link to generate an event log for the components in your storage array. Use the **Filter events displayed** entry field to filter events by severity level.
Collect all Support Data	Use this link to collect inventory, status, diagnostic, and performance data from your storage array to send to your Technical Support Representative when you’re trying to diagnose a problem.
Create Storage	Use this link to quickly add unconfigured capacity to a disk pool or a volume group, or assign a hot spare for a volume group.
Create Volume	Use this link to quickly create a volume on an existing disk pool or a volume group.

Premium Features Pane

The Premium Features pane provides a summary of the number of Try and Buy or purchased premium features available and the number of premium features enabled or disabled for your storage array. New for this release is the Try and Buy feature designed to provide customers with the option to use a premium feature for a pre-determined evaluation period. The available Try and Buy premium features vary for different storage array configurations, but can include:

- Snapshot Groups
- Thin provisioning
- High performance tier
- Synchronous Mirroring (SM)

Use the **Manager Premium Features** link to view which premium features are enabled or disabled for your storage array, to enable a premium feature using a feature key identifier, or disable Try and Buy or purchased premium feature on your storage array.

NOTE Not all premium features are supported or available for all configurations.

Hardware Pane

The Hardware pane shows a summary of the controllers, drive trays, and drives that comprise your storage array. If your storage array contains different media types or different interface types, an icon that identifies the media type or drive type appears under the **Media Type** and **Interface Type** titles. For media type, there are icons for hard disk driver (HDD) and solid state disks (SSD). For interface type, there are icons for full disk encryption (FDE) security capable drives, Serial Attached SCSI (SAS) drives, Fibre Channel (FC) drives, Serial ATA (SATA) drives, and Data Assurance (DA) -capable drive.

Storage & Copy Services Tab

The **Storage & Copy Services** tab in the AMW contains two panes: the Storage & Copy Services pane and the Properties pane.

NOTE You can resize either pane by dragging the splitter bar, located between the two panes, to the right or to the left.

Storage & Copy Services Pane

The Storage & Copy Services pane provides a tree-structured view of the logical nodes. Click the plus (+) sign or the minus (-) sign adjacent to a node to expand or collapse the view. You can right-click a node to open a pop-up menu that contains the applicable actions for that node.

Nodes in the Storage & Copy Services Pane

The *storage array*, or root node, has several types of child nodes. The Unconfigured Capacity nodes and Volume Group nodes are standard nodes and will appear for all storage arrays. The Disk Pools nodes, Consistency Groups nodes, and Asynchronous Mirror Group nodes only appear if the associated premium feature is available and enabled on your storage array.

Child Nodes of the Root Node	Description of the Child Nodes
All Logical Objects	This node lets you view information about all the logical objects that comprise your storage array. Use the Object Type drop-down menu in the View pane to select a particular object type. This is a useful way to view the status and capacity information for a disk pool or a volume group, or view all the repository volumes that are associated or not associated with a base volume used with the Snapshot (Legacy) Image, Snapshot Image, and Consistency Group premium features.
Total Unconfigured Capacity	This node represents the sum of the capacity of all unassigned drives that are not in a disk pool or a volume group.
Unconfigured Capacity	This node represents the storage array capacity that is not configured into a volume group. Multiple Unconfigured nodes appear if your storage array contains drives with different media types (hard disk drives or solid state drives) and different interface types. Each drive type has an associated Unconfigured Capacity node shown under the Total Unconfigured Capacity node if unassigned drives are available in a drive tray.
Disk Pools	The storage management software displays a Disk Pools node if one or more disk pools have been configured for your storage array. Expand the Disk Pool node to see the individual disk pools. You see the Snapshot (Legacy) Image and Snapshot Image child nodes only when the Snapshot or Snapshot (Legacy) Group premium features are enabled for your storage array. The disk pool node has several types of child nodes: ■ **Volume** – This node represents a configured and defined volume. Multiple Volume nodes can exist under a Disk Pool node. ■ **Free Capacity** – This node represents a region of capacity that you can use to create one or more new volumes within the disk pool. A Free Capacity node can exist under each Disk Pool node. ■ **Snapshot Images** – This node represents a logical point-in-time image of a selected base volume. A base volume is a standard volume or a thin volume that is the source of a snapshot image. ■ **Snapshot Groups** – This node represents the sequence of snapshot images of the same base volume. ■ **Snapshot Volumes** – This node indicates that you have created a view of a snapshot image. You create a snapshot volume to allow a host to access a snapshot image as if were a volume.

Child Nodes of the Root Node	Description of the Child Nodes
Volume Groups	This node has several types of child nodes. The Volume node and the Free Capacity node are standard child nodes. If the Snapshot premium feature is enabled, you can have the snapshot image child nodes. ■ **Volume**– This node represents a configured and defined volume. Multiple Volume nodes can exist under a Volume Group node. ■ **Free Capacity** – This node represents a region of capacity that you can use to create one or more new volumes within the volume group. Multiple Free Capacity nodes can exist under a Volume Group node. ■ **Snapshot Images** – This node represents a logical point-in-time image of a selected base volume. A base volume is a standard volume or a thin volume that is the source of a snapshot image. ■ **Snapshot Groups** – This node represents the sequence of snapshot images of the same base volume. ■ **Snapshot Volumes** – This node represents the snapshot images of a base volume that are visible to a host. ■ **Snapshot (Legacy) Volume** – This node represents child nodes of their associated base volumes.
Consistency Groups	If the Snapshot premium feature is enabled, you can have the following consistency group child nodes: ■ **Consistency Group** – This node represents a grouping node which includes all the child nodes created for this consistency group. Expand this node to see the child nodes. ■ **Snapshot Images** –This node represents a collection of logical point-in-time image of the member volumes of a consistency group. ■ **Member Volumes** – This node is a collection of the volumes that are members of this consistency group. ■ **Snapshot Volumes** – This node represents the snapshot images of member volumes that are visible to a host.
Asynchronous Mirror Groups	These are special volumes in the storage array that are created as a resource for each controller in both local storage arrays and remote storage arrays. The controller stores duplicate information on the mirror repository volume, including information about remote writes that are not yet written to the secondary volume.

Types of Volumes

These types of volumes appear under the Disk Pool or Volume Group nodes. With the exception of the standard volume, all other types of volumes are available only when the related premium feature is enabled for a storage array.

- *Standard volumes* are the types of volume you can create from a volume group or a disk pool in a storage array to store data. When you configure a standard volume from a volume group or a disk pool, you must specify a capacity that is all or part of the volume group or disk pool capacity. The operating system sees a volume as one drive.
- *Thin volumes* are the types of volume you can create from a disk pool if the Thin Provisioning premium feature is available and enabled for your storage array. With a thin volume, capacity is allocated as the data is written. You can configure a thin volume only in a disk pool.
- *Primary volumes* that participate in a mirror relationship in the primary role. Primary volumes are standard volumes with a synchronized mirror relationship. The remote *secondary volume* that is associated with the primary volume appears as a child node.
- *Secondary volumes* appear directly under the Volume Group node when the local storage array contains this volume.
- *Mirror repository volumes* are special volumes in the storage array that are created as a resource for each controller in both local storage arrays and remote storage arrays. The controller stores duplicate information on the mirror repository volume, including information about remote writes that are not yet written to the secondary volume.
- *Snapshot (Legacy) repository volumes* are volumes in the storage array that are used as a resource for a snapshot (legacy) volume.
- *Snapshot (Legacy) volumes* are child nodes of their associated *base volume*.
- *Snapshot volumes* are volumes with associated repositories that enable a host to perform ongoing write operations for a specified volume.
- *Base volumes* are standard volumes or thin volumes that are being used in conjunction with the Snapshot premium feature or Consistency Groups premium feature.
- *Snapshot Group repositories* are physical standard volumes that store data for all the snapshot images taken of a base volume.
- *Source volumes* are standard volumes that participate in a volume copy relationship. Source volumes are used as the copy source for a target volume. Source volumes accept host I/O requests and store application data. A source volume can be a standard volume, a snapshot (legacy) volume, a snapshot (legacy) base volume, or a Synchronous Mirroring primary volume.

- *Target volumes* are standard volumes that participate in a volume copy relationship and contain a copy of the data from the source volume. Target volumes are read-only and do not accept write requests. A target volume can be created from a standard volume, the base volume of a snapshot (legacy) volume, or a Remote Volume Mirror primary volume. The volume copy overwrites any existing volume data if an existing volume is used as a target.

Properties Pane

The Properties pane provides detailed information about the component selected in the Logical pane. The information varies depending on what type of component is selected.

You can view the physical components that are associated with a logical component by selecting the **Storage & Copy Services** tab, right-clicking a component, and selecting **View Associated Physical Components**.

Host Mappings Tab

The **Host Mappings** tab in the AMW contains two panes: the Topology pane and the Defined Mappings pane.

NOTE You can resize either pane by dragging the splitter bar, located between the two panes, to the right or to the left.

Host Mappings Pane

The Host Mappings pane shows a tree-structured view of logical nodes that are related to *storage partitions*. Click the plus (+) sign or the minus (-) sign adjacent to a node to expand or collapse the view. You can right-click a node to open a pop-up menu that contains the applicable actions for that node.

Nodes in the Host Mappings Pane

The storage array, or the root node, has these types of child nodes.

Child Nodes of the Root Node	Description of the Child Nodes
Undefined Mappings	The Undefined Mapping node has one type of child node. **Individual Undefined Mapping** – Represents a *volume* with an undefined mapping. Multiple Volume nodes can exist under an *Undefined Mappings node*.

Child Nodes of the Root Node	Description of the Child Nodes
Default Group	**NOTE** If SANshare Storage Partitioning is disabled, all of the created volumes are in the Default Group. A Default Group node has two types of child nodes: ■ ***Host Group*** – Defined host groups that are not participating in specific mappings are listed. This node can have host child nodes, which can have child host port nodes. ■ ***Host*** – Defined hosts that are not part of a specific host group but are part of the Default Group and are not participating in specific mappings are listed. This node can have child host port nodes.
Unassociated Host Port Identifier	An Unassociated Host Port Identifier node has one type of child node. **Host Port Identifier** – Host port identifier that has not been associated with any host.
Host Group	A Host Group node has one type of child node. **Host** – Defined hosts that belong to this defined host group are listed. This node can have child host port nodes. **NOTE** The host nodes that are child nodes of this host group can also participate in mappings specific to the individual host rather than the host group.
Host	A Host node has one type of child node. **Host Port** – This node has child nodes that represent all of the host ports or single ports on a host adapter that are associated with this host.

SANshare Storage Partitioning

When the SANshare storage partitioning premium feature is available for your storage array, you see a representative icon in the status bar at the bottom of the window. When this icon is gray this feature is disabled; when the icon has color the feature is enabled.

Defined Mappings Pane

The Defined Mappings pane shows the mappings associated with a node selected in the Host Mappings pane.

The information in the table appears for a selected node.

Column Name	Description
Volume Name	The user-supplied volume name. The factory-configured *access volume* also appears in this column. **NOTE** An access volume mapping is required for a storage array with an *in-band* connection to enable the storage management software to communicate with the storage array. For a storage array with out-of-band connections, you can remove an access volume mapping.
Accessible By	Shows the Default Group, a defined host group, or a defined host that has been granted access to the volume in the mapping.
LUN	The LUN assigned to the specific volume that the host or hosts use to access the volume.
Volume Capacity	Shows the volume capacity in units of GB.
Type	Indicates the type of volume.

You can right-click a volume name in the Defined Mappings pane to open a pop-up menu. The pop-up menu contains options to change and remove the mappings.

The information shown in the Defined Mappings pane varies according to what node you select in the Host Mappings pane, as shown in this table.

Node Selected	Information That Appears in the Defined Mappings Pane
Root (storage array) node	All defined mappings.
Default Group node or any child node of the Default Group	All mappings that are currently defined for the Default Group (if any).

Node Selected	Information That Appears in the Defined Mappings Pane
Host Group node (outside of Default Group)	All mappings that are currently defined for the Host Group.
Host node that is a child node of a Host Group node	All mappings that are currently defined for the Host Group, plus any mappings specifically defined for a specific host.
Host Port node or individual host port node outside of the Default Group	All mappings that are currently defined for the host port's associated host.

Hardware Tab

The **Hardware** tab in the Array Management Window contains two panes: the Hardware pane on the left and the Properties pane on the right.

NOTE You can resize either pane by dragging the splitter bar, located between the two panes, to the right or to the left.

The Hardware pane provides a view of the hardware components in a storage array, including their status. You can right-click a hardware component to open a pop-up menu that contains the applicable actions for that component.

NOTE The icons that you see might differ from what is shown in this topic because the icons are determined by the hardware that is installed in your storage array. For example, the controller tray icon and the drive tray icon look like the actual controller trays and drive trays that are installed. Also, the drive icons are either horizontal or vertical to match the orientation of the physical drives in the drive tray.

The Properties pane provides information for the hardware component that is selected in the Hardware pane. The information in the Properties pane is specific to each hardware component. If you select a controller icon in the Hardware pane, a list of properties for that controller is shown in the Properties pane. If you select a drive icon in the Hardware pane, a list of properties for that drive is shown in the Properties pane.

Controller Status

The storage management software provides visual cues to indicate the status of each controller in your storage array. In the Hardware pane (left side) the software overlays an indication of the status if the controller is not in an online, optimal state. The overlays are different colors depending on the state of the controller. For example, if a controller is in an Offline or Service Mode state, you see a red overlay with an additional icon that represents the state. In the Properties pane (right side), the software displays the state of the selected controller in the **Status** field.

The states displayed for a controller can include: Online/Optimal, Offline, Service Mode, Slot Empty, Unsupported, Needs Attention, or Suspended.

View Tray Components

The **View Tray Components** command on each tray shows the status of the secondary components within the tray, such as power supplies, fans, and temperature sensors.

You can use the **Drive type** drop-down list and the **Show** button in the Hardware tab to identify drives of a particular type, speed, and capacity. In the Drive type drop-down list, select the type of drive you want to identify, and click Show. A green triangle appears on top of the relevant drives.

AMW Setup Tab

The AMW **Setup** tab provides links to these tasks:

- Locating a storage array
- Renaming a storage array
- Changing the hardware view order
- Setting a storage array password
- Managing premium features
- Configuring the network parameters for the iSCSI host ports
- Provision drives into disk pools, volume groups, or a hot spare
- Saving configuration parameters in a file

NOTE The Save Configuration function generates a CLI script that contains storage array settings, volume configuration, topology, or volume-to-LUN mappings for a storage array. You can use this generated CLI script to replicate a configuration to another storage array. However, you should not use this generated CLI script for disaster recovery for storage arrays running SANtricity ES Version 10.83. Instead, to do a system restore use the configuration database backup file that you create manually or by having the Persistent Monitor running in the background.

- Manually defining the hosts
- Mapping volumes to hosts
- Configuring the Ethernet management ports
- Managing the additional iSCSI settings for authentication, identification, and discovery (this link only appears on the Setup tab when the controllers contain iSCSI host ports)

Managing Multiple Software Versions

When you open the Array Management Window (AMW) to manage a storage array, the version of software that is appropriate for the version of firmware that the storage array uses is opened. For example, you manage two storage arrays using this software; one storage array has firmware version 6.14, and the other has firmware version 7.8*x*, where *x* represents a number. When you open the AMW for a particular storage array, the correct AMW version is used. The storage array with firmware version 6.14 uses version 9.14 of the storage management software, and the storage array with firmware version 7.8*x* uses version 10.8*x* of the storage management software. You can verify the version that you are currently using by selecting **Help > About** in the AMW.

This bundling of previous versions of the AMW provides the flexibility of upgrading the firmware only on selected storage arrays instead of having to perform an upgrade on all of the storage arrays at one time.

Configuring the Storage Arrays 3

The topics in this section describe the methods for configuring storage arrays, including managing security, and premium features.

For additional information and detailed procedures for the options described in this section, refer to the online help topics in SANtricity ES Storage Manager.

Disk Pools and Volume Groups

The first logical component you configure for your storage array is a disk pool or a volume group. You can think of a disk pool or a volume group as a container for organizing like drives in your storage array. When you configure a storage array for the first time, you must create either a disk pool or a volume group, decide which data protection strategy is most appropriate for your storage array, and determine how the total storage capacity must be organized into volumes and shared among hosts.

Both a disk pool and a volume group consist of a set of drives. You use the storage management software to logically group the drives together to provide one or more volumes to an application host. A disk pool consists of only SAS HDD drives but a volume group can consist of Fibre Channel, SAS, or SATA drives that are either SSD or HDD media type. Drives in a volume group must be the same type. If you have a combination of SAS, Fibre Channel, or SATA drives in your storage array, you must create three containers; one for each type of drive. If you have a minimum of 11 SAS HDD drives, you can add all of these drives to a disk pool, you can create one or more volume groups, or you can create one disk pool with 11 of the SAS HDD drives and use the remaining SAS HDD drives to create one or more volume groups.

The RAID level you select when you configure a volume group determines the number of drives to add to a volume group. Other factors to consider when determining which drives to add to a disk pool or a volume group are media type, spindle speed, security level, and capacity. The media type and security level setting must be the same for all drives in a disk pool or a volume group. To allow for more efficient use of drives in a disk pool or a volume group, the spindle speed and capacity of the drives should be the same or very similar. If you choose drives with different capabilities, the capacity on each drive equal to the smallest drive in the disk pool or volume group is used. This means that if there are several 8-GB drives and several 4-GB drives, 4 GB on each 8-GB drive remains unused.

In general, disk pools are easier to configure and maintain. Most of the configuration settings for a disk pool are set automatically, such as the RAID level, and you do not have to configure a hot spare drive. Adding drives to a disk pool is a simpler and faster process than adding drives to a volume group. You can add up to 12 drives to a disk pool at one time as compared to adding one drive at a time to a volume group.

A storage array can contain one or more disk pools or volume groups. Disk pools can coexist with volume groups on the same storage array.

Some of the differences between a disk pool and a volume group are:

- RAID implementation – RAID level is selectable for volume groups, but auto-assigned for a disk pool.
- Recovery from drive failure – Volume groups use hot spare drives during the drive recovery operation. Disk pools use reserved reconstruction space to recover data during the reconstruction process.
- Minimum number of drives required – The RAID level selected for a volume group determines the minimum number of required drives for a volume group. A minimum of 11 SAS HDD drives are required to create a disk pool.
- Ability to use thin provisioning – You can create thin volumes only in disk pools.
- Availability of premium features – Not all premium features are available for use with disk pools. For example, you cannot use the Snapshot (Legacy) Images feature for disk pools.

RAID Implementation

The RAID level determines how redundant/parity data is striped across volumes in a disk pool or a volume group. Striping is the process of storing segments of data among all drives, with the exception of the hot spare drive, in a volume. Data is sequentially striped across all volumes in a volume group. Because data is randomly striped across volumes in a disk pool, the stripe width of 8+2 for RAID stripe for drives in a disk pool is independent of the number of drives in a disk pool. Stripe width refers to the total number of drives used for both data and redundancy in a stripe.

Regardless of whether you are configuring a disk pool or a volume group, the configured RAID level applies to all volumes in a disk pool or a volume group. For a disk pool, the RAID level is automatically set to RAID 6, but for a volume group you can select RAID 0, RAID 1, RAID 3, RAID 5, RAID 6, or RAID 10. If your storage array consists of several volume groups, you can assign different RAID levels to each volume group.

Recovery from Drive Failure

You use the hot spare functionality only with volume groups. If a drive fails in a volume group, the hot spare drive takes over operation for the failed drive. The controller uses redundancy/parity data stored on the volume to reconstruct the data from the failed drive.

Instead of hot spare drives, a disk pool uses a small capacity referred to as reserved reconstruction space on each drive to store redundancy data. In the event of a drive failure, the controller uses the reconstruction data space on the remaining operational drives to reconstruct the data from the failed drive. The controller redistributes the I/O operations and data storage across the remaining drives in the disk pool.

Volume Group Creation

Volume groups are created from the Total Unconfigured Capacity of a storage array. Total Unconfigured Capacity is the sum of the capacity of all the unassigned drives that are not in a disk pool or a volume group. A volume group can be comprised of several volumes. All volumes in a volume group use the same collection of drives and function at the RAID level configured for the volume group.

Create Volume Group Wizard

The storage management software provides a Create Volume Group Wizard which guides you through the process of creating a volume group that is comprised of one or more drives in your storage array. When you create a volume group you must specify two key parameters: the RAID level and the capacity. The RAID level defines how the data is organization, how redundancy is performed, and the minimum and maximum number of drives permitted in a volume group. The capacity is the sum of the capacity of the drives you select for your volume group.

Both the RAID level and capacity settings for a volume group can be determined by the storage management software or entered manually. With the automatic method you select the RAID level and the storage management software automatically selects the best collection of drives for your volume group. With the manual method you select the RAID level and the appropriate type and number of drives to correspond to the selected RAID level. Whenever possible, use the automatic method.

After you create a volume group, the storage management software prompts you to create at least one volume. You must configure at least one volume in a volume group and map the volume to a host before the host operating system can save data to the volume on the volume group. If you do not configure a volume in your newly created volume group, the storage management software creates a free-capacity volume group. At some point you must create volumes from the free capacity to enable the host operating system to save data to the volumes.

Size of a Volume Group

The minimum and maximum number of drives that can comprise a volume group depends on the RAID level selected for a volume group. All RAID levels except RAID 0 provide a level of data redundancy. Table 4 shows the number of drives required to support data redundancy, and the minimum and maximum number of drives your volume group can have for each RAID level. You must select an even number of drives for RAID 10.

The limit on the number of volume groups is the number of drives supported by the storage array. This number varies with the different storage array models.

Table 4 RAID Levels for a Volume Group

RAID Level	Minimum # of drives	Maximum # of drives	Redundancy
0	1	All drives in a storage array	None
10	2	All drives in a storage array	Mirrored pairs
3	3	30	1 drive
5	3	30	1 drive
6	5	30	2 drives

NOTE The information in Table 4 reflects RAID levels for volume groups but not disk pools. Information about the number of drives required for disk pools is discussed in "Disk Pools and Volume Groups" on page 41.

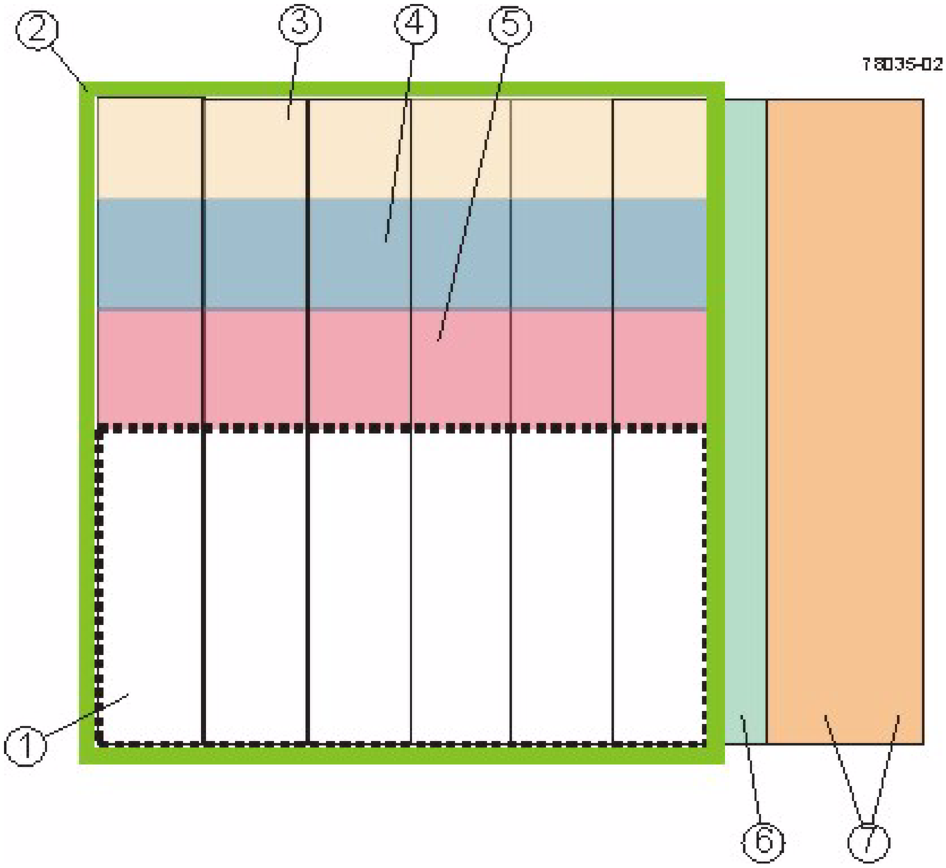
Types of Capacity

Available capacity in a volume group consists of these types of storage space:

- **Free capacity** – The usable capacity in a volume group minus the capacity of any defined volumes. Use the Free Capacity node in a volume group to create a volume or expand the capacity of an existing volume.
- **Unconfigured capacity** – The sum of the capacity of all the unassigned drives that are not in a volume group or a disk pool. One unconfigured capacity node exists for each type of drive type and drive media.
- **Unassigned drive** – Any drive in a storage array that is not in a volume group or a disk pool, or is not configured as a hot spare drive for a volume group.

Figure 1 shows a volume group that consists of three volumes and free capacity. One of the drives in the storage array has been configured as a hot spare drive that is available to a volume group in the storage array. The figure also shows the location of free capacity within the volume group and unconfigured capacity in the storage array.

Figure 1 Collection of Drives in a Volume Group



1. Free Capacity within the Volume Group
2. Volume Group
3. Volume
4. Volume
5. Volume
6. Hot Spare Drive
7. Unconfigured Drive Capacity within the Storage Array

Volume Group States

When a volume group is operational, the storage management software displays the status of the volume group.

Optimal – All drives in the volume group are present and the volume group has full redundancy, except for RAID 0 which has no redundancy.

Degraded – Enough drives in the volume group are present that data is accessible but redundancy has been reduced or completely lost.

Failed – All drives in a volume group are not present in the storage array due to drive failure or removing a drive. The data in the volume is not accessible in this state.

Change the RAID Level

The storage management software lets you change the RAID level configured for a volume group. Use the Change RAID Level option when you want to change the level of redundancy or enhance performance of a volume group. Successfully changing the RAID level configured for a volume group requires the following conditions:

- The volume group must be operational.
- Sufficient free capacity must be available in the volume group to support the new RAID level.
- The status of the volume group must be Complete.

This operation is always carried out as a background task and volumes remain fully accessible during this operation.

Volume Group Attributes

When you use the storage management software to create a volume group, some of the attributes you need to set are described in Table 5.

Table 5 Create Volume Group Attributes

Attribute	Description
Volume Group Creation	Select the Create Volume Group option.
Volume Group Name	Assign a name to the volume group.
Drive Selection Method	Select either the **automatic** or **manual** drive selection method. The automatic method provides a list of drive and capacity options based on the selected RAID level. The manual method lets you choose specific drives.
RAID Level	Select **RAID 0, RAID 1, RAID 3, RAID 5,** or **RAID 6**. This is the RAID level for the volume group. RAID 6 is available only when the RAID 6 premium feature is enabled.

Disk Pool Creation

Disk pools are created from the Total Unconfigured Capacity of a storage array. Total Unconfigured Capacity is the sum capacity of the unassigned drives in the storage array. To create a disk pool, the storage array must have a minimum of 11 SAS Hard Disk Drives (HDD). In addition, the drives in a disk pool must have the same security level, spindle speed, and the same capacity.

The storage management software provides two ways to create a disk pool: using the Disk Pool Automatic Configuration dialog or using the Create Disk Pool Wizard.

Disk Pool Automatic Configuration Dialog

The storage management software can detect the unconfigured capacity in a storage array. When the unconfigured capacity is detected, the storage management software lets you create one or more disk pools, or add the unconfigured capacity to an existing disk pool, or both. By default, the **Automatic Configuration** dialog appears each time you access the Array Management Window and your storage array has unassigned drives, or if new drives were added to a storage array that has at least one disk pool. This dialog displays the number of unassigned drives and calculates the free capacity of these drives.

By default, the storage management software assumes you want to create a disk pool rather than a volume group when your storage array has unassigned drives. If a disk pool already exists on your storage array and the storage management software detects unassigned drives, the Automatic Configuration dialog displays information about adding the unassigned SAS HDD drives to any existing disk pools.

When creating a disk pool using the Automatic Configuration dialog, you can indicate whether you want the storage management software to create a specific number of equal-capacity volumes in the disk pool or simply add a free-capacity disk pool. A free-capacity disk pool does not have any volumes. If you have multiple applications on your storage array and do not want them competing for the same drive resources, you might consider manually creating a smaller disk pool for one or more of the applications. You can assign just one or two volumes instead of assigning the workload to a large disk pool that has many volumes across which to distribute the data.

Selecting `No` in response to the Automatic Configuration dialog closes the dialog, causes no action to your storage array, and displays the Array Management Window.

Create Disk Pool Wizard

Use the Create Disk Pool Wizard to guide you through the process of creating a disk pool. One advantage of using this wizard rather than the automatic configuration method is the wizard lets you change the Drive Security if this premium feature is enabled, include only Data Assurance (DA) capable drives in your disk pool, select specific unassigned SAS HHD drives to comprise your disk pool, and adjust the capacity alert notification percentages.

Raid Level Auto-Assigned

Regardless of the method you use to create a disk pool, the storage management software automatically bases the RAID level of the disk pool on RAID Level 6. You cannot change the RAID level of the disk pool.

Size of Disk Pool

There is no practical limit on the number of drives that can comprise a disk pool. However, the disk pool cannot contain more drives than the maximum limit for each storage array. Total Unconfigured Capacity, which is based on the capacity of all drives in a storage array that are not in a disk pool or volume group minus the overhead, determines the size and number of volumes that can be in your disk pool.

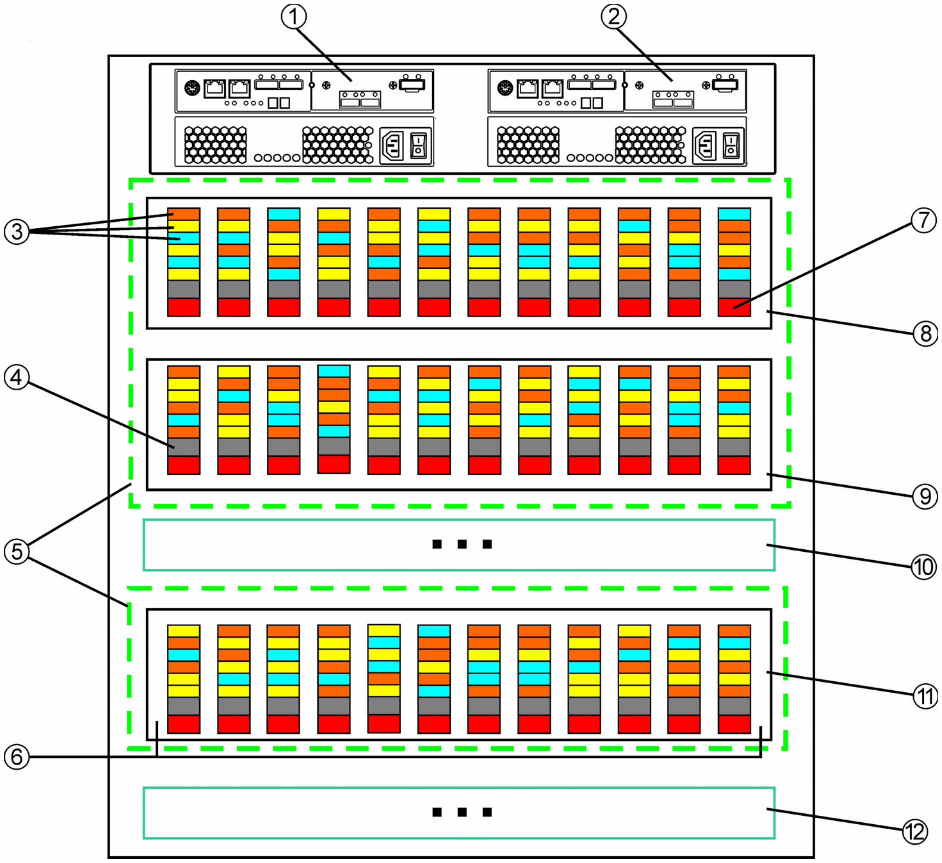
Type of Capacity

Available capacity in a disk pool consists of these types of storage space.

- Free capacity – The unassigned space on drives within a disk pool. The controller uses the free capacity when you expand the capacity of the disk pool or as additional space if it is needed in the data reconstruction process to recover from a failed drive.
- Available capacity – The amount of space in a disk pool that you can configure into volumes. This capacity does not include the reserved and non-user accessible space.
- Reserved capacity – The amount of space that is reserved for reconstructed data in the event of a drive failure.

Figure 2 shows a storage array that has been configured as a disk pool consisting of more than 30 drives. The figure shows the location of free capacity and spare capacity within the disk pool.

Figure 2 Collection of Drives in a Disk Pool



1. Controller A
2. Controller B
3. Data and parity for each volume striped across the drives randomly
4. Free capacity
5. Disk pool comprising of more that 30 drives
6. Drives in each tray
7. Spare capacity in each drive
8. Drive tray 0
9. Drive tray1
10. Drive tray 2
11. Drive tray n, where n represents a drive tray number
12. Drive tray n, where n represents a drive tray number

Capacity Alert Notifications

Over time, the storage capacity of your disk pool is consumed. Enough capacity must be available to perform I/O functions or store incoming data. Otherwise, functions of the storage array might be halted. To help prevent this type of situation, the storage management software provides capacity alert notification warnings. The storage management software generates these alert notifications based on capacity percentage values you set while configuring a disk pool from within the Array Management Window. You can use these alert notifications to determine when to add drives to the disk pool to increase the existing capacity.

When you create a disk pool using the Create Disk Pool Wizard, you can set an early warning threshold percentage and a critical warning threshold percentage. When the percentage of capacity utilized in the disk pool reaches the specified percentage, an alert notification in the form of emails and SNMP trap messages are sent to the destination addresses that are specified in the Configure Alerts dialog.

Use the following guidelines when you set the early and critical warning percentages:

- Make sure that the Early Warning percentage is less than the Critical Warning percentage
- If you set both warning percentages to the same value, the storage management software issues only a notification warning when the disk pool utilization reaches the critical warning percentage
- If you set the early warning percentage to zero percent this warning is disabled
- If you set the critical warning percentage to zero percent both the early and critical warnings are disabled
- If you set both warning percentages to 100 percent, the storage management software will not send warning notifications

The pool utilization threshold warnings are especially critical when you have thin volumes in your disk pool. When you configure thin volumes, you provision preferred (or physical) storage based on your current I/O and data storage needs. As I/O and storage needs change, you can increase the allocated preferred capacity to accommodate increased activity. When using thin volumes, the pool utilization threshold warnings help you determine when you need to provision additional capacity for a disk pool.

With a standard volume, you configure the capacity when you create the volume. To monitor the available storage capacity you can view the reports and logs available with the storage management software.

Disk Pool States

When the disk pool is operational, the storage management software displays one of the following states for the disk pool:

- Optimal – All drives in the disk pool are operational and all volume data is accessible.
- Degraded – Some drives in the disk pool are missing. The volumes are still accessible but are in a degraded state. A drive can be missing because it has failed or is involved in a drive failure reconstruction process. After the reconstruction process completes successfully, all drives involved in the reconstruction process return to the optimal state.
- Failed – All drives in a disk pool are not present in the storage array due to drive failure or drive removal. The data on the volume is not accessible in this state.

Restrictions

Some restriction that apply to disk pools include:

- You cannot export a disk pool from a storage array or import the disk pool to a different storage array.
- You can protect your disk pool with Full Disk Encryption (FDE), but the drive attributes must match.
- You can use Data Assurance (DA) capabilities of a drive set in a disk pool if all drives match in their DA capabilities.

Disk Pool Attributes

When you use the storage management software to create a disk pool you must select the appropriate values for the attributes described in Table 6.

Table 6 Create Disk Pool Attributes

Attributes	Description
Disk Pool Creation	Select the Create Disk Pool option.
Disk Pool Name	Assign a name to the disk pool.
Drive Security	Set the **Any available drives** option to create a disk pool comprising of drives that are not security capable. Set the **Only security-capable drives** option if the Drive Security premium feature has been enabled, and a security key is set up for the storage array. If the Drive Security feature is not enabled, the storage management software automatically uses the **Any available drives** default setting.
Data Assurance	Set the **Only DA-capable drives** option if your storage array has DA capable drive. Otherwise set the **Any available drives** option.

Attributes	Description
Critical warning notification threshold	When the percentage of usable capacity of the disk pool reaches this percentage, the storage management software generates an alert notification in the form of emails and SNMP trap messages. Use this threshold as an indication to increase the preferred capacity of volumes in your disk pool. The storage management software sets a default percentage value, but you can change this value during the configuration process.
Early warning notification threshold	When the percentage of usable capacity of the disk pool reaches this percentage, the storage management software generates an alert notification in the form of emails and SNMP trap messages. Use this threshold as an indication to start monitoring the usable capacity of your disk pool. The storage management software sets a default percentage value, but you can change this value during the configuration process. This percentage value should be less that the value set for the Critical warning notification threshold.

Disk Pool Reconstruction

When you configure a disk pool, a small capacity of each drive is allocated as reserved reconstruction space. When data is distributed among the drives in a disk pool the reserved reconstruction space is never used to store data. If a drive fails, incoming data is automatically distributed among the remaining functional drives. The controller uses the reserved reconstruction data space to reconstruct the data from a failed drive.

The reconstruction process runs as a background process. If during the reconstruction process the capacity of the disk pool is exhausted, the reconstruction process stops and some or all the volumes in the disk pool are left in a degraded state. If this happens, the storage management software issues a Critical Major Event Log (MEL) and generates a Needs Attention Condition message.

When you create a disk pool, you can configure the priority given to background operations, reconstruction for a drive in a degraded state, reconstruction for a drive in a critical state, and the preservation capacity available for the reconstruction process. The range for the priority settings is lowest, low, medium, high, and highest. If you select a lower setting, there is minimal effect on the host I/O and storage operations within the disk pool, but the reconstruction process typically takes a longer time. If you select a higher setting, host I/O activities may slow down a bit but the reconstruction process is active for less time.

- **Background Operation Priority** – This attribute indicates the priority given to background task activities on a disk pool. The default for this priority is **Low**.

- **Degraded Reconstruction Priority** – This attribute indicates the priority given to the reconstruction process if a drive moves to a degraded state. Degraded is defined as a single drive missing or failed in a disk pool. The default for this priority is **High**.
- **Critical Reconstruction Priority** – This attribute indicates the priority given to critical reconstruction activities. With RAID Level 6, two drives missing or two failed drives constitutes a critical state for a disk pool. The default for this priority is **Highest**.
- **Preservation Capacity** – This attribute specifies the number of drives to reserve in a disk pool for the reconstruction process in addition to the reserved reconstruction space reserved on each drive. The default for this parameter is **1**.

Volumes

Within a disk pool or a volume group you create volumes for organizing your data. You configure the free capacity on your disk pool or volume group as volumes. You can create standard volumes in either a disk pool or a volume group, whereas you can only create thin volumes in a disk pool.

Table 7 provides comparison information for the two types of volumes.

Table 7 Characteristics of Volumes

Standard Volume Characteristics	Thin Volume Characteristics
■ Can be a member of a disk pool or a volume group ■ Capacity is allocated up front ■ No minimum provisioned capacity required ■ Only available option if the thin volume premium feature is not purchased	■ Can be a member of only a disk pool ■ Capacity is provisioned as data is being written ■ Minimum required provision capacity is 4 GB ■ More efficient use of storage capacity because you allocate space as it is needed ■ Requires the purchase of the key file for the thin provisioning premium feature

NOTE Not all storage arrays or software releases of SANtricity ES allow a user to create thin volumes or disk pools.

Configure a volume to meet application needs for data availability and I/O performance. The storage management software administers a volume as if the volume is one drive for data storage. A host attached to a storage array writes data to the volumes and reads data from the volumes.

Types of Volumes

The storage management software lets you create a standard volume and a thin volume. However, there are other names used to refer to how the storage management software is using a standard volume or a thin volume, such as primary volume or source volume. In addition, the storage management software automatically creates different types of volumes when related premium features are enabled for your storage array. The different volume names are described in Table 8. With the exception of the standard volume, all other types of volumes are available when the related premium feature is enabled.

Table 8 Volume Descriptions

Volume Name	Description
Standard Volume	A standard volume is the types of volume you can create from a volume group or a disk pool in a storage array to store data. When you configure a standard volume from a volume group or a disk pool, you must specify a capacity that is all or part of the volume group or disk pool capacity. The operating system sees a volume as one drive.
Thin Volume	You can create a thin volume in a disk pool when the Thin Provisioning Premium Feature is enabled for your storage array. With a thin volume, capacity is allocated as the data is written. RAID level 6 is auto-assigned to disk pools and therefore applied to thin volumes.
Primary Volume	A primary volume is a standard volume in a Synchronous Mirroring relationship. The primary volume accepts host data transfers and stores application data. When you first create the mirror relationship, data from the primary volume is copied in its entirety to the associated secondary volume. Thin volumes cannot participate in Synchronous Mirroring relationships.
Secondary Volume	A standard volume in a Synchronous Mirroring relationship that maintains a mirror (or copy) of the data from its associated primary volume. The secondary volume remains unavailable to host applications while mirroring is underway. In the event of a disaster or a catastrophic failure of the primary site, a system administrator can promote the secondary volume to a primary role. Thin volume cannot participate in Synchronous Mirroring relationships.

Volume Name	Description
Mirror Repository Volume	A special volume in a Synchronous Mirroring configuration that is created as a resource for each controller in both the local storage array and the remote storage array. The controller stores mirroring information on this volume, including information about remote writes that are not yet complete. A controller can use this information to recover from controller resets and accidental power shutdown of the storage arrays. Thin volumes cannot participate in Synchronous Mirroring relationships.
Source Volume	With the Volume Copy feature, the source volume contains the data you need to copy to a different volume copy within the same storage array, backup to another volume, or restore from a snapshot (legacy) volume to a base volume. A source volume can be either a standard volume, a thin volume, a snapshot (legacy) volume, a base volume, or a Synchronous Mirroring primary volume.
Target Volume	With the Volume Copy feature, the target volume is the recipient volume for data being transferred, backed up, or restored. You can create a target volume from a standard volume, the base volume of a snapshot (legacy) volume, or a Synchronous Mirroring primary volume. Target volumes are read-only and do not accept write requests. The volume copy overwrites any existing volume data if an existing volume is used as a target. You cannot use a thin volume as a target volume.
Snapshot (Legacy) Volume	A logical snapshot image of another volume. A snapshot (legacy) volume is the logical equivalent of a complete physical copy; however, it is not an actual, physical copy. Instead, the firmware tracks only the data blocks that are overwritten and copies those blocks to a snapshot (legacy) repository volume.
Snapshot (Legacy) Repository Volume	A special volume in a storage array that is created as a resource for a snapshot (legacy) volume. A snapshot (legacy) repository volume contains snapshot data and copy-on-write data for a particular snapshot (legacy) volume.

Volume Name	Description
Base Volume	A volume from which you create a snapshot (legacy) volume or a snapshot volume. The term base volume is used only to show the relationship between a volume from which you are taking the snapshot image and a snapshot (legacy) volume or a snapshot image and a snapshot volume.
Snapshot Volume	A snapshot image that is read/write accessible by hosts.
Snapshot Group Repository	A physical volume created to store the data for all the snapshot images taken of a base volume.
Consistency Group Volume	Allows hosts to access a copy of the data contained in a consistency group snapshot image. This volume contains its own repository, which is used to save any subsequent modifications made by the host application to the member volume without affecting the referenced consistency group snapshot image.

Thin Volumes

A thin volume is a logical structure within a disk pool. Each volume is assigned a logical unit number (LUN). A host uses the LUN to perform I/O writes to a volume. The Thin Provisioning premium feature must be supported on your storage array to enable or disable this feature. When the Thin Provisioning premium feature is enabled, you can create a thin volume in a disk pool. Thin volumes can exist only in disk pools, whereas a standard volume can exist in either a disk pool or a volume group.

For a standard volume you specify the total available free capacity allocated for a volume up front. For a thin volume you initially specify a small portion of the free capacity to be allocated for the thin volume and increase the capacity over time as storage demands increase.

When you create a thin volume, unlike a standard volume where you specify only the volume capacity, you specify a *virtual capacity* and a *preferred capacity*. The virtual capacity is the capacity the volume reports to a host for read or write operations. This is the maximum size you speculate a thin volume will reach over time. The minimum value you can specify for the virtual capacity is 63 TB.

The preferred capacity is the amount of physical drive space you want to allocate for the repository the controller uses to store data for the host write operations issued against a thin volume. The software calculates this value for you automatically, or you can set this capacity manually. If you select the manual method, the minimum value you can specify for the preferred capacity is 4 GB; the maximum is 64 TB. You must specify the preferred capacity in increments of 4 GB. The storage management software translates the specified preferred capacity as a percentage of virtual capacity allocated for the thin volume. Typically, the preferred capacity is much smaller than the amount specified for the virtual capacity.

The storage management software automatically assigns RAID Level 6 for a disk pool. This means that all thin volumes and standard volumes in a disk pool are RAID 6 volumes.

You can use the dynamic volume expansion (DVE) operation to increase the capacity specified for a standard volume or a thin volume. The difference between initiating the DVE operation on a standard volume as compared to a thin volume is the type of capacity this operation changes. For a standard volume, use the DVE operation to increases the capacity of a standard volume—the free capacity of the associated volume group or disk pool decreases by the amount specified with the DVE operation. For a thin volume, the DVE operation increases the amount specified for the virtual capacity—the free capacity of the disk pool remains unchanged.

For a thin volume, you can increase the preferred capacity automatically or manually based on how you configure the Repository Expansion Policy. If you select the **automatic** method, when the repository utilization reaches a level that exceeds an internally determined threshold the controller increases the preferred capacity amount. If you select the **manual** method, an administrator uses the Increase Provisioned Capacity volume command when the storage management software generates a capacity alert modification warning. With the manual method you can increase the preferred capacity in 4-GB increments. Using the automatic method is the recommended option. If you select the automatic method, the system displays an error message if you attempt to manually increase the preferred capacity.

Use the Create Volume Wizard to create a thin volume in a disk pool. During the volume creation process, the wizard prompts you to select the type of volume, the capacity to allocate for the volume, and to define basic volume attributes and optional advanced attributes.

Standard Volumes

A standard volume is a logical structure that a host uses to access data storage on a storage array. You create a standard volume from a collection of drives that comprise a disk pool or a volume group. A volume assumes the RAID level configured for the volume group or disk pool. The capacity of a volume is limited by the amount of free capacity available in a volume group or a disk pool.

If you have not configured any volumes on a storage array, the only node that is available is the Unconfigured Capacity node. Node is used in the context of a connection point. Each volume is assigned a logical unit number (LUN) which a host uses to access a volume. Because the description refers to a volume that is not configured, hence has not been assigned a LUN, we use the term node to refer to the unconfigured capacity.

The hosts that are attached to the storage array write data to the volumes and read data from the volumes. The host operating system sees a volume as a single logical drive, although for RAID 1 and higher, data for a volume is written across several physical drives located in a storage array. With a standard volume, the data is distributed across the drives based on a RAID level. When you create a volume group, you specify the RAID level. All volumes within a volume group use the RAID level specified for the volume group. The data for each volume is written sequentially across a set of drives that comprise the volume group.

For standard volumes, redundancy (or parity) data is stored on the volumes in a volume group based on the RAID level assigned to a volume group. In the event of a drive failure, the controller uses the redundant (or parity) data and a hot spare drive configured for a volume group to complete the recovery process.

The storage management software provides a wizard that lets users create a volume. Use the Create Volume Wizard to create one or more volumes on a disk pool or a volume group. During the volume creation process, the wizard prompts you to select the type of volume (standard volume or thin volume), the capacity to allocate for the volumes, and to define basic volume parameters and optional advanced volume parameters for the volume.

NOTE The host operating system might have specific limits about how many volumes and the size of a single volume that the host can access. You must consider these limits when you create volumes that are used by a particular host.

Specify Standard Volume Attributes

Table 9 provides a brief explanation of how to configure volume attributes when creating a standard volume using the different types of available capacity in a volume group.

Table 9 Create Standard Volume Attributes

Attribute Name or Function	Free Capacity	Unconfigured Capacity
Volume Group Creation	The volume group is predefined.	You must create a volume group before configuring a new volume.
Specify Capacity/Name Dialog	Assign a name to the volume. Change the default capacity.	Assign a name to the volume. Change the default capacity.
Storage Partitioning will be used	Select the **Map Later using the Mappings View** option. This option specifies that a LUN not be assigned to the volume during volume creation. This option defines specific mappings and creates storage partitions.	Select the **Map Later using the Mappings View** option. This option specifies that a LUN not be assigned to the volume during volume creation. This option defines specific mappings and creates storage partitions.

Attribute Name or Function	Free Capacity	Unconfigured Capacity
Storage Partitioning will *not* be used	Select the **Default Mapping** option. This option automatically assigns the next available LUN in the Default Group to the volume. The option grants volume access to host groups or hosts that have no specific mappings, which are shown under the Default Group node in the Topology pane.	Select the **Default Mapping** option. This option automatically assigns the next available LUN in the Default Group to the volume. The option grants volume access to host groups or hosts that have no specific mappings, which are shown under the Default Group node in the Topology pane.
Advanced Volume Parameters	You can customize these advanced volume parameters: ■ Volume I/O characteristics ■ Preferred controller owner	You can customize these advanced volume parameters: ■ Volume I/O characteristics ■ Preferred controller owner

Dynamic Capacity Expansion

Dynamic Capacity Expansion (DCE) is a modification operation in the storage management software that increases the capacity of a volume group or a disk pool. This modification operation enables you to add unassigned drives to a volume group or disk pool. Adding unassigned drives increases the free capacity in the volume group or the disk pool. You can use this free capacity to create additional volumes or add reserve capacity for a disk pool or a volume group.

This operation is considered to be dynamic because you have the ability to continually access data in the volume group throughout the entire operation.

Keep these guidelines in mind when you add unassigned drives to a volume group or a disk pool:

- The number of unassigned drives that you can select for a DCE modification operation is limited by the controller firmware. You can add two unassigned drives at a time for a volume group. You can add up to 12 drives at a time for a disk pool. However, after you have completed a DCE operation, you can add more drives again until the desired capacity is reached.
- The existing volumes in the volume group or the disk pool do not increase in size when you add unassigned drives to expand the free capacity. This operation redistributes existing volume capacity over the larger number of drives in the volume group or the disk pool.

- The unassigned drives that you add to a volume group or a disk pool must be of the same media type and interface type, have the same spindle speed, and preferably have the same capacity. Mixing different drive types within a single volume group or disk pool is not permitted. Only security capable drives can be added to a security enabled volume group or disk pool, or a security capable volume group or disk pool. Whenever possible, select drives that have a capacity equal to the capacities of the current drives in the volume group or the disk pool. Drives with a capacity larger or equal to the capacity of the drives currently in a disk pool might be added as part of a Dynamic Capacity Expansion operation. However, if drives with larger capacity than those currently in a disk pool are added, the capacity above the smallest drive in the disk pool is not used and the amount unused is reported as unuseable capacity.
- In a RAID Level 1 volume group, you must add two drives to make sure that data redundancy is configured.
- In a volume group or a disk pool that is Data Assurance (DA) capable and contains a DA-enabled volume, you can add only DA-capable drives.

Register the Volume with the Operating System

After you have created all of your volumes and have assigned mappings, use a volume registration utility to scan the mapped volumes and register the volumes with the operating system.

Premium Features

The following premium features may be optionally provided through the Array Management Window of SANtricity ES:

- Thin Provisioning
- SANshare Storage Partitioning
- Snapshot
- Snapshot (Legacy) Volume
- Synchronous Mirroring (this premium feature is supported only in storage arrays with the Fibre Channel [FC] host ports)
- Volume Copy
- Drive Security
- Enterprise Security Key Manager
- Data Assurance (DA)
- Solid State Drive Support (SSDs)
- RAID 6 Volumes
- High Performance Tier
- Mixed Drive Types
- Drive Slot Limit

Thin Provisioning Premium Feature

The Thin Provisioning Premium Feature enables a disk pool to present more logical storage to hosts or users than is actually available on the physical drives in your disk pool. Instead of allocating a pre-determined amount of physical storage up front, storage space is dynamically allocated to each volume or LUN as data is written. Using thin provisioning helps to eliminate the large amounts of unused capacity that occurs with standard volumes. For a standard volume, all of the capacity is allocated up front.

You can create a thin volume only in a disk pool, not in a volume group. When you create a thin volume, you specify two types of capacity: the virtual capacity and the provisioned capacity. The **virtual capacity** is the capacity that is reported to the hosts. The maximum virtual capacity you can specify for a thin volume is 63 TB. The **preferred** (or provisioned) **capacity** is the amount of physical drive space that is currently allocated for writing data. The minimum preferred capacity required for a thin volume is 4 GB. The maximum preferred capacity allowed for a thin volume is 64 TB.

With a thin volume, capacity is referenced as virtual, provisioned, or consumed. The *virtual capacity* of the thin volume is the capacity that the host sees as being available for READ or WRITE operations. The *provisioned capacity* is the physical capacity used to store new data from host write requests. The provisioned capacity is typically a smaller capacity than the virtual capacity. The *consumed capacity* is the amount of provisioned capacity the host uses for saving data during processing of host write requests. When the consumed capacity reaches the provisioned capacity, the storage array cannot accommodate additional write requests until the storage management software increases the provisioned capacity. The storage management software can automatically expand the provisioned capacity or you can do it manually. If you select the automatic expansion options, you can set a maximum expansion capacity. The maximum expansion capacity enables you to limit the automatic growth of the volume to be an amount below the virtual capacity.

If you have not configured any volumes on the storage array, you use the Disk Pool Free Capacity node to configure a thin volume. A node is a connection point that you can click to configure a volume. Disk pool free capacity is the unassigned space in a disk pool that you use to make a volume.

NOTE The host operating system might have specific limits about how many volumes and the size of a single volume that the host can access. You must consider these limits when you create volumes that are used by a particular host.

Thin Volume Attributes

When you configure a thin volume, you must select the thin volume option and enter a virtual capacity and volume name. After entering this information, the storage management software can automatically configure the remaining attributes or you can select the **customize capacity settings** option to set the values yourself. With the customize capacity settings option, you can specify values for the following attributes:

- **Preferred Capacity** – This attribute indicates the initial physical capacity of the volume. Use the **Units** list to indicate that the capacity is in MB, GB, or TB. Preferred capacity in a disk pool is allocated in 4-GB increments. If you specify a preferred capacity amount that is not a multiple of 4 GB, the storage management software allocates physical capacity in an increment of 4 GB and the remaining capacity is unused. For example, if you specify preferred capacity as 22 GB, the system allocated 20 GB and the remaining 2 GB is unused capacity. To make sure that the entire capacity is usable, specify the capacity in 4-GB increments. If unusable capacity exists, the only way to regain it is to increase the capacity of the thin volume.
- **Repository (volume) Expansion Policy** – This attribute indicates whether the storage management software or a user is responsible for expanding the preferred (or physical) capacity of a thin volume as the consumed capacity gets close to the allocated preferred capacity. If you select the **automatic** expansion method, enter a maximum expansion capacity value. The storage management software will expand the preferred capacity in increments of 4 GB until it reaches the specified maximum expansion capacity. If you select the **manual** expansion method, you are responsible for expanding the preferred capacity when the consumed capacity gets close to the physical capacity. With the manual method, you need to rely on the Warning Threshold alerts you receive to determine when to increase the preferred capacity. The automatic method is recommended.

- **Maximum Expansion Capacity** – This attribute is used with the Automatic Repository Expansion Policy. The entered expansion capacity indicates the maximum capacity to which the storage management software can automatically expand the preferred capacity. The expansion capacity you enter must be below the specified virtual capacity of the thin volume. Use the **Units** list to indicate that the capacity is in MB, GB, or TB.
- **Warning Threshold** – This attribute indicates when the storage management software will send an alert email or SNMP message to indicate that the consumed capacity has reached this percentage of preferred capacity. The default setting is 85 percent.

Guidelines

While most features work the same with standard volumes and thin volumes, there are a few differences:

- You cannot delete a thin volume if it has associated snapshot images.
- You can convert a thin volume to a standard volume by creating a Volume Copy of a thin volume.
- You cannot use a thin volume as the target in a Volume Copy.
- You cannot perform a Synchronous Mirroring operation with a thin volume.

You should consider creating a standard volume rather than a thin volume when you anticipate that storage consumption on a volume will be unpredictable or highly volatile, or an application using a volume will be mission critical.

Thin Volume States

When a thin volume is operational, the storage management software displays one of the following states for the volume:

- Optimal – The thin volume is operating normally.
- Full – The preferred (physical) capacity of the thin volume is full, meaning that no more host write requests can be processed for this volume.
- Over Threshold – The preferred capacity of the thin volume is utilized at or beyond the specified Warning Threshold percentage. The storage management software assigns a *Needs Attention* condition for the storage array.
- Failed – The thin volume has failed and is no longer available for read or write operations. The storage management software assigns a *Needs Attention* condition for the storage array.

Rollback

Rollback operations are fully supported for thin volumes. A Rollback operation restores the logical content of a thin volume to match the selected snapshot image. There will be no change to the consumed capacity of the thin volume as a result of the rollback operation.

SANshare Storage Partitioning Premium Feature

SANshare Storage Partitioning lets hosts with different operating systems share access to a storage array. Hosts with different operating systems that share access to a storage array are called heterogeneous hosts.

A storage partition is a logical entity that consists of one or more storage array standard volumes that can be shared among hosts. To create a storage partition after the total storage capacity has been configured into Standard volumes, you must define a single host or collection of hosts (or host group) that will access the storage array. Then you must define a mapping, which lets you specify the host group or the host that will have access to a particular volume in your storage array.

Based on the premium feature key file purchased, the storage management software can support the maximum storage partitions shown in this table.

Storage Array	Maximum Number of Storage Partitions Supported
E5400 controller-drive tray	Up to 512
CE7900 controller tray	Up to 512
E2600 controller-drive tray	Up to 128
CE4900 controller-drive tray	Up to 128

You can define a maximum of 256 volumes per partition (except for the HP-UX 11.23 operating system); this number is limited to the total number of volumes on your storage array.

Enhanced Snapshot Premium Feature

The storage management software provides a Snapshot Premium Feature that lets you take a logical copy of the content of a standard volume or a thin volume at a particular point in time. These point-in-time snapshots of volumes are named snapshot images. Taking a snapshot image is useful any time you need to be able to roll back to a known good data set at a specific point in time. For example, you can create a snapshot image as a backup that you can use during a recovery operation.

When you take a snapshot image of a volume, the storage management software saves the read-only snapshot image in a repository associated with a snapshot group. To provide a host access to snapshot images stored within a snapshot group repository, you must create a snapshot volume.

Some important details to remember about the relationships between a snapshot image, a snapshot group, and a snapshot volume are:

- Every snapshot image is created in the context of exactly one snapshot group.
- A snapshot image is not host accessible. Only images in a snapshot volume are host-accessible.

- A snapshot group is a sequence of snapshot images of a single associated standard volume or thin volume. A volume used to create a snapshot image is referred to as a base volume.
- A snapshot group has exactly one repository that it uses to save the snapshot images that are part of the snapshot group.
- All snapshot images within a snapshot group repository have a direct association with that snapshot group.
- A snapshot group has an association with a single volume.
- Every snapshot volume has a direct association with a snapshot image.
- Every snapshot volume has a persistent relationship to the base volume of the snapshot image for which the snapshot volume was initially created.
- The repository associated with snapshot volume has an association with a snapshot group.

Snapshot Images

The Snapshot Image premium feature lets you take logical copies of the content of a standard volume or a thin volume at a particular point in time. These point-in-time images of volumes are named snapshot images. The volumes that are the source of a snapshot image are referred to as base volumes. You use the snapshot image feature to create multiple copies of production data of volumes in a disk pool, a volume group, or a consistency group. A consistency group is a collection of base volumes in your storage array. Snapshot images are useful any time you need to be able to roll back to a known good data set at a specific point in time. You can use a snapshot image to restore the database during a recovery operation or as an image to use to perform testing before you upgrade to a newer version of software.

When you create your first snapshot image of a base volume, the storage management software automatically creates a snapshot group if one does not already exist. The first snapshot image is an exact logical copy of the base volume at that point in time. Thereafter, when the system generates a snapshot image, only the data changes since the last snapshot image are captured.

The snapshot mechanism creates the initial snapshot image and tracks source changes from the time each snapshot image is created until the snapshot image is disabled by a user. The snapshot mechanism saves existing data for the base volume to a repository volume associated with a snapshot group—referred to as a snapshot group repository volume—before the data in the base volume is overwritten with new data. The snapshot mechanism updates an index in the snapshot group repository volume to reflect the location of each new snapshot image.

A snapshot image is not directly read or write accessible to hosts because snapshot images contain only the changed data captured from the base volume. You need to create a snapshot volume to view snapshot images.

Some of the important characteristics of snapshot images are:

- Snapshot images are always created inside a snapshot group.
- Each snapshot image is associated with exactly one snapshot group.
- You can add up to 32 snapshot images to a snapshot group.
- You cannot create a snapshot image of a failed volume.

Snapshot Groups

A snapshot group is a sequence of snapshot images of a single associated base volume. You create a snapshot group for each base volume for which you want to create snapshot images. The purpose of a snapshot group is to provide a means of creating a sequence of snapshot images for a given base volume. Each snapshot group has one associated repository volume, referred to as a snapshot group repository volume. The snapshot mechanism uses the repository volume to save the snapshot images. Every snapshot image is created in the context of exactly one snapshot group.

The base volume associated with a snapshot group can reside in a disk pool or a volume group. If the base volume resides in a volume group, the repository members for any associated snapshot group can reside in a disk pool or a volume group. However, if a base volume resides in a disk pool, all repository members for any associated snapshot group must reside in the same disk pool as the base volume.

You must enable the Snapshot premium feature on the storage array before you create a snapshot group. You can create a snapshot group only for standard volumes and thin volumes. There are two ways to create a snapshot group:

- The storage management software will automatically create a snapshot group when you create the first snapshot image for a base volume.
- You can create an empty snapshot group before you issue the Create Snapshot Image command.

When you create a new snapshot group for a snapshot image, you can select to create the repository using either the automatic or manual method. With the automatic method, the storage management software creates the snapshot group repository with the default capacity settings. Using the automatic method is the recommended option.

Use the manual method to create a new snapshot group if you want to specify all of the customizable settings for the snapshot group repository. The manual method is considered advanced and only those who understand drive redundancy and optimal drive configurations should use this option. The snapshot group customizable settings include:

- **Repository capacity** – Capacity of the associated snapshot group repository volume. You specify this capacity as either as a percentage of the base volume capacity or an actual capacity amount.
- **Automatic deletion snapshot image limit** – System deletes the oldest snapshot image upon reaching the specified limit. The maximum limit is 32 snapshot images for a snapshot group.

- **Repository utilization threshold percentage** – System sends an e-mail or SNMP alert to the administrator when the specified percentage of capacity of a snapshot repository volume has reached or exceeds the specified utilization threshold percentage.
- **Action required for a repository full condition** – Select the `auto-purge` option if you want the system to delete the oldest snapshot image in the snapshot group. Select the `fail base writes` option if you want the system to fail the current I/O write request because the repository is full.

The snapshot images in a snapshot group are stored in a specific order based on their creation time. The strict order of the snapshot images helps you to determine which snapshot image to use in a roll back operation for the base volume or which snapshot image to delete when it is no longer needed.

Keep the following guidelines in mind when you create a snapshot group:

- You can create up to four snapshot groups for a single associated base volume.
- You can add up to 32 snapshot images to a snapshot group.
- Each snapshot image is associated with exactly one snapshot group.
- Each snapshot group repository volume is associated with only one base volume.
- You cannot create a snapshot group on a failed base volume.
- A snapshot group has an association with a base volume for the related snapshot group.
- The snapshot group repository volume must have the same Data Assurance (DA) and Quality of Service (QoS) settings as the associated base volume for the snapshot group. For example, if a base volume for a snapshot group is DA enabled, then the associated snapshot group repository volume must also be DA enabled.

Snapshot Group Repository Volume

Each snapshot group has an associated repository volume that the system uses to store the snapshot images for a given base volume. When you use the storage management software GUI to create a snapshot group for a base volume, the software automatically creates this repository volume as part of the Create Snapshot Group process.

Snapshot Volume

Snapshot images are not directly accessible for either read or write operations by a host. To provide a host access to snapshot images stored within a snapshot group repository volume, you must create a snapshot volume.

When you create a snapshot volume, you can designate the volume as either read-only or read-write. A read-write snapshot volume requires an associated repository to provide the host application with write access to a copy of the data contained in the snapshot image. Any modifications made by the host application to the snapshot image are saved in this repository to allow the data of the original snapshot image to remain unchanged.

An administrator must monitor the utilization of a snapshot volume to ensure that ongoing write operations for the base volume are handled properly. The storage management software provides mechanisms for viewing the current utilization of a repository volume and remaining free space of a snapshot volume, and for managing alert thresholds that trigger notification when utilization reaches configured levels.

Every snapshot volume has a direct association with a base volume.

Schedule Snapshot Images

You can create a schedule for snapshot images and specify the frequency that the storage management software creates snapshot images. You can create a schedule when you initially create a snapshot group or consistency group, or you can add one later to an existing snapshot group or consistency group.

When you enable snapshot image scheduling:

- You can set up a schedule for a snapshot group to automatically create a snapshot image at a specific time in the future or on a regular basis.
- You can set up a schedule for a consistency group to automatically create a snapshot image of each member volume in the group at a specific time in the future or on a regular basis.

You can create a schedule that runs daily or weekly in which you select specific days of the week (Sunday through Saturday). To make scheduling easier, you can import an existing schedule for a snapshot group or consistency group. In addition, you can temporarily suspend scheduled snapshot image creation by disabling the schedule. When a schedule is disabled, the schedule timer continues to run, but the scheduled snapshot image creations do not occur.

Keep the following guidelines in mind when creating schedules for snapshot groups and consistency groups:

- Using a schedule can result in a large number of snapshot images, so be sure that you have sufficient drive space.
- Each snapshot group or consistency group can have only one schedule.
- Scheduled snapshot image creations do not occur when the storage array is offline or powered off.
- If you delete a snapshot group or consistency group that has a schedule, the schedule is also deleted.
- Schedules are stored in the configuration database on the storage array. The management station does not need to be running the Enterprise Management Window (EMW) or the Array Management Window (AMW) for the scheduled snapshot image creation to occur.

Rollback to a Snapshot Image

The rollback operation removes all data modifications that were made to a base volume since the specified snapshot image was taken. The host can continue to access the base volume for I/O operations during the rollback operation. You can roll back data by creating a snapshot volume of a snapshot image, which lets you view the base volume in its original state when the snapshot image was created. Alternatively, you can roll back data by restoring a snapshot image to the base volume, which lets you roll back the base volume to a previous state.

You can start a rollback from a snapshot image or a consistency group snapshot image. When you perform a rollback operation on a snapshot image, the system rolls back the base volume associated with a snapshot group to a previous state. The rollback operation does not change the content of the snapshot images that are associated with the base volume. When you roll back a consistency group snapshot image, the system rolls back all or select member volumes of the consistency group to a previous state.

Before you use the Start Rollback option:

- Make sure there is enough capacity in the repository to start a rollback operation.
- Make sure the selected snapshot image is in an Optimal state. If the snapshot image is in a Purged state or has been automatically deleted due to the Auto-Delete Limit, the system displays an error message.
- Make sure the selected volume is in an Optimal state. You cannot start a rollback operation on a failed volume.
- Make sure the selected volume does not have a rollback operation already in progress. You cannot start more than one rollback operation for a base volume at a time.

Keep these guidelines in mind before you start a rollback operation:

- During a rollback operation you cannot delete the snapshot image that is being used for the rollback.
- During a rollback operation you cannot create a new snapshot image for a base volume that is participating in a rollback operation.
- During a rollback operation you cannot change the associated snapshot group’s Repository-Full Policy.
- You cannot start a rollback operation when a Dynamic Capacity Expansion (DCE), Dynamic Volume Expansion (DVE), a Dynamic RAID Migration (DRM), or a Dynamic Segment Size (DSS) operation is in progress.
- You cannot start a rollback operation if the base volume is participating in a Volume Copy.

- You cannot start a rollback operation if the base volume is a secondary volume in a remote mirror. However, if the base volume is the primary volume in a remote mirror, you can start a rollback operation. Additionally, you cannot perform a role reversal in a remote mirror if the primary volume is participating in a rollback operation.
- A rollback operation fails if any of the used capacity in the associated snapshot repository volume has unreadable sectors.

For more information about using the rollback operation for snapshot images, see the topic *Performing Rollback Operations* in online help.

Convert a Snapshot (Legacy) Volume to a Snapshot Group

Use the Convert Snapshot (Legacy) to Snapshot Group option to convert a snapshot (legacy) volume and its associated repository to a snapshot group. The system performs the following actions for each converted snapshot (legacy) volume:

- Deletes the snapshot (legacy) volume definition and creates a new snapshot group (the new snapshot group is created empty, with no snapshot images).
- Converts the associated snapshot (legacy) repository volume to a snapshot group repository.
- Retains the same schedule (if a schedule has been defined) for the new snapshot group.
- Creates a read-only snapshot volume with a Paused status. The new snapshot volume inherits the World-Wide Name (WWN) and host mappings as the converted snapshot (legacy) volume.

NOTE If the number of snapshots (legacy) that exist for a given base volume exceeds the maximum number of allowed snapshot groups per base volume, a conversion request for that base volume will be rejected. Any excess snapshot (legacy) beyond the limit must be deleted before you can perform the conversion process.

Keep the following guidelines in mind when you use the Convert Snapshot (Legacy) to Snapshot Group option:

- The conversion process is performed on a given base volume, and applies to all snapshots of a given base volume.
- Snapshot (Legacy) volume and snapshot groups cannot exist on the same base volume; therefore, any snapshot (legacy) volume that you do not select for conversion will be deleted from the storage array.
- If a base volume has snapshot (legacy) images created as part of an online Volume Copy operation, those volume copy definitions must be deleted before you attempt to convert a snapshot (legacy) image to a snapshot image.
- You can perform the conversion operation only for those snapshot (legacy) volumes that are in the Stopped state.

Create Consistency Groups

A consistency group is a collection of base volumes in your storage array. These base volumes, which are the source of a snapshot image, are referred to as member volumes of a consistency group. The purpose of a consistency group is to take simultaneous snapshot images of multiple volumes, thus ensuring consistent copies of a collection of volumes at a particular point in time. For example, you can create a consistency group if you want to take a synchronized snapshot image of several volumes that are in different volume groups or disk pools in a storage array. Using the consistency group mechanism is ideal for applications that span multiple volumes, for example, a database application that has the logs on one volume and the database on another volume. Every base volume that belongs to a consistency group is referred to as a member volume. A member volume is either a standard volume in a disk pool or a volume group, or a thin volume in a disk pool.

When you create a consistency group, the storage management software lets you add member volumes during the creation process or create the consistency group with no member volumes. If you want to add member volumes as part of the creation process, you select the desired volumes from the eligible volumes list and select the **automatic** or **manual** member repository creation option. With the automatic method, the storage management software uses the default values when creating the associated member repository for each member volume you add to the consistency group. When you select the manual snapshot volume repository creation option, you need to select the **Add members now** option and select the desired volumes from the list of eligible volumes. With the manual method, you also need to understand how to use the auto-choose utility, how to use the repository candidate table, how to set the auto-deletion setting, and how to set the repository utilization threshold percentage. The manual method is considered advanced and only those who understand consistency group functions and optimal drive configurations should use this option.

- **Auto-choose utility** – Use the Auto-Choose utility to enable the storage management software to automatically generate a list of recommended candidates for each member volume based on either a percentage of the member volume capacity or a preferred capacity. The system displays the best repository candidates for each member volume based on your selection.
- **Repository candidate table** – The repository candidate table displays a list of repository volumes available for member volumes. When you run the auto-choose utility, the proposed repository candidates are displayed in this table for the new and existing member volumes.
- **Automatic deletion snapshot image limit** – System deletes the oldest snapshot image upon reaching this specified limit.
- **Repository utilization threshold percentage** – System sends an e-mail or SNMP alert to the administrator when the specified percentage of capacity of an associated snapshot repository volume has reached or exceeds the specified utilization threshold percentage.

When you add a member volume to a consistency group, the system automatically creates an associated member repository and a snapshot group for the member volume.

Some of the characteristics of consistency groups are:

- There is a maximum allowable limit to the number of member volumes that can belong to a consistency group (depending on your configuration).
- You can create a schedule for creating snapshot images for all member volumes of a consistency group.
- You can perform a Rollback operation for a consistency group.
- A member volume can belong to several consistency groups.

For more information about creating a consistency group, see the topic *Managing Consistency Group Operations* in online help.

Mirroring

When you add a base volume that is a member of a consistency group to an asynchronous mirror group, the system automatically changes the Repository Full Policy to automatically purge the oldest snapshot image and sets the auto-delete limit to the maximum allowable snapshot limit for a consistency group.

All member volumes in a consistency group that also belong to an asynchronous mirror group must belong to the same asynchronous mirror group. You can use consistency groups for snapshot and mirroring, so it is good practice to define separate and specific consistency groups for snapshot images and mirroring.

Consistency Group Snapshot Images

A consistency group snapshot image is a logical point-in-time image of the content of each member volume in the consistency group at the same point in time. This action creates synchronized snapshot images of all the volumes in a consistency group. Consistency group snapshot images are stored consecutively based on creation time, with the oldest snapshot image at the top of the list.

Creating a snapshot image for a consistency group requires hosts to suspend all pending I/O operations for each member volume of the consistency group prior to taking the snapshot image. If the storage management software cannot successfully complete the snapshot image operation for all member volumes, the operation will fail and no new snapshot images are created.

When you add a new member volume after snapshot images have been created for a consistency group, the existing member volumes will have a different number of stored snapshot images as compared to the newly added member volume. If you roll back to a snapshot image that was taken before new member volumes were added to a consistency group, the rollback operation will only affect the member volumes that were in the consistency group at the time of the snapshot image.

You can think of a consistency group snapshot image as a restore point. The snapshot image is not directly read or write accessible to hosts as the consistency group snapshot image is used to save only the original data captured from the member volume. You must create a consistency group snapshot volume to enable the host access to a copy of the data contained in the consistency group snapshot image. The consistency group snapshot volume contains its own repository volume, which the storage management software uses to save any subsequent modifications made by the host application to the member volume without affecting the referenced consistency group snapshot image.

NOTE If you enable Auto-Delete for a consistency, the system deletes the oldest consistency group snapshot image in the group when the system creates a new consistency group snapshot image.

Keep these guidelines in mind when creating a consistency group snapshot image:

- You cannot create a snapshot image for a consistency group that has reached its maximum number of snapshot images. You must enable auto-delete for the consistency group or manually delete one or more snapshot images from the consistency group, and then retry the **Create Consistency Group Snapshot Image** operation.
- You cannot create a snapshot image of a failed drive.
- If a volume is a member of a consistency group, then the storage management software creates a snapshot group for that member volume. This snapshot group counts towards the maximum allowable number of snapshot groups per base volume.

Consistency Group Snapshot Volume

Snapshot images for member volumes of a consistency group are not directly accessible for either read or write operations by a host. To permit a host read-write access to snapshot images, you need to create a consistency group snapshot volume. A consistency group must contain at least one member volume before you create a consistency group snapshot volume. You can store up to four snapshot images in a consistency group snapshot volume.

Read-write consistency group snapshot volumes require a repository to save any subsequent modifications made by the host application to a member volume. The storage management software creates the repository, referred to as a consistency group snapshot volume repository, as part of the consistency group snapshot volume creation process.

Keep these guidelines in mind when you create a consistency group snapshot volume:

- You can create a consistency group snapshot volume using an existing snapshot image that is in the optimal state.
- You can increase the capacity of a consistency group snapshot volume repository if you have the storage capacity. Monitoring and increasing the capacity helps to avoid a repository full message.
- You can convert a consistency group snapshot volume from read-only to read-write. This conversion operation requires that you manually create a consistency group snapshot volume repository to support the host write operations to the member volumes.

Consistency Group Snapshot Volume Repository

During the creation of a consistency group snapshot volume that is designated as read-write, the storage management software creates a consistency group snapshot volume repository for every member of the consistency group. This repository provides the host application with write access to a copy of the data contained in the consistency group snapshot image. You can create the volume repository automatically using the default settings or you can manually create the repository by defining the capacity settings for the repository.

Use manual option if you want to manually define the capacity requirements for a consistency group snapshot volume repository. The manual method is considered advanced and only those who understand drive redundancy, provisioning, and optimal drive configurations should use this method.

Keep these guidelines in mind when you create a consistency group snapshot volume repository:

- The minimum required capacity of a consistency group snapshot volume repository is 32 MB.
- When you define the capacity requirements for a repository, keep in mind any future requirements that you might have for other volumes in this volume group or disk pool. Make sure that you have enough capacity to meet your data storage needs, but you do not over allocate because you can quickly use up all the storage in your system.
- The list of repository candidates can contain both new and existing repository volumes. Existing repository volumes are left on the storage array by default when you delete a consistency group snapshot volume. Existing repository volumes are placed at the top of the list. The benefit of reusing an existing repository volume is that you can avoid the initialization process that occurs when you create a new one.
- When you select the Overall Repository Increase Capacity option in the storage management software GUI to increase the capacity of a consistency group snapshot volume repository, the system is actually adding a standard volume to the end of a concatenated set of standard volumes that are already being used as the consistency group snapshot volume repository.

Snapshot (Legacy) Volume Premium Feature

The Snapshot (Legacy) Volume premium feature creates a logical point-in-time image of another volume. Snapshot (Legacy) Volume is a premium feature of the storage management software. You or your storage vendor must enable this premium feature, if it is available for your storage array.

Because the only data blocks that are physically stored in the snapshot (legacy) repository volume are those that have changed since the time that the snapshot (legacy) volume was created, the snapshot (legacy) volume uses less drive space than a full physical copy.

Typically, you create a snapshot (legacy) so that an application (for example, a backup application) can access the snapshot (legacy) and read the data; meanwhile, the base volume stays online and is user accessible. When the backup is completed, the snapshot (legacy) volume is no longer needed.

You can also create snapshots (legacy) of a base volume and write data to the snapshot (legacy) volumes to perform testing and analysis. Before upgrading your database management system, for example, you can use snapshot (legacy) volumes to test different configurations. Then you can use the performance data that is provided by the storage management software to help you decide how to configure your live database system.

Storage Array	Maximum Number of Snapshots (Legacy) per Volume	Maximum Number of Snapshots (Legacy) per Storage Array
E5400 controller-drive tray	Up to 16	Up to 1024
CE7900 controller tray	Up to 16	Up to 1024
E2600 controller-drive tray	Up to 16	Up to 256
CE4900 controller-drive tray	Up to 8	Up to 512

Creating Snapshot (Legacy) Volumes

When a snapshot (legacy) volume is created, the controller suspends I/O activity to the base volume for a few seconds while it creates a physical volume, called the snapshot (legacy) repository volume. The snapshot (legacy) repository volume stores the snapshot (legacy) volume metadata and the copy-on-write data.

You can create snapshot (legacy) volumes by using the Create Snapshot (Legacy) Volume Wizard in the Array Management Window. The first dialog of the Create Snapshot (Legacy) Volume Wizard lets you select either the simple path or the advanced path to be followed through the wizard. You can choose the simple path to create a snapshot (legacy) volume if the volume group of the base volume has the required amount of free capacity. The simple path lets you specify the basic parameters for the snapshot (legacy) volume. The simple path accepts the default settings for the advanced parameters.

NOTE If sufficient free capacity is not available in the volume group of the base volume, the Create Snapshot (Legacy) Volume Wizard uses the advanced path by default.

In the advanced path, either you can choose to place the snapshot (legacy) repository volume in another volume group, or you can use unconfigured capacity in the storage array to create a new volume group. The advanced path lets you customize the advanced settings for the snapshot (legacy) volume, such as the full conditions of the snapshot (legacy) repository volume and the notification settings.

If you want to create a snapshot (legacy) volume that performs snapshot (legacy) operations at a later time or at regularly occurring intervals, specify a schedule. If you do not specify a schedule, the snapshot (legacy) operation occurs immediately.

Scheduling Snapshots (Legacy)

If you want to create a snapshot (legacy) volume that performs snapshot (legacy) operations at a later time or at regularly occurring intervals, add a schedule to the snapshot (legacy) volume. If you do not add a schedule to the snapshot (legacy) volume, the snapshot (legacy) operation occurs immediately. You can add a schedule when you create a snapshot (legacy) volume, or you can add a schedule to an existing snapshot (legacy) volume. Each snapshot (legacy) volume can have only one schedule.

Typical Uses of Scheduling Snapshots (Legacy)

Scheduled backups – For example, an application stores business-critical data in two volumes in the storage array. You back up this data every work day at 11:00 p.m. To accomplish this type of backup, select the first volume. Create a schedule that runs once a day on Monday, Tuesday, Wednesday, Thursday, and Friday. Choose a time between the end of your work day and 11:00 p.m. Select a starting date of today and no end date. Apply this schedule to the second volume, also. Map the two snapshot (legacy) volumes to your backup host, and perform the regular backup procedures. Unmap the two snapshot (legacy) volumes before the next scheduled snapshot (legacy) operation time. If you do not unmap the snapshot (legacy) volumes, the storage array skips the next snapshot (legacy) operation to avoid data corruption.

Rapid recovery – In this example, you back up your data at the end of every work day and keep hourly snapshots (legacy) from 8:00 a.m. to 5:00 p.m. If data loss or corruption occurs during the work day, you can recover the data from the snapshots (legacy) so that the data loss window is smaller than one hour. To accomplish this type of recovery, create a schedule that contains a start time of 8:00 a.m. and an end time of 5:00 p.m. Select 10 snapshots (legacy) per day on Monday, Tuesday, Wednesday, Thursday, and Friday. Select a start date of today and no end date. Create an end-of-day backup as described in the "Scheduled backups" example.

Guidelines for Creating Schedules

Keep the following guidelines in mind when creating schedules for snapshot (legacy) volumes:

- Either you can create a schedule when you create a snapshot (legacy) volume, or you can add a schedule to an existing snapshot (legacy) volume.
- Scheduled snapshot (legacy) operations do not take place when these conditions occur:
  - The snapshot (legacy) volume is mapped.
  - The storage array is offline or powered off.
  - The snapshot (legacy) volume is used as a source volume in a Volume Copy operation, and the status of the copy operation is Pending or In progress.

- If you delete a snapshot (legacy) volume that has a schedule, the schedule is also deleted.
- Schedules are stored in the configuration database in the storage array. The management station does not need to be running the Enterprise Management Window (EMW) or the Array Management Window (AMW) for the scheduled snapshot (legacy) operation to occur.

Enabling and Disabling Schedules

You temporarily can suspend scheduled snapshot (legacy) operations by disabling the schedule. When a schedule is disabled, the schedule's timer continues to run, but the scheduled snapshot (legacy) operations do not occur.

Discontinuing the Use of a Snapshot (Legacy) Volume

As long as a snapshot (legacy) volume is enabled, storage array performance is affected by the copy-on-write activity to the associated snapshot (legacy) repository volume. When you no longer need a snapshot (legacy) volume, you can disable it, reuse it, or delete it.

- **Disable** – Stops copy-on-write activity. This option keeps the snapshot (legacy) volume and snapshot (legacy) repository volume intact.
- **Reuse** – Creates a different point-in-time image of the same base volume. This action takes less time to configure than re-creating the snapshot (legacy) volume.
- **Delete** – Completely removes the snapshot (legacy) volume and the associated snapshot (legacy) repository volume. If you want to re-enable a snapshot (legacy) volume, you must re-create it.

Disabling and Restarting Multiple Snapshot (Legacy)s

If multiple volumes require regular snapshot (legacy)s for backup purposes, keeping the snapshot (legacy)s enabled might significantly affect storage array performance. In this situation, you can disable the snapshot (legacy) function for multiple volumes and then restart the snapshot (legacy)s for all of the volumes before the next backup is scheduled.

The list of snapshot (legacy)s to be restarted is treated as a single operation. The new point-in-time snapshot (legacy) images are created from the previously defined parameters. If an error is encountered on any of the listed snapshot (legacy)s, none of the snapshot (legacy)s on the list are re-created.

Snapshot (Legacy) Rollback

You can use the snapshot (legacy) rollback feature for changing the content of a base volume to match the point-in-time image that is saved in a snapshot (legacy) volume. The host can continue to access the base volume for I/O operations during the rollback operation.

NOTE The snapshot (legacy) rollback feature is supported only in SANtricity ES Storage Manager Version 10.80.

The snapshot (legacy) volume is set as read-only during the rollback operation. The snapshot (legacy) volume becomes available for write operations after the rollback operation is completed. You cannot restart, delete, or disable the snapshot (legacy) volume during a rollback operation. The associated snapshot (legacy) repository volume must have sufficient capacity to process the rollback operation and the write operations from the host.

NOTE The content in the snapshot (legacy) volume might have changed after the creation of the snapshot (legacy) volume because of write operations from the host. The rollback operation also copies these changes to the base volume.

You can set the priority for a rollback operation. Higher priority allocates more system resources for the rollback operation and might affect the overall system performance.

Keep these guidelines in mind before you start a rollback operation:

- The rollback operation does not change the content of the snapshot (legacy) volumes that are associated with the base volume.
- You cannot start more than one rollback operation for a base volume at a time.
- You cannot create new snapshot (legacy) volumes for a base volume that is participating in a rollback operation.
- You cannot start a rollback operation when any of these operations are in progress in the storage array:
  - Dynamic Capacity Expansion (DCE) to increase the capacity of a volume group
  - Dynamic Volume Expansion (DVE) to increase the capacity of a volume
  - Dynamic RAID Migration (DRM) to change the RAID level of a volume group
  - Dynamic Segment Size (DSS) to change the segment size of a volume
- You cannot start a rollback operation if the base volume is participating in a volume copy.
- You cannot start a rollback operation if the base volume is a secondary volume in a remote mirror. However, if the base volume is the primary volume in a remote mirror, you can start a rollback operation. Additionally, you cannot perform a role reversal in a remote mirror if the primary volume is participating in a rollback operation.
- A rollback operation fails if any of the used capacity in the associated snapshot (legacy) repository volume has unreadable sectors.

The rollback operation is paused if an error occurs during the rollback operation. The base volume and the snapshot (legacy) volume display Needs Attention icons, and the controller logs the event to the Major Event Log (MEL). You can follow the Recovery Guru procedure to correct the problem and then try to resume the rollback operation.

ATTENTION Risk of data loss – You can cancel a rollback operation, but this action leaves the base volume in an unusable state, and the snapshot (legacy) volume appears as failed in the storage management software. Therefore, you must consider canceling a rollback operation only when recovery options exist for restoring the content of the base volume.

You also can use the command line interface (CLI) to start a rollback operation, cancel a rollback operation, resume a rollback operation, modify the priority of a rollback operation, and view the progress of a rollback operation.

Recovering from a Failed Rollback Operation

Prior to starting a rollback operation, you can create a new snapshot (legacy) volume from the base volume. If the rollback operation from a snapshot (legacy) volume fails, you can use the new snapshot (legacy) volume as a source in a rollback operation and restore the content of the base volume.

Snapshot (Legacy) Volumes from Prior Versions of the Storage Management Software

If the snapshot (legacy) volumes were created using a prior version of the storage management software that did not support the snapshot (legacy) rollback feature, you can upgrade the version of the storage management software and the version of the controller firmware. After the upgrade, the snapshot (legacy) volumes will support the rollback feature. However, if you revert to an older version of the storage management software after a rollback operation, the storage management software will not support the snapshot (legacy) volume.

Dynamic Volume Expansion

NOTE Increasing the capacity of a standard volume is only supported on certain operating systems. If volume capacity is increased on a host operating system that is not supported, the expanded capacity is unusable, and you cannot restore the original volume capacity.

Dynamic Volume Expansion (DVE) is a modification operation that increases the capacity of standard volumes or snapshot (legacy) repository volumes, if this operation is supported by your operating system. The increase in capacity can be achieved by using any free capacity available on the volume group of the standard volume or the snapshot (legacy) repository volume. Data is accessible on volume groups, volumes, and drives throughout the entire modification operation.

If you receive a warning that the snapshot (legacy) repository volume is in danger of becoming full, you can use the DVE modification operation to increase the capacity of the snapshot (legacy) repository volume.

Increasing the capacity of a snapshot (legacy) repository volume does not increase the capacity of the associated snapshot (legacy) volume. The capacity of the snapshot (legacy) volume is always based on the capacity of the base volume at the time that the snapshot (legacy) volume was created.

Contact your Technical Support representative to determine whether your operating system allows you to increase the capacity of a volume.

Synchronous Mirroring Premium Feature

The Synchronous Mirroring premium feature is used for online, real-time data replication between storage arrays over a remote distance. Storage array controllers manage the mirroring, which is transparent to host machines and software applications. You create one or more mirrored volume pairs that consist of a primary volume at the primary site and a secondary volume at a secondary, remote site. After you create the mirror relationship between the two volumes, the current owner of the primary volume copies all of the data from the primary volume to the secondary volume. This process is called a full synchronization.

There is a base number of defined mirrors that are allowed for each storage array. You can increase the number of defined mirrors that are allowed for each model with the purchase of an optional feature pack upgrade key. This table shows the maximum number of defined mirrors to which you can upgrade with a feature pack upgrade key.

Storage Array	Maximum Number of Defined Mirrors
E5400 controller-drive tray	Up to 128
CE7900 controller tray	Up to 128
E2600 controller-drive tray	Up to 16
CE4900 controller-drive tray	Up to 64

The Synchronous Mirroring premium feature is not supported in a simplex configuration. You must disable the Synchronous Mirroring premium feature before converting a storage array from a duplex configuration to a simplex configuration. The Synchronous Mirroring premium feature is supported only in storage arrays with Fibre Channel (FC) host ports. The Synchronous Mirroring premium feature also requires a Fibre Channel network switch.

ATTENTION Possible loss of data access – You cannot create a mirror relationship if the primary volume contains unreadable sectors. Furthermore, if an unreadable sector is discovered during a mirroring operation, the mirror relationship fails.

NOTE Because replication is managed on a per-volume basis, you can mirror individual volumes in a primary storage array to appropriate secondary volumes in several *different* remote storage arrays.

Disaster Recovery

The secondary, remote volume is unavailable to secondary host applications while mirroring is in progress. In the event of a disaster at the primary site, you can fail over to the secondary site. To fail over, perform a role reversal to promote the secondary volume to a primary volume. Then the recovery host can access the newly promoted volume, and business operations can continue.

Data Replication

When the current owner of the primary volume receives a write request from a host, the controller first logs information about the write to a special volume. This volume is called a mirror repository volume. It writes the data to the primary volume. Next, the controller initiates a remote write operation to copy the affected data blocks to the secondary volume at the remote site.

Finally, the controller sends an I/O completion indication back to the host system to confirm that the data was copied successfully to the secondary storage array. The write mode that you selected when you first created a remote volume mirror determines when the I/O completion indication is sent to the host system.

The storage management software provides two write modes:

- **Synchronous** – When you select this write mode, any host write requests are written to the primary volume and then copied to the secondary storage volume. The controller sends an I/O completion indication to the host system *after* the copy has been successfully completed.
- **Asynchronous** – When you select this write mode, host write requests are written to the primary volume. Then the controller sends an I/O completion indication back to the host system *before* the data has been successfully copied to the secondary storage array.

When write caching is enabled on either the primary volume or the secondary volume, the I/O completion is sent when data is in the cache on the side (primary or secondary) where write caching is enabled. When write caching is disabled on either the primary volume or the secondary volume, the I/O completion is not sent until the data has been stored to physical media on that side.

Host write requests received by the controller are handled normally. No communication takes place between the primary storage array and the secondary storage array.

Link Interruptions or Secondary Volume Errors

When processing write requests, the primary controller might be able to write to the primary volume, but a link interruption prevents communication with the remote secondary controller.

In this case, the remote write cannot complete to the secondary volume. The primary volume and the secondary volume are no longer appropriately mirrored. The primary controller changes the mirrored pair into Unsynchronized status and sends an I/O completion to the primary host. The primary host can continue to write to the primary volume, but remote writes do not take place.

When connectivity is restored between the current owner of the primary volume and the current owner of the secondary volume, a full synchronization takes place. Only the blocks of data that have changed on the primary volume during the link interruption are copied to the secondary volume. The mirrored pair changes from an Unsynchronized state to Mirror Synchronization in Progress status.

The primary controller also marks the mirrored pair as Unsynchronized when a volume error on the secondary side prevents the remote write from completing. For example, an offline secondary volume or a failed secondary volume can cause the remote mirror to become unsynchronized. When the volume error is corrected (the secondary volume is placed online or is recovered to Optimal status), a full synchronization automatically begins. The mirrored pair then changes to Synchronization in Progress status.

Connectivity and Volume Ownership

A primary controller attempts to communicate only with its matching controller in the secondary storage array. For example, controller A in the primary storage array attempts communication only with controller A in the secondary storage array. The controller (A or B) that owns the primary volume determines the current owner of the secondary volume. If the primary volume is owned by controller A on the primary side, the secondary volume is owned by controller A on the secondary side. If primary controller A cannot communicate with secondary controller A, controller ownership changes do not take place.

The next remote write processed automatically triggers a matching ownership change on the secondary side if one of these conditions exists:

- When an I/O path error causes a volume ownership change on the primary side
- If the storage administrator changes the current owner of the primary volume

For example, controller A owns a primary volume, and then you change the controller owner to controller B. In this case, the next remote write changes the controller owner of the secondary volume from controller A to controller B. Because controller ownership changes on the secondary side are controlled by the primary side, they do not require any special intervention by the storage administrator.

Controller Resets and Storage Array Power Cycles

Sometimes a controller reset or a storage array power cycle interrupts a remote write before it can be written to the secondary volume. The storage array controller does not need to perform a full synchronization of the mirrored volume pair in this case. A controller reset causes a controller ownership change on the primary side from the preferred controller owner to the alternate controller in the storage array. When a remote write has been interrupted during a controller reset, the new controller owner on the primary side reads information stored in a log file in the mirror repository volume of the preferred controller owner. The new controller owner then copies the affected data blocks from the primary volume to the secondary volume, which eliminates the need for a full synchronization of the mirrored volumes.

Synchronous Mirroring Premium Feature Activation

Like other premium features, you enable the Synchronous Mirroring premium feature by purchasing a feature key file from your storage supplier. You must enable the premium feature on both the primary storage array and the secondary storage array.

Unlike other premium features, you also must *activate* the premium feature after you enable it. To activate the premium feature, use the Activate Synchronous Mirroring Wizard in the Array Management Window (AMW). Each controller in the storage array must have its own mirror repository volume for logging write information to recover from controller resets and other temporary interruptions. The Activate Synchronous Mirroring Wizard guides you to specify the placement of the two mirror repository volumes (on newly created free capacity or existing free capacity in the storage array).

After you activate the premium feature, one Fibre Channel (FC) host side I/O port on each controller is solely dedicated to Synchronous Mirroring operations. Host-initiated I/O operations are not accepted by the dedicated port. I/O requests received on this port are accepted only from remote controllers that are participating in Synchronous Mirroring operations with the controller.

Connectivity Requirements

You must attach dedicated Synchronous Mirroring ports to a Fibre Channel fabric environment. In addition, these ports must support the Directory Service interface and the Name Service.

You can use a fabric configuration that is dedicated solely to the Synchronous Mirroring ports on each controller. In this case, host systems can connect to the storage arrays using fabric, Fibre Channel Arbitrated Loop (FC-AL), or point-to-point configurations. These configurations are totally independent of the dedicated Synchronous Mirroring fabric.

Alternatively, you can use a single Fibre Channel fabric configuration for both the Synchronous Mirroring connectivity and for the host I/O paths to the controllers.

The maximum distance between the primary site and the secondary site is 10 km (6.2 miles), using single-mode fiber gigabit interface converters (GBICs) and optical long-wave GBICs.

Restrictions

These restrictions apply to mirrored volume candidates and storage array mirroring:

- The RAID level, the caching parameters, and the segment size can be different on the two mirrored volumes.
- The secondary volume must be at least as large as the primary volume.
- The only type of volume that can participate in a mirroring relationship is a standard volume. Snapshot (Legacy) volumes cannot participate.
- You can create a snapshot (legacy) volume by using either a primary volume or a secondary volume as the base volume.
- A primary volume can be a source volume or a target volume in a volume copy. A secondary volume cannot be a source volume or a target volume unless a role reversal was initiated after the volume copy has completed. If a role reversal is initiated during a Copy in Progress status, the volume copy fails and cannot be restarted.
- A given volume might participate in only *one* mirror relationship.

Volume Copy Premium Feature

ATTENTION Possible loss of data access – The volume copy operation overwrites existing data on the target volume and renders the volume read-only to hosts. This option fails all snapshot (legacy) volumes that are associated with the target volume, if any exist.

The Volume Copy premium feature copies data from one volume (the source) to another volume (the target) in a single storage array.

Use the Volume Copy premium feature to perform these tasks:

- Copy data from volume groups that use smaller capacity drives to volume groups that use larger capacity drives.
- Create an online copy of data from a volume within a storage array, while still being able to write to the volume with the copy in progress.
- Back up data or restore snapshot (legacy) volume data to the base volume.

Volume Copy is a premium feature of the storage management software and must be enabled either by you or your storage vendor. For more information about using the Volume Copy premium feature with a snapshot group, refer to "Volume Copy with Snapshot Groups" on page 91.

Storage Array	Maximum Number of Volume Copies per Storage Array
E5400 controller-drive tray	Up to 2047
CE7900 controller tray	Up to 2047
E2600 controller-drive tray	Up to 511
CE4900 controller-drive tray	Up to 1023

Volume Copy Features

Data Copying for Greater Access

As your storage requirements for a volume change, use the Volume Copy premium feature to copy data to a volume in a volume group that uses larger capacity drives within the same storage array. This premium feature lets you perform these functions:

- Move data to larger drives; for example, 73 GB to 146 GB.
- Change to drives with a higher data transfer rate; for example, 2 Gb/s to 4 Gb/s.
- Change to drives using new technologies for higher performance.

Data Backup

The Volume Copy premium feature lets you back up a volume by copying data from one volume to another volume in the same storage array. You can use the target volume as a backup for the source volume, for system testing, or to back up to another device, such as a tape drive.

Snapshot (Legacy) Volume Data Restoration to the Base Volume

If you need to restore data to the base volume from its associated snapshot (legacy) volume, use the Volume Copy premium feature to copy data from the snapshot (legacy) volume to the base volume. You can create a volume copy of the data on the snapshot (legacy) volume, and then copy the data to the base volume.

ATTENTION Possible loss of data – If you are using the Windows 2000 operating system or the Linux operating system, use the Volume Copy premium feature with the Snapshot (Legacy) Volume premium feature to restore snapshot (legacy) volume data to the base volume. Otherwise, the source volume and the target volume can become inaccessible to the host.

Types of Volume Copies

You can perform either an *offline* volume copy or an *online* volume copy. To ensure data integrity, all I/O to the target volume is suspended during either volume copy operation. This suspension occurs because the state of data on the target volume is inconsistent until the procedure is complete. After the volume copy operation is complete, the target volume automatically becomes read-only to the hosts.

The offline and online volume copy operations are described as follows.

Offline Copy

An offline copy reads data from the source volume and copies it to a target volume, while suspending all updates to the source volume with the copy in progress. All updates to the source volume are suspended to prevent chronological inconsistencies from being created on the target volume. The offline volume copy relationship is between a source volume and a target volume.

Source volumes that are participating in an offline copy are available for read requests only while a volume copy has a status of In Progress or Pending. Write requests are allowed after the offline copy has completed. If the source volume has been formatted with a journaling file system, any attempt to issue a read request to the source volume might be rejected by the storage array controllers, and an error message might appear. The journaling file system driver issues a write request before it attempts to issue the read request. The controller rejects the write request, and the read request might not be issued due to the rejected write request. This condition might result in an error message appearing, which indicates that the source volume is write protected. To prevent this issue from occurring, do not attempt to access a source volume that is participating in an offline copy while the volume copy has a status of In Progress. Also, make sure that the Read-Only attribute for the target volume is disabled after the volume copy has completed to prevent error messages from appearing.

Online Copy

An online copy creates a point-in-time snapshot (legacy) copy of a volume within a storage array, while still being able to write to the volume with the copy in progress. This function is achieved by creating a snapshot (legacy) of the volume and using the snapshot (legacy) as the actual source volume for the copy. The online volume copy relationship is between a snapshot (legacy) volume and a target volume. The volume for which the point-in-time image is created is known as the base volume and must be a standard volume in the storage array.

A snapshot (legacy) volume and a snapshot (legacy) repository volume are created during the online copy operation. The snapshot (legacy) volume is not an actual volume containing data; rather, it is a reference to the data that was contained on a volume at a specific time. For each snapshot (legacy) that is taken, a snapshot (legacy) repository volume is created to hold the copy-on-write data for the snapshot (legacy). The snapshot (legacy) repository volume is used only to manage the snapshot (legacy) image.

Before a data block on the source volume is modified, the contents of the block to be modified are copied to the snapshot (legacy) repository volume for safekeeping. Because the snapshot (legacy) repository volume stores copies of the original data in those data blocks, further changes to those data blocks write only to the source volume.

NOTE If the snapshot (legacy) volume that is used as the copy source is active, the base volume performance is degraded due to copy-on-write operations. When the copy is complete, the snapshot (legacy) is disabled, and the base volume performance is restored. Although the snapshot (legacy) is disabled, the repository infrastructure and copy relationship remain intact.

The online copy function is enabled with the Snapshot (Legacy) Volume premium feature. To use the online copy function, you must enable the Snapshot (Legacy) Volume premium feature by purchasing a feature key file from your storage vendor.

Components of the Volume Copy Premium Feature

The Volume Copy premium feature includes these components:

Create Copy Wizard, which assists in creating a volume copy.

You can use the Create Copy Wizard to guide you through the following steps in creating a Volume Copy:

- Selecting a source volume from a list of available volumes and the type of copy you want to perform (offline or online)
- Selecting a target volume from a list of available volumes
- Allocating capacity for the snapshot (legacy) repository volume for online copy types
- Setting the copy priority for the volume copy

When you have completed the wizard dialogs, the volume copy starts, and data is read from the source volume and written to the target volume. Operation in Progress icons appear on the source volume and the target volume while the volume copy has a status of In Progress or Pending.

Copy Manager, which monitors volume copies after they have been created.

After you create a volume copy with the Create Copy Wizard, you can monitor the volume copy through the Copy Manager. You can use the Copy Manager to perform the following actions:

- Monitor the progress of a volume copy
- Stop a volume copy
- Re-copy a volume copy
- Remove copy pairs
- Change target volume permissions
- Change copy priority

Keep these guidelines in mind when you create a volume copy.

Failed Controller	You must manually change controller ownership to the alternate controller to allow the volume copy to complete under all of these conditions: ■ The preferred controller of the source volume fails. ■ The ownership transfer does not occur automatically in the failover.
Volume Failover for Online Copy Types	Ownership changes affect the base volume and all of its snapshots (legacy). The same controller should own the base volume, the snapshot (legacy) volume, and the snapshot (legacy) repository volume. The rules that apply to the base volume for host-driver-based or controller-based failover modes also apply to the associated snapshots (legacy) and snapshot (legacy) repository volumes. If a failover situation occurs, all related volumes change controller ownership as a group.
Volume Copy and Modification Operations for Offline Copy Types	For offline copy operations, if a modification operation is running on a source volume or a target volume, and the volume copy has a status of In Progress, Pending, or Failed, the volume copy does not take place. If a modification operation is running on a source volume or a target volume after a volume copy has been created, the modification operation must complete before the volume copy can start. If a volume copy has a status of In Progress, any modification operation does not take place.
Preferred Controller Ownership	During a volume copy, the same controller must own both the source volume and the target volume. If both volumes do not have the same preferred controller when the volume copy starts, the ownership of the target volume is automatically transferred to the preferred controller of the source volume. When the volume copy is completed or is stopped, ownership of the target volume is restored to its preferred controller. If ownership of the source volume is changed during the volume copy, ownership of the target volume is also changed.
Failed Volume Copy	A volume copy can fail due to these conditions: ■ A read error from the source volume ■ A write error to the target volume ■ A failure in the storage array that affects the source volume or the target volume, such as a remote volume mirror role reversal When the volume copy fails, a Needs Attention icon appears in the Array Management Window. While a volume copy has this status, the host has read-only access to the source volume. Read requests from and write requests to the target volume do not take place until the failure is corrected by using the Recovery Guru.
Volume Copy Status	If eight volume copies with a status of In Progress exist, any subsequent volume copy will have a status of Pending, which remains until one of the eight volume copies completes.

Snapshot (Legacy) Volume	A volume copy fails all snapshot (legacy) volumes that are associated with the target volume, if any exist. If you select a base volume of a snapshot (legacy) volume, you must disable all of the snapshot (legacy) volumes that are associated with the base volume before you can select it as a target volume. Otherwise, the base volume cannot be used as a target volume. A volume copy overwrites data on the target volume and automatically makes the target volume read-only to hosts.
Snapshot (Legacy) Failure	If a snapshot (legacy) volume that is serving as an online copy fails, the volume copy relationship is still maintained between the snapshot (legacy) volume and the target volume. If the snapshot (legacy) failure occurs when the physical copy is in progress, the status of “Failed” is displayed in the Copy Manager.
Volume Consistency	When using the online volume copy operation, make sure that the source volume is in a consistent state. If the source volume is not consistent, the online volume copy is also inconsistent. An inconsistent volume might be unusable for its purpose, such as backup.
Copy Failure for Online Copy Types	A copy failure terminates the copy-on-write process for the snapshot (legacy) volume. If a copy failure occurs due to a snapshot (legacy) failure because of snapshot (legacy) repository volume overflow, you can correct the failure by deleting the copy relationship and re-creating it.

Restrictions on Volume Copy

These restrictions apply to the source volume, the target volume, and the storage array when performing volume copy operations.

For an offline volume copy, the source volume is available for read requests only while a volume copy has a status of In Progress or Pending. Write requests are allowed after the volume copy is completed.

- You can use a volume as a target volume in only *one* volume copy at a time.
- The maximum allowable number of volume copies per storage array depends on the number of target volumes that are available in your storage array.
- A storage array can have up to *eight* volume copies running at any given time.
- The capacity of the target volume must be equal to or greater than the capacity of the source volume.

For an offline volume copy, a source volume can be one of the following volumes:

- A standard volume
- A snapshot (legacy) volume
- A snapshot (legacy) base volume
- A remote volume mirror primary volume

For an online volume copy, a source volume can only be a *standard volume*.

- If the source volume is a primary volume, the capacity of the target volume must be equal to or greater than the usable capacity of the source volume.
- You cannot use the snapshot (legacy) volume copy until after the online copy operation completes.
- You cannot use any of the Snapshot (Legacy) Volume options (**Disable**, **Re-create**, **Create Copy**, **Delete**, and **Rename**) or perform host mapping on a snapshot (legacy) volume that was created using the online copy operation in the Create Copy Wizard.

A target volume can be one of these volumes:

- A standard volume
- A base volume of a disabled snapshot (legacy) volume or a failed snapshot (legacy) volume
- A remote volume mirror primary volume

NOTE If you choose a base volume of a snapshot (legacy) volume as your target volume, you must disable all snapshot (legacy) volumes that are associated with the base volume before you can select it as a target volume. Otherwise, you cannot use the base volume as a target volume.

Volumes that have these statuses cannot be used as a source volume or a target volume:

- A volume that is reserved by the host cannot be selected as a source volume or a target volume
- A volume that is in a modification operation
- A volume that is the source volume or a target volume in another volume copy operation with a status of Failed, In Progress, or Pending
- A volume with a status of Failed
- A volume with a status of Degraded

For detailed information about this premium feature, refer to the online help topics in the Array Management Window.

Volume Copy with Snapshot Groups

The Volume Copy premium feature has been enhanced to work in conjunction with the Snapshot premium feature. The enhancements permits a user to initiate a volume copy operation while the source volume is online and available for data writes.

With the enhanced volume copy feature, a *source volume* can be a standard volume or a thin volume. A *target volume* can be a standard volume in a volume group, a standard volume in a disk pool, or snapshot (legacy) base volume if the snapshot feature is disabled. A target volume cannot be a thin volume or a base volume in a snapshot group.

When you initiate a volume copy operation for a source volume, the storage management software creates a snapshot image of the base volume and a copy relationship between the snapshot image of the base volume and a target volume. Using the snapshot image as the source volume permits the controller to continue to write to the source volume while the copy is in progress. The volume copy mechanism automatically detects whether the snapshot (legacy) or snapshot feature is enabled for your storage array.

You also can use the volume copy feature to copy data from a thin volume to a standard volume in disk pool that reside within the same storage array. But you cannot use this feature to copy data from a standard volume to a thin volume. When using the re-copy command for a volume copy operation, you can use a volume that is not in a snapshot group but is the target of a volume copy.

When you use the volume copy feature in conjunction with a snapshot group, keep the following guidelines in mind.

- You cannot create a new snapshot group for a target volume that is involved in a volume copy operation.
- For a base volume that is in a snapshot group but is not being used as a target in a volume copy operation, you can create another snapshot group for the same base volume and create a snapshot image of the base volume.
- You cannot use a base volume in a snapshot repository volume as a source volume or a target volume.
- While a snapshot image of a source volume is being used in a volume copy operation, the performance of the base volume associated with the snapshot image is degraded.

Drive Security and Enterprise Security Key Manager

Drive Security is a premium feature that prevents unauthorized access to the data on a Full Disk Encryption (FDE) drive that is physically removed from the storage array. Controllers in the storage array have a security key. Secure drives provide access to data only through a controller that has the correct security key. Drive Security is a premium feature of the storage management software and must be enabled either by you or your storage vendor.

The Drive Security premium feature requires security capable FDE drives. A security capable FDE drive encrypts data during writes and decrypts data during reads. Each security capable FDE drive has a unique drive encryption key.

When you create a secure volume group from security capable drives, the drives in that volume group become security enabled. When a security capable drive has been security enabled, the drive requires the correct security key from a controller to read or write the data. All of the drives and controllers in a storage array share the same security key. The shared security key provides read access and write access to the drives, while the drive encryption key on each drive is used to encrypt the data. A security capable drive works like any other drive until it is security enabled.

Whenever the power is turned off and turned on again, all of the security enabled drives change to a *security locked* state. In this state, the data is inaccessible until the correct security key is provided by a controller.

The Enterprise Security Key Manager premium feature integrates external key management products.

You can view the Drive Security status of any drive in the storage array. The status information reports whether the drive is in one of these states:

- Security Capable
- Secure – Security enabled or security disabled
- Read/Write Accessible – Security locked or security unlocked

You can view the Drive Security status of any volume group in the storage array. The status information reports whether the storage array is in one of these states:

- Security Capable
- Secure

Table 10 interprets the security properties status of a volume group.

Table 10 Volume Group Security Properties

	Security Capable – yes	Security Capable – no
Secure – yes	The volume group is composed of all FDE drives and is in a Secure state.	Not applicable. Only FDE drives can be in a Secure state.
Secure – no	The volume group is composed of all FDE drives and is in a Non-Secure state.	The volume group is not entirely composed of FDE drives.

When the Drive Security premium feature has been enabled, the **Drive Security** menu appears in the **Storage Array** menu. The **Drive Security** menu has these options:

- **Security Key Management**
- **Create Security Key**
- **Change Security Key**
- **Save Security Key**
- **Validate Security Key**
- **Import Security Key File**

The **Security Key Management** option lets you specify how to manage the security key. By default, the security key is managed locally by the controllers. The controllers generate the security key and save the security key in the nonvolatile static random access memory (NVSRAM) of the controllers. You can use the Enterprise Security Key Manager to have an external key management server generate the security key.

NOTE If you have not created a security key for the storage array, the **Create Security Key** option is active. If you have created a security key for the storage array, the **Create Security Key** option is inactive with a check mark to the left. The **Change Security Key** option, the **Save Security Key** option, and the **Validate Security Key** option are now active.

The **Import Security Key File** option is active if there are any security locked drives in the storage array.

When the Drive Security premium feature has been enabled, the **Secure Drives** option appears in the **Volume Group** menu. The **Secure Drives** option is active if these conditions are true:

- The selected storage array is not security enabled but is comprised entirely of security capable drives.
- The storage array does not contain any snapshot (legacy) base volumes or snapshot (legacy) repository volumes.
- The volume group is in an Optimal state.
- A security key is set up for the storage array.

The **Secure Drives** option is inactive if the conditions are not true.

The **Secure Drives** option is inactive with a check mark to the left if the volume group is already security enabled.

You can erase security enabled drives so that you can reuse the drives in another volume group, in another storage array, or if you are decommissioning the drives. When you erase security enabled drives, you make sure that the data cannot be read. When all of the drives that you have selected in the Physical pane are security enabled, and none of the selected drives are part of a volume group, the **Secure Erase** option appears in the **Drive** menu.

The storage array password protects a storage array from potentially destructive operations by unauthorized users. The storage array password is independent from the Drive Security premium feature and should not be confused with the pass phrase that is used to protect copies of a security key. However, as a best practice, set a storage array password before you create, change, or save a security key or unlock secure drives.

Creating a Security Key

Drives with the full disk encryption technology are *security capable*. This capability enables the controller to apply security to every security capable drive in the storage array. The controller firmware creates a key and activates the drive's security function, which encrypts data as it enters, and decrypts data as it is read. Without the key, the data written on a drive is inaccessible and unreadable. A security enabled drive can also be configured to require a password, PIN, or certificate; however, this function is separate from the encryption and decryption processes.

The storage array password protects a storage array from potentially destructive operations by unauthorized users. The storage array password is independent from the Drive Security premium feature and should not be confused with the pass phrase that is used to protect copies of a Drive Security key. However, it is good practice to set a storage array password before you create a Drive Security key.

After the controller creates the key, the storage array moves from a state of *security capable* to a state of *security enabled*. The security enabled condition requires the drives to obtain a key to access their media. As an added security measure, when power is applied to the storage array, the drives are all placed in a *security locked* state. They are only unlocked during drive initialization with the controller's key. The *security unlocked* state allows the drives to be accessible so that read and write activities can be performed.

Changing a Security Key

A new security key is generated by the controller firmware for these reasons:

- You need to change the security key.
- You need to change the method of managing the security key from local to external.

ATTENTION Changing the method of managing the security key makes any previously saved security keys invalid.

The new security key is stored in the *nonvolatile static random access memory (NVSRAM)* of the controllers. The new key replaces the previous key. You cannot see the security key directly. A copy of the security key must be kept on some other storage medium for backup, in case of controller failure or for transfer to another storage array. A *pass phrase* that you provide is used to encrypt and decrypt the security key for storage on other media.

The storage array password protects a storage array from potentially destructive operations by unauthorized users. The storage array password is independent from the Drive Security feature and should not be confused with the pass phrase that is used to protect copies of a Drive Security key. However, it is good practice to set a storage array password before you change a Drive Security key.

Saving a Security Key

You save an externally storable copy of the security key when the security key is first created and each time it is changed. You can create additional storable copies at any time. To save a new copy of the security key, you must provide a pass phrase. The pass phrase that you choose does not need to match the pass phrase that was used when the security key was created or last changed. The pass phrase is applied to the particular copy of the security key that you are saving.

Keep these guidelines in mind when you create a pass phrase:

- The pass phrase must be between eight and 32 characters long.
- The pass phrase must contain at least one uppercase letter.
- The pass phrase must contain at least one lowercase letter.
- The pass phrase must contain at least one number.
- The pass phrase must contain at least one non-alphanumeric character, for example, <, >, @, or +.

The characters you enter are not readable in the **Pass phrase** text box.

The storage array password protects a storage array from potentially destructive operations by unauthorized users. The storage array password is independent from the Drive Security feature and should not be confused with the pass phrase that is used to protect copies of a security key. However, it is good practice to set a storage array password before you save a security key.

Importing a Security Key to Unlock Secure Drives

You can export a security enabled volume group to move the associated drives to a different storage array. After you install those drives in the new storage array, you must unlock the drives before data can be read from or written to the drives. To unlock the drives, you must import the security key from the original storage array. The security key on the new storage array is different and cannot unlock the drives.

You must import the security key from a security key file that was saved on the original storage array. You must provide the pass phrase that was used to encrypt the security key file to extract the security key from this file.

The storage array password protects a storage array from potentially destructive operations by unauthorized users. The storage array password is independent from the Drive Security feature and should not be confused with the pass phrase that is used to protect copies of a security key. However, it is good practice to set a storage array password before you unlock secure drives.

Validating the Security Key

You validate a file in which a security key is stored through the **Validate Security Key** dialog. To transfer, archive, or back up the security key, the controller firmware encrypts (or wraps) the security key and stores it in a file. You must provide a pass phrase and identify the corresponding file to decrypt the file and recover the security key.

NOTE You also can install the security key from an external key management server. External key management must be enabled for both the source storage array and the target storage array. The key management server used by the source storage array must be accessible by the target storage array.

Data can be read from a security enabled drive only if a controller in the storage array provides the correct security key. If you move security enabled drives from one storage array to another, you also must import the appropriate security key to the new storage array. Otherwise, the data on the security enabled drives that were moved is inaccessible.

NOTE After 20 consecutive unsuccessful attempts to validate a security key, you might be blocked from making further attempts at validation. The Recovery Guru guides you to reset the limit and make additional attempts. Data on the drives is temporarily inaccessible during the reset procedure.

Data Assurance Premium Feature

The Data Assurance (DA) premium feature checks for and corrects errors that might occur as data is moved within the controller, such as from cache to the drive. This checking leads to correction of write errors and increases data integrity across the entire storage system. DA is implemented using the SCSI direct-access block-device protection information model. DA creates error-checking information, such as a cyclic redundancy check (CRC) and appends that information to each block of data. Any errors that might occur when a block of data is transmitted or stored is then detected and corrected by checking the data with its error-checking information.

Only certain configurations of hardware, including DA-capable drives, controllers, and host interface cards (HICs), support the Data Assurance premium feature. When you install the DA premium feature on a storage array, SANtricity ES Storage Manager provides options to use DA with certain operations. For example, you can create a volume group that includes DA-capable drives and then create a volume within that volume group that is DA enabled. Other operations that use a DA-enabled volume have options to support the DA premium feature.

For detailed information about this premium feature, refer to the online help topics in the Array Management Window.

Solid State Disks

Some controllers and drive trays now support Solid State Disks (SSDs). SSDs are data storage devices that use solid state memory (flash) to store data persistently. An SSD emulates a conventional hard drive, thus easily replacing it in any application. SSDs are available with the same interfaces used by hard drives.

SSDs have the following advantages:

- Faster start up (no spin up)
- Faster access to data (no rotational latency or seek time)
- Higher I/O operations per second (IOPS)
- Higher reliability with fewer moving parts
- Lower power usage
- Less heat produced and less cooling required

SSD support is a premium feature of the storage management software that must be enabled by either you or your storage vendor.

Identifying SSDs

You can identify SSDs in the storage management software by the label “SSD."

In addition to drive firmware, SSDs have field-programmable gate array (FPGA) code that might be updated periodically. An FPGA version is listed in the drive properties, which you can see in the storage management software by selecting a drive on the **Physical** tab. Also, SSDs do not have a speed listed in the drive properties like hard drives do.

Creating Volume Groups

All of the drives in a volume group must have the same media type (hard drive or SSD) and the same interface type. Hot spare drives also must be of the same drive type as the drives they are protecting.

Wear Life

A flash-based SSD has a limited wear life before individual memory locations can no longer reliably persist data. The drive continuously monitors itself and reports its wear life status to the controller. Two mechanisms exist to alert you that an SSD is nearing the end of its useful life: average erase count and spare blocks remaining. You can find these two pieces of information in the drive properties, which you can see in the storage management software by selecting a drive on the **Physical** tab.

The average erase count is reported as a percentage of the rated lifetime. When the average erase count reaches 80 percent, an event is logged to the Major Event Log (MEL). At this time, you should schedule the replacement of the SSD. When the average erase count reaches 90 percent, a Needs Attention condition occurs. At this time, you should replace the SSD as soon as possible.

The spare blocks remaining are reported as a percentage of the total blocks. When the number of spare blocks remaining falls below 20 percent, an event is logged to the MEL. At this time, you should schedule the replacement of the SSD. When the number of spare blocks remaining falls below 10 percent, a Needs Attention condition occurs. At this time, you should replace the SSD as soon as possible.

Write Caching

Write caching will always be enabled for SSDs. Write caching improves performance and extends the life of the SSD.

Background Media Scans

Background media scans are not necessary for SSDs because of the high reliability of SSDs.

High Performance Tier Premium Feature

The High Performance Tier premium feature provides an increase of performance of I/O operations on your storage array. Contact your Technical Support representative for more information about this feature.

The High Performance Tier feature might be available as a Try and Buy offering. If this feature is available for your storage array, you can enable the Try and Buy version to use for a pre-determined evaluation period before you purchase it.

NOTE The available premium features and the availability of the High Performance Tier feature as a Try and Buy offering vary by storage array.

Mixed Drive Type Premium Feature

The Mixed Drive Type premium feature lets you mix different types of drives that are supported by a array in a storage array. For example, if your storage array can be comprised of SAS or Fibre Channel drives, with the Mixed Drive Type premium feature you can have both drive types in the same array.

NOTE The available premium features and the availability of the Mixed Drive Type feature vary by storage array.

Drive Slot Limit Premium Feature

The Drive Slot Limit premium feature lets you increase the number of drive slots available for drives in your drive trays to a maximum value supported by your configuration. Contact your Technical Support representative for more information about this feature.

NOTE The available premium features and the availability of the Drive Slot Limit feature vary by storage array.

Heterogeneous Hosts

Heterogeneous hosts are hosts with different operating systems that share access to the same storage array. When you change a host type, you are changing the *operating system (OS)* for the host adapter’s host port.

To specify different operating systems for attached hosts, you must specify the appropriate *host* type when you define the host ports for each host. Host types can be completely different operating systems, or can be variants of the same operating system. By specifying a host type, you define how the controllers in the storage array will work with the particular operating system on the hosts that are connected to it.

Password Protection

NOTE Running operations that alter the configuration of your storage array can cause serious damage, including data loss. Configuring a password for each storage array that you manage prevents unauthorized access to destructive commands.

For added security, you can configure each storage array with a password to protect it from unauthorized access. A password protects any options that the controller firmware deems destructive. These options include any functions that change the state of the storage array, such as creating a volume or modifying the cache setting.

NOTE If you forget the password, contact your Technical Support representative.

After the password has been set on the storage array, you are prompted for that password the first time you attempt an operation in the Array Management Window that can change the state of the storage array, such as modifying the cache settings. You are asked for the password only once during a single management session.

For storage arrays with a password and alert notifications configured, any attempts to access the storage array without the correct password are reported.

The storage management software provides other security features to protect data, including generation numbering to prevent replay attacks and hashing and encryption to guard against client spoofing and snooping.

Persistent Reservations Management

ATTENTION Technical Support representative supervision required – Do not perform this procedure unless you are supervised by your Technical Support representative.

Persistent reservation management lets you view and clear volume reservations and associated registrations. Persistent reservations are configured and managed through the cluster server software and prevent other hosts from accessing particular volumes.

Unlike other types of reservations, a persistent reservation performs these functions:

- Reserves access across multiple host ports
- Provides various levels of access control
- Offers the ability to query the storage array about registered ports and reservations
- Optionally, provides for persistence of reservations in the event of a storage array power loss

The *storage management software* lets you manage persistent reservations by performing these tasks:

- Viewing registration and reservation information for all of the volumes in the storage array
- Saving detailed information on volume reservations and registrations
- Clearing all registrations and reservations for a single volume or for all of the volumes in the storage array.

HotScale Technology

HotScale™ technology lets you configure, reconfigure, add, or relocate storage array capacity without interrupting user access to data.

Port bypass technology automatically opens ports and closes ports when drive trays are added to or removed from your storage array. Fibre Channel loops stay intact so that system integrity is maintained throughout the process of adding and reconfiguring your storage array.

For more information about using the HotScale technology, contact your Technical Support representative.

Maintaining and Monitoring Storage Arrays 4

The topics in this section describe the methods for maintaining storage arrays, including troubleshooting storage array problems, recovering from a storage array problem using the Recovery Guru, and configuring alert notifications using the Event Monitor.

For additional conceptual information and detailed procedures for the options described in this section, refer to the topic *Learn About Monitoring Storage Arrays* in online help.

Storage Array Health

NOTE To receive notification of events for the storage arrays, you must configure alert notifications in the Enterprise Management Window, and the Event Monitor must be running.

The Enterprise Management Window summarizes the conditions of all of the known storage arrays being managed. Appropriate status indicators appear in the Tree view on the **Devices** tab, the Table view on the **Devices** tab, and the Health Summary Status area in the lower-left corner of the window. To show the status bar, select **View >> Status Bar**.

Background Media Scan

A background media scan is a background process that is performed by the controllers to provide error detection on the drive media. A background media scan can find media errors before they disrupt normal drive reads and writes. The background media scan process scans all volume data to make sure that it can be accessed. The errors are reported to the Event Log.

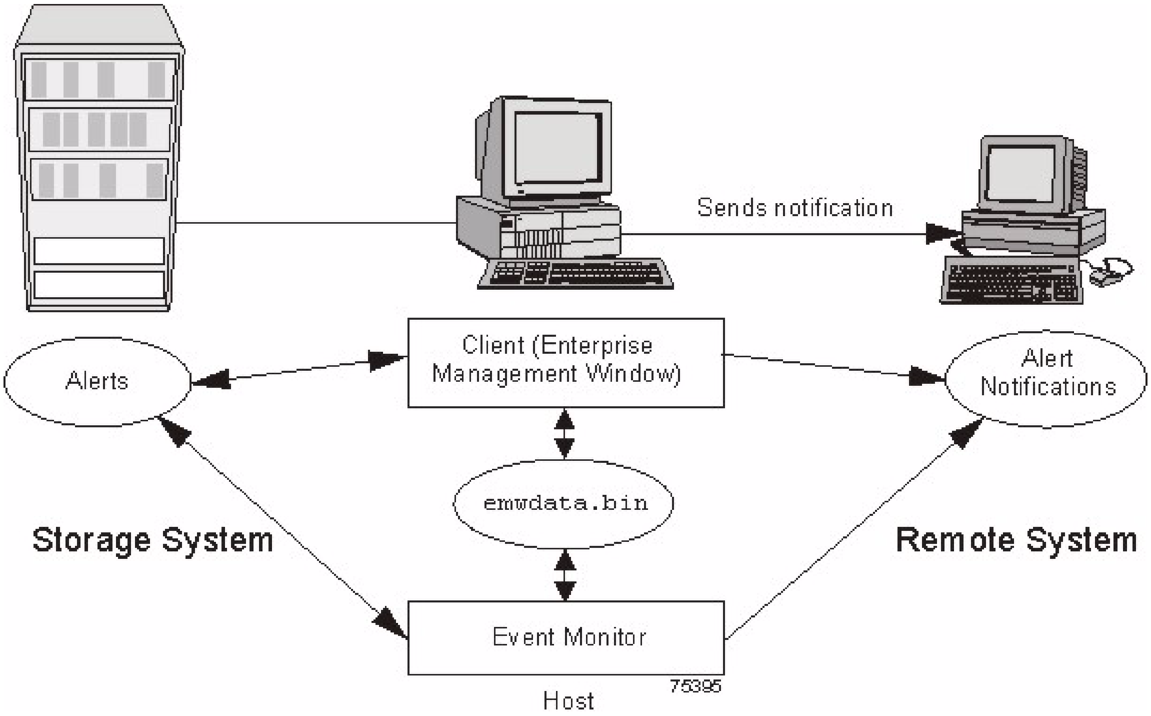
A background media scan runs on all volumes in the storage array for which it has been enabled. You must enable the media scan for the entire storage array, and for individual volumes. If you enable a redundancy check, the background media scan also scans the redundancy data on a RAID Level 1 volume, a RAID Level 3 volume, a RAID Level 5 volume, or a RAID Level 6 volume.

Event Monitor

The Event Monitor runs continuously in the background, monitoring activity on a storage array and checking for problems. Examples of problems include impending drive failures or failed controllers. If the Event Monitor detects any problems, it can notify a remote system by using email notifications, *Simple Network Management Protocol (SNMP)* trap messages, or both, if the Enterprise Management Window is not running.

The Event Monitor is a client that is bundled with the client software. Install the Event Monitor on a computer that runs 24 hours a day. The client and the Event Monitor are installed on a *storage management station* or a *host* that is connected to the storage arrays. Even if you choose not to install the Event Monitor, you can still configure alert notifications on the computer on which the client software is installed.

The following figure shows how the Event Monitor and the Enterprise Management Window client software send alerts to a remote system. The storage management station contains a file with the name of the storage array being monitored and the address to which alerts will be sent. The alerts and errors that occur on the storage array are continuously being monitored by the client software and the Event Monitor. The Event Monitor continues to monitor the client, even after the client software package is shut down. When an event is detected, a notification is sent to the remote system.



Because the Event Monitor and the Enterprise Management Window share the information to send alert messages, the Enterprise Management Window has some visual cues to assist in the installation and synchronization of the Event Monitor.

Using the Event Monitor involves these three key steps:

1. Installing the client software
2. Setting up the alert destinations for the storage arrays that you want to monitor from the Enterprise Management Window
3. Synchronizing the Enterprise Management Window and the Event Monitor

Alert Notifications

You can configure alert notifications by using the storage management software.

Configuring Alert Notifications

You must configure alert notification settings to receive email notifications or SNMP notifications when an event occurs in a storage array. The notification summarizes the event and details about the affected storage array, including these items:

- The name of the affected storage array
- The host IP address (for an in-band managed storage array)
- The host name and ID (shown as out-of-band if the storage array is managed through the Ethernet connection of each controller)
- The event error type related to an Event Log entry
- The date and the time when the event occurred
- A brief description of the event

NOTE To set up alert notifications using SNMP traps, you must copy and compile a management information base (MIB) file on the designated network management station.

Three key steps are involved in configuring alert notifications:

1. Select a node in the Enterprise Management Window that shows alert notifications for the storage arrays that you want to monitor. You can select each storage array being managed, every storage array attached to and managed through a particular host, and individual storage arrays.
2. Configure email destinations, if desired.
3. Configure SNMP trap destinations, if desired. The SNMP trap destination is the IP address or the host name of a station running an SNMP service, such as a network management station.

Customer Support Alert Notifications

If an event occurs in a storage array, the Enterprise Management Window contains options to configure the system to send email notifications to a specified customer support group. After the alert notification option is configured, the email alert notification summarizes the event, provides details about the affected storage array, and provides customer contact information. For more information about setting up this file, contact your Technical Support representative.

Performance Monitor

The Performance Monitor provides visibility into performance activity across your monitored storage devices. You can use the Performance Monitor to perform these tasks:

- View in real time the values of the data collected for a monitored device. This capability helps you to determine if the device is experiencing any problems.
- See a historical view of a monitored device to identify when a problem started or what caused a problem.
- Specify various reporting attributes, such as time increments and filtering criteria, to examine performance trends and to pinpoint the cause of availability and performance issues.
- Display data in tabular format (actual values of the collected metrics) or graphical format (primarily as line-graphs), or export the data to a file.

About Metrics

Metrics are measurements of the data that the Performance Monitor collects from the storage devices that you monitor. Metrics help to pinpoint problems and define their cause. Metrics define the types of data that you collect as well as the type of data source from which you collect the data.

Performance Metric Data

You can collect the following metric data:

- **Total I/Os** – Total I/Os performed by this device since the beginning of the polling session.
- **Read Percentage** – The percentage of total I/Os that are read operations for this device. Write percentage can be calculated as 100 minus this value.
- **Cache Hit Percentage** – The percentage of total I/Os that are processed with data from the cache rather than requiring a read from drive.
- **Current or Maximum KBs per second** – The current or maximum transfer rate during the current polling interval. The transfer rate is the amount of data in kilobytes (Table view) or megabytes (Graphical view) that can be moved through the I/O data connection in a second (also called throughput).

NOTE A kilobyte is equal to 1024 bytes, and a megabyte is equal to 1024 x 1024 bytes (1,048,576 bytes).

- **Current or Maximum I/O per second** – The current or maximum number of I/O requests serviced per second during the current polling interval (also called an I/O request rate).

Metric Sources

Metrics define how the Performance Monitor collects data from supported data sources called metric sources. Metric sources are the aspects of a storage array or a controller that provide data. You can configure the Performance Monitor to report data from the following metric sources:

- Volume
- Volume group
- Disk Pools
- Controller
- Storage array

You can use the data to create reports, and make tuning decisions based on the data values. If a value is outside of the desired range or is in an undesired state, you can take action to correct the problem.

NOTE The Performance Monitor reports volume metrics and volume group or disk pool metrics at the storage array level, regardless of volume controller ownership changes that might occur during monitoring.

Viewing Performance Data

The Performance Monitor provides both real-time analysis and historical context of performance metrics. The metrics are available in either of two views:

- **Table view** – In the Table view, the data is displayed in a tabular format. The actual numeric values of the collected metrics are displayed in a data table.
- **Graphical view** – In the Graphical view, the data is presented with a single x-axis and a single y-axis. The x-axis represents the time for which you selected to view performance data. The y-axis represents the metric you selected to view for a particular metric source.

Performance Tuning

The Performance Monitor provides you with data about devices. You use this data to make storage array tuning decisions, as described in the following table. When performance issues are encountered, tuning is required to alleviate the issues.

Performance Metric Data	Implications for Performance Tuning
Total I/Os	This data is useful for monitoring the I/O activity of a specific controller and a specific volume, which can help identify possible high-traffic I/O areas. If the I/O rate is slow on a volume, try increasing the volume group size or disk pool size by selecting the options from the **Storage** menu that allow you to add capacity. You might notice a disparity in the total I/Os (workload) of controllers. For example, the workload of one controller is heavy or is increasing over time while that of the other controller is lighter or more stable. In this case, you might want to change the controller ownership of one or more volumes to the controller with the lighter workload. Use the volume total I/O statistics to determine which volumes to move. You might want to monitor the workload across the storage array. Look at the Total I/Os column of the Storage Array Totals row in the **Performance Monitor** window. If the workload continues to increase over time while application performance decreases, you might need to add additional storage arrays. By adding storage arrays to your enterprise, you can continue to meet application needs at an acceptable performance level.
Read Percentage	Use the Read Percentage for a volume to determine actual application behavior. If a low percentage of read activity exists relative to write activity, you might want to change the RAID level of a volume group from RAID Level 5 to RAID Level 1 to obtain faster performance.
Cache Hit Percentage	A higher cache hit percentage is desirable for optimal application performance. A positive correlation exists between the cache hit percentage and the I/O rates. The cache hit percentage of all of the volumes might be low or trending downward. This trend might indicate inherent randomness in access patterns. In addition, at the storage array level or the controller level, this trend might indicate the need to install more controller cache memory if you do not have the maximum amount of memory installed. If an individual volume is experiencing a low cache hit percentage, consider enabling dynamic cache read prefetch for that volume. Dynamic cache read prefetch can increase the cache hit percentage for a sequential I/O workload.
KB/s or MB/s	The transfer rates of the controller are determined by the application I/O size and the I/O rate. Generally, small application I/O requests result in a lower transfer rate but provide a faster I/O rate and shorter response time. With larger application I/O requests, higher throughput rates are possible. Understanding your typical application I/O patterns can help you determine the maximum I/O transfer rates for a specific storage array.

Performance Metric Data	Implications for Performance Tuning
IOPS	Factors that affect input/output operations per second (IOPS) include these items: ■ Access pattern (random or sequential) ■ I/O size ■ RAID level ■ Segment size ■ The number of drives in the volume groups, disk pool, or storage array The higher the cache hit rate, the higher I/O rates will be. You can see performance improvements caused by changing the segment size in the IOPS statistics for a volume. Experiment to determine the optimal segment size, or use the file system size or database block size. Higher write I/O rates are experienced with write caching enabled compared to disabled. In deciding whether to enable write caching for an individual volume, look at the current IOPS and the maximum IOPS. You should see higher rates for sequential I/O patterns than for random I/O patterns. Regardless of your I/O pattern, enable write caching to maximize the I/O rate and to shorten the application response time.

For detailed information about the Performance Monitor, refer to the online help topics in the Array Management Window.

Viewing Operations in Progress

The **Operations in Progress** dialog displays all of the long-running operations that are currently running in the storage array. From this dialog, you cannot interact with the operations. You can only view their progress.

The **Operations in Progress** dialog remains open until you close it or until you close the Array Management Window (AMW). You can do other tasks in the AMW while the **Operations in Progress** dialog is open.

You can view the progress for the following long-running operations:

- Dynamic Capacity Expansion (DCE) – Adding capacity to a volume group
- Dynamic RAID Migration (DRM) – Changing the RAID level of a volume group
- Checking the data redundancy of a volume group
- Defragmenting a volume group
- Initializing a volume
- Dynamic Volume Expansion (DVE) – Adding capacity to a volume
- Dynamic Segment Size (DSS) – Changing the segment size of a volume
- Reconstruction – Reconstructing data from parity because of unreadable sectors or a failed drive

- Copyback – Copying data from a hot spare drive to a new replacement drive
- Volume copy
- Synchronizing a remote mirror

For detailed information about this feature, refer to the topic *Viewing Operation in Progress* in online help.

Retrieving Trace Buffers

NOTE Use this option only under the guidance of your Technical Support representative.

You can save trace information to a compressed file. The firmware uses the trace buffers to record processing, including exception conditions, that might be useful for debugging. Trace information is stored in the current buffer. You have the option to move the trace information to the flushed buffer after you retrieve the information. You can retrieve trace buffers without interrupting the operation of the storage array and with minimal effect on performance.

A zip-compressed archive file is stored at the location you specify on the host. The archive contains trace files from one or both of the controllers in the storage array along with a descriptor file named `trace_description.xml`. Each trace file includes a header that identifies the file format to the analysis software used by the Technical Support representative. The descriptor file has the following information:

- The World Wide Identifier (WWID) for the storage array.
- The serial number of each controller.
- A time stamp.
- The version number for the controller firmware.
- The version number for the management application programming interface (API).
- The model ID for the controller board.
- The collection status (success or failure) for each controller. If the status is Failed, the reason for failure is noted, and there is no trace file for the failed controller.

For detailed information about this feature, refer to the online help topics in the Array Management Window.

Upgrading the Controller Firmware

You can upgrade the firmware of the controllers in the storage array by using the storage management software.

In the process of upgrading the firmware, the firmware file is downloaded from the host to the controller. After downloading the firmware file, you can upgrade the controllers in the storage array to the new firmware immediately. Optionally, you can download the firmware file to the controller and upgrade the firmware later at a more convenient time.

The process of upgrading the firmware after downloading the firmware file is known as *activation*. During activation, the existing firmware file in the memory of the controller is replaced with the new firmware file.

The firmware upgrade process requires that the controllers have enough free memory space in which the firmware file resides until activation.

A version number exists for each firmware file. For example, 06.60.08.00 is a version number for a firmware file. The first two digits indicate the major revision of the firmware file. The remaining digits indicate the minor revision of the firmware file. You can view the version number of a firmware file in the **Upgrade Controller Firmware** window and the **Download Firmware** dialog. For more information, refer to the Downloading the Firmware online help topic in the Enterprise Management Window.

The process of upgrading the firmware can be either a major upgrade or a minor upgrade depending on the version of the firmware. For example, the process of upgrading the firmware is major if the version of the current firmware is 06.60.08.00, and you want to upgrade the firmware to version 07.36.12.00. In this example, the first two digits of the version numbers are different and indicate a major upgrade. In a minor upgrade, the first two digits of the version numbers are the same. For example, the process of upgrading the firmware is minor if the version of the current firmware is 06.60.08.00, and you want to upgrade the firmware to version 06.60.18.00 or any other minor revision of the firmware.

You can use the Enterprise Management Window to perform both major upgrades and minor upgrades. You can use the Array Management Window to perform minor upgrades only.

The storage management software checks for existing conditions in the storage array before upgrading the firmware. Any of these conditions in the storage array can prevent the firmware upgrade:

- An unsupported controller type or controllers of different types that are in the storage array that cannot be upgraded
- One or more failed drives
- One or more hot spare drives that are in use
- One or more volume groups that are incomplete
- Operations, such as defragmenting a volume group, downloading of drive firmware, and others, that are in progress

- Missing volumes that are in the storage array
- Controllers that have a status other than Optimal
- The storage partitioning database is corrupt
- A data validation error occurred in the storage array
- The storage array has a Needs Attention status
- The storage array is unresponsive, and the storage management software cannot communicate with the storage array
- The Event Log entries are not cleared

You can correct some of these conditions by using the Array Management Window. However, for some of the conditions, you might need to contact your Technical Support representative. The storage management software saves the information about the firmware upgrade process in log files. This action helps the Technical Support representative to understand the conditions that prevented the firmware upgrade.

You can view the status of a storage array in the Status area of the **Upgrade Controller Firmware** window. Based on the status, you can select one or more storage arrays for which you want to upgrade the firmware.

You also can use the command line interface (CLI) to download and activate firmware to several storage arrays. For more information, refer to the About the Command Line Interface online help topic in the Enterprise Management Window.

Monitoring the Status of the Download

Monitor the progress and completion status of the *firmware* and *NVSRAM* download to the controllers to make sure that errors did not occur. After the **Confirm Download** dialog is dismissed, the file is transferred to the storage array. Each controller is sent the new file one at a time. If the file transfer to the first controller succeeds, then the file is transferred to the second controller. The status of the file transfer and the update to each participating controller appear in the **Upgrade Controller Firmware** window.

NOTE When the firmware download successfully completes, a dialog might appear stating that the current version of the Array Management Window (AMW) is not compatible with the new firmware just downloaded. If you see this message, dismiss the AMW for the storage array, and open it again after selecting the storage array in the Enterprise Management Window (EMW) and selecting **Tools >> Manage Storage Array**. This action launches a new version of the AMW that is compatible with the new firmware.

The progress and status of optimal controllers that are participating in the download appear. Controllers with statuses other than Optimal are not represented.

Status	Description
During Firmware or NVSRAM Download	
Progress bar	Transferring the firmware or the NVSRAM and the completed percentage
During Firmware or NVSRAM Activation	
Progress bar	Activating the firmware or the NVSRAM and the completed percentage of firmware activation
After Download and Results	
Firmware Pending 🕒	The storage array has pending firmware that is ready for activation.
Refreshing 🔄	The storage array status is refreshing.
Error ❌	An error occurred during the operation.
Unresponsive ⚡	The storage array cannot be contacted.
Not-upgradeable 🚫	The storage array cannot be upgraded for one or more reasons. For more information, refer to the Upgrading the Controller Firmware online help topic.
Health Check Passed ⬆	No problems were detected, and you can upgrade the storage array.
Upgradeable: Needs Attention ⇧	One or more problems were detected, but you can still upgrade the storage array.

Status	Description
Firmware Upgraded ✓	The firmware is successfully upgraded in the storage array.

During firmware downloads, the storage management software periodically polls the controller to see if the download has completed successfully. Sometimes, controller problems occur that keep the download from occurring. This table shows the results of firmware downloads if a controller is failed.

Task	Result
You download new firmware to a storage array. A controller in the storage array fails, and you replace the failed controller with a new one.	After the new controller is installed, the storage array detects the controller replacement and synchronizes the firmware on both controllers.
You download new firmware to a storage array. A controller in the storage array fails, but you place the controller back online (assuming the problem was with something other than the controller).	The firmware synchronization does *not* occur.

Problem Notification

NOTE To receive notification of events for the storage arrays, the Enterprise Management Window (EMW) or the Event Monitor must be running. In addition, you must have configured the alert notifications in the Enterprise Management Window.

Typically, storage array problems are indicated by using these status notifications:

- A Needs Attention status icon appears in several locations:
  - In the Status bar of the EMW
  - In the Tree view and the Table view on the **Devices** tab of the EMW
  - In the title bar of the Array Management Window (AMW)
  - In the storage array name and status area above the tabs in the AMW
- On the **Summary** tab, the **Logical** tab, and the **Physical** tab in the AMW

Event Log Viewer

The Event Log is a detailed record of events that occur in the storage array. You can use the Event Log as a supplementary diagnostic tool to the Recovery Guru for tracing storage array events. Always refer to the Recovery Guru first when you attempt to recover from component failures in the storage array.

The Event Log is stored in reserved areas on the disks in the storage array.

You can perform these actions in the **Event Log** window:

- View and filter the events that are displayed in the Event Log.
- Update the display to retrieve any new events.
- View detailed information about a selected event.
- Save selected Event Log data to a file.
- Clear the events in the Event Log.

The Event Log displays three levels of events: Critical, Informational, and Warning. To configure the destination addresses for delivery of email and SNMP trap messages that contain event details affecting managed storage arrays, select **Edit >> Configure Alerts** in the Enterprise Management Window. For more information about SMTP notification, refer to the online help topics in the Enterprise Management Window.

Viewing the Event Log

From the Array Management Window (AMW), select **Advanced >> Troubleshooting >> View Event Log**.

Several minutes might elapse for an event to be logged and to become visible in the **Event Log** window.

Storage Array Problem Recovery

When you see a storage array **Needs Attention** icon or link, launch the Recovery Guru. The Recovery Guru is a component of the Array Management Window that diagnoses the problem and provides the appropriate procedure to use for troubleshooting.

Recovery Guru

The **Recovery Guru** window is divided into three panes:

- **Summary** - This pane lists storage array problems.
- **Details** - This pane shows information about the selected problem in the Summary pane.
- **Recovery Procedure** - This pane lists the appropriate steps to resolve the selected problem in the Summary pane.

For detailed information about the Recovery Guru, refer to the online help topics in the Array Management Window.

Glossary

C

configured capacity

Space on drives in a storage array that has been designated for use in a volume group.

controller

A circuit board and firmware that is located within a controller tray or a controller-drive tray. A controller manages the input/output (I/O) between the host system and data volumes.

copyback

The process of copying data from a hot spare drive to a replacement drive. When a failed drive has been physically replaced, a copyback operation automatically occurs from the hot spare drive to the replacement drive.

D

Default Group

A standard node to which all host groups, hosts, and host ports that do not have any specific mappings are assigned. The standard node shares access to any volumes that were automatically assigned default logical unit numbers (LUNs) by the controller firmware during volume creation.

duplex

A disk array system with two active controllers handling host input/output (I/O) requests, referred to as dual-active controllers.

Dynamic RAID-Level Migration (DRM)

A modification operation that changes the Redundant Array of Independent Disks (RAID) level on a selected volume group. During the entire modification process, the user can access data on volume groups, volumes, and drives in the storage management software. The user cannot cancel this operation after it starts.

Dynamic Volume Expansion (DVE)

A modification operation in the storage management software that increases the capacity of a standard volume or a snapshot (legacy) repository volume. The operation uses the free capacity available on the volume group of the standard volume or the snapshot (legacy) repository volume. This operation is considered to be dynamic because the user has the ability to continually access data on volume groups, volumes, and drives throughout the entire operation.

F

Fibre Channel (FC)

A high-speed, serial, storage and networking interface that offers higher performance and greater capacity and cabling distance. FC offers increased flexibility and scalability for system configurations and simplified cabling. FC is a host interface that is a channel-network hybrid using an active, intelligent interconnection scheme (topology) to connect devices over a serial bus. The storage management software uses this connection between the host (where it is installed) and each controller in the storage array to communicate with the controllers.

firmware

Low-level program code that is installed into programmable read-only memory (PROM), where it becomes a permanent part of a computing device. The firmware contains the programming needed for boot and to implement storage management tasks.

Free Capacity node

A contiguous region of unassigned capacity on a defined volume group. The user assigns free capacity space to create volumes.

full disk encryption (FDE)

A type of drive technology that can encrypt all data being written to its disk media.

H

HBA host port

The physical and electrical interface on the host bus adapter (HBA) that provides for the connection between the host and the controller. Most HBAs will have either one or two host ports. The HBA has a unique World Wide Identifier (WWID) and each HBA host port has a unique WWID.

heterogeneous hosts

Hosts with different operating systems that share access to the same storage array.

host

A computer that is attached to a storage array. A host accesses volumes assigned to it on the storage array. The access is through the HBA host ports or through the iSCSI host ports on the storage array.

host group

A logical entity that identifies a collection of hosts that share access to the same volumes.

hot spare drive

A spare drive that contains no data and that acts as a standby in case a drive fails in a Redundant Array of Independent Disks (RAID) Level 1, RAID Level 3, RAID Level 5, or RAID Level 6 volume. The hot spare drive can replace the failed drive in the volume. Hot spare drives are used only in volume groups, not disk pools.

I

in-band management

A method to manage a storage array in which a storage management station sends commands to the storage array through the host input/output (I/O) connection to the controller.

L

logical unit number (LUN)

The number assigned to the address space that a host uses to access a volume. Each host has its own LUN address space. Therefore, the same LUN can be used by different hosts to access different volumes.

M

media scan

A background process that runs on all volumes in the storage array for which it has been enabled. A media scan provides error detection on the drive media. The media scan process scans all volume data to verify that it can be accessed. Optionally, the media scan process also scans the volume redundancy data.

mirror repository volume

A special volume on the storage array that is created as a resource for each controller in both local storage arrays and remote storage arrays. The controller stores duplicate information on the mirror repository volume, including information about remote writes that are not yet written to the secondary volume. The controller uses the mirrored information to recover from controller resets and from accidental powering-down of storage arrays.

N

network management station (NMS)

A console with installed network management software that is Simple Network Management Protocol (SNMP) compliant. The NMS receives and processes information about managed network devices in a form that is supported by the Management Information Base (MIB) that the NMS uses.

SANtricity ES Storage Manager provides information about critical events, using SNMP trap messages, to the configured NMS.

node

CONTEXT [Network] [Storage System] An addressable entity connected to an input/output (I/O) bus or network. Used primarily to refer to computers, storage devices, and storage subsystems. The component of a node that connects to the bus or network is a port. (*The Dictionary of Storage Networking Terminology*)

O

out-of-band management

A method to manage a storage array in which a storage management station sends commands to the storage array through the Ethernet connections on the controller.

P

parity

A method that provides complete data redundancy while requiring that only a fraction of the storage capacity of mirroring. The data and parity blocks are divided between the drives so that if any single drive is removed (or fails), the data on the drive can be reconstructed. Data is reconstructed by using the data on the remaining drives. The parity data might exist on only one drive, or the parity data might be distributed between all of the drives in the Redundant Array of Independent Disks (RAID) group.

premium feature

A feature that is not available in the standard configuration of the storage management software.

primary volume

A standard volume in a mirror relationship that accepts host input/output (I/O) and stores application data. When the mirror relationship is first created, data from the primary volume is copied in its entirety to the associated secondary volume. The primary volume contains the original user data in a mirror relationship.

protocol

CONTEXT [Fibre Channel] [Network] [SCSI] A set of rules for using an interconnect or a network so that information conveyed on the interconnect can be correctly interpreted by all parties to the communication. Protocols include such aspects of communication as data representation, data item ordering, message formats, message and response sequencing rules, block data transmission conventions, timing requirements, and so forth. (*The Dictionary of Storage Networking Terminology*, 2004)

R

RAID Level 0

A level of non-redundant Redundant Array of Independent Disks (RAID) in which data is striped across a volume or volume group. RAID Level 0 provides high input/output (I/O) performance and works well for non-critical data. All drives are available for storing user data; however, data redundancy does not exist. Data availability is more at risk than with other RAID levels, because any single drive failure causes data loss and a volume status of Failed.

RAID Level 0 is not actually RAID unless it is combined with other features to provide data and functional redundancy, regeneration, and reconstruction, such as RAID Level 1+0 or RAID Level 5+0.

RAID Level 1

A redundant Redundant Array of Independent Disks (RAID) level in which identical copies of data are maintained on pairs of drives, also known as mirrored pairs. RAID Level 1 uses disk mirroring to make an exact copy from one drive to another drive.

RAID Level 1 offers the best data availability, but only half of the drives in the volume group are available for user data. If a single drive fails in a RAID Level 1 volume group, all associated volumes become degraded, but the mirrored drive allows access to the data. RAID Level 1 can survive multiple drive failures as long as no more than one failure exists per mirrored pair. If a drive pair fails in a RAID Level 1 volume group, all associated volumes fail, and all data is lost.

RAID Level 3

A high-bandwidth mode Redundant Array of Independent Disks (RAID) level in which both user data and redundancy data (parity) are striped across the drives. The equivalent of one drive's capacity is used for redundancy data. RAID Level 3 is good for large data transfers in applications, such as multimedia or medical imaging, that read and write large sequential blocks of data.

If a single drive fails in a RAID Level 3 volume group, all associated volumes become degraded, but the redundancy data allows access to the data. If two or more drives fail in a RAID Level 3 volume group, all associated volumes fail, and all data is lost.

RAID Level 5

A high input/output (I/O) Redundant Array of Independent Disks (RAID) level in which data and redundancy are striped across a volume group or volume. The equivalent of one drive's capacity is used for redundancy data. RAID Level 5 is good for multiuser environments, such as database or file system storage, where typical I/O size is small, and there is a high proportion of read activity.

If a single drive fails in a RAID Level 5 volume group, then all associated volumes become degraded, but the redundancy data allows access to the data. If two or more drives fail in a RAID Level 5 volume group, then all associated volumes fail, and all data is lost.

RAID Level 6

A further development of Redundant Array of Independent Disks (RAID) Level 5. RAID Level 6 protects against simultaneous failure of two member drives by using two independent error correction schemes. Although RAID Level 6 provides ultra-high data reliability, its write penalty is even more severe than that of RAID Level 5 because redundant information must be generated and written twice for each application update. As with RAID Level 4 and RAID Level 5, the write penalty in RAID Level 6 is often mitigated by other storage technologies, such as caching.

RAID Level 10

A striping and mirroring mode used for high performance.

redundancy (data)

Additional information stored along with user data that enables a controller to reconstruct lost data. Redundant Array of Independent Disks (RAID) Level 1 uses mirroring for redundancy. RAID Level 3, RAID Level 5, and RAID Level 6 use redundancy information, sometimes called parity, that is constructed from the data bytes and is striped along with the data on each drive.

redundancy (hardware)

The use of some hardware components that take over operation when the original hardware component fails. For example, if one power-fan canister fails in a tray, the second power-fan canister can take over the power and cooling requirements for the tray.

redundancy check

A scan of volume redundancy data, performed as a part of a background media scan.

Redundant Array of Independent Disks (RAID)

CONTEXT [Storage System] A disk array in which part of the physical storage capacity is used to store redundant information about user data stored on the remainder of the storage capacity. The redundant information enables regeneration of user data in the event that one of the array's member disks or the access path to it fails.

Although it does not conform to this definition, disk striping is often referred to as RAID (RAID Level 0). (*The Dictionary of Storage Networking Terminology*)

remote mirror

A mirrored volume pair that consists of a primary volume at the primary site and a secondary volume at a secondary, remote site.

The secondary, remote volume is unavailable to secondary host applications while mirroring is underway. In the event of disaster at the primary site, the user can fail over to the secondary site. The failover is done by performing a role reversal to promote the secondary volume to a primary volume. Then the recovery host will be able to access the newly promoted volume, and business operations can continue.

remote mirroring

A configuration in which data on one storage array (the primary storage array) is mirrored across a fabric storage area network (SAN) to a second storage array (the secondary storage array). In the event that the primary storage array fails, mirrored data at the secondary site is used to reconstruct the data in the volumes.

role reversal

The acts of promoting the secondary volume to be the primary volume of a mirrored pair and demoting the primary volume to be the secondary volume.

S

secondary volume

A standard volume in a mirror relationship that maintains a mirror (or copy) of the data from its associated primary volume. The secondary volume is available for host read requests only. Write requests to the secondary volume are not permitted. In the event of a disaster or catastrophic failure of the primary site, the secondary volume can be promoted to a primary role.

Simple Network Management Protocol (SNMP)

CONTEXT [Network] [Standards] An IETF protocol for monitoring and managing systems and devices in a network. The data being monitored and managed is defined by a Management Information Base (MIB). The functions supported by the protocol are the request and retrieval of data, the setting or writing of data, and traps that signal the occurrence of events. (*The Dictionary of Storage Networking Terminology*)

simplex

A one-way transmission of data. In simplex communication, communication can only flow in one direction and cannot flow back the other way.

snapshot (legacy) repository volume

A volume in the storage array that is made as a resource for a snapshot (legacy) volume. A snapshot (legacy) repository volume holds snapshot (legacy) volume metadata and copy-on-write data for a specified snapshot (legacy) volume.

snapshot (legacy) volume

A point-in-time image of a standard volume. A snapshot (legacy) is the logical equivalent of a complete physical copy, but a snapshot (legacy) is created much more quickly than a physical copy. In addition, a snapshot (legacy) requires less unconfigured capacity.

SNMP trap

A notification event issued by a managed device to the network management station when a significant event occurs. A significant event is not limited to an outage, a fault, or a security violation.

Solid State Disk (SSD)

[Storage System] A disk whose storage capability is provided by solid-state random access or flash memory rather than magnetic or optical media.

A solid state disk generally offers very high access performance compared to that of rotating magnetic disks, because it eliminates mechanical seek and rotation time. It may also offer very high data transfer capacity. Cost per byte of storage, however, is typically higher. (*The Dictionary of Storage Networking Terminology*)

source volume

A standard volume in a volume copy that accepts host input/output (I/O) and stores application data. When the volume copy is started, data from the source volume is copied in its entirety to the target volume.

standard volume

A logical component created on a storage array for data storage. Standard volumes are also used when creating snapshot (legacy) volumes and remote mirrors.

storage management station

A computer running storage management software that adds, monitors, and manages the storage arrays on a network.

storage partition

A logical entity that is made up of one or more storage array volumes. These storage array volumes can be accessed by a single host or can be shared with hosts that can be part of a host group.

striping

CONTEXT [Storage System] Short for data striping; also known as Redundant Array of Independent Disks (RAID) Level 0 or RAID 0. A mapping technique in which fixed-size consecutive ranges of virtual disk data addresses are mapped to successive array members in a cyclic pattern. (*The Dictionary of Storage Networking Terminology*)

T

target volume

A standard volume in a volume copy that contains a copy of the data from the source volume.

topology

The logical layout of the components of a computer system or network and their interconnections. Topology deals with questions of what components are directly connected to other components from the standpoint of being able to communicate. It does not deal with questions of physical location of components or interconnecting cables. (*The Dictionary of Storage Networking Terminology*)

U

Unconfigured Capacity node

The capacity present in the storage array from drives that have not been assigned to a volume group.

V

volume

The logical component created for the host to access storage on the storage array. A volume is created from the capacity available on a disk pool or a volume group. Although a volume might consist of more than one drive, a volume appears as one logical component to the host.

Volume Copy

A premium feature that copies data from one volume (the source volume) to another volume (the target volume) within a single storage array.

volume group

A set of drives that is logically grouped and assigned a RAID level. Each volume group created provides the overall capacity needed to create one or more volumes.

W

write caching

An operation in which data is moved from the host to the cache memory on the controllers. This operation allows the controllers to copy the data to the drives that comprise a volume. Write caching helps improve data throughput by storing the data from the host until the controller can access the volume and move the data.

Please
Recycle

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