

E-Series

Hardware Cabling Guide

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NetApp®

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Deciding whether to use this guide

This guide contains conceptual information and best practices for cabling your storage array. It includes the following types of procedures:

- Host cabling
- Drive cabling
- Ethernet cabling for a management station
- Cabling to support mirroring features

This guide is intended for a hardware installer or system administrator who is installing or expanding a storage array, or cabling to support mirroring features. The procedures in this guide assume that you have installed the storage array as described in the *Installation and Setup Instructions* for your hardware. In addition to controller shelves (controller-drive trays) and drive shelves (drive trays), you might need some or all of the following components:

- Cables: SAS, Fibre Channel (FC), Ethernet, InfiniBand
- Small form-factor pluggable (SFP) or Quad SFP (QSFP) transceivers
- Switches
- Host bus adapters (HBAs)
- Host channel adapters (HCAs)
- Network interface cards (NICs)

This guide references the *Installation Instructions* for various hardware, *E-Series Site Preparation Guide*, *SANtricity System Manager Upgrade Guide*, and the *SANtricity Storage Manager Upgrade Guide*.

Related information

NetApp E-Series and EF-Series Systems Documentation Center
E-Series Site Preparation Guide
SANtricity System Manager 11.30 Upgrade Guide
SANtricity Storage Manager 11.30 Upgrade Guide

Cabling concepts and best practices

This chapter describes cabling concepts, best practices, and common procedures that apply generally across the specific cabling configuration that are covered in subsequent chapters.

Cabling concepts

Learn more about cabling concepts to help you cable your storage array.

Fabric (switched) topologies compared to direct-attach topologies

Fabric topologies use a switch or router, while direct-attach topologies do not. A fabric topology is required if the number of host connections to a controller-drive tray is greater than the number of available host ports on that tray's controllers.

Host connections might be InfiniBand, SAS, Fibre Channel, iSCSI, or a mix of connection types. Switches or routers must support the required connection type or types. A combination of switches or routers of different types might be appropriate for some configurations that support a mixture of connection types. Drive connections are always direct.

Trays and shelves

Storage arrays with an E2800 controller shelf typically use SANtricity System Manager. You might also use the Enterprise Management Window (EMW) from SANtricity Storage Manager to manage E2800 controller shelves. All other controller-drive trays referenced in this document use SANtricity Storage Manager. The following table summarizes differences in terminology between E2800 controller shelves and earlier models of controller drive trays.

Term used for E2700 and E5600 storage arrays, and EF560 flash arrays	Term used for E2800 storage arrays	Definition
tray	shelf	An enclosure you can install in a cabinet or rack. E-Series enclosures might include controller canisters and drives, or they might contain drives only.
controller-drive tray	controller shelf	An enclosure that includes one or two controller canisters and drives.
drive tray (or "expansion drive tray")	drive shelf (or "expansion drive shelf")	An enclosure that includes drives and either two environmental service modules (ESMs) or two I/O modules (IOMs).
slot	bay	One of the locations in an enclosure for a drive, controller canister, or ESM or IOM.

Term used for E2700 and E5600 storage arrays, and EF560 flash arrays	Term used for E2800 storage arrays	Definition
controller canister	controller canister	The component in a controller-drive tray or controller shelf that includes a controller card, a battery, and–optionally–a host interface card.
ESM (environmental service module)	IOM (I/O module)	The component in a drive tray or drive shelf that manages the activities performed by the enclosure.
power-fan canister	power-fan canister	The component in a 12-drive or 24-drive enclosure that includes the power supply (or PSU) and integrated fans.

Keep in mind that some drive shelves (drive trays) can be used with E2800 controller shelves as well as with other controller-drive trays. The terminology that applies for this hardware depends on the context in which it is used. Where either terminology might apply, this document uses the newer terminology. The first occurrence of the term is followed by the alternative term in parentheses — for example, controller shelf (controller-drive tray).

The controllers configure, access, and manage the storage capacity of the drives in the controller shelf (or controller tray) and the storage capacity of the drives in any attached drive shelves (or drive trays). The controllers also support connections to hosts. A controller shelf with, optionally, any attached drive shelves (drive trays) comprise a storage array. With SANtricity System Manager, you manage a storage array through a web interface from a computer with an Ethernet connection to the controller shelf. With SANtricity Storage Manager, you manage a storage array through an attached host, called the management station.

A controller shelf (controller-drive tray) can be attached to one or more expansion drive shelves (or drive trays) to increase the capacity of a storage array or to increase the redundancy of volume groups or disk pools in the storage array. The controllers can configure, access, and manage the storage capacity of the drives in the attached drive shelves or drive trays. Expansion ports on the controllers connect to drive ports on the environmental services modules (ESMs) of the drive trays or the I/O modules (IOMs) in the drive shelves. A drive tray or drive shelf can connect to controllers indirectly through another drive tray or drive shelf.

Host channels and drive channels

In this document, the term *channel* refers to a path for the transfer of data and control information between a host and a controller shelf (controller-drive tray), or between drive shelves (drive trays) and an attached controller shelf. A data path from a host to a controller shelf is a *host channel*. A host channel might be Fibre Channel, InfiniBand, iSCSI, or SAS. A path from a drive shelf to a controller shelf is a *drive channel*. Each drive channel is defined by a series of SAS devices connected through expanders.

In an E2700 controller drive tray or an E2800 controller shelf, each controller has one drive channel along with an internal SAS expander (switch) that enables both drive ports on the controller to share that channel. Other models of controller shelf use direct port connections. With direct port connections, there is a one-to-one correspondence between ports and channels.

Note: When you mix different types of drive shelves, you must consider the total number of drive bays that are available in the final configuration of the storage array. Your configuration must meet both the limit on the total number of drive bays and the limit on the number of shelves in the storage array.

Host ports and drive ports

The ports are the physical connectors on the controller shelf (controller-drive tray) that, along with the cabling, enable the transfer of data. If the port communicates with the host server, it is a *host port*. If the port communicates with a drive shelf (drive tray), it is a *drive port*. The figures under *Component locations* on page 21 show the connectors on the rear of each model of controller shelf. These figures help you differentiate between host ports and drive ports.

Dual-ported drives

Each drive in a controller shelf (controller-drive tray) or a drive shelf (drive tray) is dual ported. This allows every drive in a duplex (two-controller) storage array, with proper cabling, to benefit from redundant connections to the controllers.

Preferred controllers and alternate controllers

A controller shelf (controller-drive tray) might have a duplex configuration with two controllers, or a simplex configuration with one controller. In a duplex configuration, the preferred controller is the controller that “owns” a volume. SANtricity Storage Manager or SANtricity System Manager automatically selects one controller to be the preferred controller when a volume is created. You can override that default selection.

When a failover event occurs, ownership of volumes is shifted to the alternate controller. Any one of the following conditions might initiate a failover:

- The preferred controller is physically removed.
- The preferred controller is being updated with new firmware.
- The preferred controller has sustained a fatal event.
- A host has detected a path failure and failed over to the alternate controller.

The paths used by the controller to access either the drives or the hosts are called the preferred paths, and the redundant paths are called the alternate paths. If a controller failure occurs that causes the preferred paths to become inaccessible, the storage array automatically switches to the alternate path. If a path failure occurs between a host and the preferred controller, the alternate path software on the host switches to the alternate controller.

Alternate path software

Alternate path software or an alternate path (failover) driver is a software tool that provides redundant data path management between host adapters and controllers. The tool discovers and identifies multiple paths to a single volume and establishes a preferred path to that volume. If any component in the preferred path fails, the alternate path software automatically reroutes I/O requests to the alternate path so that the system continues to operate without interruption.

Failover

Failover is an automated process that takes advantage of physical redundancy in a storage array to maintain access to data even if a component of the network fails. Controller failover is possible only in a storage array that contains two controllers. If one controller fails, or can no longer perform I/O operations with the volumes it owns, the other controller takes over the ownership of those volumes and provides I/O through an alternative drive connection.

Host connections can also be redundant. A host connected to a storage array that contains two controllers can have independent connection to each controller. If one of the connections fails, multipath software installed on the host detects the failure and transfers I/O operations to the other connection.

For more information, see the *SANtricity Power Guide for Advanced Users* for your operating system.

Related information

SANtricity 11.30 Installing and Configuring for Linux Power Guide for Advanced Users
SANtricity 11.30 Installing and Configuring for VMware Power Guide for Advanced Users
SANtricity 11.30 Installing and Configuring for Windows Power Guide for Advanced Users

Redundant and non-redundant components

In storage area network technology, redundancy means that essential services are implemented using duplicated components in such a way that if one component fails, an alternative component continues to provide the service. This redundancy ensures the availability of data in case a component fails.

In most RAID systems, most of the components are redundant, but the system might not be fully redundant. In other words, there might be one or two components whose individual failures would cause loss of access to data. Therefore, a *fully redundant system* duplicates all components and is configured to make sure that the duplicate components can be accessed in case of a failure. The manner in which the system is cabled is an essential component of creating a successfully configured redundant system.

Single point of failure

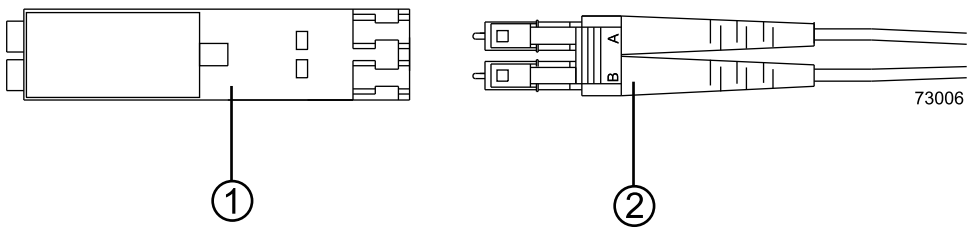
Any component or path that is not duplicated (redundant) or whose failure can cause loss of data access is called a potential *single point of failure*. The cabling scenarios in this document note the components that present a potential single point of failure. Choose a cabling topology that does not create a single point of failure.

SFP transceivers, fiber-optic cables, and copper cables

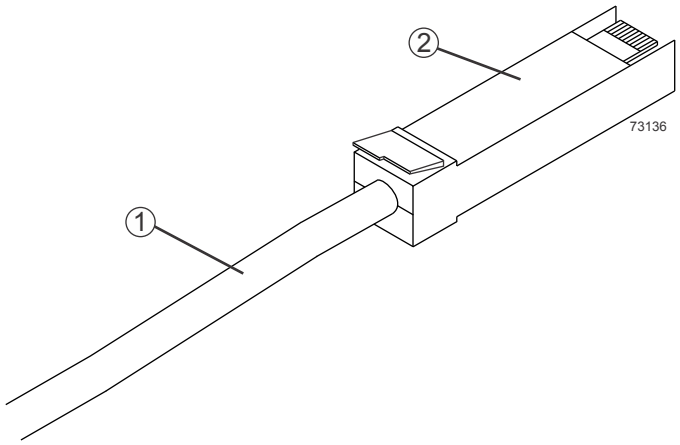
Fibre Channel host connections use fiber-optic cables while InfiniBand host connections use either fiber-optic or copper cables. If your system will be connected with Fibre Channel or InfiniBand fiber-optic cables, you must install an active SFP transceiver (for Fibre Channel) or QSFP transceivers (for InfiniBand) into each port in which a fiber-optic cable will be connected before you plug in the fiber-optic cable. Connections for 10-Gb/s iSCSI use copper or optical cables with SFP transceivers. Connections for 1-Gb/s iSCSI use copper cables with RJ-45 connectors and do not require SFP transceivers. Connections for SAS use copper or optical cables with SFF 8088 or SFF 8644 connectors and do not require SFP transceivers.

The following figures show the two types of cables that use SFP transceivers. Note that your SFP transceivers and cables might look slightly different from the ones shown. The differences do not affect the performance of the SFP transceivers.

Warning: Risk of exposure to laser radiation – Do not disassemble or remove any part of a Small Form-factor Pluggable (SFP) transceiver because you might be exposed to laser radiation.



1.	Active SFP transceiver
2.	Fiber-optic cable



1.	Copper cable
2.	Passive SFP transceiver

Host adapters

Each connection from a host port on a controller to a host is made through a host adapter on the host. A host adapter can be a host bus adapter (HBA) for Fibre Channel or SAS connections, a host channel adapter (HCA) for InfiniBand connections, or an Ethernet adapter for iSCSI connections. The host adapter provides the interface to the internal bus of the host. For hardware redundancy, use two host adapters in each host computer. The two host adapters must be of the same type (HBAs, HCAs, or Ethernet adapters). For duplex controller shelves, connect each host adapter to a different controller in the controller shelf to make sure that the server can access data even if one HBA or one controller fails.

Attention: Possible loss of data access – Do not use a combination of HBAs from different vendors in the same storage array. For the HBAs to perform correctly, use HBAs from only one manufacturer.

You can obtain information about supported host adapters from the NetApp Interoperability Matrix Tool.

Related information

NetApp Interoperability

Host interface cards

A host interface card (HIC) is a component of a controller that contains host ports. A controller might also have host ports, called baseboard host ports, that are not on a HIC. Different types of HICs are installed in a controller depending on the types of host connections a storage array supports. A HIC is cabled to a host adapter on a server: a host bus adapter (HBA) for Fibre Channel or SAS, a host channel adapter (HCA) for InfiniBand, or an Ethernet adapter for iSCSI. The host connection might be direct or through a switch fabric. The host adapter in the host must support the same interface protocols as the type of HIC to which it is cabled.

Network interface cards

A network interface card (NIC) is an expansion board that is installed in the host server. Some servers are equipped with an integrated NIC. The NIC supports Ethernet technology. The NIC is

required for network communication. Each Ethernet cable connection for out-of-band storage array management is made through an NIC.

Note: If your configuration requires a host Ethernet connection through an NIC, you must obtain and install the required NICs.

Related concepts

In-band management and out-of-band management on page 12

Switches and zoning

A switch is an intelligent device that connects multiple devices. A switch allows data transfer between the devices, depending upon the designated source (*initiator*) and the destination (*target*) of the data. A switch provides full bandwidth per port and high-speed routing of data.

Zoning allows a single hardware switch to function as two or more virtual switches. In a zoned configuration, communication among devices in each zone is independent of communication among devices in another zone or zones. Zoned switches allow an administrator to restrict access to specific areas within a storage area network (SAN).

In-band management and out-of-band management

You can manage a storage array from a storage management station, which is a workstation on which the SANtricity Storage Manager Client is installed. Requests and status information sent between the storage array and the storage management station are managed in one of two ways: in-band or out-of-band. A storage array that uses out-of-band management requires a different network topology from a storage array that uses in-band management.

For in-band management, requests and status information are communicated through the same connection that is used to write data to and read data from volumes in the storage array. For out-of-band management, requests and status information are communicated through a separate Ethernet connection between the management station and the storage array.

You can manage an E2800 storage array through the SANtricity System Manager. SANtricity System Manager has a web interface that is available through any supported browser on a system that can access an E2800 controller through an Ethernet network. This is an example of out-of-band management. You might also use the SANtricity Storage Manager to manage an E2800 storage array through the Enterprise Management Window (EMW) using either in-band or out-of-band management.

Best practices

To make sure that your cabling topology results in optimal performance and reliability, familiarize yourself with cabling best practices. If your existing storage array cabling does not comply with the best practices described in this section, do not re-cable your storage array unless specifically requested to do so by technical support.

Drive shelf cabling for redundancy

When you attach the drive shelves (drive trays), to a two-controller (duplex) controller shelf (controller-drive tray), use a cabling topology that does not create a single point of failure. A single point of failure might appear as a drive shelf failure or another component failure in the middle of a series of drive shelves. If a drive shelf fails, you can no longer access the drive shelves beyond the point of failure. By creating an alternate path, you make sure that the drive shelves are accessible in the event of a component failure.

For cabling examples, ranging from simple to complex, see *Drive shelf or drive tray cabling* on page 73.

Host cabling for redundancy

To ensure that the storage array remains accessible to the host in the event that a host channel fails, establish two physical paths from each host to the controllers, and install alternate path software on the host. This cabling topology, when used with alternate path software, makes sure that a redundant path exists from the host to the controllers.

Attention: Possible loss of data access – You must install alternate path software or an alternate path (failover) driver on the host to support failover in the event of an HBA failure or a host channel failure.

For examples of redundant topologies, see *Host cabling* on page 58.

Cabling for performance

Generally speaking, performance is enhanced by maximizing bandwidth, which is the ability to process more I/O across more channels. Therefore, a configuration that maximizes the number of host channels and the number of drive channels available to process I/O maximizes performance. Of course, faster processing speeds also maximize performance.

In addition to planning a topology that provides maximum performance, choose a RAID level that suits the planned applications.

How best to approach zone configuration

Some of the host cabling topologies shown in this document require the use of a zoned switch. By default, the switch uses no zoning, which is not sufficiently robust for most applications. You must configure the switch before you use it.

When an initiator first accesses the fabric, it queries the World Wide Identifier (WWID) name server for all of the attached controllers and their capabilities. Zoning is like a filter that the WWID name server applies to the query from the initiator that limits the information returned by the WWID name server to the initiator. A zone defines the WWID of the initiator and the WWID of the devices that a particular zone is allowed to access. Devices that are not part of the zone are not returned as accessible devices.

The fabric provides universal access for all initiators and targets. Any initiator can query (probe) the fabric for all targets, which can affect performance when many targets are connected to the fabric. The querying process also provides access to devices for which access is not needed. Use zoning to limit the number of devices that an initiator can access. Within your storage area network, you should zone the fabric switches so that the initiators do not “see” or communicate with each other.

Zone configuration is managed on a per-fabric basis. While you can administer zone configuration from any switch, use the best practice of selecting one switch for all zone administration. Give preference to the primary switches within the SAN, and choose only a switch that has the most up-to-date storage management software and switch management software installed on it.

Host cabling for mirroring

The Synchronous Mirroring feature and the Asynchronous Mirroring feature provide online, real-time replication of data between storage arrays in separate locations. In the event of a disaster or a catastrophic failure at one storage array, you can promote a second storage array to take over responsibility for computing services. See *Hardware installation for Synchronous Mirroring and Asynchronous Mirroring* on page 136 for detailed information.

Note: When you use Fibre Channel connections for mirroring, the last Fibre Channel host port on *each* controller must be dedicated for communications that occur between primary volumes on one storage array and secondary volumes on the other. If you use iSCSI connections with Asynchronous Mirroring, these host ports are available for ordinary host connections. If you use

iSCSI connections for mirroring, any one of the iSCSI ports can be used for the mirroring connection.

Single-controller topologies and dual-controller topologies

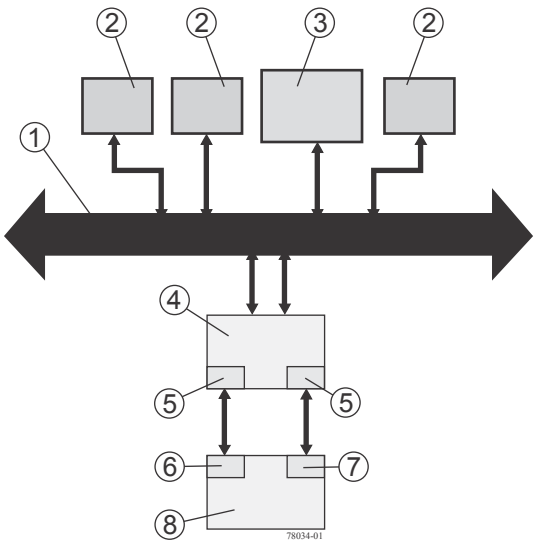
A controller shelf (controller-drive tray) that contains two controllers is called a duplex configuration. A controller shelf with only one controller is called a simplex configuration. If you are creating a topology for a simplex controller shelf, you can attach only drive trays that contain a single environmental services module (ESM) or a single I/O module (IOM). Do not attach a drive tray that contains two ESMs or IOMs to a simplex controller shelf.

Adding new drive shelves to an existing storage array

You can add drive shelves (drive trays) to an existing storage array without interrupting power or data transfer to the storage array. See *Drive shelf or drive tray cabling* on page 73 for the recommended cabling patterns for various numbers of attached drive shelves. For step-by-step instructions, see *Using SANtricity Storage Manager to add a drive tray to an existing storage array* on page 125.

Cabling for different management methods

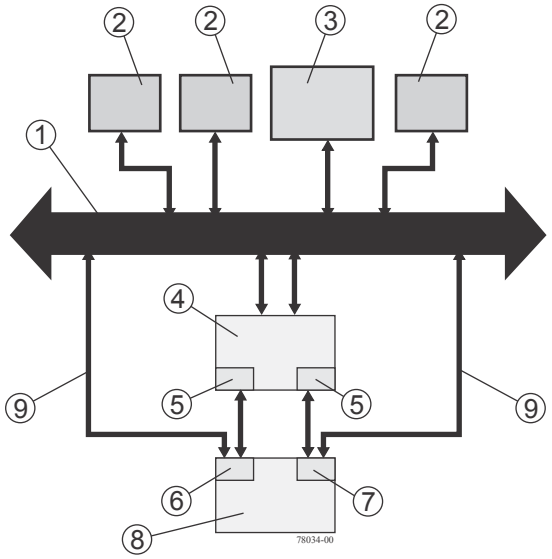
When you use *in-band management*, a SANtricity Storage Manager agent running on the host receives requests from the management station. The host agent processes the requests through the host I/O interface to the storage array. The host I/O interface might be Fibre Channel, SAS, or iSCSI. InfiniBand host interfaces do not support in-band management.



1.	Ethernet network
2.	User workstations sending and receiving data
3.	Storage management station
4.	Host
5.	Host adapters
6.	Controller A
7.	Controller B

8.	Controller-drive tray for the storage array

When you use *out-of-band management*, the storage management station is connected through an Ethernet network to each of the controllers in the controller shelf or controller-drive tray. E2800 controller shelves can use out-of-band management with SANtricity System Manager. E2800 controller shelves might also use the SANtricity Storage Manager Enterprise Management Window (EMW) with either management method. Out-of-band management is an optional alternative to in-band management for all other models of controller-drive trays.



1.	Ethernet network
2.	User workstations sending and receiving data
3.	Storage management station
4.	Host
5.	Host adapters
6.	Controller A
7.	Controller B
8.	Controller shelf (controller-drive tray)
9.	Ethernet cable from the controllers to the ethernet network

With out-of-band management, a Dynamic Host Configuration Protocol (DHCP) server is recommended for assigning IP addresses and other network configuration settings. A DHCP server provides the network administrators the ability to manage and automatically assign IP addresses. If a DHCP server is not used, you must manually configure the controllers. For more information, see *SANtricity Power Guide for Advanced Users* for your operating system or the "Adding a Host or Storage Array" online help topic in the Enterprise Management Window.

Attention: Risk of unauthorized access to or loss of data – If you use the out-of-band management method, connect the management Ethernet ports on the controllers to a private network segment behind a firewall. If the Ethernet connection is not protected by a firewall, your storage array might be at risk of being accessed from outside of your network.

Note: Where two Ethernet ports are available on a controller, use the port labeled P1 for out-of-band Ethernet connections. Reserve the second Ethernet port (labeled P2) for access by technical support.

For information about how to create a redundant out-of-band topology, see *Fabric out-of-band Ethernet topology* on page 135.

Related information

SANtricity 11.30 Installing and Configuring for Linux Power Guide for Advanced Users
SANtricity 11.30 Installing and Configuring for VMware Power Guide for Advanced Users
SANtricity 11.30 Installing and Configuring for Windows Power Guide for Advanced Users

Labeling cables

Cabling is an important part of creating a robust storage array. Labeling the cables identifies system components, drive connections, and host connections. System maintenance is easier when the cables are correctly identified. Label both ends of each cable. You can use adhesive office labels that are folded in half over the ends of each cable. Mark the labels with the port identifiers for the ports to which the cable is connected. You can provide additional information by using color-coded cable straps (or ties) to group all of the cables associated with one component, drive channel, or host channel.

If a component fails, you must disconnect the cables, replace the failed component, and reattach the cables. Detailed labeling of the cables simplifies the component replacement process.

If you add a new drive shelf (drive tray) to an existing configuration, correctly labeled cables helps you identify where to connect the new drive shelf.

Cabling information provided by storage management software

You can use SANtricity System Manager or SANtricity Storage Manager to view cabling information. SANtricity Storage Manager shows a table that lists all of the connections in the cabling topology and identifies any incorrectly cabled drive channels or non-redundant drive channels. For more information, see the online help topics in your storage management software.

Common procedures

Make sure to understand the tasks that might be required to cable your storage array. This section includes procedures that are common to most cable installations.

Handling static-sensitive components

Static electricity can damage dual inline memory modules (DIMMs), system boards, and other static-sensitive components. To prevent damaging the system, follow these precautions:

- Move and store all components in the static-protective packaging in which they came.
- Place components on a grounded surface before removing them from their static-protective packaging. Grounded surfaces include static-dissipating mats or grounded workstations.
- Always be properly grounded when touching a static-sensitive component. To properly ground yourself, wear a wrist strap or boot strap made for this purpose.
- Handle the component by its edges. Do not touch solder joints, pins, or printed circuitry.
- Use conductive field service tools.

Installing an SFP transceiver and a fiber-optic cable

You must install SFP transceivers into each connector to which you will connect a fiber-optic cable.

About this task

Be aware of potential hardware risks when performing this task.

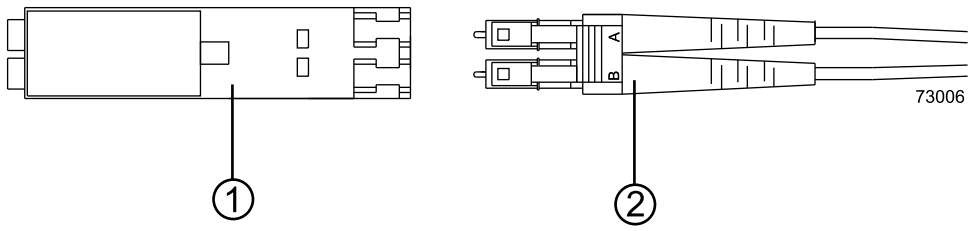
Attention: Potential degraded performance – To prevent degraded performance, do not twist, fold, pinch, or step on the fiber-optic cables. Many cables have a minimum bending radius. For example, do not bend fiber-optic Fibre Channel cables tighter than a 2 in. (5 cm) radius. Check the specifications for your cables and do not bend any cable more tightly than the minimum specified radius.

Attention: Possible hardware damage – To prevent electrostatic discharge damage to the tray, use proper antistatic protection when handling shelf (tray) components.

Steps

1. Put on antistatic protection.
2. Make sure that your cables are fiber-optic cables by comparing them to the fiber-optic cable shown in the following figure.

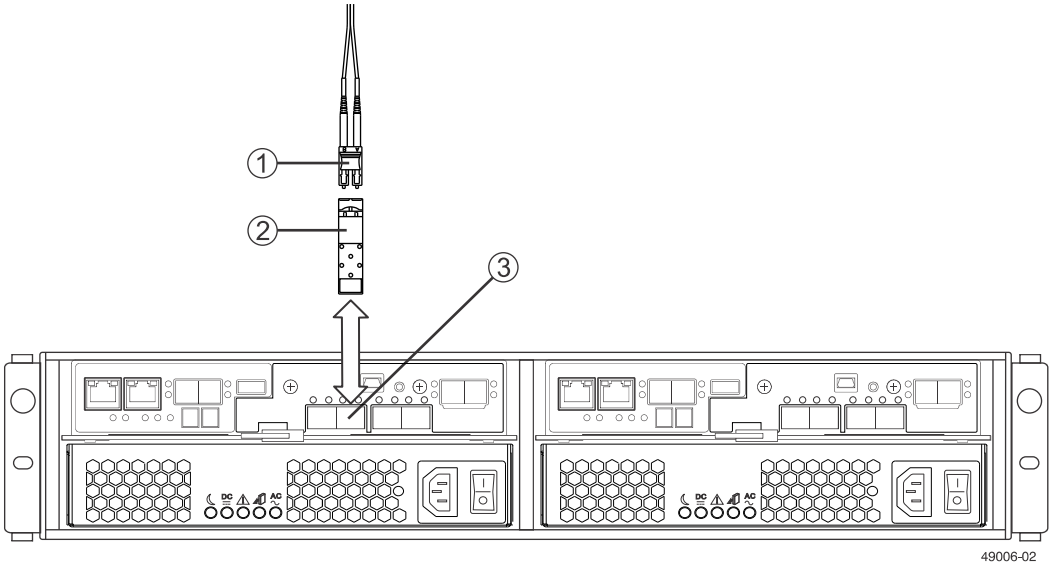
   Your SFP transceivers might look slightly different from the one shown. The differences do not affect the performance of the SFP transceiver.



1.	SFP transceiver
2.	Fiber-optic cable

3. Insert an SFP transceiver into the port in which the fiber-optic cable will be installed.

   Note: Make sure that the SFP transceiver installs with an audible click.



1.	Fiber-optic cable
2.	SFP transceiver
3.	Host interface port

4. Install the fiber-optic cable.

Installing a copper cable with a passive SFP transceiver

You must install a passive SFP transceiver into each connector to which you will connect a copper cable.

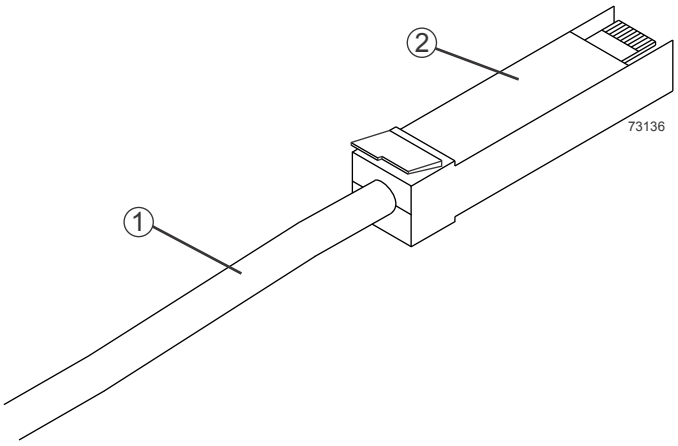
About this task

Attention: Possible hardware damage – To prevent electrostatic discharge damage to the shelf (tray), use proper antistatic protection when handling components.

Steps

1. Put on antistatic protection.
2. Verify that your cables are copper cables by comparing them to the cable shown in the following figure.

Your passive SFP transceivers might look slightly different from the one shown. The differences do not affect the performance of the SFP transceiver.



1.	Copper cable
2.	Passive SFP transceiver

Note: Make sure that the passive SFP transceiver installs with an audible click.

3. Insert the passive SFP transceiver into the port in which the copper cable will be installed.

Installing an RJ-45 cable for iSCSI connections

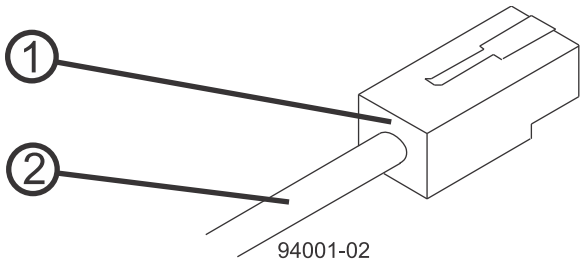
For iSCSI connections, you must install RJ-45 connectors for cables. Some 10-Gb/s iSCSI connections use optical cables with SFP+ connectors or twin-ax passive copper cables.

About this task

Attention: Possible hardware damage – To prevent electrostatic discharge damage to the shelf (tray), use proper antistatic protection when handling tray components.

Steps

1. Put on antistatic protection.
2. Verify that you have the correct cables for your iSCSI connections by comparing them to the cable shown in the following figure.



1.	RJ-45 connector
2.	iSCSI cable

3. For each cable, insert one RJ-45 connector into a host interface port on the controller and the other RJ-45 connector into a port on the host's Ethernet adapter or Ethernet switch.

Installing a SAS cable

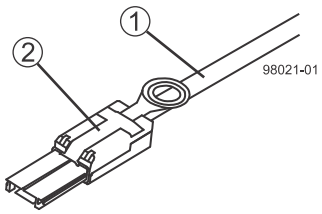
You must install SAS cables to be used for drive shelf (drive tray) connections or for host connections.

About this task

Attention: Possible hardware damage – To prevent electrostatic discharge damage to the shelf (tray), use proper antistatic protection when handling components.

Steps

1. Put on antistatic protection.
2. Verify that you have the correct cables for SAS connections by comparing them to the cable shown in the following figure.



1.	SAS cable
2.	SFF-8088 connector

Some drive shelf cabling configurations require a SAS cable with a mini-SAS (SFF-8088) connector at one end and a mini-SAS HD (SFF-8644) connector at the other end. Cables for SAS connections do not require SFP transceivers.



1.	SAS cable
2.	SFF-8644 connector

3. For each cable, insert one SFF-8088 or SFF-8644 connector into a port on the controller and the other SFF-8088 or SFF-8644 connector into a port on a host's HBA or on a drive shelf (drive tray) ESM/IOM.

   Note: When you install SAS cables, make sure that the blue tabs on the SAS cables face the bottom of the tray or shelf and that each connector clicks into place.

Component locations

You must make sure that you have correctly identified the cable connection for host cabling, drive shelf cabling, and Ethernet cabling.

The figures included in this section identify the locations of controllers, environmental services modules or I/O modules (ESMs/IOMs), host ports, drive ports, and Ethernet ports. The figures also show port identifiers.

Component locations on the E5500 and E5600 controller-drive trays and the EF550 and EF560 flash arrays

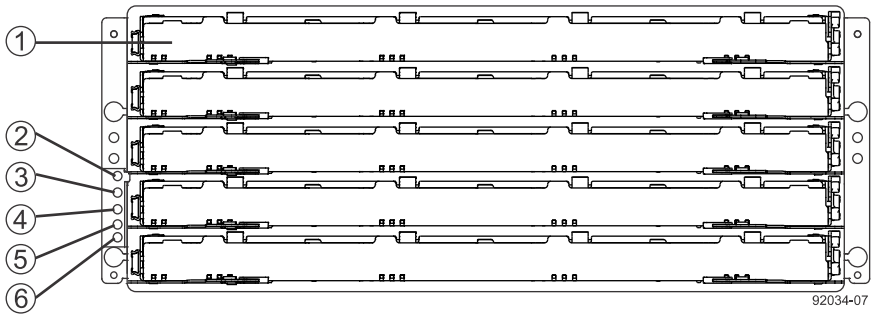
The E5500 controller-drive trays and the E5600 controller-drive trays have the same component locations. Both models support both HDD and SSD drives. Similarly, the EF550 flash array and the EF560 flash array have the same component locations. This topic covers the following controller-drive tray and flash array models:

- E5560
- E5524
- E5512
- EF550
- E5660
- E5624
- E5612
- EF560

Keep these points in mind when you compare the figures in this section to your hardware:

- The top of the controller-drive tray is the side with the labels.
- The configuration of the host ports depends on which host interface card configuration is installed.
- The figures in this section show the AC power option.
- The three E5500 controller-drive tray models and the EF550 share the same controller and have the same HIC options.
- The three E5600 controller-drive tray models and the EF560 share the same controller and have the same HIC options.

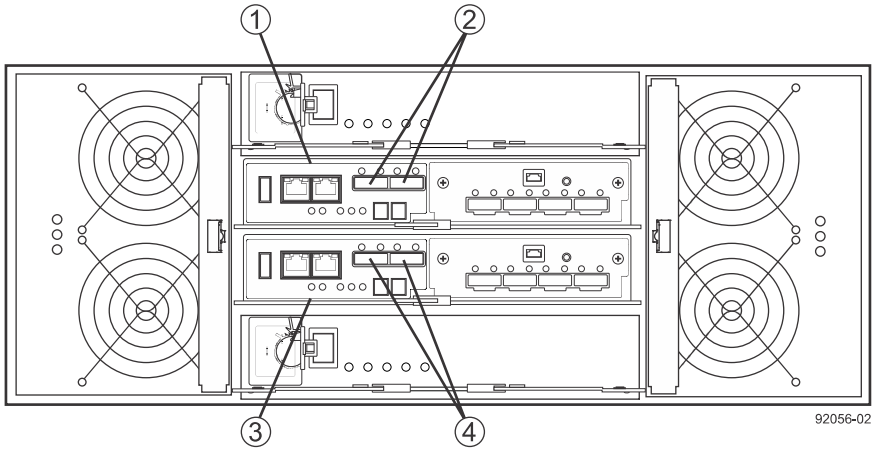
E5560 controller-drive tray or E5660 controller-drive tray - front view with bezel removed



1.	Drive drawer
2.	Locate LED
3.	Service Action Required LED
4.	Over-Temperature LED
5.	Power LED
6.	Standby Power LED

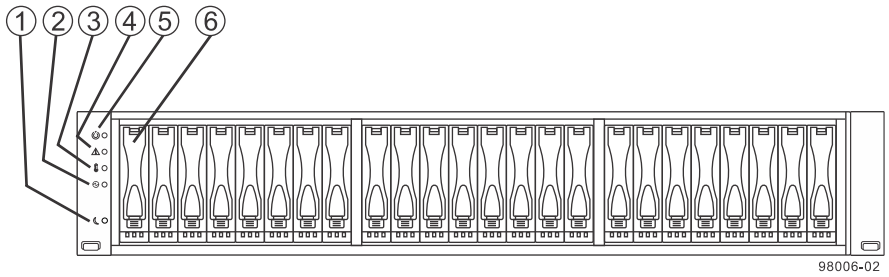
The following figure shows the controller-drive tray or flash array with a 12-Gb/s SAS HIC. Your controller-drive tray might have a different HIC.

E5560 controller-drive tray or E5660 controller-drive tray - rear view



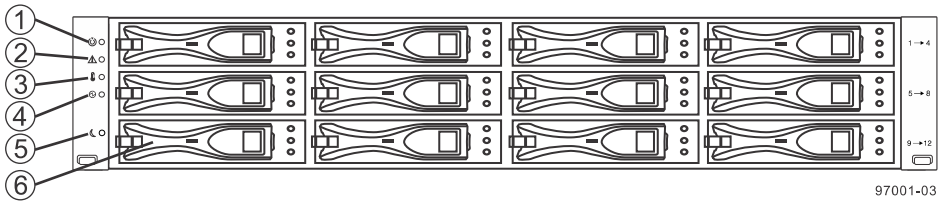
1.	Controller canister A
2.	Drive channel ports (SAS drive expansion connectors)
3.	Controller canister B
4.	Drive channel ports (SAS drive expansion connectors)

E5524, E5624, EF550, and EF560 controller-drive trays - front view with bezel removed



1.	End cap Standby Power LED
2.	End cap Power LED
3.	End cap Over-Temperature LED
4.	End cap Service Action Required LED
5.	End cap Locate LED
6.	Drive canister

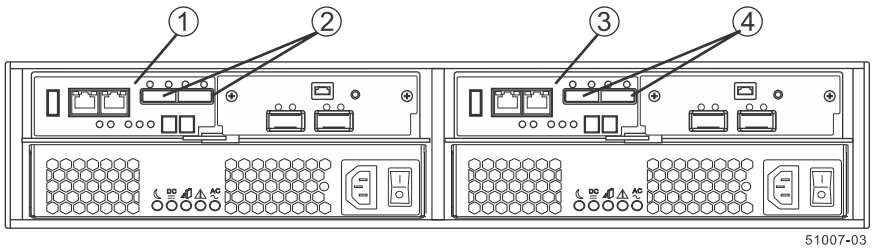
E5512 controller-drive tray and E5612 controller-drive tray - front view with bezel removed



1.	Identify LED
2.	Service Action Required LED
3.	Over-Temperature LED
4.	Power LED
5.	Standby Power LED
6.	Drive canister

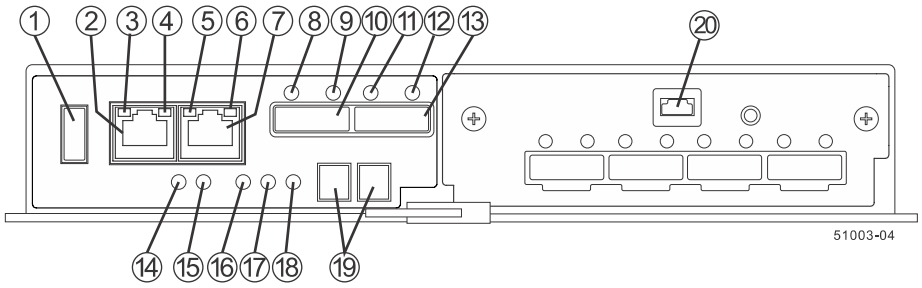
The following figure shows the controller-drive tray or flash array with an InfiniBand HIC. Your controller-drive tray might have a different HIC.

E5524, E5624, EF550, and EF560 controller-drive trays - rear view



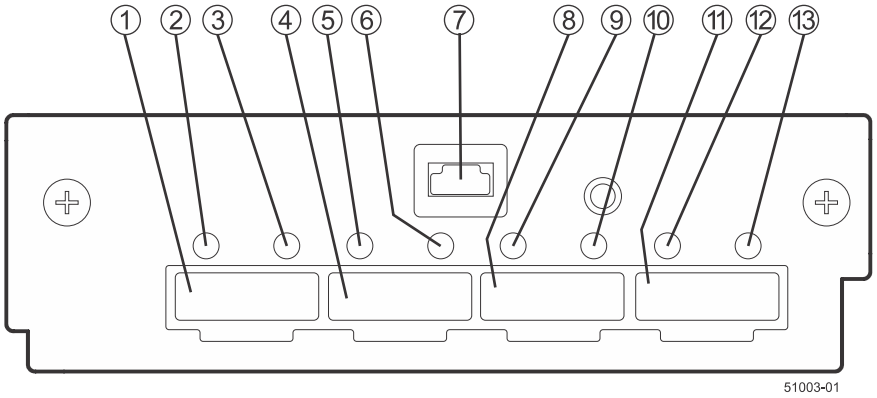
1.	Controller canister A
2.	Drive channel ports (SAS drive expansion connectors)
3.	Controller canister B
4.	Drive channel ports (SAS drive expansion connectors)

E5500, E5600, EF550, and EF560 controller module



1.	USB connector	11.	SAS Expansion Link 2 Fault LED
2.	1GbE management connector 1	12.	SAS Expansion Link 2 Up LED
3.	1GbE Link 1 Fault LED	13.	SFF-8088 SAS connector 2 (expansion)
4.	1GbE Link 1 Up LED	14.	Standby Power LED
5.	1GbE Link 2 Fault LED	15.	Power-Fan DC Power LED
6.	1GbE Link 2 Up LED	16.	Power-Fan Service Action Allowed LED
7.	GbE management connector 2	17.	Power-Fan Service Action Required LED
8.	SAS Expansion Link 1 Fault LED	18.	Power-Fan AC Power LED
9.	SAS Expansion Link 1 Up LED	19.	Seven-segment display
10.	SFF-8088 SAS connector 1 (expansion)	20.	Serial port

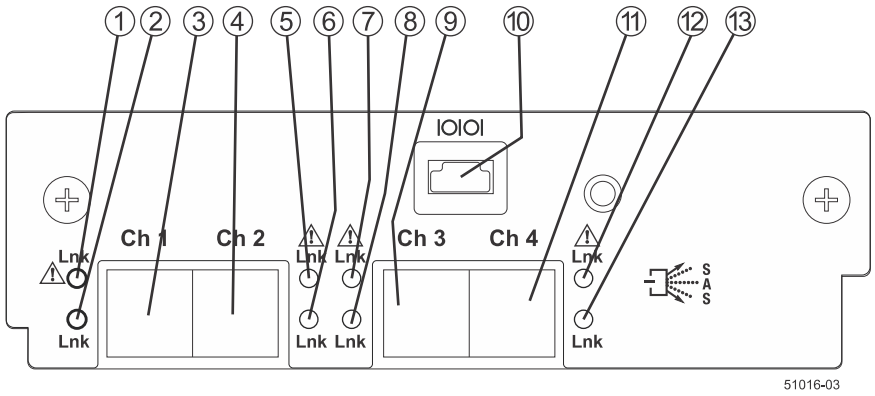
Right, rear subplate with a SAS-2 HIC



1.	SFF-8088 HIC connector 1	8.	SFF-8088 HIC connector 3

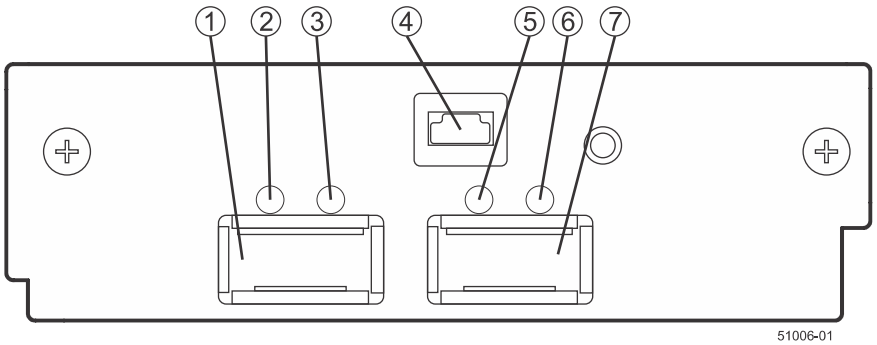
2.	Mini-SAS Port 1 Link Fault LED	9.	Mini-SAS Port 3 Link Fault LED
3.	Mini-SAS Port 1 Link Up LED	10.	Mini-SAS Port 3 Link Up LED
4.	SFF-8088 HIC connector 2	11.	SFF-8088 HIC connector 4
5.	Mini-SAS Port 2 Link Fault LED	12.	Mini-SAS Port 4 Link Fault LED
6.	Mini-SAS Port 2 Link Up LED	13.	Mini-SAS Port 4 Link UP LED
7.	Serial port		

Right, rear subplate with a SAS-3 HIC



1.	Port 1 Link Fault LED	8.	Port 3 Link Up LED
2.	Port 1 Link Up LED	9.	SFF-8644 HIC connector 3
3.	SFF-8644 HIC connector 1	10.	Serial Port
4.	SFF-8644 HIC connector 2	11.	SFF-8644 HIC connector 4
5.	Port 2 Link Fault LED	12.	Port 4 Link Fault LED
6.	Port 2 Link Up LED	13.	Port 4 Link Up LED
7.	Port 3 Link Fault LED		

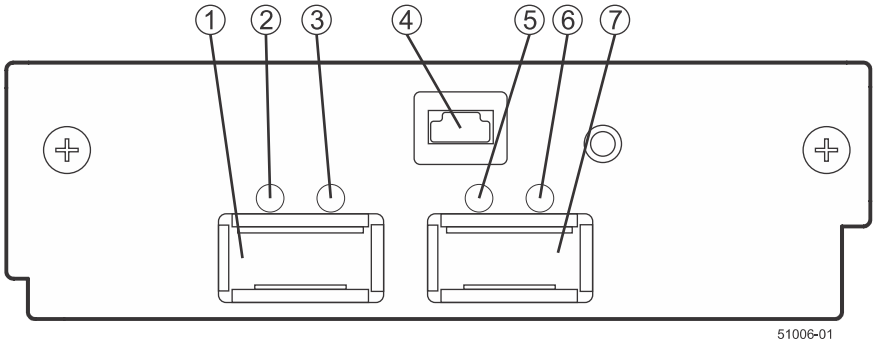
Right, rear subplate with a 40-Gb InfiniBand HIC



1.	HIC QSFP channel 1

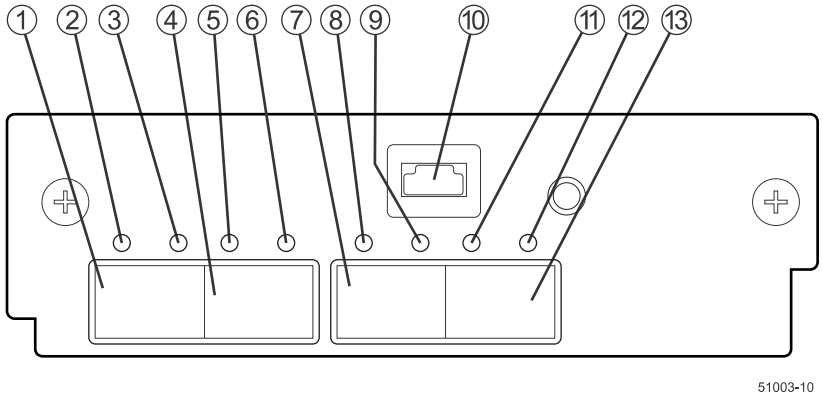
2.	HIC Logical Link 1 Active LED
3.	HIC Physical Link 1 Active LED
4.	Serial port
5.	HIC Logical Link 2 Active LED
6.	HIC Physical Link 2 Active LED
7.	HIC QSFP channel 2

Right, rear subplate with a 56-Gb InfiniBand HIC



1.	HIC QSFP channel 1
2.	HIC Logical Link 1 Active LED
3.	HIC Physical Link 1 Active LED
4.	Serial port
5.	HIC Logical Link 2 Active LED
6.	HIC Physical Link 2 Active LED
7.	HIC QSFP channel 2

Right, rear subplate with a 16-Gb FC or a 10-Gb iSCSI HIC



1.	SFP+ HIC channel 1	8.	HIC Link 3 Fault LED

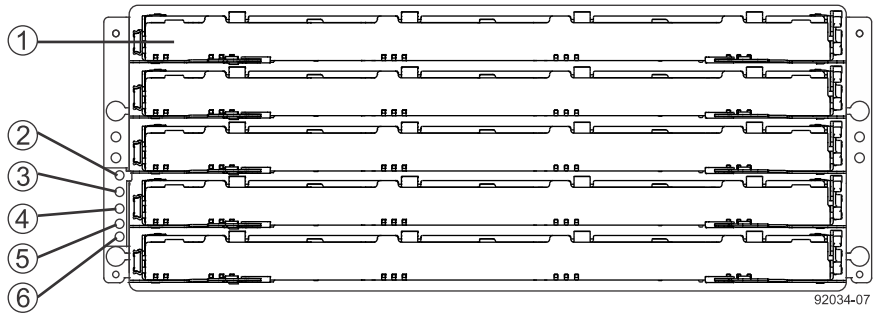
2.	HIC Link 1 Fault LED	9.	HIC Link 3 Active LED
3.	HIC Link 1 Active LED	10.	Serial port
4.	SFP+ HIC channel 2	11.	HIC Link 4 Fault LED
5.	HIC Link 2 Fault LED	12.	HIC Link 4 Active LED
6.	HIC Link 2 Active LED	13.	SFP+ HIC channel 4
7.	SFP+ HIC channel 3		

Component locations on the E5400 controller-drive trays and the EF540 flash array

The E5400 controller-drive trays include three models: the E5460, the E5424, and the E5412. The EF540 flash array has the same enclosure and cabling interfaces as the E5412 controller-drive tray. Keep these points in mind when you compare the figures in this section to your hardware.

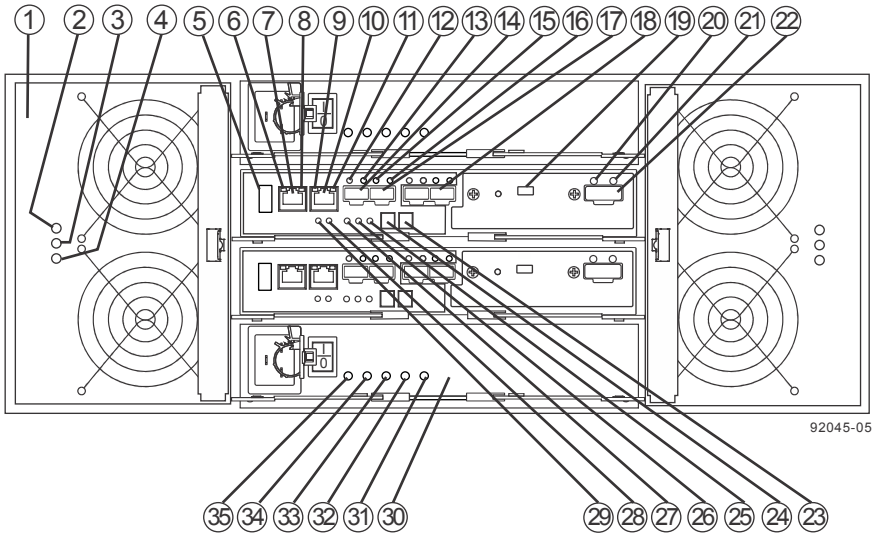
- The top of the controller-drive tray is the side with the labels.
- The configuration of the host ports depends on which host interface card is installed.
- The figures in this section show the AC power option.

E5460 controller-drive tray - front view with bezel removed



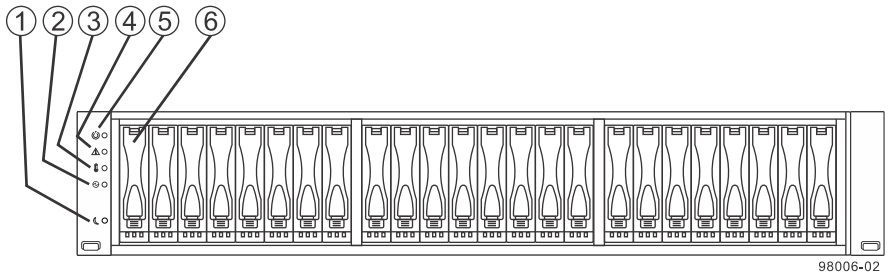
1.	Drive drawer
2.	Locate LED
3.	Service Action Required LED
4.	Over-Temperature LED
5.	Power LED
6.	Standby Power LED

E5460 controller-drive tray - rear view



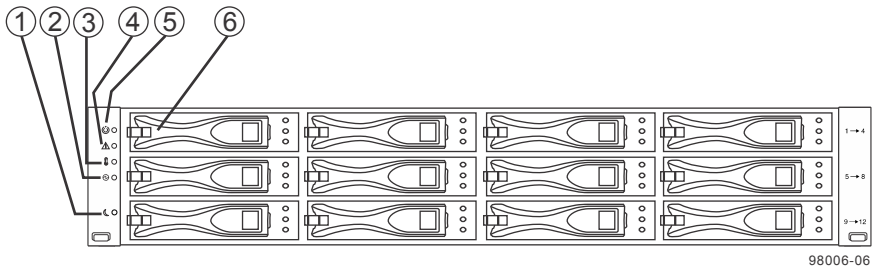
1.	Fan canister	19.	Mini USB connector
2.	Fan Power LED	20.	Expansion Fault LED
3.	Fan Service Action Required LED	21.	Expansion Active LED
4.	Fan Service Action Allowed LED	22.	Expansion SFF-8088 port connector
5.	USB connector	23.	Second seven-segment display field
6.	Ethernet Link 1 Active LED	24.	First seven-segment display field
7.	Ethernet connector 1	25.	Cache Active LED
8.	Ethernet Link 1 Rate LED	26.	Controller A Service Action Required LED
9.	Ethernet Link 2 Active LED	27.	Controller A Service Action Allowed LED
10.	Ethernet connector 2	28.	Battery Charging LED
11.	Ethernet Link 2 Rate LED	29.	Battery Service Action Required LED
12.	Fibre Channel Link 1 Up LED	30.	Power canister
13.	Fibre Channel Link 1 Active LED	31.	Power canister AC Power LED
14.	Fibre Channel connector 1	32.	Power canister Service Required Allowed LED
15.	Fibre Channel Link 2 Up LED	33.	Power canister Service Action Allowed LED
16.	Fibre Channel Link 2 Active LED	34.	Power canister DC Power LED
17.	Fibre Channel connector 2	35.	Power canister Standby Power LED
18.	Fibre Channel connector 4		

E5424 controller-drive tray and EF540 flash array - front view



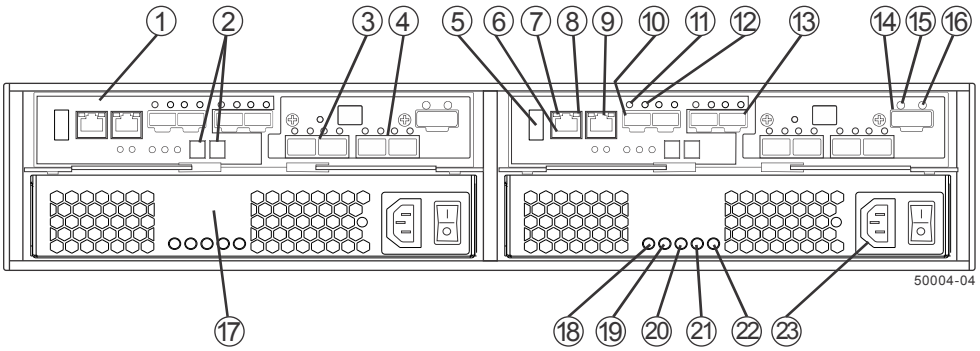
1.	Locate LED
2.	Service Action Required LED
3.	Over-Temperature LED
4.	Power LED
5.	Standby Power LED
6.	Drive canister

E5412 controller-drive tray - front view



1.	Locate LED
2.	Service Action Required LED
3.	Over-Temperature LED
4.	Power LED
5.	Standby Power LED
6.	Drive canister

E5424 controller-drive tray and EF540 flash array - rear view

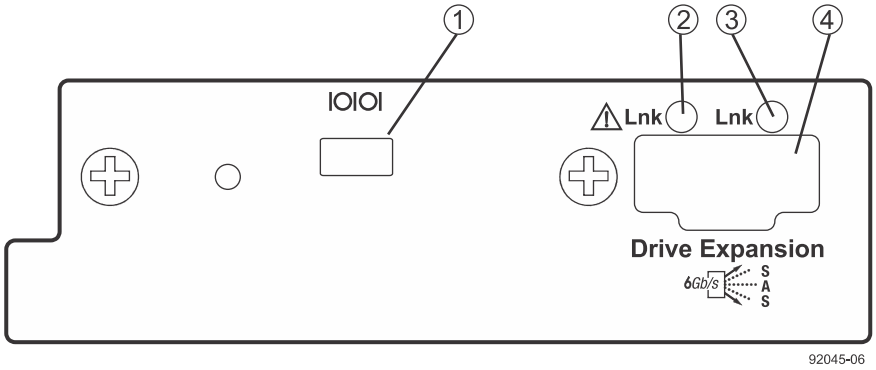


1.	Controller A canister	13.	Base host Fibre Channel SFP+ connectors
2.	Seven-segment display	14.	Expansion SFF-8088 port connector
3.	HIC connector 1	15.	SAS expansion Fault LED
4.	HIC connector 2	16.	SAS expansion Active LED
5.	USB connector	17.	Power-fan canister
6.	Ethernet connector 1	18.	Standby Power LED
7.	Ethernet Link Active LED	19.	Power-fan DC Power LED
8.	Ethernet Link Rate LED	20.	Power-Fan Service Action Allowed LED
9.	Ethernet connector 2	21.	Power-Fan Service Action Required LED
10.	Base host Fibre Channel SFP+ connectors	22.	Power-Fan AC Power LED
11.	Host Link 1 Fault LED	23.	AC power connector
12.	Host Link 1 Active LED		

Each controller in the controller-drive tray might have no host interface card or one of the following types of optional HICs:

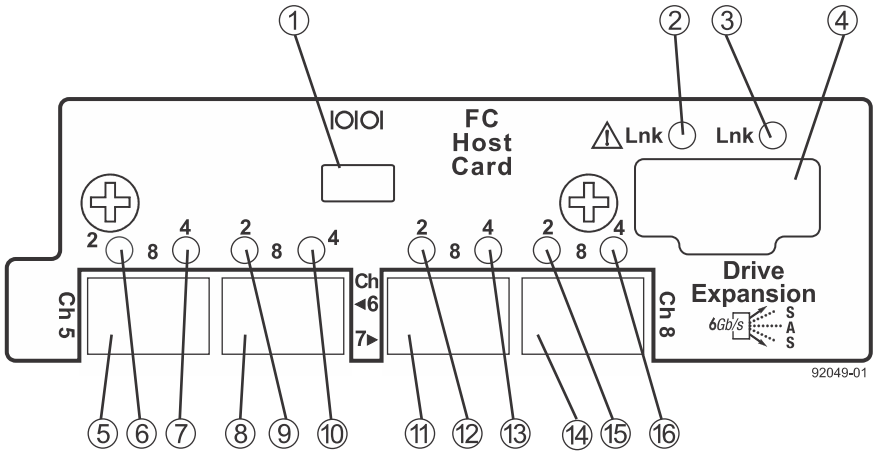
- Fibre Channel HIC with four 8-Gb/s Fibre Channel host ports
- InfiniBand HIC with two 40-Gb/s InfiniBand host ports
- SAS HIC with four 6-Gb/s mini-SAS-8088 connectors
- iSCSI HIC with two 10-Gb/s iSCSI host ports

Right, rear subplate with no HIC



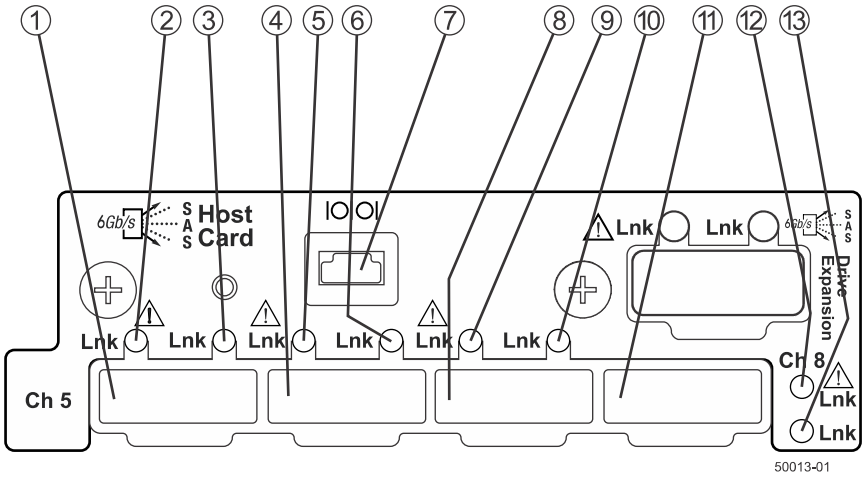
1.	Mini USB connector
2.	SAS expansion Fault LED
3.	SAS expansion Active LED
4.	SAS SFF-8088 port connector

Right, rear subplate with a Fibre Channel HIC



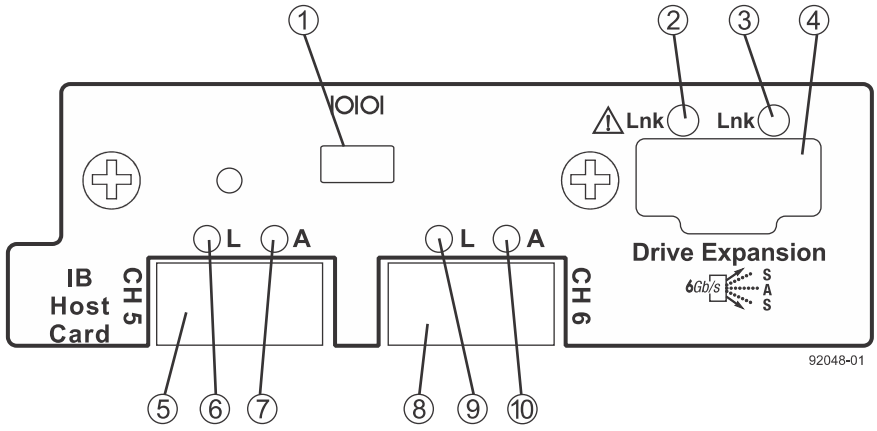
1.	Mini USB connector	9.	HIC Link 6 LED 0
2.	SAS expansion Fault LED	10.	HIC Link 6 LED 1
3.	SAS expansion Active LED	11.	FC HIC connector 7
4.	SAS expansion SFF-8088 port connector	12.	HIC Link 7 LED 0
5.	FC HIC connector 5	13.	HIC Link 7 LED 1
6.	HIC Link 5 LED 0	14.	FC HIC connector 8
7.	HIC Link 5 LED 1	15.	HIC Link 8 LED 0
8.	FC HIC connector 6	16.	HIC Link 8 LED 1

Right, rear subplate with a SAS HIC



1.	SAS expansion SFF-8088 port connector 1	8.	SAS Host SFF-8088 port connector 3
2.	SAS Host Interface Port 1 Fault LED	9.	SAS Host Interface Port 3 Fault LED
3.	SAS Host Interface Port 1 Link Up LED	10.	SAS Host Interface Port 3 Link Up LED
4.	SAS Host SFF-8088 port connector 2	11.	SAS Host SFF-8088 port connector 4
5.	SAS Host Interface Port 2 Fault LED	12.	SAS Host Interface Port 4 Fault LED
6.	SAS Host Interface Port 2 Link Up LED	13.	SAS Host Interface Port 4 Link Up LED
7.	Mini USB connector		

Right, rear subplate with an InfiniBand HIC



1.	Mini USB connector	6.	IB HIC Physical Link 1 LED (Green)
2.	SAS expansion Fault LED	7.	IB HIC Logical Link 1 LED (Amber)

3.	SAS expansion Link Up LED	8.	IB HIC connector 2
4.	SAS expansion SFF-8088 port connector	9.	IB HIC Physical Link 2 LED (Green)
5.	IB HIC connector 1	10.	IB HIC Logical Link 2 LED (Amber)

Component locations on the E2800 controller shelves

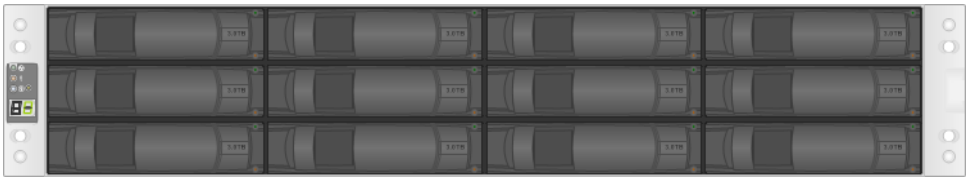
The E2812 controller shelf has twelve 3.5 in. drive bays. The E2824 controller shelf has twenty-four 2.5 in. drive bays. With either drive configuration, the controller shelf is available in two controller configurations: simplex (single controller) and duplex (two controllers).

The E2860 controller shelf has five drawers. Each drawer has twelve 3.5 in. drive bays. The E2860 is available only in the duplex configuration.

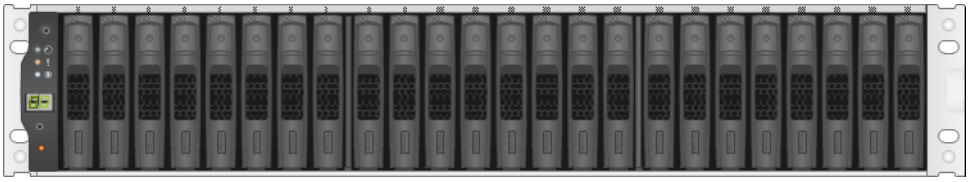
Keep these points in mind when you compare the figures in this section to your hardware:

- The top of the controller shelf is the side with the labels.
- The configuration of the host ports depends on which host interface card is installed.

E2812 controller shelf - front view (front bezel removed)



E2824 controller shelf - front view (front bezel removed)

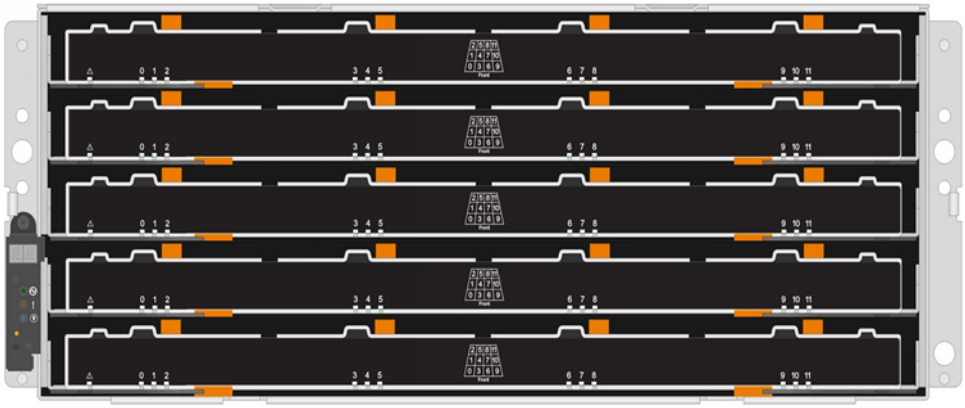


E2812 or E2824 controller shelf front bezel, showing LEDs on the operator display panel

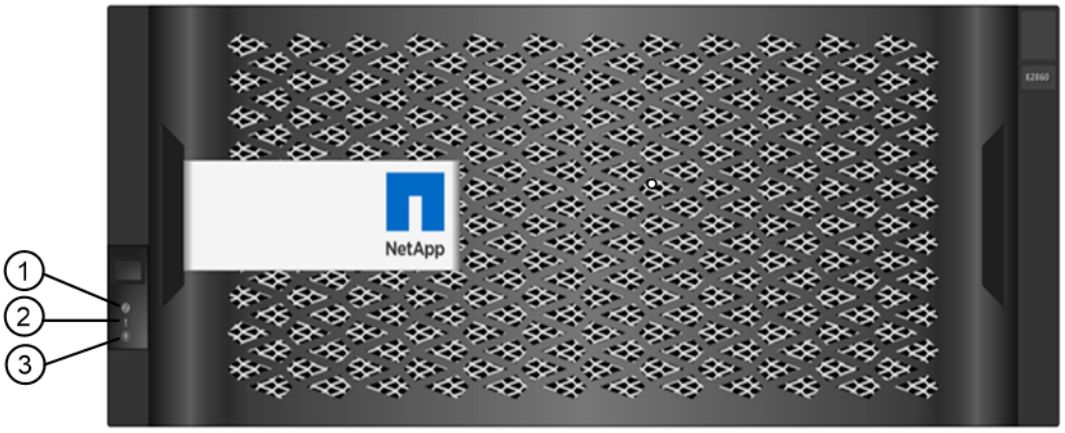


1.	Power
2.	Attention
3.	Locate

E2860 controller shelf - front view (front bezel removed)

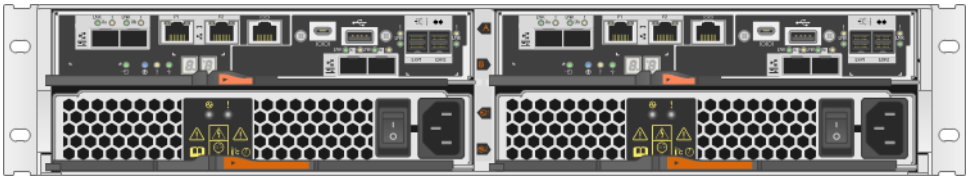


E2860 controller shelf front bezel

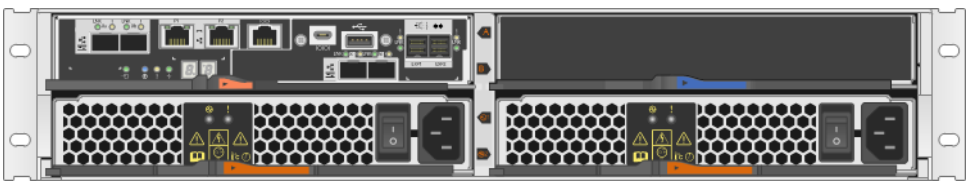


1.	Power
2.	Attention
3.	Locate

E2812 or E2824 controller shelf – duplex configuration (rear view)



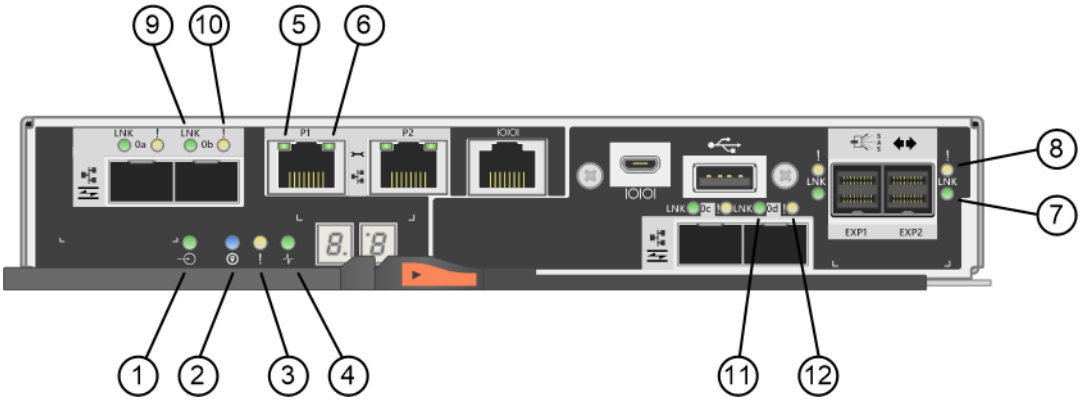
E2812 or E2824 controller shelf – simplex configuration (rear view)



E2860 controller shelf (rear view)

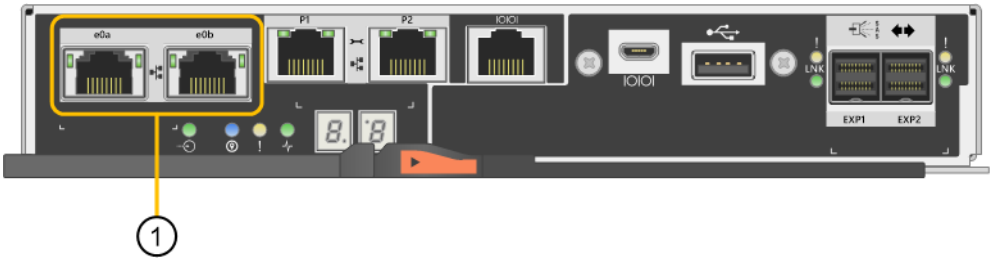


E2800 controller LEDs



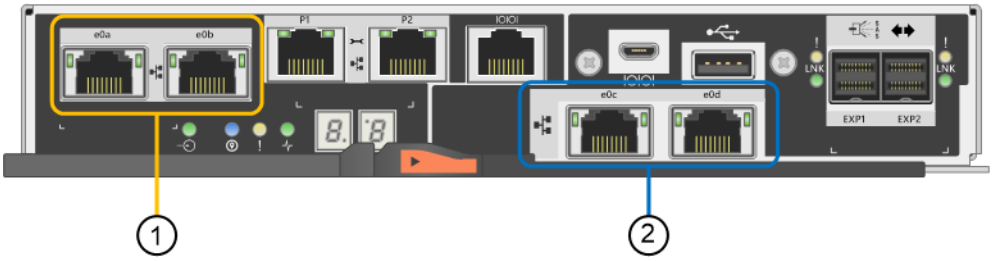
1.	Cache Active
2.	Locate
3.	Attention
4.	Activity
5.	Ethernet Activity
6.	Ethernet Link Speed
7.	Expansion Port Link Status (SAS expansion port)
8.	Expansion Port Attention (SAS expansion port)
9.	Host Port Link Status (baseboard host port)
10.	Host Port Attention (baseboard host port)
11.	Host Port Link Status (HIC host port)
12.	Host Port Attention (HIC host port)

E2800 controller with RJ-45 baseboard ports and no host interface card



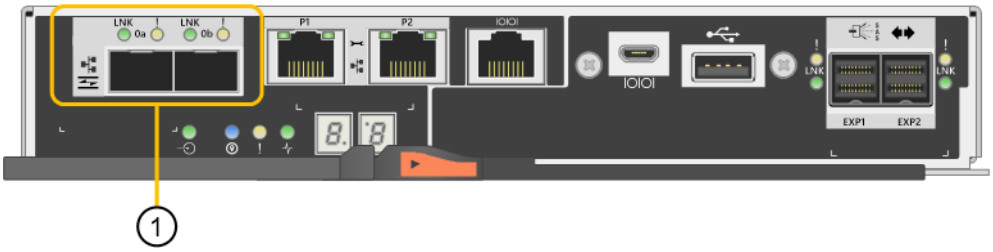
1.	Two baseboard host ports – 10 Gb/s iSCSI

E2800 controller with RJ-45 baseboard ports and a dual-port RJ-45 host interface card



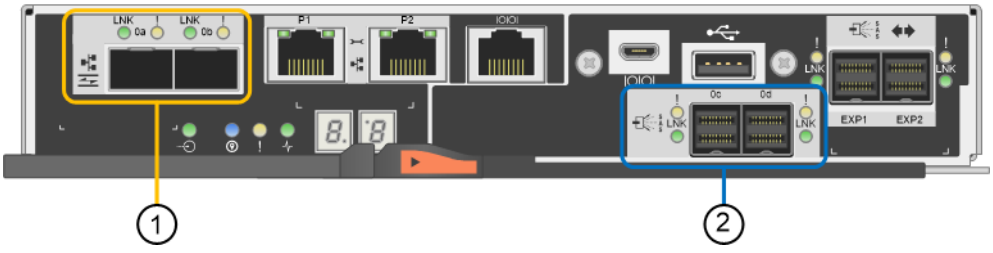
1.	Two baseboard host ports –10 Gb/s iSCSI
2.	Two HIC ports –10 Gb/s iSCSI

E2800 controller with SFP baseboard ports and no host interface card



1.	Two baseboard host ports –16 Gb/s FC or 10 Gb/s iSCSI

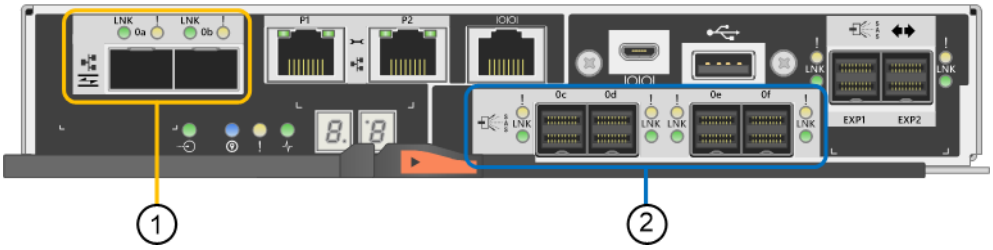
E2800 controller with SFP baseboard ports and a dual-port SAS host interface card



1.	Two baseboard host ports –16 Gb/s FC or 10 Gb/s iSCSI

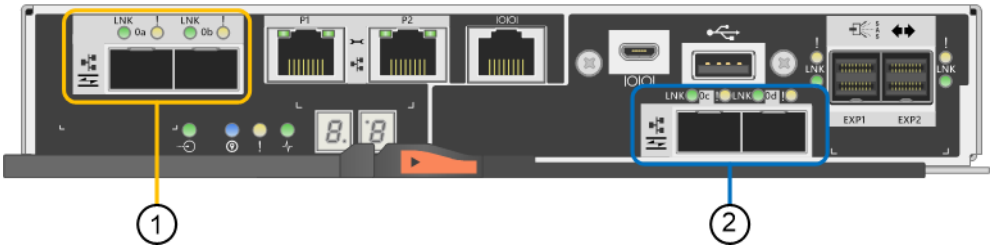
2.	Two HIC ports – 12 Gb/s SAS

E2800 controller with SFP baseboard ports and a quad-port SAS host interface card



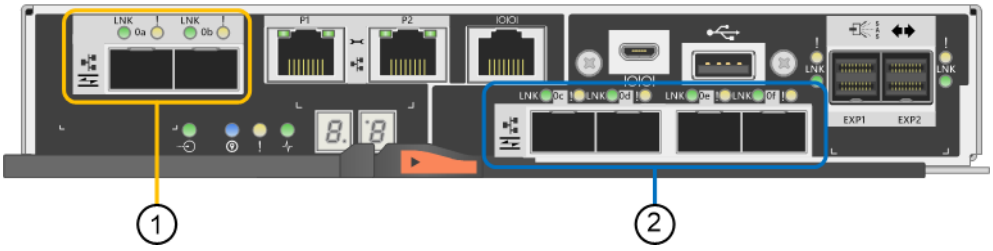
1.	Two baseboard host ports –16 Gb/s FC or 10 Gb/s iSCSI
2.	Four HIC ports –12 Gb/s SAS

E2800 controller with SFP baseboard ports and a dual-port SFP (FC or iSCSI) host interface card



1.	Two baseboard host ports –16 Gb/s FC or 10 Gb/s iSCSI
2.	Two HIC ports –16 Gb/s FC or 10 Gb/s iSCSI

E2800 controller with SFP baseboard ports and a quad-port SFP (FC or iSCSI) host interface card



1.	Two baseboard host ports –16 Gb/s FC or 10 Gb/s iSCSI
2.	Four HIC ports –16 Gb/s FC or 10 Gb/s iSCSI

Component locations on the E2700 controller-drive trays

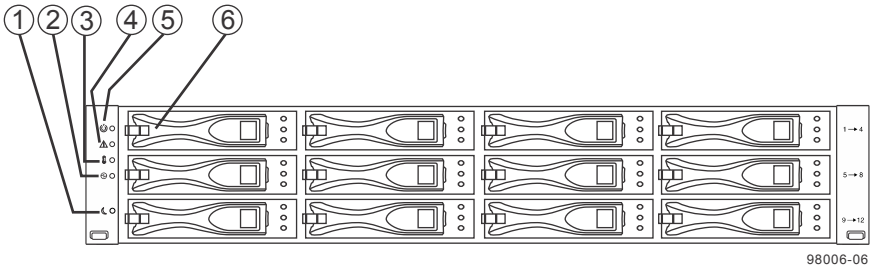
The E2712 controller-drive tray has twelve 3.5-in. drive bays. The E2724 controller-drive tray has twenty-four 2.5-in. drive bays. With either drive configuration, the controller-drive tray is available in

two different controller configurations: simplex (one controller) and duplex (two controllers). The E2760 controller-drive tray is available only in the duplex configuration.

Keep these points in mind when you compare the figures in this section to your hardware:

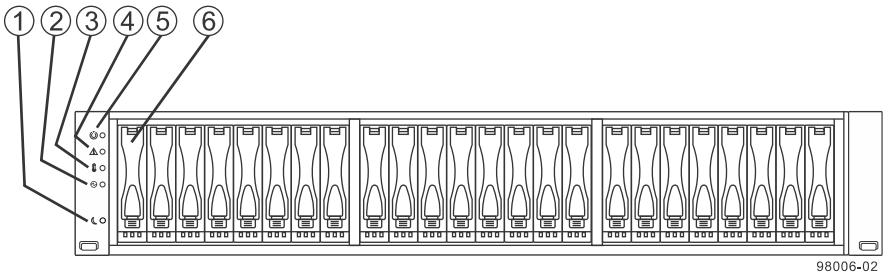
- The top of the controller-drive tray is the side with the labels.
- The configuration of the host ports depends on which host interface card configuration is installed.
- The figures in this section show the AC power option.

E2712 controller-drive tray - front view



1.	Standby Power LED
2.	Power LED
3.	Over-Temperature LED
4.	Service Action Required LED
5.	Locate LED
6.	Drive Canister

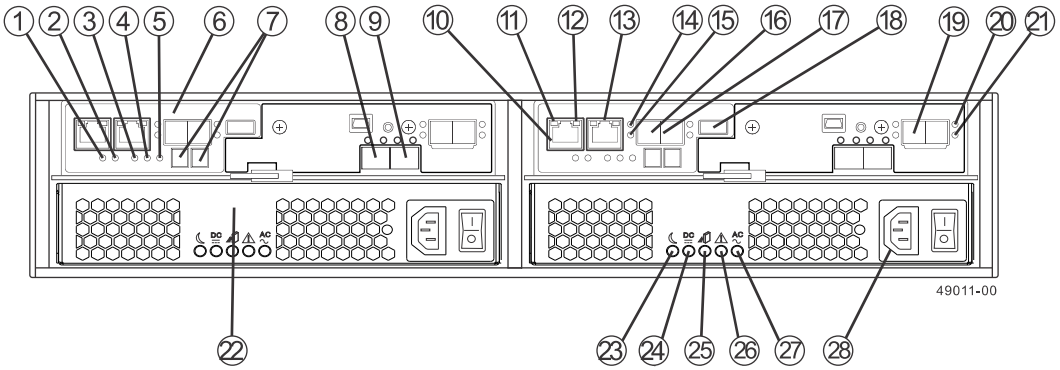
E2724 controller-drive tray - front view



1.	Standby Power LED
2.	Power LED
3.	Over-Temperature LED
4.	Service Action Required LED

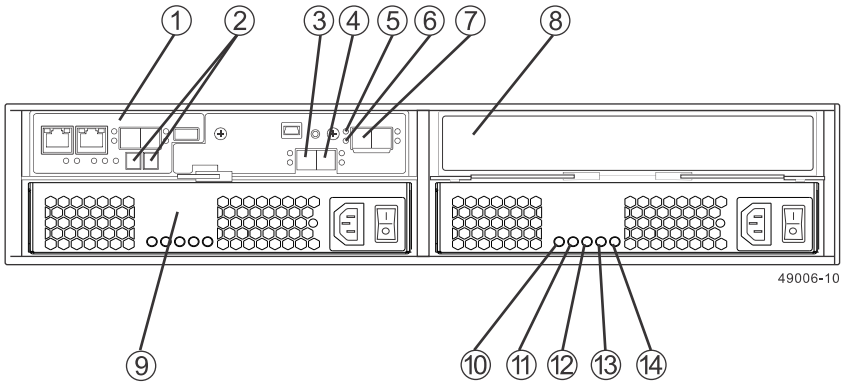
5.	Locate LED
6.	Drive Canister

E2712 controller-drive tray or E2724 controller-drive tray duplex configuration - rear view



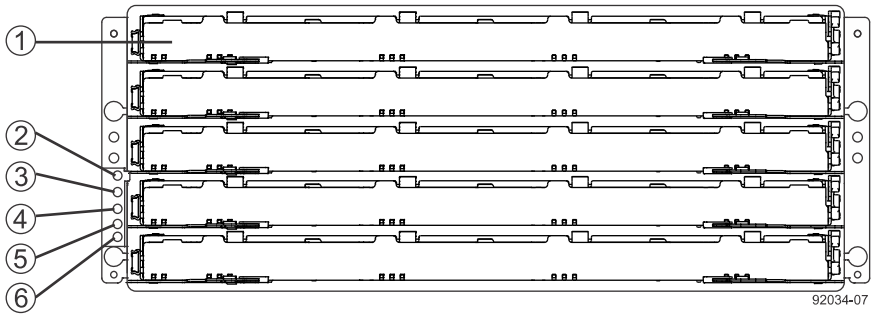
1.	Battery Charging LED	15.	Host Link 1 Active LED
2.	Battery Service Action Required LED	16.	Base Host SFF-8644 Connector 1
3.	Controller A Service Action Allowed LED	17.	Base Host SFF-8644 Connector 2
4.	Controller A Service Action Required LED	18.	USB Connector
5.	Cache Active LED	19.	Expansion SFF-8644 Port Connector
6.	Controller A Canister	20.	Expansion Fault LED
7.	Seven-Segment Display	21.	Expansion Active LED
8.	Host Interface Card Connector 1	22.	Power-Fan Canister
9.	Host Interface Card Connector 2	23.	Standby Power LED
10.	Ethernet Connector 1	24.	Power-Fan DC Power LED
11.	Ethernet Link Active LED	25.	Power-Fan Service Action Allowed LED
12.	Ethernet Link Rate LED	26.	Power-Fan Service Action Required LED
13.	Ethernet Connector 2	27.	Power-Fan AC Power LED
14.	Host Link 1 Fault LED	28.	AC Power Connector

E2712 controller-drive tray or E2724 controller-drive tray simplex configuration - rear view



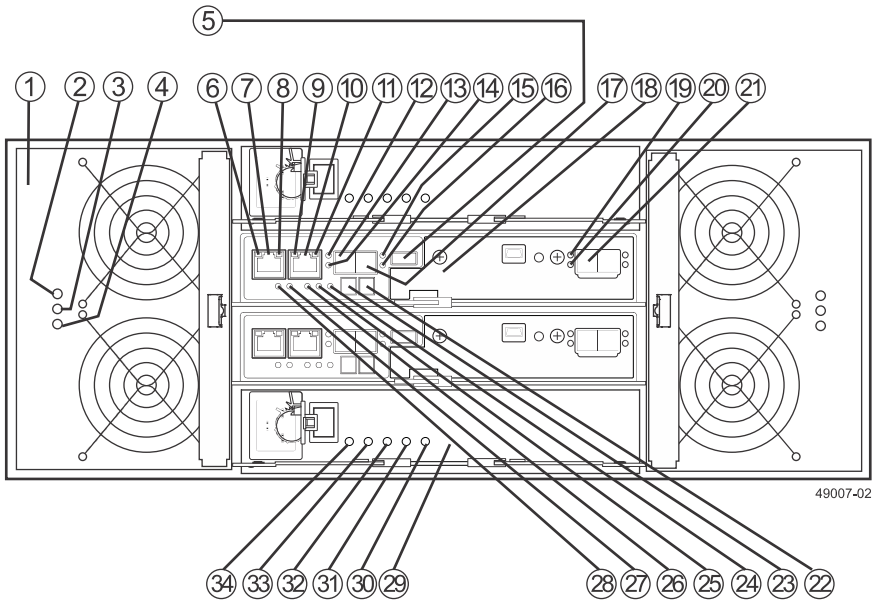
1.	Controller A Canister	8.	Unused Controller B Slot
2.	Seven-Segment Display	9.	Power-Fan A Canister
3.	Host Interface Card Connector 1	10.	Standby Power LED
4.	Host Interface Card Connector 2	11.	Power-Fan DC Power LED
5.	Expansion Fault LED	12.	Power-Fan Service Action Allowed LED
6.	Expansion Active LED	13.	Power-Fan Service Action Required LED
7.	Expansion Port SFF-8644 Connector	14.	Power-Fan AC Power LED

E2760 controller-drive tray - front view



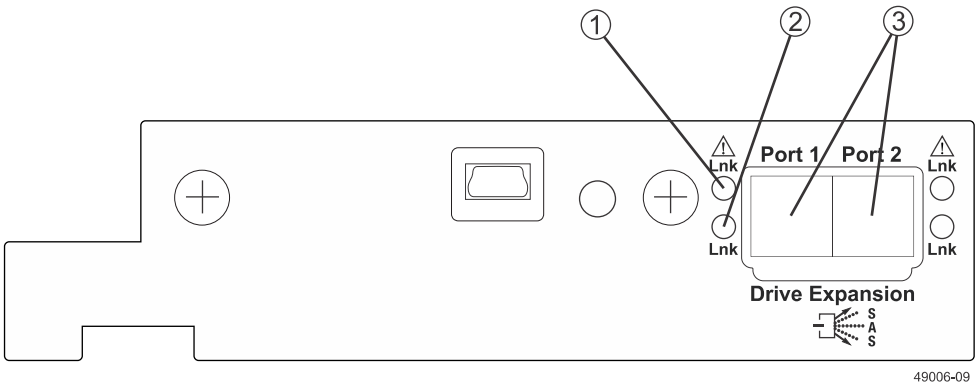
1.	Drive Drawer
2.	Standby Power LED
3.	Power LED
4.	Over-Temperature LED
5.	Service Action Required LED
6.	Locate LED

E2760 controller-drive tray duplex configuration - rear view



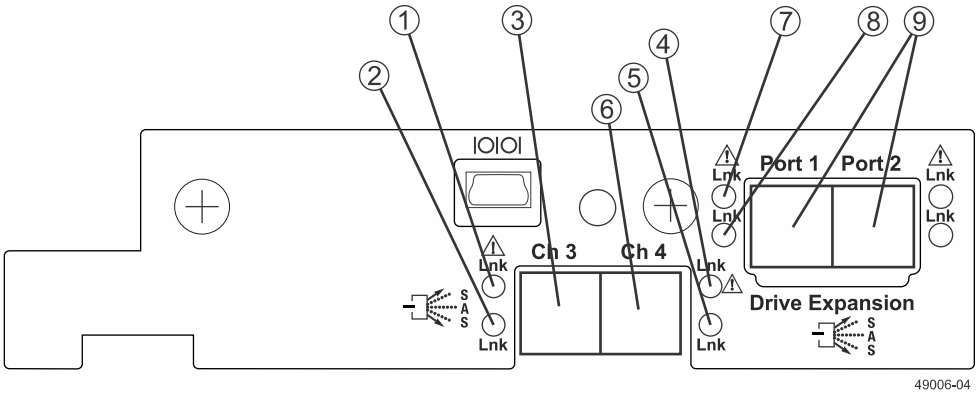
1.	Fan Canister	19.	Expansion Fault LED
2.	Fan Power LED	20.	Expansion Active LED
3.	Fan Service Action Required LED	21.	Expansion SFF-8644 Port Connector
4.	Fan Service Action Allowed LED	22.	Second Seven-Segment Display Field
5.	USB Connector	23.	First Seven-Segment Display Field
6.	Ethernet Link 1 Active LED	24.	Cache Active LED
7.	Ethernet Connector 1	25.	Controller A Service Action Required LED
8.	Ethernet Link 1 Rate LED	26.	Controller A Service Action Allowed LED
9.	Ethernet Link 2 Active LED	27.	Battery Service Action Required LED
10.	Ethernet Connector 2	28.	Battery Charging LED
11.	Ethernet Link 2 Rate LED	29.	Power Canister
12.	Host Link 1 Fault LED	30.	Power Canister AC Power LED
13.	Base Host SFF-8644 Connector 1	31.	Power Canister Service Required Allowed LED
14.	Host Link 1 Active LED	32.	Power Canister Service Action Allowed LED
15.	Host Link 2 Fault LED	33.	Power Canister DC Power LED
16.	Host Link 2 Active LED	34.	Power Canister Standby Power LED
17.	Base Host SFF-8644 Connector 2		
18.	Controller A Cannister		

E2700 right, rear subplate with no host interface card



1.	Expansion Fault LED
2.	Expansion Active LED
3.	Expansion SFF-8644 Port Connector

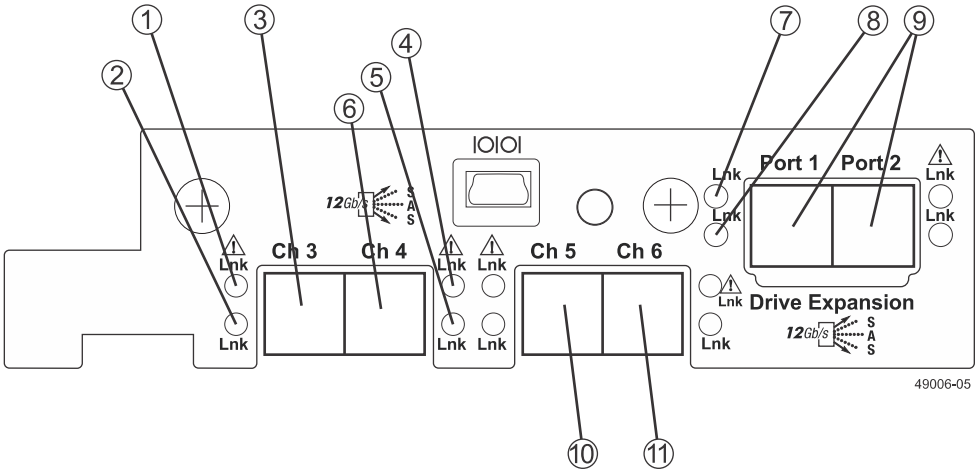
E2700 right, rear subplate with a dual port SAS host interface card



1.	Host Interface Link 3 Fault LED	6.	SFF-8644 Host Interface Connector 4
2.	Host Interface Link 3 Active LED	7.	Expansion Fault LED
3.	SFF-8644 Host Interface Connector 3	8.	Expansion Active LED
4.	Host Interface Link 4 Fault LED	9.	Expansion SFF-8644 Port Connector

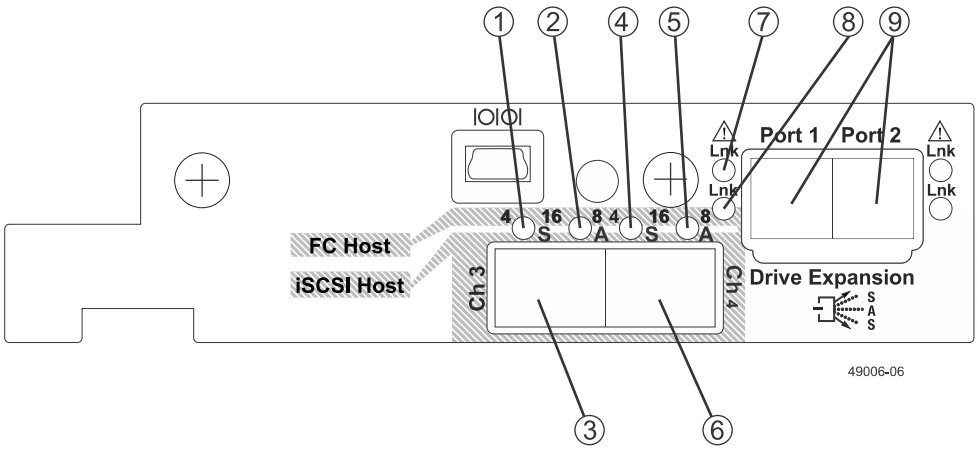
5.	Host Interface Card Link 4 Active LED		

E2700 right, rear subplate with a quad port SAS host interface card



1.	Host Interface Link 3 Fault LED	6.	SFF-8644 Host Interface Connector 4
2.	Host Interface Link 3 Active LED	7.	Expansion Fault LED
3.	SFF-8644 Host Interface Connector 3	8.	Expansion Active LED
4.	Host Interface Link 4 Fault LED	9.	Expansion SFF-8644 Port Connector
5.	Host Interface Card Link 4 Active LED		

E2700 right, rear subplate with a dual port FC or iSCSI host interface card

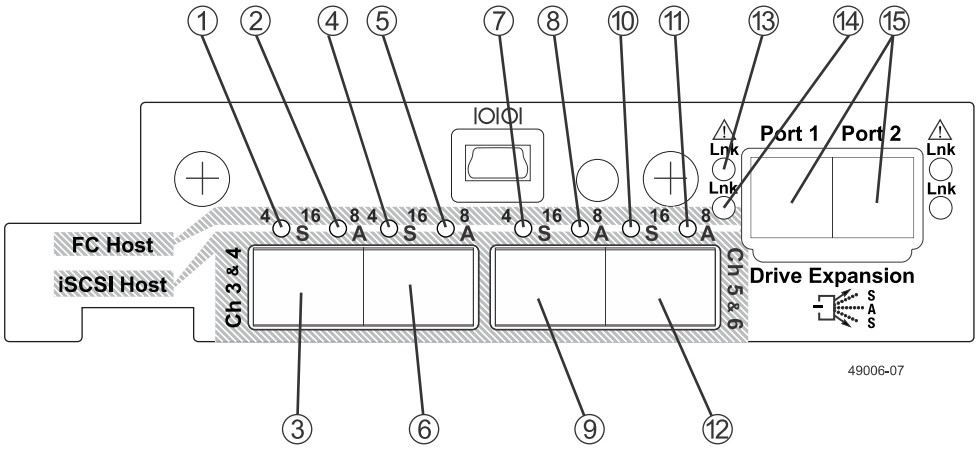


1.	Host Interface Link 3 Up LED	6.	FC Host Interface Connector 4
2.	Host Interface Link 3 Active LED	7.	Expansion Fault LED
3.	FC Host Interface Connector 3	8.	Expansion Active LED
4.	Host Interface Link 4 Up LED	9.	Expansion SFF-8644 Port Connector
5.	Host Interface Card Link 4 Active LED		

For each pair of LEDs associated with a host connector (1 and 2, 4 and 5), the following table shows what different lighting patterns indicate.

	Left (green) on Right (yellow) on	**Left (green) off Right (yellow) on**	**Left (green) on Right (yellow) off**	**Left (green) off Right (yellow) off**
FC	link down	link up, 8Gb/s	link up, 4Gb/s	link up, 16Gb/s
iSCSI	1. (green) speed 2. (yellow) activity	1. (green) speed 2. (yellow) activity	1. (green) speed 2. (yellow) activity	1. (green) speed 2. (yellow) activity

E2700 right, rear subplate with a quad port FC or iSCSI host interface card

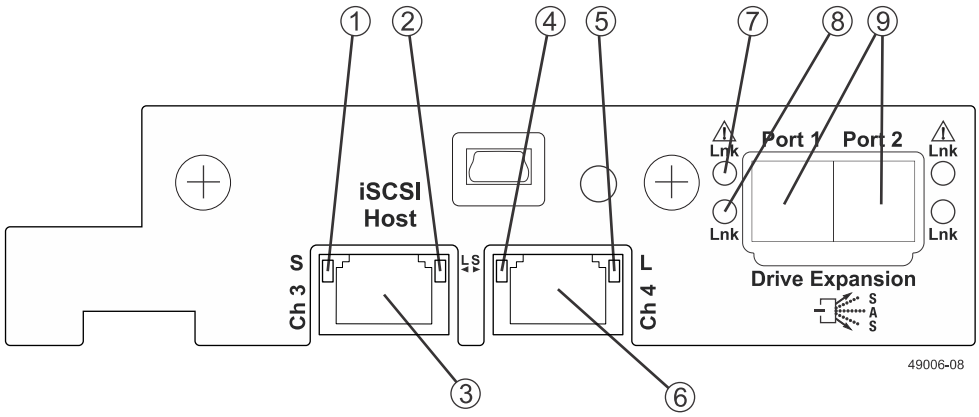


1.	Host Interface Link 3 Up LED	9.	FC Host Interface Connector 5
2.	Host Interface Link 3 Active LED	10.	Host Interface Card Link 6 Up LED
3.	FC Host Interface Connector 3	11.	Host Interface Card Link 6 Active LED
4.	Host Interface Link 4 Up LED	12.	FC Host Interface Card Connector 6
5.	Host Interface Link 4 Active LED	13.	Expansion Fault LED
6.	FC Host Interface Connector 4	14.	Expansion Active LED
7.	Host Interface Link 5 Up LED	15.	Expansion SFF-8644 Port Connector
8.	Host Interface Link 5 Active LED		

For each pair of LEDs associated with a host connector (1 and 2, 4 and 5, 7 and 8, 10 and 11), the following table shows what different lighting patterns indicate.

	Left (green) on Right (yellow) on	**Left (green) off Right (yellow) on**	**Left (green) on Right (yellow) off**	**Left (green) off Right (yellow) off**
FC	link down	link up, 8Gb/s	link up, 4Gb/s	link up, 16Gb/s
iSCSI	1. (green) speed 2. (yellow) activity	1. (green) speed 2. (yellow) activity	1. (green) speed 2. (yellow) activity	1. (green) speed 2. (yellow) activity

E2700 right, rear subplate with a 1-Gb/s iSCSI host interface card



1.	Host Interface Link 3 Up LED	6.	iSCSI Host Interface Connector 4
2.	Host Interface Link 3 Active LED	7.	Expansion Fault LED
3.	iSCSI Host Interface Connector 3	8.	Expansion Active LED
4.	Host Interface Link 4 Up LED	9.	Expansion SFF-8644 Port Connector
5.	Host Interface Card Link 4 Active LED		

Component locations on the E2600 controller-drive trays

The E2600 controller-drive tray is available in two different drive configurations: one with twelve 3.5-in. drive bays and another twenty-four 2.5-in. drive bays. With either drive configuration, the controller-drive tray is available in two different controller configurations: simplex and duplex.

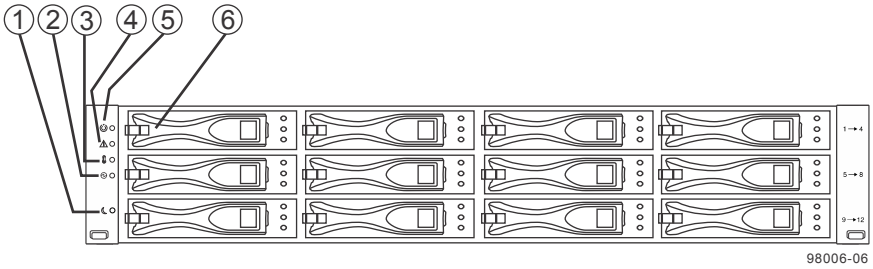
Keep these points in mind when you compare the figures in this section to your hardware.

- The top of the controller-drive tray is the side with the labels.
- The configuration of the host ports depends on which host interface card configuration is installed.
- The figures in this section show the AC power option.

Note: On the E2600 controller-drive trays, each controller has a pair of levers with handles for removing the controller from the controller-drive tray. If a controller has a HIC installed, one of these handles on the controller is located next to a host port on the HIC. The close spacing between

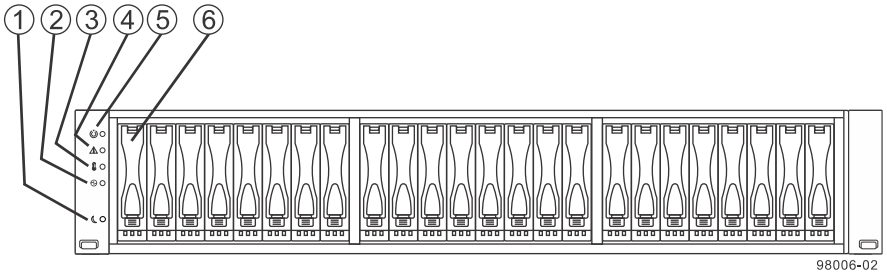
the handle and the host port might make it difficult to remove a cable that is attached to the host port. If this problem occurs, use a flat-blade screwdriver to compress the release on the cable connector.

E2600 controller-drive tray with 12 drives - front view



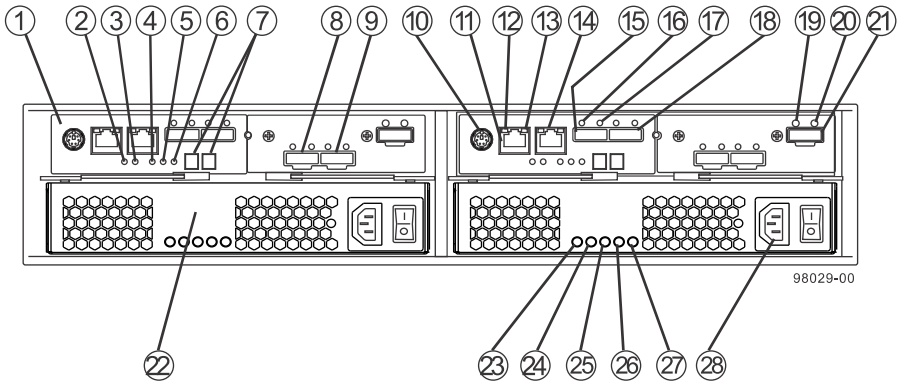
1.	Standby Power LED
2.	Power LED
3.	Over-Temperature LED
4.	Service Action Required LED
5.	Locate LED
6.	Drive Canister

E2600 controller-drive tray with 24 drives - front view



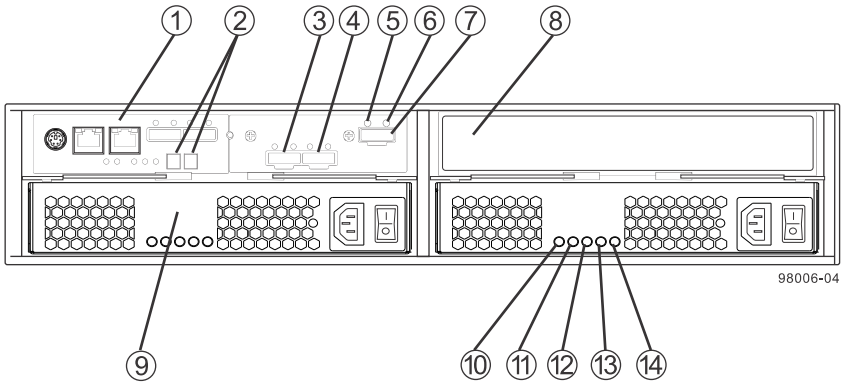
1.	Standby Power LED
2.	Power LED
3.	Over-Temperature LED
4.	Service Action Required LED
5.	Locate LED
6.	Drive Canister

E2600 controller-drive tray duplex configuration - rear view



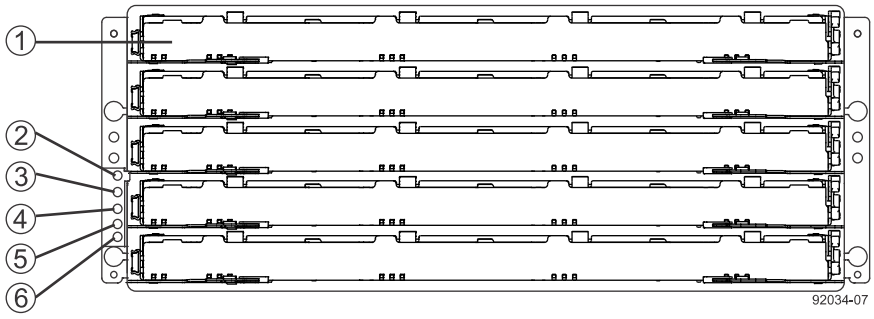
1.	Controller A	15.	Host SFF-8088 Connector 1
2.	Battery Charging LED	16.	Host Link 1 Fault LED
3.	Battery Service Action Required LED	17.	Host Link 1 Active LED
4.	Controller A Service Action Allowed LED	18.	Base Host SFF-8088 Connector 2
5.	Controller A Service Action Required LED	19.	Expansion Fault LED
6.	Cache Active LED	20.	Expansion Active LED
7.	Seven-Segment Display	21.	Expansion SFF-8088 Port Connector
8.	Host Interface Card Connector 1	22.	Power-Fan Canister
9.	Host Interface Card Connector 2	23.	Standby Power LED
10.	Serial Connector	24.	DC Power LED
11.	Ethernet Connector 1	25.	Power-Fan Service Action Allowed LED
12.	Ethernet Link Active LED	26.	Power-Fan Service Action Required LED
13.	Ethernet Link Rate LED	27.	AC Power LED
14.	Ethernet Connector 2	28.	AC Power Connector

E2600 controller-drive tray simplex configuration - rear view



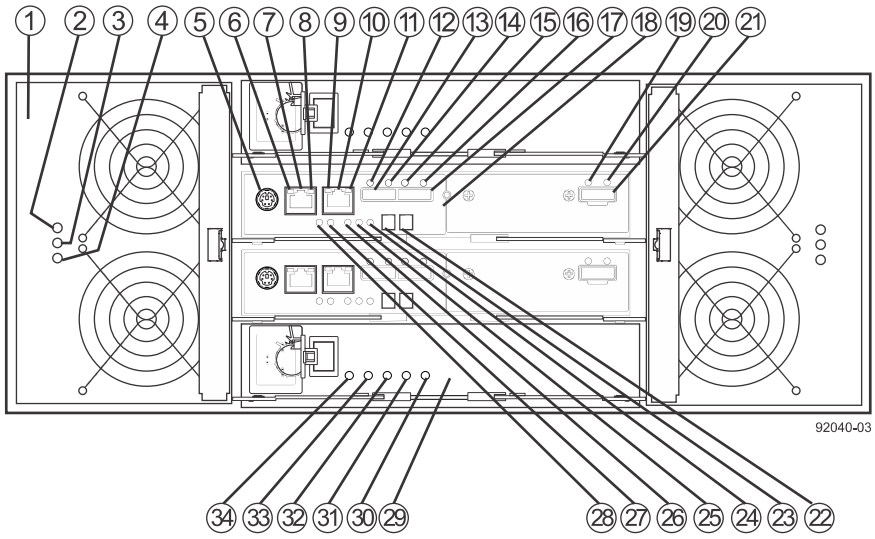
1.	Controller A Canister	8.	Unused Controller B Slot
2.	Seven-Segment Display	9.	Power-Fan A Canister
3.	Host Interface Card Connector 1	10.	Standby Power LED
4.	Host Interface Card Connector 2	11.	Power-Fan DC Power LED
5.	Expansion Fault LED	12.	Power-Fan Service Action Allowed LED
6.	Expansion Active LED	13.	Power-Fan Service Action Required LED
7.	Expansion Port SFF-8088 Connector	14.	Power-Fan AC Power LED

E2660 controller drive tray front view



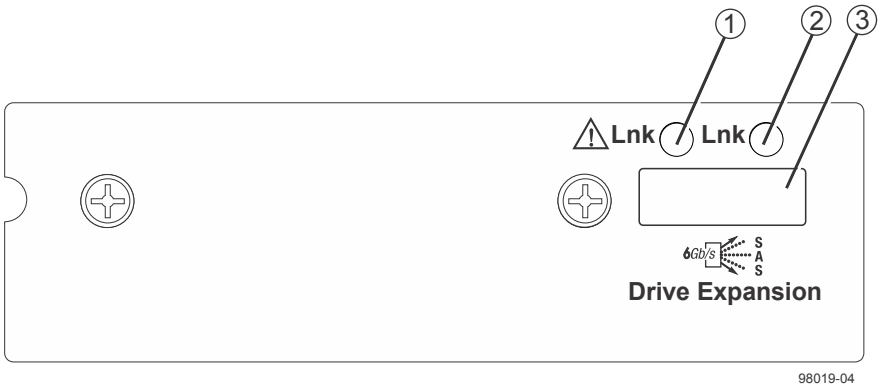
1.	Drive Drawer
2.	Standby Power LED
3.	Power LED
4.	Over-Temperature LED
5.	Service Action Required LED
6.	Locate LED

E2660 controller drive tray - rear view



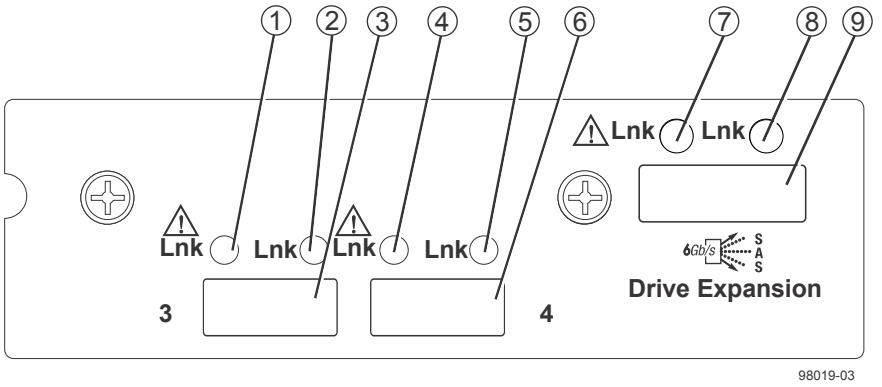
1.	Fan Canister	18.	Controller A Canister
2.	Fan Power LED	19.	Expansion Fault LED
3.	Fan Service Action Required LED	20.	Expansion Active LED
4.	Fan Service Action Allowed LED	21.	Expansion SFF-8088 Port Connector
5.	Serial Connector	22.	Second Seven-Segment Display
6.	Ethernet Link 1 Active LED	23.	First Seven-Segment Display
7.	Ethernet Connector 1	24.	Cache Active LED
8.	Ethernet Link 1 Rate LED	25.	Controller A Service Action Required LED
9.	Ethernet Link 2 Active LED	26.	Controller A Service Action Allowed LED
10.	Ethernet Connector 2	27.	Battery Service Action Required LED
11.	Ethernet Link 2 Rate LED	28.	Battery Charging LED
12.	Host Link 1 Fault LED	29.	Power Canister
13.	Base Host SFF-8088 Connector 1	30.	Power AC Power LED
14.	Host Link 1 Active LED	31.	Power Service Action Required LED
15.	Host Link 2 Fault LED	32.	Power Service Action Allowed LED
16.	Host Link 2 Active LED	33.	Power DC Power LED
17.	Base Host SFF-8088 Connector 2	34.	Power Standby Power LED

E2600 right, rear subplate with no host interface card



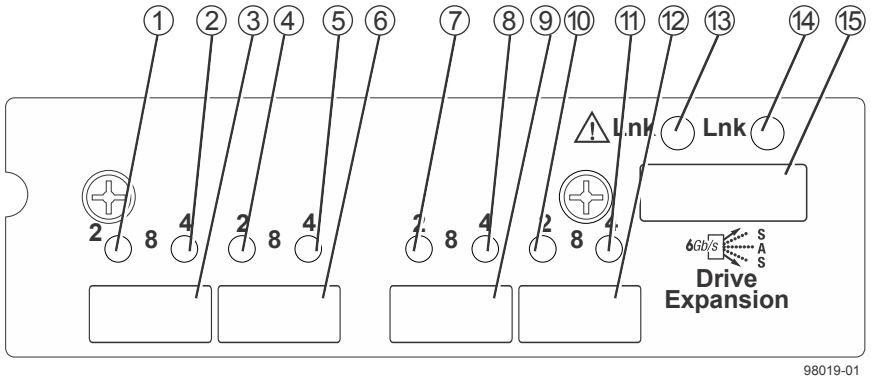
1.	Expansion Fault LED
2.	Expansion Active LED
3.	Expansion SFF-8088 Port Connector

E2600 right, rear subplate with a SAS host interface card



1.	Host Interface Link 3 Fault LED	6.	SFF-8088 Host Interface Connector 4
2.	Host Interface Link 3 Active LED	7.	Expansion Fault LED
3.	SFF-8088 Host Interface Connector 3	8.	Expansion Active LED
4.	Host Interface Link 4 Fault LED	9.	Expansion SFF-8088 Port Connector
5.	Host Interface Card Link 4 Active LED		

E2600 right, rear subplate with an FC host interface card

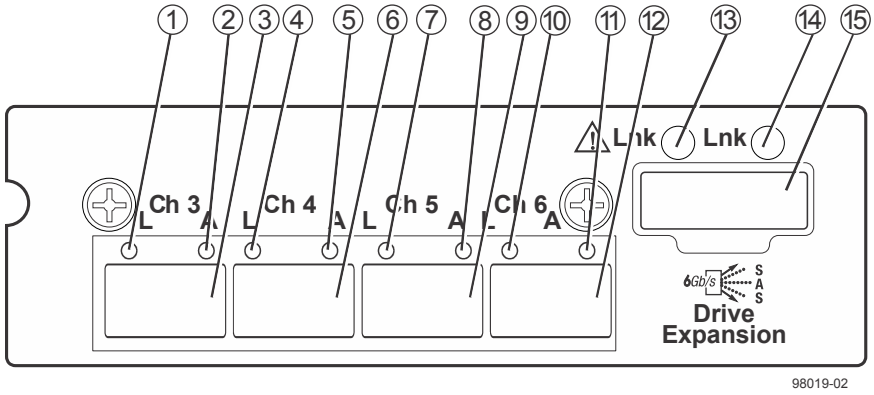


1.	Host Interface Link 3 Up LED	9.	FC Host Interface Connector 5
2.	Host Interface Link 3 Active LED	10.	Host Interface Card Link 6 Up LED
3.	FC Host Interface Connector 3	11.	Host Interface Card Link 6 Active LED
4.	Host Interface Link 4 Up LED	12.	FC Host Interface Card Connector 6
5.	Host Interface Link 4 Active LED	13.	Expansion Fault LED
6.	FC Host Interface Connector 4	14.	Expansion Active LED
7.	Host Interface Link 5 Up LED	15.	Expansion SFF-8088 Port Connector
8.	Host Interface Link 5 Active LED		

For each pair of LEDs associated with a host connector (1 and 2, 4 and 5, 7 and 8, 10 and 11), the following table gives the interpretations of the LEDs.

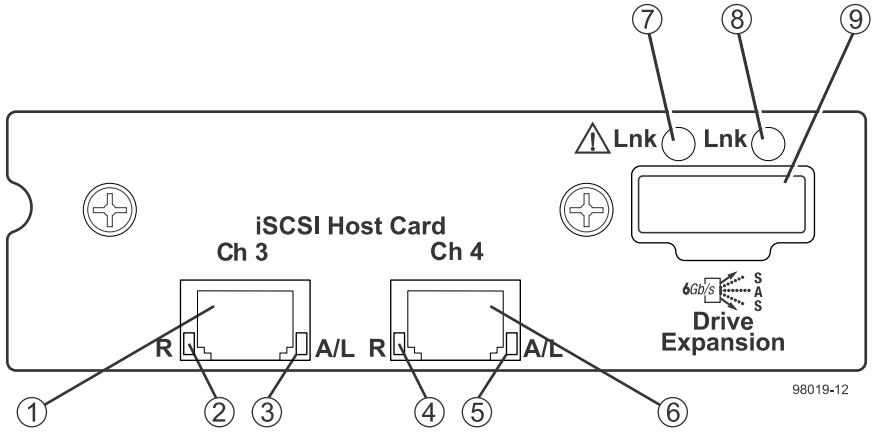
	Left (green) on Right (yellow) on	**Left (green) off Right (yellow) on**	**Left (green) on Right (yellow) off**	**Left (green) off Right (yellow) off**
FC	link down	link up, 8Gb/s	link up, 4Gb/s	link up, 16Gb/s

E2600 right, rear subplate with a 1-Gb/s iSCSI host interface card



1.	Host Interface Link 3 Up LED	9.	iSCSI Host Interface Connector 5
2.	Host Interface Link 3 Active LED	10.	Host Interface Card Link 6 Up LED
3.	iSCSI Host Interface Connector 3	11.	Host Interface Card Link 6 Active LED
4.	Host Interface Link 4 Up LED	12.	iSCSI Host Interface Card Connector 6
5.	Host Interface Link 4 Active LED	13.	Expansion Fault LED
6.	iSCSI Host Interface Connector 4	14.	Expansion Active LED
7.	Host Interface Link 5 Up LED	15.	Expansion SFF-8088 Port Connector
8.	Host Interface Link 5 Active LED		

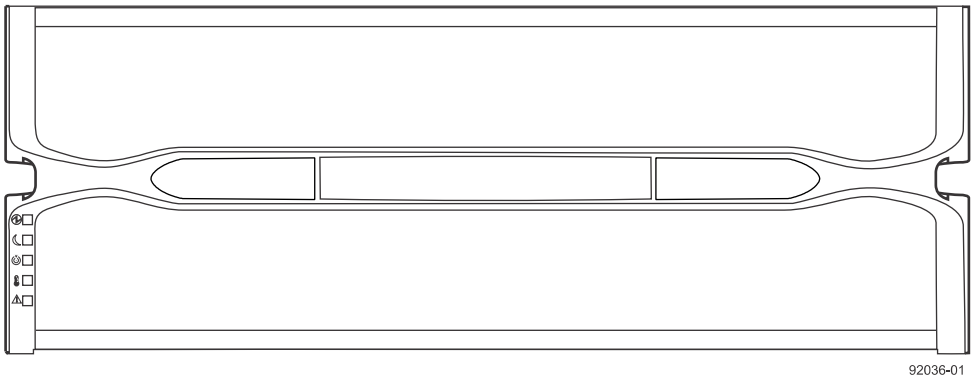
E2600 right, rear subplate with a 10-Gb/s iSCSI host interface card



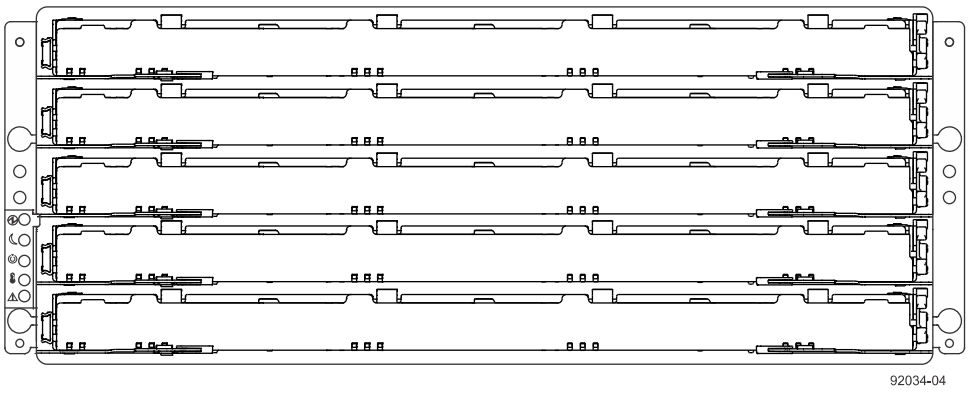
1.	iSCSI Host Interface Connector 3	6.	iSCSI Host Interface Connector 4
2.	Host Interface Link 3 Up LED	7.	Expansion Fault LED
3.	Host Interface Link 3 Active LED	8.	Expansion Active LED
4.	Host Interface Link 4 Up LED	9.	Expansion SFF-8088 Port Connector
5.	Host Interface Card Link 4 Active LED		

Component locations on the DE6600 drive shelf (drive tray)

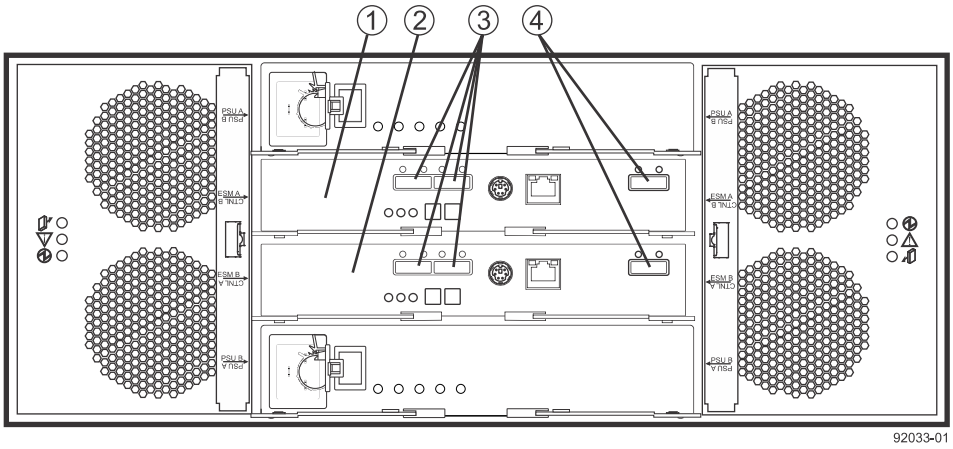
DE6600 drive shelf - front view with the bezel in place



DE6600 drive shelf - front view with the bezel in removed



DE6600 drive shelf - rear view

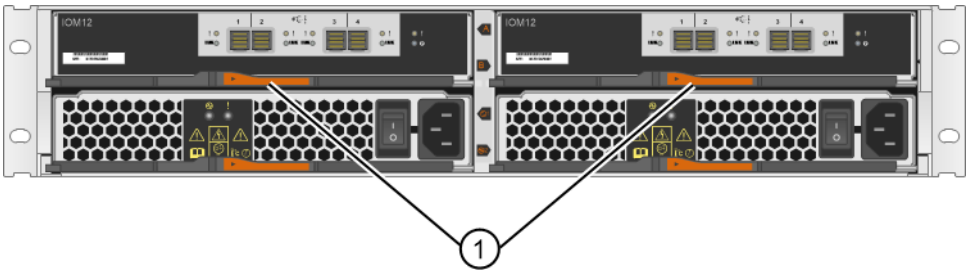


1	ESM A
2	ESM B
3	SAS In connectors
4	Expansion connectors

Component locations on the DE212C drive shelf and the DE224C drive shelf

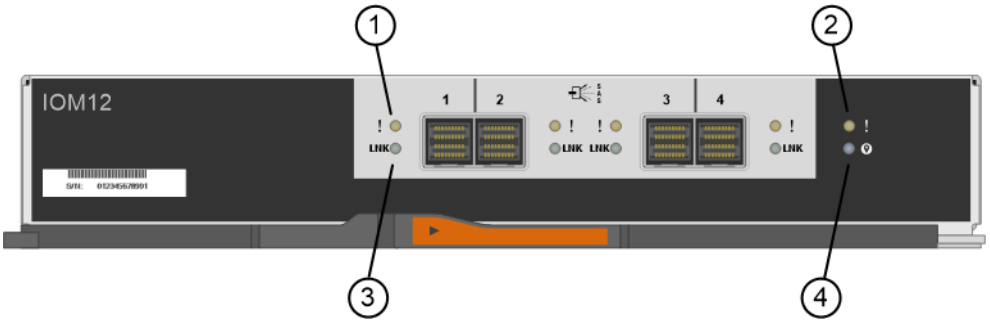
The DE212C drive shelf has twelve 3.5 in. drive bays. The DE224C drive shelf has twenty-four 2.5 in. drive bays. The component locations on the rear of these drive shelves are the same. The front view and the location of LEDs on the operator display panel are the same as for the E2800 controller shelves.

DE212C drive shelf or DE224C drive shelf - rear view



1.	I/O modules (IOMs)

DE212C or DE224C drive shelf - IOM LEDs

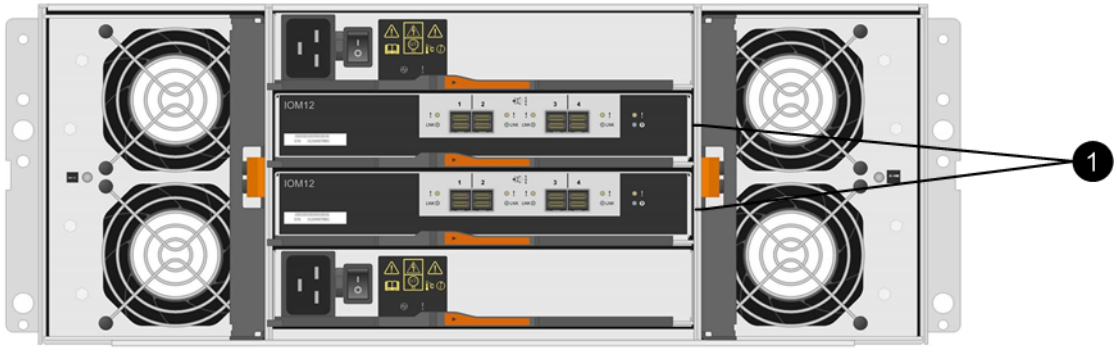


1.	SAS port Attention
2.	IOM Attention
3.	Locate
4.	SAS port Link Status

Component locations on the DE460C drive shelf

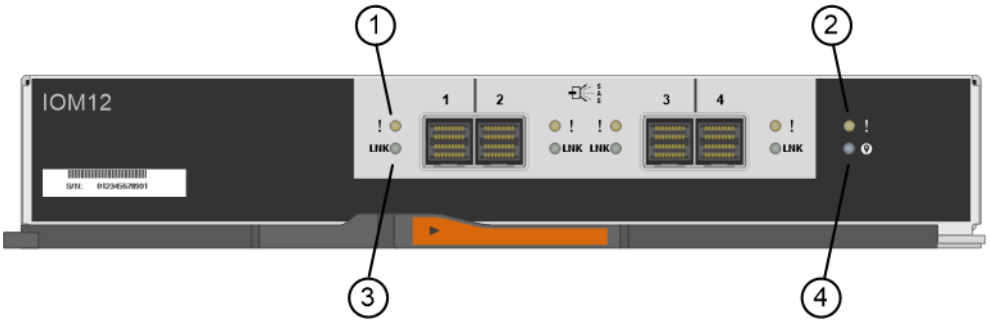
The DE460C drive shelf has five drawers. Each drawer has twelve 2.5 in. drive bays. The front view and the location of LEDs on the operator display panel are the same as for the E2860 controller shelves.

DE460C drive shelf - rear view



1.	I/O modules (IOMs)

DE460C drive shelf - IOM LEDs

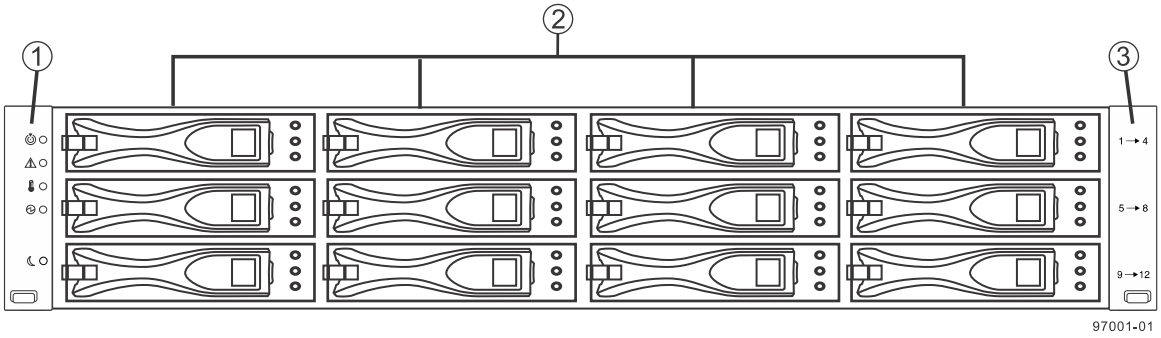


1.	SAS port Attention
2.	IOM Attention
3.	Locate
4.	SAS port Link Status

Component locations on the DE1600 drive shelf (drive tray) and the DE5600 drive shelf (drive tray)

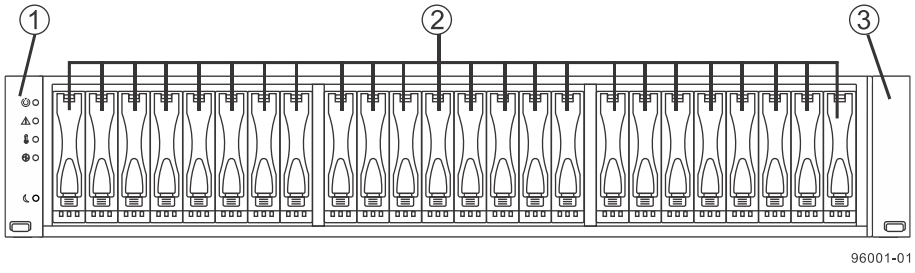
The DE1600 drive shelf has twelve 3.5 in. drive bays. The DE5600 drive shelf has twenty-four 2.5 in. drive bays. The component locations on the rear of these drive shelves are the same. The following figures show the AC power option.

DE1600 drive shelf - front view



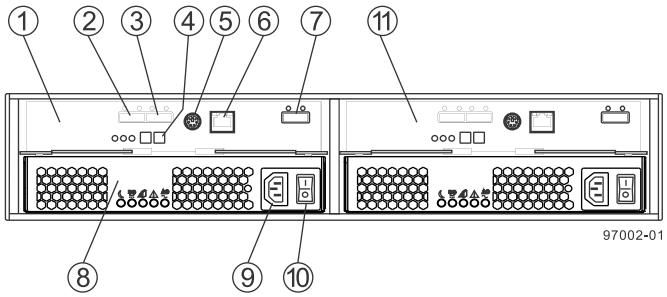
1.	Left end cap (Has the drive shelf LEDs)
2.	Drives
3.	Right end cap

DE5600 drive shelf - front view



1.	Left end cap (Has the drive shelf LEDs)
2.	Drives
3.	Right end cap

DE1600 drive shelf or DE5600 drive shelf - rear view



1.	ESM A canister	7.	Expansion port SFF-8088 connector
2.	SAS In connector 1	8.	Power-fan canister
3.	SAS In connector 2	9.	Power connector
4.	Seven-segment display indicators	10.	Power switch
5.	Serial connector	11.	ESM B canister
6.	Ethernet connector		

Host cabling

This chapter provides examples of cabling topologies between one or more hosts and a controller shelf or controller-drive tray. Direct-attach topologies, fabric topologies, and mixed topologies are addressed.

You have several options for cabling between one or more hosts and a controller shelf or controller-drive tray. Options include direct-attach topologies, fabric topologies, and mixed topologies. The examples provided in this chapter show basic concepts to help you define an optimal host-cabling topology. You are not limited to using only these topologies. A table that lists the maximum supported number of hosts is included.

For host port locations on the specific controller shelf or controller-drive tray model that you are installing, see *Component locations* on page 21.

Note: If you are using the Synchronous Mirroring feature or the Asynchronous Mirroring feature, see *Hardware installation for Synchronous Mirroring and Asynchronous Mirroring* on page 136 for information on cabling for these features.

Host interface connections

The E5600 controller-drive trays (E5612, E5624, and E5660) and the EF560 flash array connect to hosts through one HIC on each controller. The E5500 controller-drive trays (E5512, E5524, and E5560) and the EF550 flash array connect to hosts through one HIC on each controller.

Each controller in an E5400 controller-drive tray (E5412, E5424, and E5460) or an EF540 flash array has built-in (base) Fibre Channel ports, and might also have an optional HIC installed.

Each controller in an E2800 controller shelf (E2812, E2824, or E2860) has one of the following options for built-in (base) ports:

- Dual RJ-45 ports for 1-Gb/s or 10-Gb/s iSCSI connection
- Dual SFP ports that can be configured for 1-Gb/s or 10-Gb/s iSCSI connections or for 4-Gb/s, 8-Gb/s or 16-Gb/s Fibre Channel connections

Each controller in and E2800 might also have an optional HIC installed.

Each controller in an E2700 controller-drive tray (E2712, E2724, or E2760) has built-in (base) SAS connectors for host connections and might also have an optional HIC installed. Each controller in an E2600 controller-drive tray (E2612, E2624, or E2660) has built-in (base) SAS connectors for host connections and might also have an optional HIC installed.

The following table shows host cabling configurations for the E5500 and E5600 controller-drive trays and the EF550 and EF560 flash arrays.

HIC		**Cable**		
Data rate and protocol	**Number of connectors**	**Connector**	**Type**	**Length**
12 Gb/s SAS	4	MiniSAS-HD	passive copper	1-5m
		MiniSAS-HD	active copper	8-15m
		MiniSAS-HD	optical	5-100m
		Fan-out cable type #2	passive copper	2m
		Fan-out cable type #3	passive copper	2m
6 Gb/s SAS	4	MiniSAS	passive copper	1-10m
		MiniSAS	active copper	5-20m
		Fan-out cable type #1	passive copper	2m
56 Gb/s InfiniBand[1]	2	QSFP+	passive copper	1-3m
		QSFP+	optical	5-100m
40 Gb/s InfiniBand[2]	2	QSFP+	passive copper	1-5m
		QSFP+	optical	10-300m
16 Gb/s Fibre Channel	4	SFP+	OM2 SW optical	2, 3, 5, 10, 25m
		SFP+	OM3 SW optical	50-150m
		SFP+	OS2 LW optical	50-300m
10 Gb/s iSCSI	4	SFP+	OM2 optical	2, 3, 5, 10, 25m
		SFP+	OM3 optical	50-150m
		Twin-Ax	passive copper	2-7m
1 Gb/s iSCSI	4	SFP+[3]	OM2 optical	2, 3, 5, 10, 25m
		SFP+[3]	OM3 optical	50-150m
		Twin-Ax	passive copper	2-7m
		RJ-45[4]	passive copper	2-70m

[1]This information applies to HICs with a maximum data rate of 56 Gb/s. These HICs can also be operated at 40 Gb/s.

[2]This information applies to HICs with a maximum data rate of 40 Gb/s. These HICs can also be operated at 20 Gb/s. Use these HICs only in the E5500 and EF550 models.

[3]Optical cables for 1-Gb/s iSCSI connections require a 1-Gb/s SFP.

[4] Copper cables with RJ-45 connectors for iSCSI connections require an SFP adapter.

The following table shows host cabling configurations for the E5400 controller-drive tray and the EF540 flash array.

HICs and Base Ports		**Cable**		
Data rate and protocol	**Number of connectors**	**Connector**	**Type**	**Length**
6 Gb/s SAS	4	MiniSAS	passive copper	1-10m
		MiniSAS	active copper	5-20m
		Fan-out cable type #1	passive copper	2m
40 Gb/s InfiniBand	2	QSFP+	passive copper	1-5m
		QSFP+	optical	10-300m
Base Ports: 8 Gb/s Fibre Channel	4	SFP	OM2 SW optical	2 ,3, 5, 10, 25m
		SFP	OM3 SW optical	50-150m
8 Gb/s Fibre Channel	4	SFP	OM2 SW optical	2 , 3, 5, 10, 25m
		SFP	OM3 SW optical	50-150m
10 Gb/s iSCSI	2	SFP+	OM2 optical	2, 3, 5, 10, 25m
		SFP+	OM3 optical	50-150m
		Twin-Ax	passive copper	2-7m
1 Gb/s iSCSI		RJ-45	passive copper	2-70m

Note: For an E5400 controller-drive tray with an InfiniBand HIC, use only InfiniBand host connections. Do not mix Fibre Channel host connections with InfiniBand host connections.

The following table shows host cabling configurations for the E2800 controller shelves.

HICs and base ports		**Cable**		
Data rate and protocol	**Number and type of connectors**	**Connector**	**Type**	**Length**
12 Gb/s SAS or 6 Gb/s SAS	4 or 2 HIC ports	MiniSAS-HD	passive copper	1-5m
		MiniSAS-HD	optical	5-100m
		Fan-out cable type #3	passive copper	2m
6 Gb/s SAS only	4 or 2 HIC ports	Fan-out cable type #2	passive copper	2m
16 Gb/s, 8 Gb/s, or 4 Gb/s Fibre Channel	4 or 2 HIC optical ports	SFP+	OM2 SW optical	2,3,5,10,25 m
		SFP+	OM3 SW optical	50-100m
	2 base optical ports	SFP+	OM2 SW optical	2,3,5,10,25 m
		SFP+	OM3 SW optical	50-100m
		SFP+	OS1 LW optical	50-300m

HICs and base ports		**Cable**		
Data rate and protocol	**Number and type of connectors**	**Connector**	**Type**	**Length**
10 Gb/s iSCSI or 1 Gb/s iSCSI	4 HIC optical ports	SFP+	OM2 optical	2,3,5,10,25 m
		SFP+	OM3 optical	50-300m
		Twin-Ax (DAC)	passive copper	2-7m
	2 base optical ports	SFP+	OM2 optical	2,3,5,10,25 m
		Twin-Ax (DAC)	passive copper	2-7m
	2 base RJ-45 ports	RJ-45	Cat6a passive copper	2-100m
	2 HIC optical ports	SFP+	OM2 optical	2,3,5,10,25 m
		SFP+	OM3 optical	50-300m
		Twin-Ax (DAC)	passive copper	2-7m
	2 HIC RJ-45 ports	RJ-45	Shielded Cat6a passive copper	2-100m
1 Gb/s iSCSI only	4 HIC optical ports	RJ-45 with 1 Gb/s SFP	Cat5 passive copper	2-100m
	2 HIC optical ports	RJ-45 with 1 Gb/s SFP	Cat5 passive copper	2-70m

The following table shows host cabling configurations for the E2700 controller-drive trays.

HIC		**Cable**		
Data rate and protocol	**Number of connectors**	**Connector**	**Type**	**Length**
12 Gb/s SAS	4	MiniSAS-HD	passive copper	1-5m
		MiniSAS-HD	active copper	8-15m
		MiniSAS-HD	optical	5-100m
	2	MiniSAS-HD	passive copper	1-5m
		MiniSAS-HD	active copper	8-15m
		MiniSAS-HD	optical	5-100m
	4	Fan-out cable type #2	passive copper	2m
		Fan-out cable type #3	passive copper	2m

HIC		**Cable**		
Data rate and protocol	**Number of connectors**	**Connector**	**Type**	**Length**
16 Gb/s Fibre Channel	4	SFP+	OM2 SW optical	2,3,5,10,25 m
		SFP+	OM3 SW optical	50-150m
		SFP+	OS2 LW optical	50-300m
	2	SFP+	OM2 SW optical	2,3,5,10,25 m
		SFP+	OM3 SW optical	50-150m
		SFP+	OS2 LW optical	50-300m
10 Gb/s iSCSI	4	SFP+	OM2 optical	2,3,5,10,25 m
		SFP+	OM3 optical	50-150m
		Twin-Ax	passive copper	2-7m
	2	SFP+	OM2 optical	2,3,5,10,25 m
		SFP+	OM3 optical	50-150m
		Twin-Ax	passive copper	2-7m
		RJ-45	Cat6a passive copper	2-100m
1 Gb/s iSCSI	4	SFP+[1]	OM2 optical	2, 3, 5, 10, 25m
		SFP+[1]	OM3 optical	50-150m
		Twin-Ax	passive copper	2-7m
		RJ-45[2]	passive copper	2-70m
	2	SFP+[1]	OM2 optical	2, 3, 5, 10, 25m
		SFP+[1]	OM3 optical	50-150m
		Twin-Ax	passive copper	2-7m
		RJ-45[2]	Cat5 passive copper	2-70m
		RJ-45	Cat6a passive copper	2-100m

[1]Optical cables for 1-Gb/s iSCSI connections require a 1-Gb/s SFP.

[2] Copper cables with RJ-45 connectors for iSCSI connections require an SFP adapter.

The following table shows host cabling configurations for the E2600 controller-drive trays.

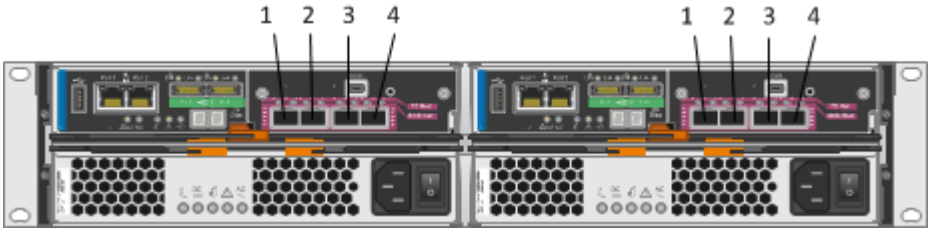
HICs and base ports		**Cable**		
Data rate and protocol	**Number of connectors**	**Connector**	**Type**	**Length**
Base Ports: 6 Gb/s SAS	2	MiniSAS	passive copper	1-5m
		Fan-out cable type #1	passive copper	2m
6 Gb/s SAS	2	MiniSAS	passive copper	1-5m
		Fan-out cable type #1	passive copper	2m
8 Gb/s Fibre Channel	4	SFP	OM2 SW optical	2, 3, 5, 10, 25m
		SFP	OM3 SW optical	50-150m
10 Gb/s iSCSI	2	RJ45	Shielded Cat 6a	2-100m
1 Gb/s iSCSI	2	RJ-45	Cat 6a	2-70m

Note: When an E2600 controller-drive tray has a 10-Gb/s iSCSI HIC, some restrictions apply to the types of cables you can use for host cabling. The previous table shows the types and lengths of cables that you can use. Do not use Category 5e cables or Category 6 cables.

Note: On the E2600 controller-drive tray, each controller has a pair of levers with handles for removing the controller from the controller-drive tray. If a controller has a HIC installed, one of these handles on the controller is located next to a host port on the HIC. The close spacing between the handle and the host port might make it difficult to remove a cable that is attached to the host port. If this problem occurs, use a flat-blade screwdriver to compress the release on the cable connector.

E2800 and E2700 controller shelves can have a mix of interface types. The HIC interface might be different from that of the base ports. The base ports on an E2800 controller shelf are might be Fibre Channel or iSDSI. The base ports on an E2700 are SAS.

E5600 storage arrays (E5612, E5624, and E5660) and EF560 flash arrays support a four-port HIC that might be configured with four Fibre Channel ports, four iSCSI ports, or with two ports for Fibre Channel and two ports for iSCSI (split mode). If you have a HIC installed with all four ports configured for the same protocol, you can apply a feature pack in SANtricity Storage Manager to convert the protocol of the host ports to Fibre Channel-iSCSI split mode. Unified SFPs are available that support both 16-Gb/s Fibre Channel and 10-Gb/s iSCSI. In *split mode*, ports 1 and 2 on both HICs operate as iSCSI ports, while ports 3 and 4 on both HICs operate as Fibre Channel ports. You can also convert all four ports on a HIC from one protocol to the other. The following figure shows the rear view of the E5612 controller-drive tray with two four-port HICs installed.



HIC port	**Before the conversion to split mode**	**After the conversion to split mode**
1	16 Gb/s Fibre Channel or 10 Gb/s iSCSI	10 Gb/s iSCSI

HIC port	Before the conversion to split mode	After the conversion to split mode
2	16 Gb/s Fibre Channel or 10 Gb/s iSCSI	10 Gb/s iSCSI
3	16 Gb/s Fibre Channel or 10 Gb/s iSCSI	16 Gb/s Fibre Channel
4	16 Gb/s Fibre Channel or 10 Gb/s iSCSI	16 Gb/s Fibre Channel

A host can have both iSCSI and Fibre Channel adapters for connections to a storage array that has a mix of host port protocols. Several restrictions apply to such configurations:

- The root boot feature is not supported for hosts with mixed connections to one storage array.
- Cluster configurations are supported for hosts with mixed connections to one storage array.
- When the host operating system is VMware, mixing connection types within a storage partition is not supported.
- When the host operating system is Windows, mixing connection types within a storage partition is not supported. A single server that attaches to multiple storage partitions on a single storage array must not have any overlap in LUN number assignments given to the volumes.
- For other operating systems, mixed connection types from a host to a single storage array are not supported.

A host port is connected to a host adapter: a host bus adapter (HBA) for Fibre Channel or SAS, a host channel adapter (HCA) for InfiniBand, or an Ethernet adapter for iSCSI. The host adapter in the host must support the same interface protocols as the type of host port to which it is connected.

Connect an 16-Gb/s Fibre Channel host port to an 16-Gb/s HBA. If the data rate for the HBA is lower, the data transfer rate is at the lower rate. For instance, if you connect an 16-Gb/s Fibre Channel host port to a 8-Gb/s HBA, the data transfer rate is 8 Gb/s.

Maximum number of host connections

Model	Maximum number of hosts
E5600 controller-drive trays and EF560 flash arrays	1024
E5500 controller-drive trays and EF550 flash arrays	1024
E5400 controller-drive trays and EF540 flash arrays	1024
E2800 controller shelves	256
E2700 controller-drive trays	256
E2600 controller-drive trays	256

Attention: Possible loss of data access – Do not use a combination of HBAs from different vendors in the same storage area network (SAN). For the HBAs to perform correctly, use only HBAs from one manufacturer in a SAN.

Direct-attach topologies

This section describes topologies that do not use switches to connect hosts to your storage array. The host adapters in the hosts might be HBAs for Fibre Channel or SAS, HCAs for InfiniBand, or Ethernet for iSCSI. Some controller shelves (controller-drive trays) support more direct host connections than the examples shown. To cable more host connections, follow the pattern established by the examples in this section.

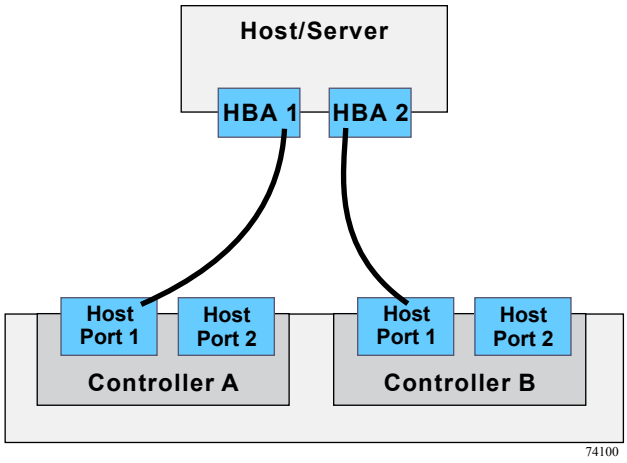
When a host is cabled to a duplex controller shelf, each attached host should have two host adapters installed. For redundancy, connect one host adapter to controller A and the other to controller B.

Direct host connections to one controller shelf or controller-drive tray

These example configurations show HBAs as connecting points on the host. For other configurations, these connecting points might be host channel adapters (HCAs) for InfiniBand connections, Ethernet adapters for iSCSI connections, or a combination of one HBA and one iSCSI Ethernet adapter.

Attention: Possible loss of data access – You must install alternate path software or an alternate path (failover) driver on the host to support failover in the event of an HBA, an HCA, or an iSCSI Ethernet adapter failure or a host channel failure. Simplex configurations do not support failover.

The following figure shows an example of a direct-attach topology with one host and a duplex controller shelf (controller-drive tray).

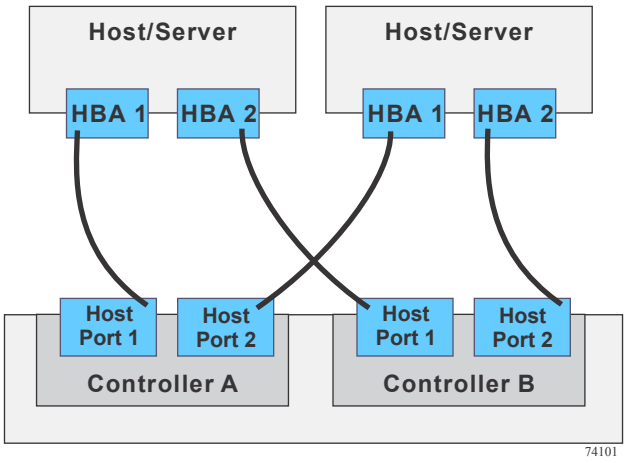


The following table lists the redundant and non-redundant components in a direct-attached configuration with one host and a controller shelf.

Component	Redundancy
Host/server	Non-redundant
HBA, HCA, or iSCSI Ethernet adapter	Redundant
Host-to-controller cable	Redundant
Controller	Redundant

The following figure shows an example of a direct-attach topology with two hosts and a duplex controller shelf.

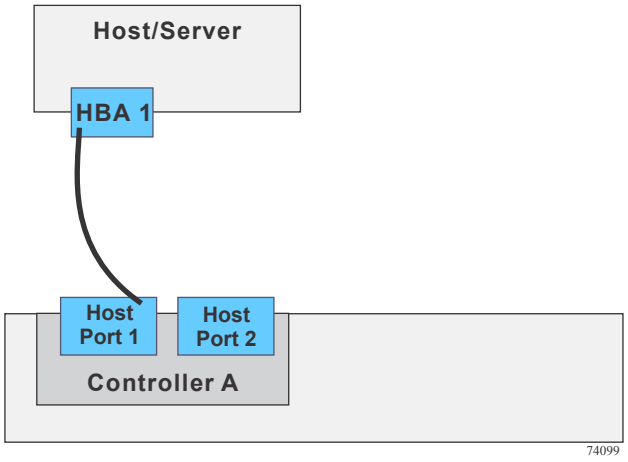
Note: In this example, the hosts/servers must be clustered to guarantee redundancy.



The following table lists the redundant and non-redundant components in a direct-attached configuration with one host and a controller-drive tray.

Component	Redundancy
Host/server	Redundant
HBA, HCA, or iSCSI Ethernet adapter	Redundant
Host-to-controller cable	Redundant
Controller	Redundant

The following figure shows an example of a direct-attach topology with one host and a simplex controller shelf.



The following table lists the redundant and non-redundant components in a direct-attached configuration with one host and a simplex controller shelf.

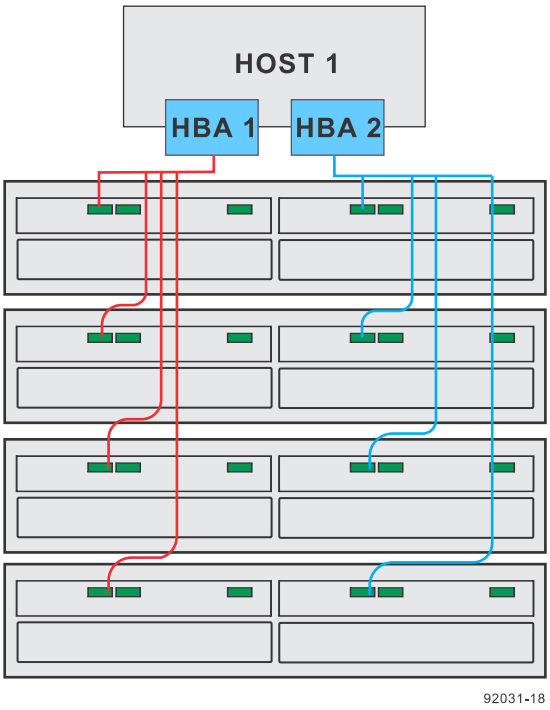
Component	Redundancy
Host/server	Non-redundant
HBA, HCA, or iSCSI Ethernet adapter	Non-redundant
Host-to-controller cable	Non-redundant
Controller	Non-redundant

One host with direct SAS connections to four controller shelves or controller-drive trays

You can use a SAS fan-out cable to connect a host to multiple storage arrays.

Attention: Possible loss of data access – You must install alternate path software or an alternate path (failover) driver on the host to support failover in the event of a SAS HBA failure or a host channel failure.

The following figure shows an example of a direct-attach topology with one host and a four duplex controller shelves. Each controller shelf might have attached drive shelves (drive trays), but these are not shown in the figure.



The following table lists the redundant and non-redundant components in a direct-attached configuration with one host and four duplex controller-drive trays.

Component	Redundant	Non-redundant
Host/server (see note)		Non-redundant
HIC (SAS)	Redundant	
Host-to-controller cables	Redundant	
Controllers	Redundant	

Switch topologies

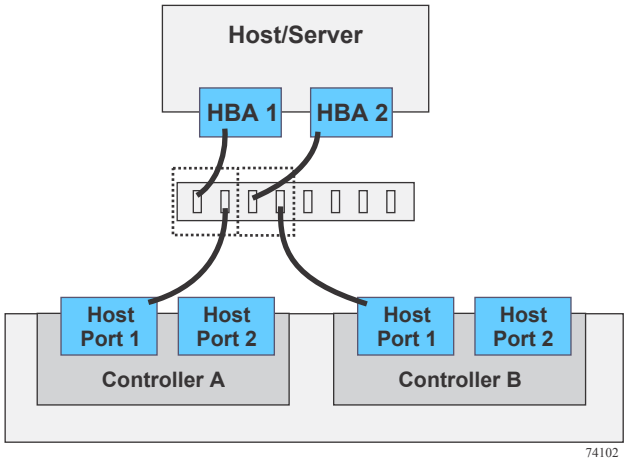
This section describes topologies that use switches to connect hosts to your storage array. The host adapters in the hosts might be HBAs for Fibre Channel, HCAs for InfiniBand, or Ethernet for iSCSI. The switches must support the connection type (Fibre Channel, InfiniBand or Ethernet) used between the host and the storage array.

When a host is cabled to a duplex controller shelf (controller-drive tray), each attached host should have two host adapters installed. For redundancy, attach each of the host adapters to a different switch (or switch zone) so that one switch (or zone) connects to controller A and the other to controller B in the controller shelf. In the case where a host has one HBA and one iSCSI Ethernet adapter, the two connections might require two different types of switches.

Attention: Possible loss of data access – You must install alternate path software or an alternate path (failover) driver on the host to support failover in the event of an HBA failure or a host channel failure. Simplex controller configurations do not support failover.

One host to a storage array

The following figure shows an example of a switch topology with one host, a controller shelf, and a zoned switch. Each outlined group of ports on the switch represents a zone.



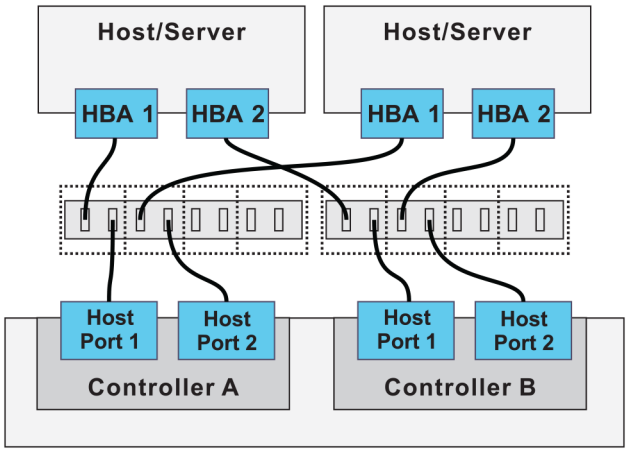
The following table lists the redundant and non-redundant components in a switched configuration with one host and a controller shelf.

Component	Redundant
Host/server	Non-redundant
Host adapter	Redundant
Host-to-controller cable	Redundant
Switch	Use two switches for full redundancy. A single zoned switch is not redundant.
Controller	Redundant

Two hosts to a storage array

The following figure shows an example of a switch topology with two hosts, a controller shelf, and a zoned switch. Each outlined group of ports on the switch represents a zone.

Note: The hosts/servers in this example must be clustered to be redundant.



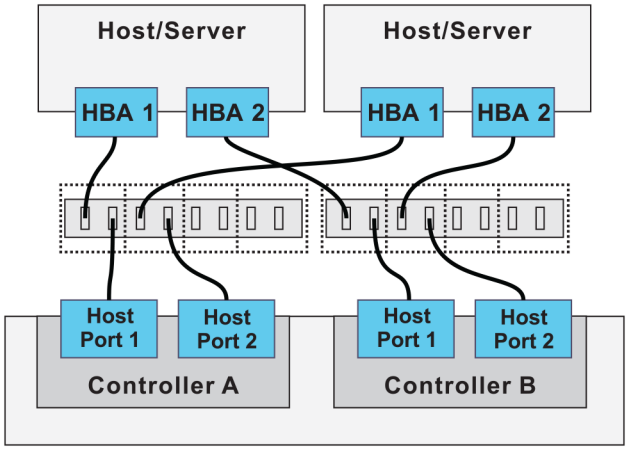
The following table lists the redundant and non-redundant components in a switched configuration with two hosts and a controller shelf.

Component	Redundancy
Host/server (see note)	Redundant
Host adapter	Redundant
Host-to-controller cable	Redundant
Switch	Use two switches for full redundancy. A single zoned switch is not redundant.
Controller	Redundant

Two hosts and two zoned switches

The following figure shows an example of a switch topology with two hosts, a controller shelf, and two zoned switches. Each outlined group of ports on a switch represents a zone.

Note: The hosts/servers in this example must be clustered to be redundant.



The following table lists the redundant and non-redundant components in a switched configuration with four hosts, a controller shelf, and two zoned switches.

Component	**Redundancy**
Host/server (see note)	Redundant
Host adapter	Redundant
Host-to-controller cable	Redundant
Switch	Redundant
Controller	Redundant

Mixed topologies

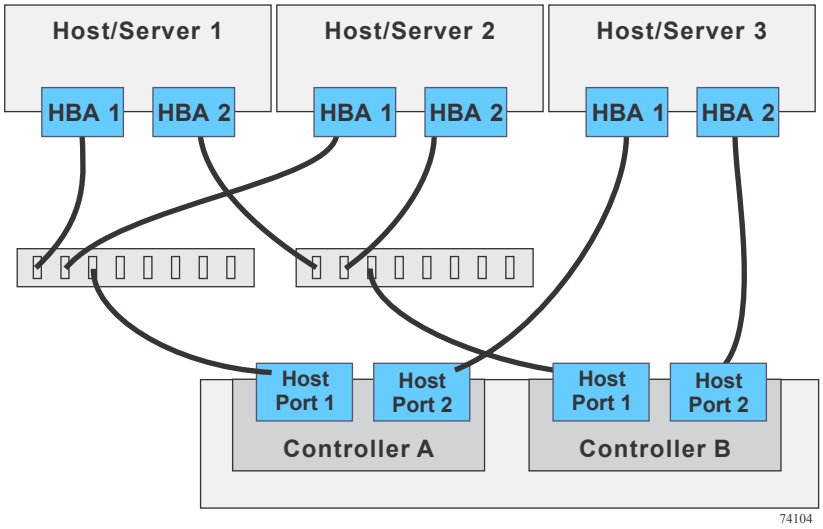
This section describes an example host cabling configuration where a storage array connects to one hosts directly and to two other hosts through a switched fabric. The host adapters in the hosts might be HBAs for Fibre Channel or SAS, HCAs for InfiniBand, or Ethernet for iSCSI. The switches must support the connection type (Fibre Channel, InfiniBand or Ethernet) used between the host and the storage array.

The example in the figure identifies HBA1 and HBA2 on each host as connecting points. For other configurations, these connecting points might be Ethernet adapters for iSCSI connections, or a combination of one HBA and one iSCSI Ethernet adapter.

When a host is cabled to a duplex controller shelf (controller-drive tray), each attached host should have two host adapters installed. For redundancy, attach each of the host adapters to a different switch (or switch zone) so that one switch (or zone) connects to controller A and the other to controller B in the controller shelf. In the case where a host has one HBA and one iSCSI Ethernet adapter, the two connections might require two different types of switches. Redundancy for a host that attaches directly to a storage array requires that each host adapter attach to a different controller.

Attention: Possible loss of data access – You must install alternate path software or an alternate path (failover) driver on the host to support failover in the event of an HBA failure or a host channel failure.

Note: The hosts/servers in this example must be clustered to be redundant.



The following table lists the redundant and non-redundant components in a mixed configuration with three hosts and a controller shelf.

Component	Redundant	Non-redundant
Host/servers 1 and 2	Redundant	
Host/server 3		Non-redundant (unless all three hosts are in the same cluster and have similar operating systems and adapters)
HBA or Ethernet iSCSI adapter	Redundant	
Host-to-controller cable	Redundant	
Switch	Redundant	
Controller	Redundant	

Drive shelf or drive tray cabling

A controller shelf (controller-drive tray) along with any drive shelves (drive trays) that are attached to it, comprise a storage array. When a storage array includes drive shelves, each controller in the controller shelf is connected to an environmental services module (ESM) for SAS-2 connections, or to an I/O module (IOM) for SAS-3 connections in a drive shelf.

The ESMs/IOMs in drive shelves are either connected to a controller in the controller shelf or to an ESM/IOM in another drive shelf. Correct drive shelf cabling is important because it affects both data availability and the performance of a storage array. This chapter provides examples of cabling between a controller shelf and one or more expansion drive shelves. See *Component locations* on page 21 for figures that show the port locations on the specified controller shelf and drive shelf models that you are connecting.

Drive shelf (drive tray) information by model

Certain shelf specifications might affect your choice of cabling topology. Make sure that your planned topology is compatible with applicable specifications and restrictions.

Note: When you mix different types of drive shelves, you must consider the total number of drive slots that are available in the final configuration of the storage array. Your configuration must meet both the limit on the total number of drive slots and the limits on the number of drive shelves of a given model.

Note: The maximum number of drive slots and the maximum number of drive shelves for a redundant pair of channels is the same as for a single non-redundant channel.

Note: Every storage array must contain at least one drive. For drive trays and controller-drive trays with a 60-drive capacity, each of the front four bays in each of the five drawers must have a drive installed, for a minimum of twenty drives.

Controller shelf or controller-drive tray	DE1600 and DE5600	DE212C, DE224C, and DE460C	DE6600	DE1600, DE5600, and DE6600
E2600	Any mixture not to exceed a total of 192 drive slots or 16 enclosures*	Not Supported	Not to exceed a total of 180 drive slots or 3 enclosures*	Any mixture not to exceed a total of 192 drive slots or 16 enclosures*
E2700	Any mixture not to exceed a total of 192 drive slots or 16 enclosures*	Any mixture not to exceed a total of 192 drive slots or 16 enclosures*	Not to exceed a total of 180 drive slots or 3 enclosures*	Any mixture not to exceed a total of 192 drive slots or 16 enclosures*
E2800	Any mixture not to exceed a total of 180 bays or 4 enclosures*	Any mixture not to exceed a total of 180 bays or 4 enclosures*	Any mixture not to exceed a total of 180 bays or 4 enclosures*	Any mixture not to exceed a total of 180 bays or 4 enclosures*
E5400	Any mixture not to exceed a total of 384 drive slots or 16 enclosures*	Not Supported	Not to exceed a total of 360 drive slots or 6 enclosures*	Any mixture not to exceed a total of 384 drive slots or 16 enclosures*

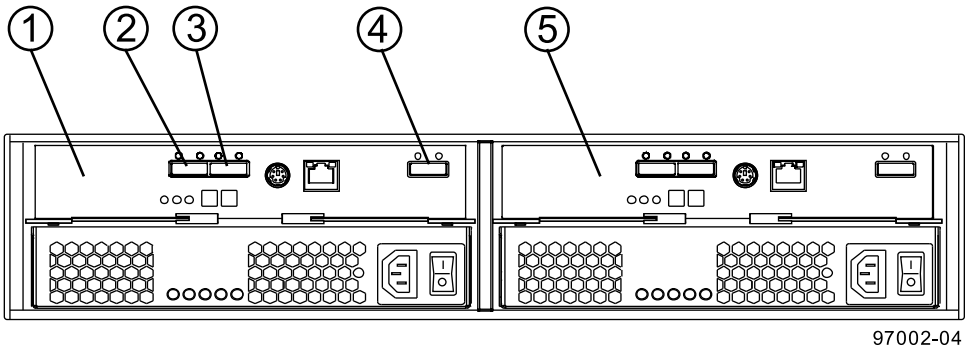
Controller shelf or controller-drive tray	DE1600 and DE5600	DE212C, DE224C, and DE460C	DE6600	DE1600, DE5600, and DE6600
EF540	DE5600 only. Solid state drives (SSDs) only not to exceed 120 drive slots or 5 enclosures*	Not Supported	Not Supported	Not Supported
E5500	Any mixture not to exceed a total of 384 drive slots or 16 enclosures*	Not Supported	Not to exceed a total of 360 drive slots or 6 enclosures*	Any mixture not to exceed a total of 384 drive slots or 16 enclosures*
EF550	DE5600 only. Solid state drives (SSDs) only not to exceed 120 drive slots or 5 enclosures*	Not Supported	Not Supported	Not Supported
E5600	Any mixture not to exceed a total of 384 drive slots or 16 enclosures*	Any mixture not to exceed a total of 384 drive slots or 16 enclosures*	Not to exceed a total of 360 drive slots or 6 enclosures*	Any mixture not to exceed a total of 384 drive slots or 16 enclosures*
EF560	DE5600 only. Solid state drives (SSDs) only not to exceed 120 drive slots or 5 enclosures*	Not Supported	Not Supported	Not Supported
*Total enclosures including drive shelves and the controller shelf.				

ESM module and IOM module arrangements

Each ESM has three SFF-8088 SAS ports, labeled In1, In2, and Out. Each IOM has four SFF-8644 SAS ports labeled 1, 2, 3, and 4. The canisters are located adjacent to one another.

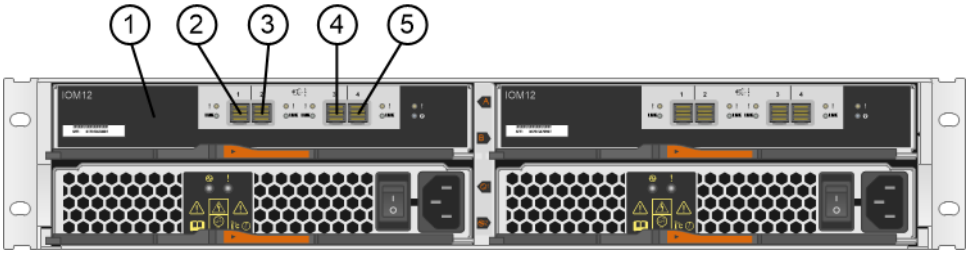
ESMs or IOMs are arranged either side-by-side or top-and-bottom depending on the enclosure type. The canisters are located adjacent to one another, as shown in the following figures.

Side-by-side ESMs in DE1600 drive shelves and DE5600 drive shelves



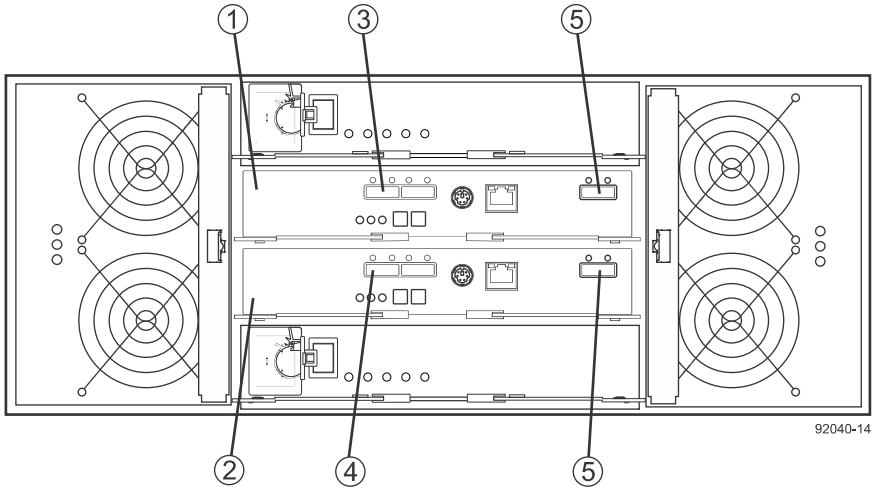
1.	ESM A
2.	SAS In - Port 1
3.	SAS In - Port 2
4.	SAS Out (Expansion) Port
5.	ESM B

Side-by-side ESMs in DE212C drive shelves and DE224C drive shelves



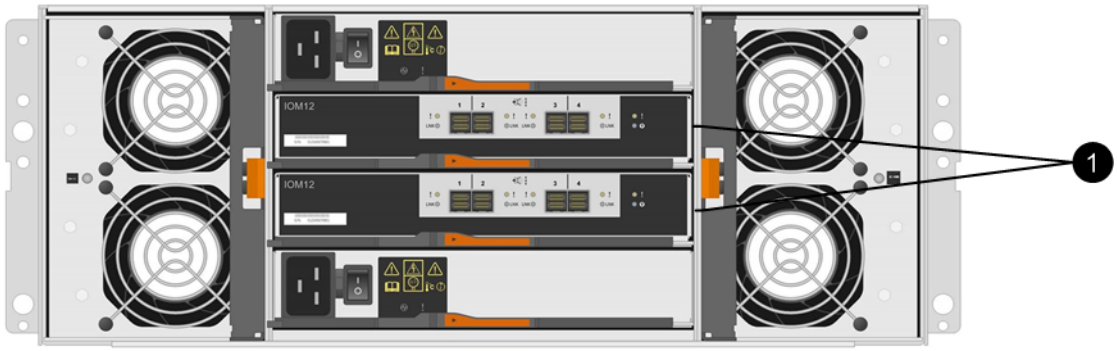
1.	ESM A
2.	SAS Port 1
3.	SAS Port 2
4.	SAS Port 3
5.	SAS Port 4

Stacked ESMs in DE6600 drive shelves



1.	ESM A
2.	ESM B
3.	SAS In Ports
4.	SAS In Ports
5.	SAS Out (Expansion) Ports

Stacked IOMs in DE460C drive shelves



1	IOMs

Drive tray cabling topologies for the E5500 and E5600 controller-drive trays and the EF550 and EF560 flash arrays

This section provides examples of drive tray cabling topologies for the E5600 (E5612, E5624, E5660) controller-drive trays, the EF560 flash array, the E5500 controller-drive trays (E5512, E5524, and the E5560), and the EF550 flash array. The following table lists ports and associated cable types and lengths.

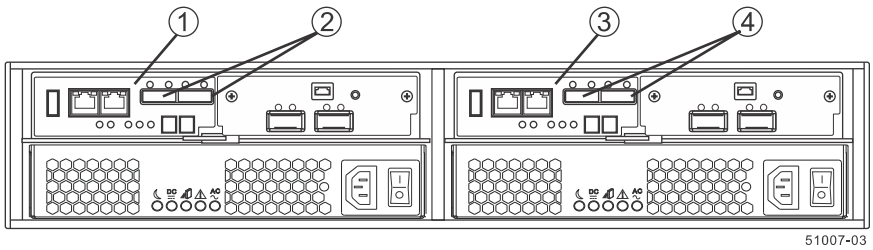
Ports		Cable		
Data rate and protocol	**Number of connectors**	**Connector**	**Type**	**Length**
Expansion: 6 Gb/s SAS	2	MiniSAS to MiniSAS	passive copper	2m or 1.5m

Drive channel redundancy for the E5500 controller drive trays, E5600 controller drive trays, EF550 flash arrays and EF560 flash arrays

Controller-drive trays

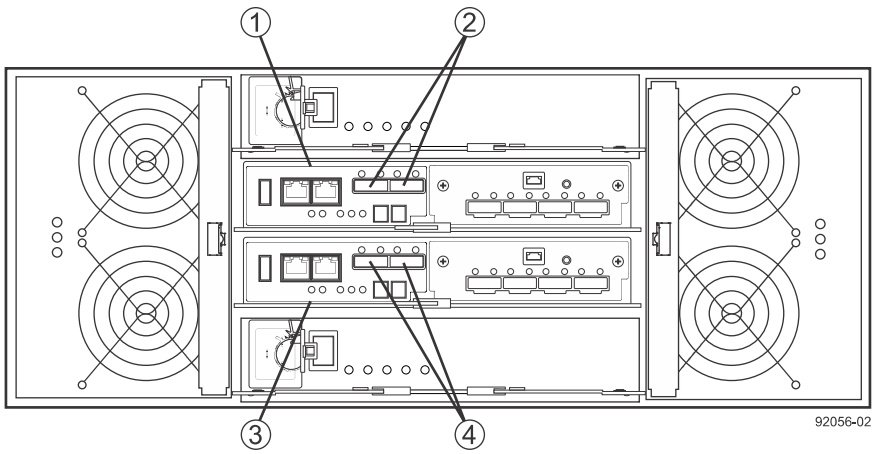
Each controller in these controller-drive trays and flash arrays has two drive expansion ports. With these controller-drive trays and flash arrays, you can cable a storage array so that each drive tray or drive shelf has two drive paths to the alternate controller if a controller fails or is removed. To maintain data access in the event of the failure of a controller, an ESM/IOM, or a drive channel, each ESM/IOM must have a path to each controller.

Redundant path pair on the E5512, E5524, E5612 and E5624 controller drive trays and the EF550 and EF560 flash arrays



1.	Controller canister A
2.	Drive channel ports (SAS drive expansion connectors)
3.	Controller canister B
4.	Drive channel ports (SAS drive expansion connectors)

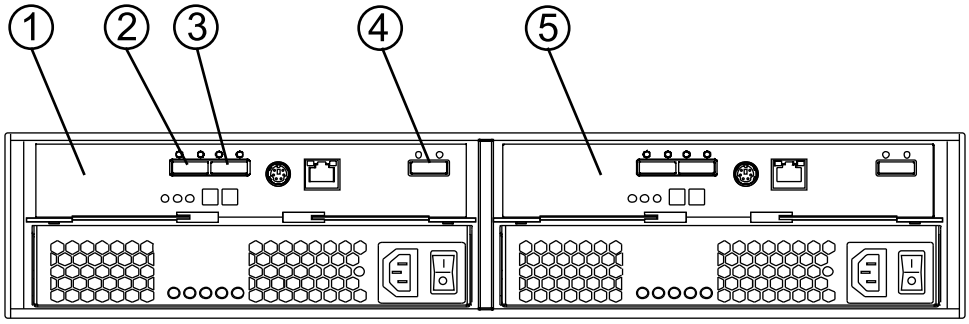
Redundant path pair on the E5560 and E5660 controller drive trays



1.	Controller canister A
2.	Drive expansion ports (SAS drive expansion connectors)
3.	Controller Canister B
4.	Drive expansion ports (SAS drive expansion connectors)

Drive trays

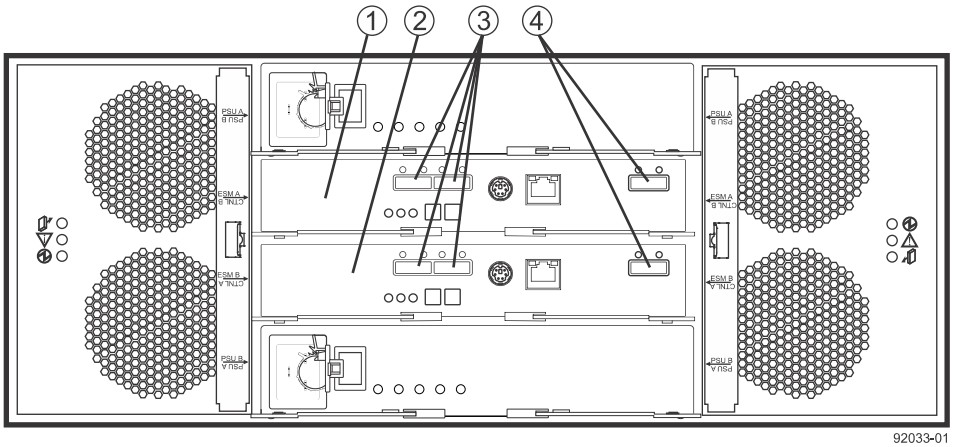
The following figure shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. Each environmental services module (ESM) has two SAS-2 in ports and one SAS-2 expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray.



97002-04

1.	ESM A
2.	SAS in - port 1
3.	SAS in - port 2
4.	SAS out (expansion) port
5.	ESM B

The following figures show the SAS ports on a DE6600 drive tray. Each environmental services module (ESM) has two SAS in ports and one SAS expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray. Follow the cabling pattern shown in the figures in this topic.

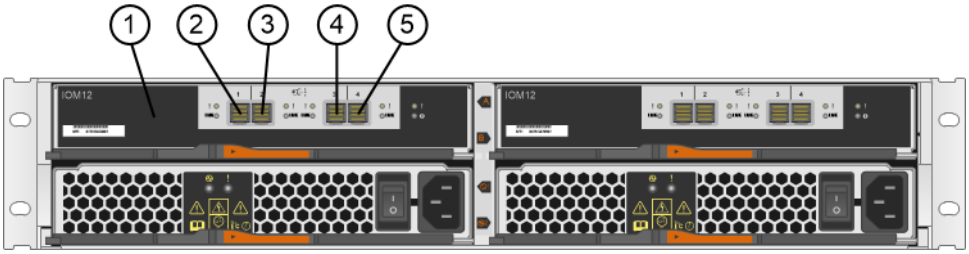


92033-01

1.	ESM A
2.	ESM B
3.	SAS in ports
4.	SAS out (expansion) port

Drive Shelves

The following figures show the SAS ports on a DE212C drive shelf or a DE224C drive shelf. The I/O modules (IOMs) occupy the top half of the shelf. Each IOM has four SAS-3 expansion ports. You can connect these ports to SAS-3 expansion ports on another drive shelf or drive tray or to SAS expansion ports on a controller shelf or controller-drive tray.



1.	IOM A
2.	SAS port 1
3.	SAS port 2
4.	SAS port 3
5.	SAS port 4

Drive tray cabling topologies for the E5524, E5512, E5612 and E5624 controller-drive trays, and the EF550 and EF560 flash arrays

The figures in this section show representative cabling configurations. The configurations shown guarantee that redundant data paths exist between the controller-drive tray and all attached drive trays in a storage array. These controller-drive trays can be cabled to SAS2 drive trays (DE1600, DE5600, and DE6600), or various combinations of those three models of drive tray. You can also cable E5612, E5624, and E5660 controller-drive trays to SAS3 drive trays (DE212C and DE224C). For any one controller-drive tray, you must not exceed the limit of 15 connected drive trays or the limit for the total number of drive slots in the storage array.

Note: The drive slot limit might be lower than 384 for some sub-models of the E5524 controller-drive tray and the E5512 controller-drive tray. You are notified through the Major Event Log (MEL) if you attempt to install drive slots in excess of the limit for your storage array. Contact technical support if this occurs.

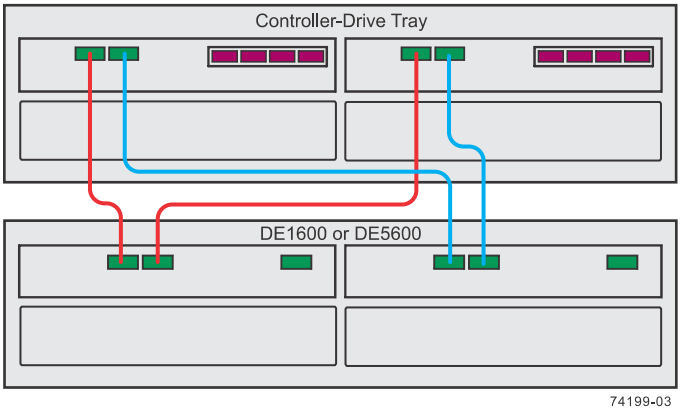
Configurations that include SAS3 drive trays require cables with a mini-SAS connector on one end and a mini-SAS HD connector on the other end. These cables connect between the controllers and the SAS-3 drive trays or between SAS-2 drive trays and SAS-3 drive trays. The mini-SAS HD connectors attach to the IOMs in the SAS3 drive trays, while the mini-SAS connectors attach to the ESMs in SAS2 drive trays or to the controllers in the controller-drive tray. If your configuration has a mix of SAS2 and SAS3 drive trays, group the SAS3 drive trays together at the bottom or the top of the stack.

Note: The EF550 controller-drive tray and the EF560 controller-drive tray can be cabled to the DE5600 drive trays only. The total number of drives in the storage array, including the drives in the EF550 controller-drive tray or the EF560 controller-drive tray and those in all of the attached drive trays, must not exceed 120. The total number of trays in the storage array, including the EF550 controller-drive tray or the EF560 controller-drive tray and all of the attached drive trays, must not exceed five. The drive trays must contain only solid-state disks (SSDs).

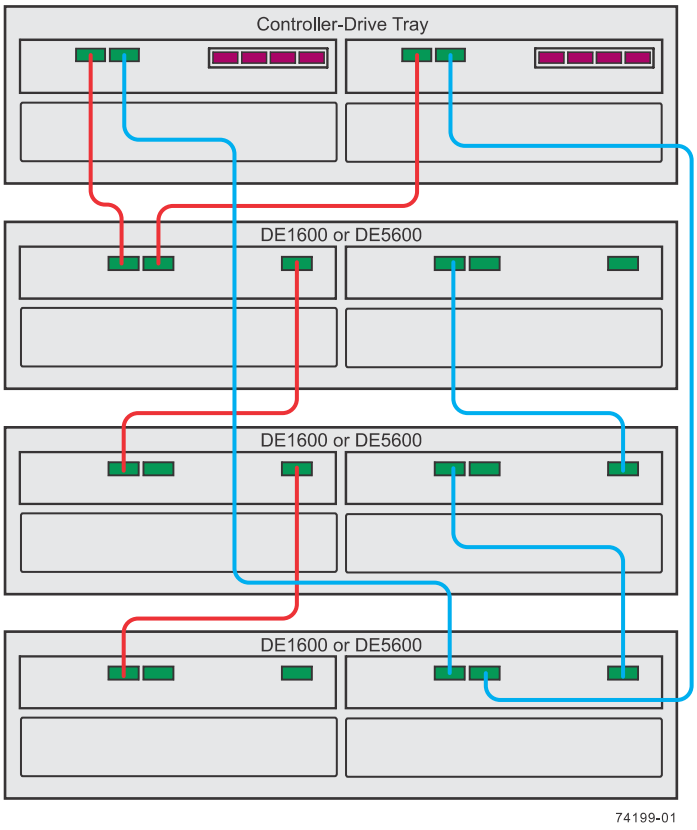
When you cable the storage array, keep these points in mind:

- To connect an ESM/IOM to a controller-drive tray, use both of the SAS in ports on the ESM or two of the SAS expansion ports on an IOM. Connect one SAS in port (or SAS expansion port) to a SAS expansion port on controller A and the other SAS in port (or SAS expansion port) to a SAS Expansion port on controller B in the controller-drive tray.
- To connect two drive trays, connect a SAS expansion port on an ESM/IOM in one drive tray to one of the SAS in ports on an ESM or one of the SAS expansion ports on an IOM in the other drive tray. Do not connect both SAS in ports on one ESM to other drive trays.

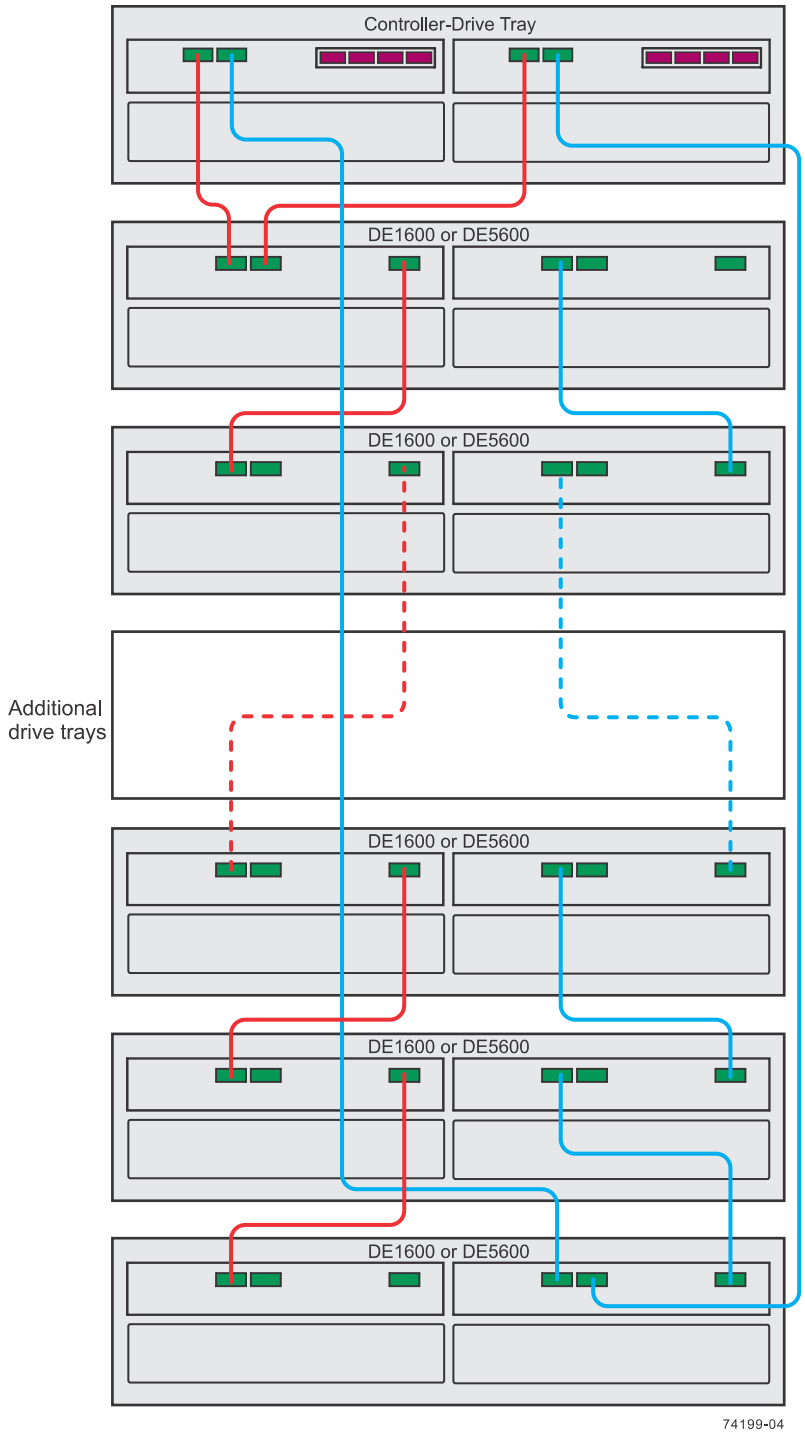
One E5500 or E5600 controller drive tray or one EF550 or EF560 flash array and one drive tray



One E5500 or E5600 controller drive tray or one EF550 or EF560 flash array and three drive trays



One E5500 or E5600 controller drive tray or one EF550 or EF560 flash array and up to 15 drive trays



The previous figures show storage arrays with DE1600 drive trays or DE5600 drive trays. A storage array might also include DE6600 drive trays. The cabling pattern remains the same, although the ESMs are arranged differently in a DE6600 drive tray. *Drive tray cabling topologies for the E5500 and E5600 controller-drive trays and the EF550 and EF560 flash arrays* on page 76 shows the arrangement of ESMs and the location of ports on the DE6600 drive tray.

Important: The cabling pattern is independent of the physical location of the trays in the cabinet. If the controller-drive tray is installed in the middle of the cabinet, the physical cabling pattern will be different from what is shown in the figures, although the topology will be consistent. If the

storage array includes DE6600 drive trays, install those drive trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

Drive tray cabling topologies for the E5560 controller-drive tray and the E5660 controller-drive tray

The figures in this section show representative cabling configurations. The configurations shown guarantee that redundant data paths exist between the controller-drive tray and all attached drive trays in a storage array. These controller-drive trays can be cabled to SAS2 drive trays (DE1600, DE5600, and DE6600), or various combinations of those three models of drive tray. You can cable E5660 controller-drive trays to SAS3 drive trays (DE2112C, DE2124C, and DE460C).

Configurations that include SAS3 drive trays require cables with a mini-SAS connector on one end and a mini-SAS HD connector on the other end. Use these cables to connect between controllers and SAS-3 druve trats ir between a SAS-2 drive tray and a SAS-3 drive tray. The mini-SAS HD connectors attach to the IOMs in the SAS3 drive trays, while the mini-SAS connectors attach to the ESMs in SAS2 drive trays or to the controllers in the controller-drive tray. If your configuration has a mix of SAS2 and SAS3 drive trays, group the SAS3 drive trays together at the bottom or the top of the stack.

Warning: Risk of bodily injury – An empty tray weighs approximately 56.7 kg (125 lb). Three persons are required to safely move an empty tray. If the tray is populated with components, a mechanized lift is required to safely move the tray.

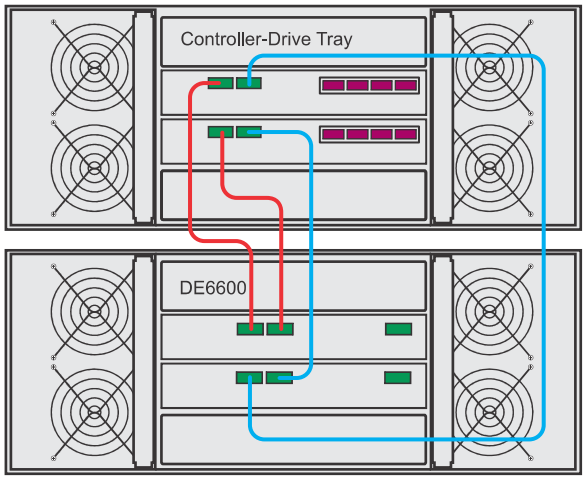
Note: To ensure cabinet stability and guarantee the lowest possible center of gravity, install only 60-drive trays (E5560 controller-drive trays, DE660 drive trays, or DE460C drive trays) at the bottom of the cabinet, and install any 12-drive trays or any 24-drive trays above all 60-drive trays, with no empty space. A top-heavy cabinet has a greater risk of falling over.

For any one controller-drive tray, you must not exceed the limit of 15 connected drive trays or the limit for the total number of drive slots in the storage array. You are notified through the Major Event Log (MEL) if you attempt to install drive slots in excess of the limit for your storage array. Contact technical support if this occurs.

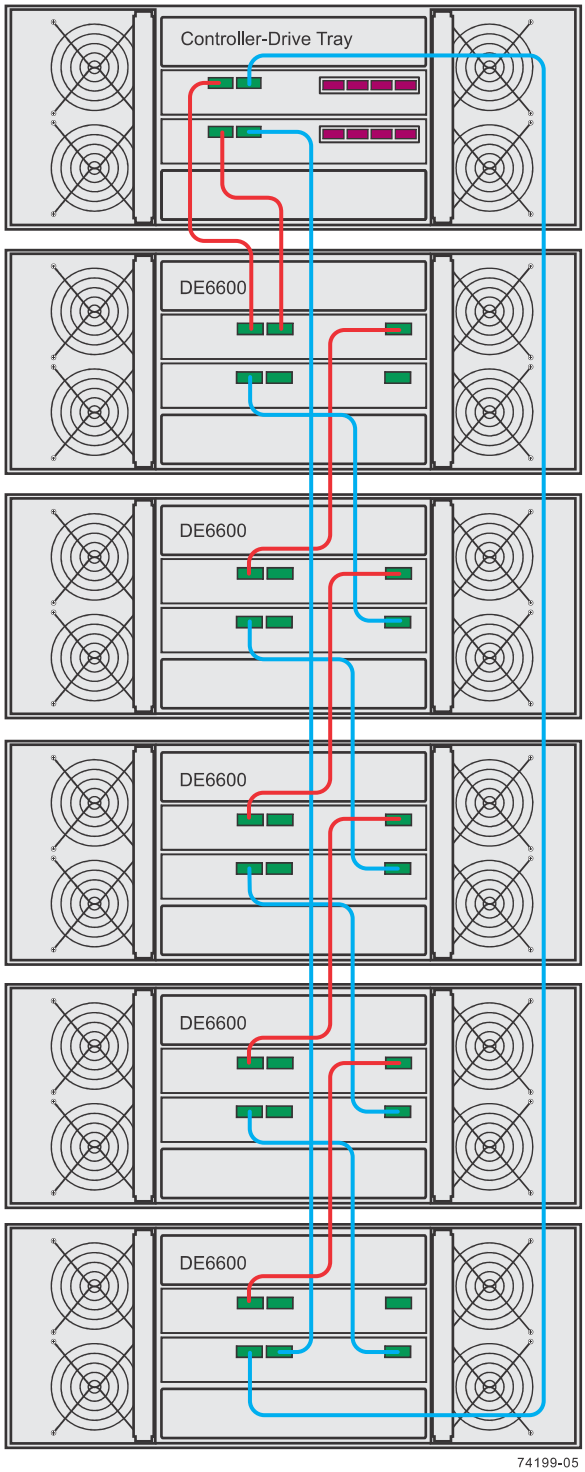
When you cable the storage array, keep these points in mind:

- To connect an ESM/IOM to a controller-drive tray, use both of the SAS in ports on the ESM or two of the SAS expansion ports on an IOM. Connect one SAS in port (or SAS expansion port) to a SAS Expansion port on controller A and the other SAS in port (or SAS expansion port) to a SAS Expansion port on controller B in the controller-drive tray.
- To connect two drive trays, connect a SAS Expansion port on an ESM/IOM in one drive tray to one of the SAS in ports on an ESM or one of the SAS expansion ports on an IOM in the other drive tray. Do not connect both SAS in ports on one ESM to other drive trays.

One E5560 controller-drive tray or one E5660 controller-drive tray and one DE6600 drive tray



One E5560 controller-drive tray or one E5660 controller-drive tray and five DE6600 drive trays



The figures above show storage arrays with DE6600 drive trays. A storage array with an E5560 controller-drive tray or an E5660 controller-drive tray might also include DE1600 drive trays or DE5600 drive trays. The cabling pattern remains the same, although the ESMs are arranged differently in DE1600 drive trays and DE5600 drive trays. *Drive tray cabling topologies for the E5524, E5512, E5612 and E5624 controller-drive trays, and the EF550 and EF560 flash arrays* on

page 79 shows the arrangement of ESMs and the location of ports on the DE1600 drive trays and DE5600 drive trays.

Drive tray cabling topologies for the E5400 controller-drive trays and the EF540 flash array

This section provides examples of drive tray cabling topologies for the E5400 controller-drive trays and the EF540 flash array.

Ports		Cable		
Data rate and protocol	**Number of connectors**	**Connector**	**Type**	**Length**
Management: RS232	1	Mini-USB to DB9	passive copper	2m
Management: 1Gb/s Ethernet	2	RJ45	passive copper	2m
Expansion: 6 Gb/s SAS	2	MiniSAS to MiniSAS	passive copper	2m or 1.5m

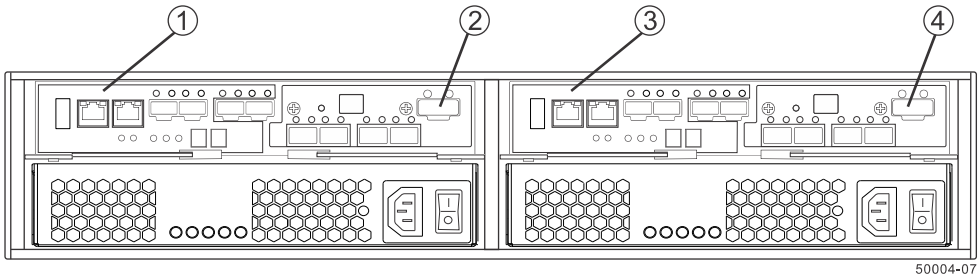
Drive channel redundancy for the E5400 controller-drive trays and the EF540 flash arrays

Controller-drive trays

Each controller in an E5412 controller-drive tray, E5424 controller-drive tray, E5460 controller-drive tray or EF540 flash array has one drive port. When a controller-drive tray has two controllers, the drive port on controller A and the drive port on controller B form a redundant pair. The following figures show the drive ports on dual-controller configurations.

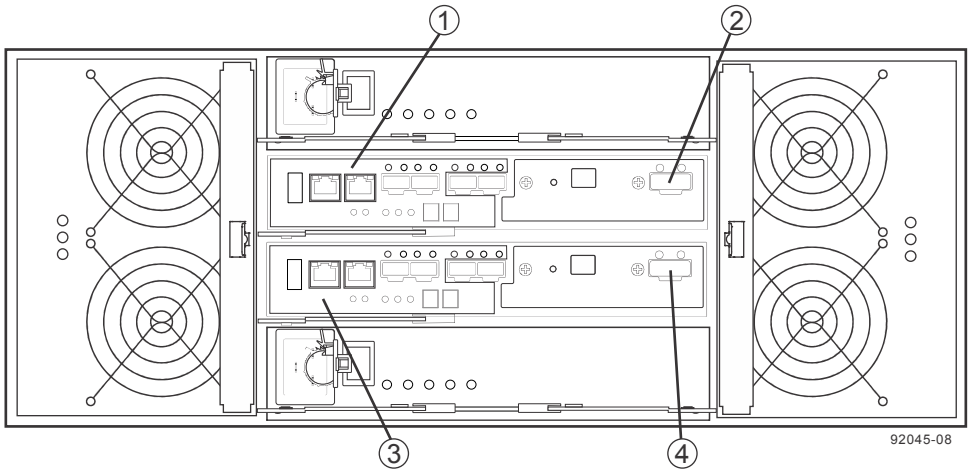
Note: To maintain data access in the event of the failure of a controller, an ESM, or a drive channel, you must connect a drive tray or a string of drive trays to both drive ports on a dual-controller configuration.

Redundant path pair on the E5412 controller-drive tray, E5424 controller-drive tray, and the EF540 flash array



1.	Controller canister A
2.	Drive expansion connector (connectors 2 and 4 comprise a redundant path pair.)
3.	Controller canister B
4.	Drive expansion connector (connectors 2 and 4 comprise a redundant path pair.)

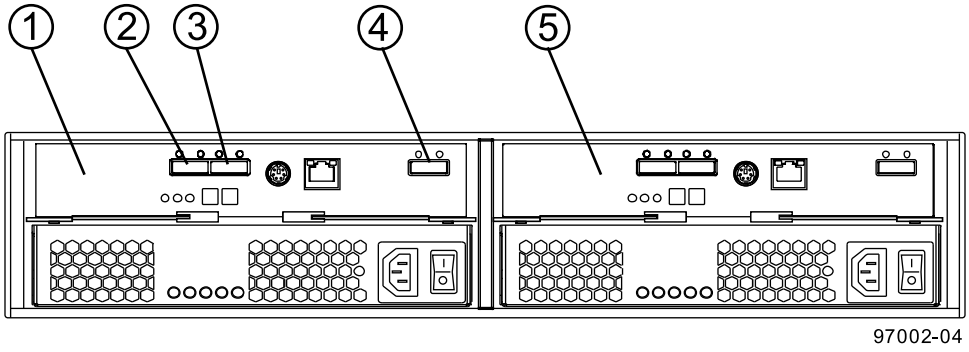
Redundant path pair on the E5460 controller-drive tray



1.	Controller canister A
2.	Drive expansion connector (connectors 2 and 4 comprise a redundant path pair.)
3.	Controller canister B
4.	Drive expansion connector (connectors 2 and 4 comprise a redundant path pair.)

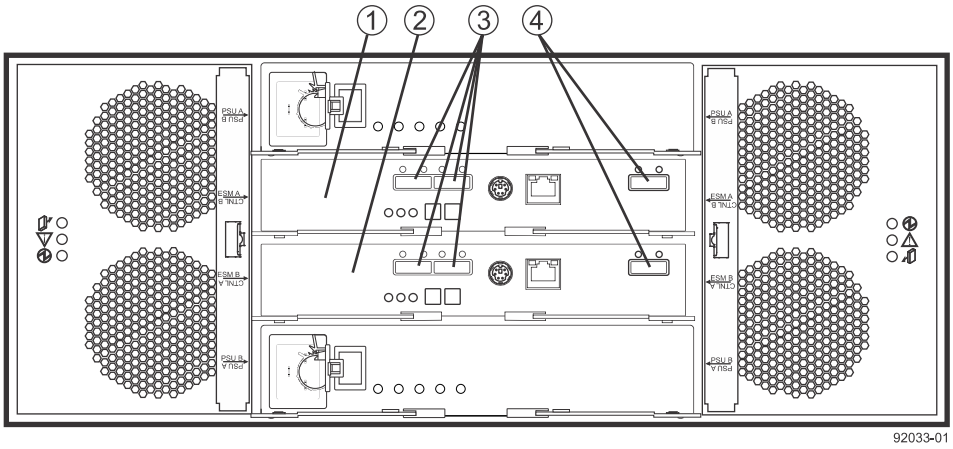
Drive trays

The following figure shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. Each environmental services module (ESM) has two SAS-2 in ports and one SAS-2 expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray.



1.	ESM A
2.	SAS in - port 1
3.	SAS in - port 2
4.	SAS out (expansion) port
5.	ESM B

The following figures show the SAS ports on a DE6600 drive tray. Each environmental services module (ESM) has two SAS in ports and one SAS expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray. Follow the cabling pattern shown in the figures in this topic.



1.	ESM A
2.	ESM B
3.	SAS in ports
4.	SAS out (expansion) port

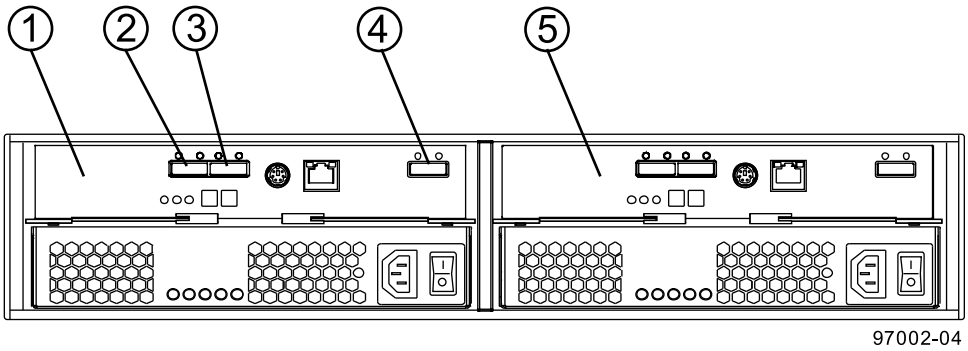
Drive tray cabling topologies for the E5424 controller-drive tray, the E5412 controller-drive tray, and EF540 flash array

The figures in this section show representative cabling configurations. The configurations shown guarantee that redundant data paths exist between the controller-drive tray and all attached drive trays in a storage array. The E5424 controller-drive tray and the E5412 controller-drive tray can be cabled to DE1600 drive trays, DE5600 drive trays, DE6600 drive trays, or various combinations of those three models of drive tray. For any one controller-drive tray, you must not exceed the limit of 15 connected drive trays or the limit for the total number of drive slots in the storage array. The drive slot limit is 384 drive slots. The drive slot limits includes drive slots in the controller-drive tray.

Note: The EF540 controller-drive tray can be cabled to the DE5600 drive trays only. The total number of drives in the storage array, including the drives in the EF540 controller-drive tray and those in all of the attached drive trays, must not exceed 120. The total number of trays in the storage array, including the EF540 controller-drive tray and all of the attached drive trays, must not exceed five. The drive trays must contain only solid-state disks (SSDs).

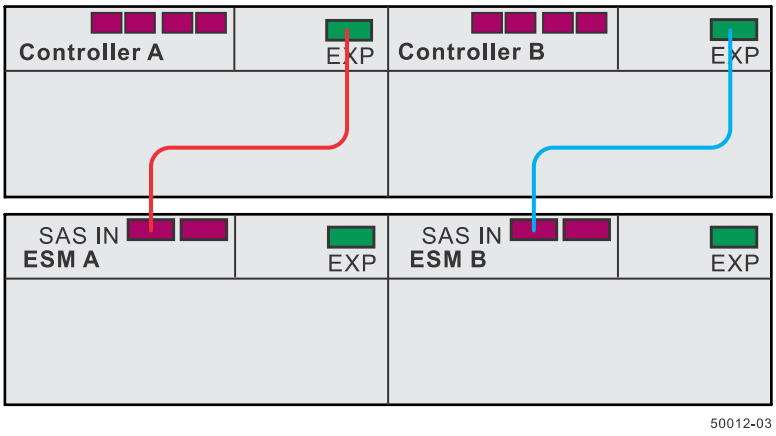
The following figure shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. You can connect either of the SAS ports labeled SAS 1 and SAS 2 to the SAS Expansion port on another drive tray or on a controller-drive tray. Do not make connections to both the SAS 1 port and the SAS 2 port on the same ESM.

SAS ports on a DE1600 drive tray or a DE5600 drive tray

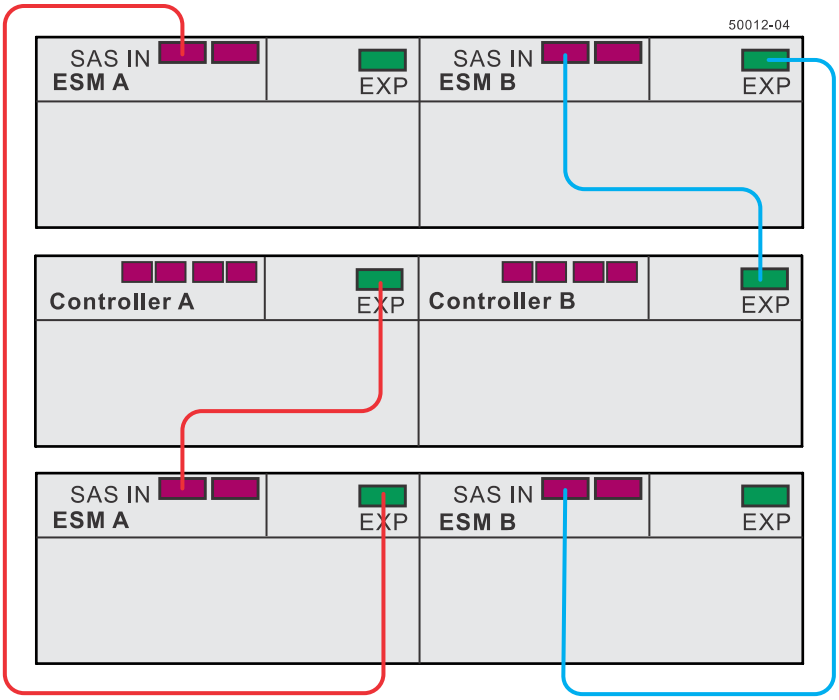


1.	ESM A
2.	SAS IN - Port 1
3.	SAS IN - Port 2
4.	SAS Out (Expansion) Port
5.	ESM B

One E5424 or E5412 controller-drive tray or one EF540 flash array and one DE1600 drive tray or DE5600 drive tray



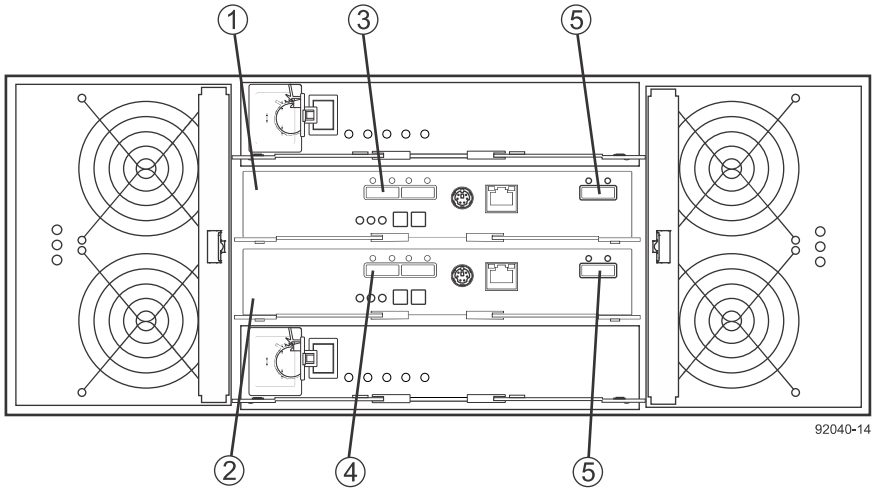
One E5424 or E5412 controller-drive tray or one EF540 flash array and two DE1600 drive trays or DE5600 drive trays



The following figures show the SAS ports on a DE6600 drive tray. You can connect either the left or right SAS port on an ESM to the SAS expansion port on another drive tray or on a controller-drive tray. Do not make connections to both the left and right SAS ports on the same ESM.

Note: The cabling pattern is independent of the physical location of the trays in the cabinet. If the storage array includes DE6600 drive trays, install those drive trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

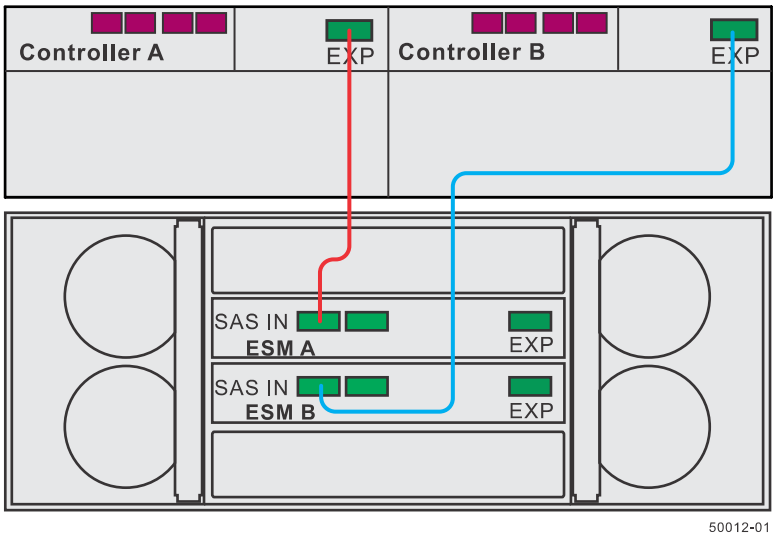
SAS ports on a DE6600 drive tray



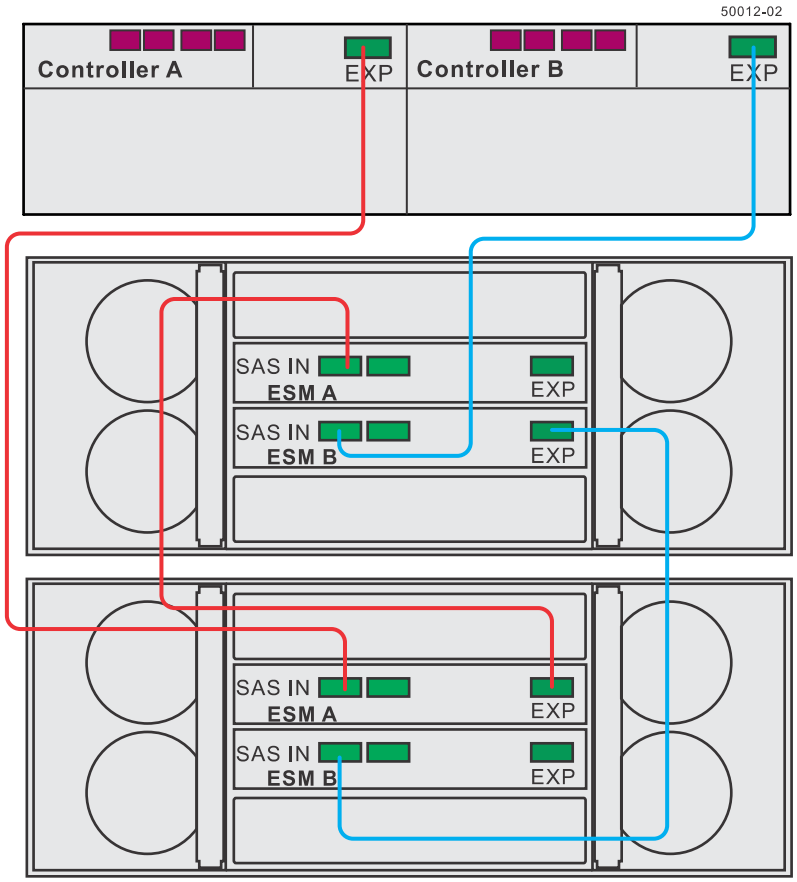
1.	ESM A
2.	ESM B
3.	SAS IN Ports
4.	SAS IN Ports
5.	SAS Out (Expansion) Port

Warning: Risk of bodily injury – An empty tray weighs approximately 56.7 kg (125 lb). Three persons are required to safely move an empty tray. If the tray is populated with components, a mechanized lift is required to safely move the tray.

One E5424 or E5412 controller-drive tray or one EF540 flash array and one DE6600 drive tray



One E5424 or E5412 controller-drive tray or one EF540 flash array and two DE6600 drive trays

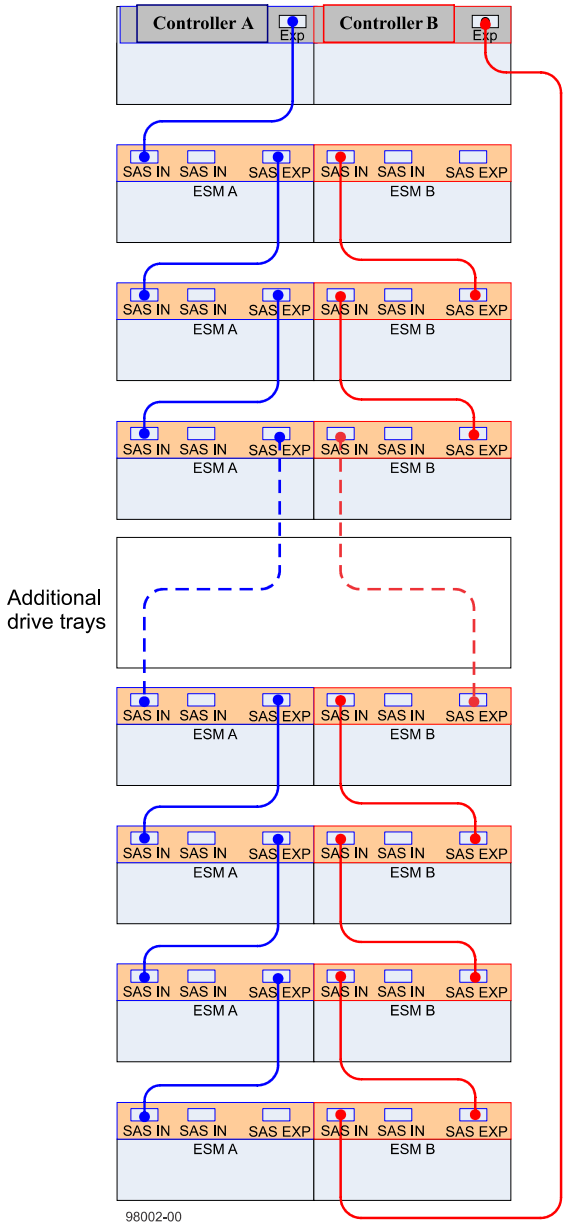


The following figure shows how the cabling pattern can be continued for additional drive trays until the 15 drive tray limit or the limit on the total number of drive slots in the storage array is reached. The figure uses the schematic representation for DE1600 drive trays or DE5600 drive trays. However, DE6600 drive trays can be included in the storage array as long as the same cabling pattern, connecting SAS Expansion ports to SAS In ports, is followed.

Important: The cabling pattern is independent of the physical location of the trays in the cabinet. If the storage array includes DE6600 drive trays, install those drive trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

Important: The cabling pattern is independent of the physical location of the trays in the cabinet. If the controller-drive tray is installed in the middle of the cabinet, as shown in the figures above, the physical cabling pattern will be different from what is shown, although the topology will be consistent. If the storage array includes DE6600 drive trays, install those drive trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

One E5424 or E5412 controller-drive tray or one EF540 flash array and seven or more DE6600 drive trays



Drive tray cabling topologies for the E5460 controller-drive tray

The figures in this section show representative cabling configurations. The configurations shown guarantee that redundant data paths exist between the controller-drive tray and all attached drive trays in a storage array. The E5460 controller-drive tray can be cabled to DE1600 drive trays, DE5600 drive trays, DE6600 drive trays, or various combinations of those three models of drive tray.

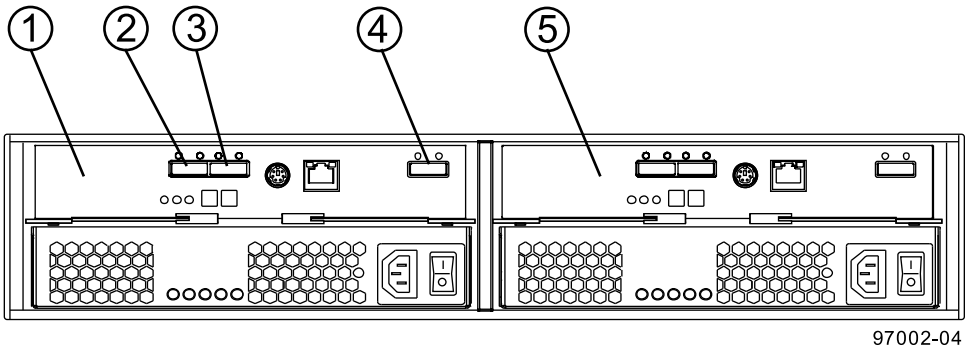
Warning: Risk of bodily injury – An empty tray weighs approximately 56.7 kg (125 lb). Three persons are required to safely move an empty tray. If the tray is populated with components, a mechanized lift is required to safely move the tray.

Note: Install the E5460 controller-drive tray at the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

For any one controller-drive tray, you must not exceed the limit of 15 connected drive trays or the limit for the total number of drive slots in the storage array. The total numbers of drive slots is limited to 384. The drive slot limit includes drive slots in the controller-drive tray.

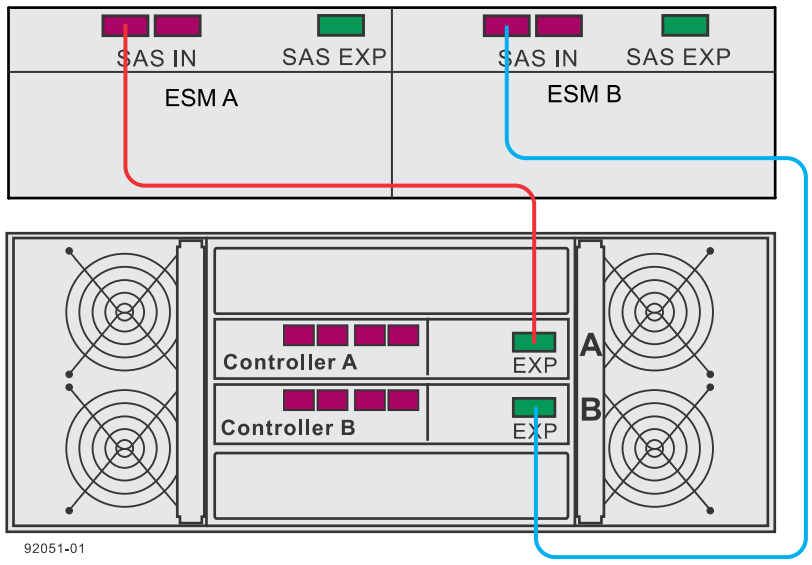
The following figure shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. You can connect either the left or right SAS port on an ESM to the SAS expansion port on another drive tray or on a controller-drive tray. Do not make connections to both the left and right SAS ports on the same ESM.

SAS ports on a DE1600 drive tray or a DE5600 drive tray

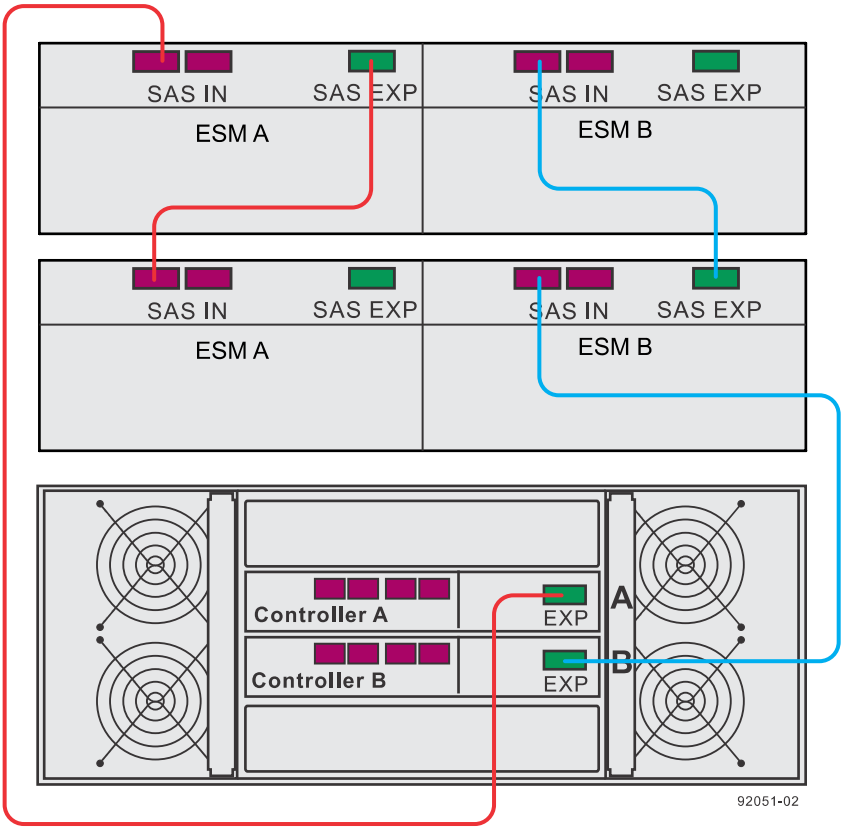


1.	ESM A
2.	SAS Port 1
3.	SAS Port 2
4.	SAS Expansion Port
5.	ESM B

One E5460 controller-drive tray and one DE1600 drive tray or DE5600 drive tray



One E5460 controller-drive tray and two DE1600 or DE5600 drive trays

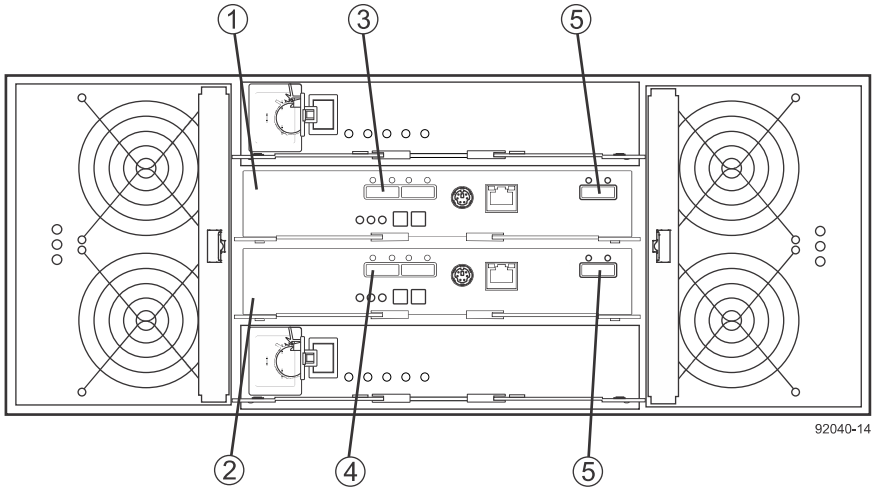


The following figures show the SAS ports on a DE6600 drive tray. You can connect either of the SAS ports labeled SAS 1 and SAS 2 to the SAS Expansion port on another drive tray or on a controller-drive tray. Do not make connections to both the SAS 1 port and the SAS 2 port on the same ESM.

Warning: Risk of bodily injury – An empty tray weighs approximately 56.7 kg (125 lb). Three persons are required to safely move an empty tray. If the tray is populated with components, a mechanized lift is required to safely move the tray.

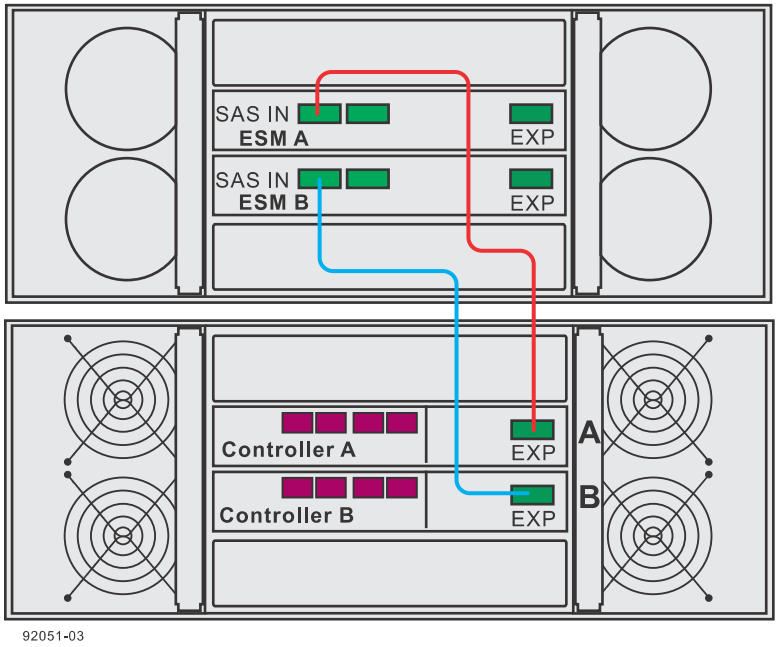
Note: If the storage array includes DE6600 drive trays, install those drive trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

SAS ports on a DE6600 drive tray

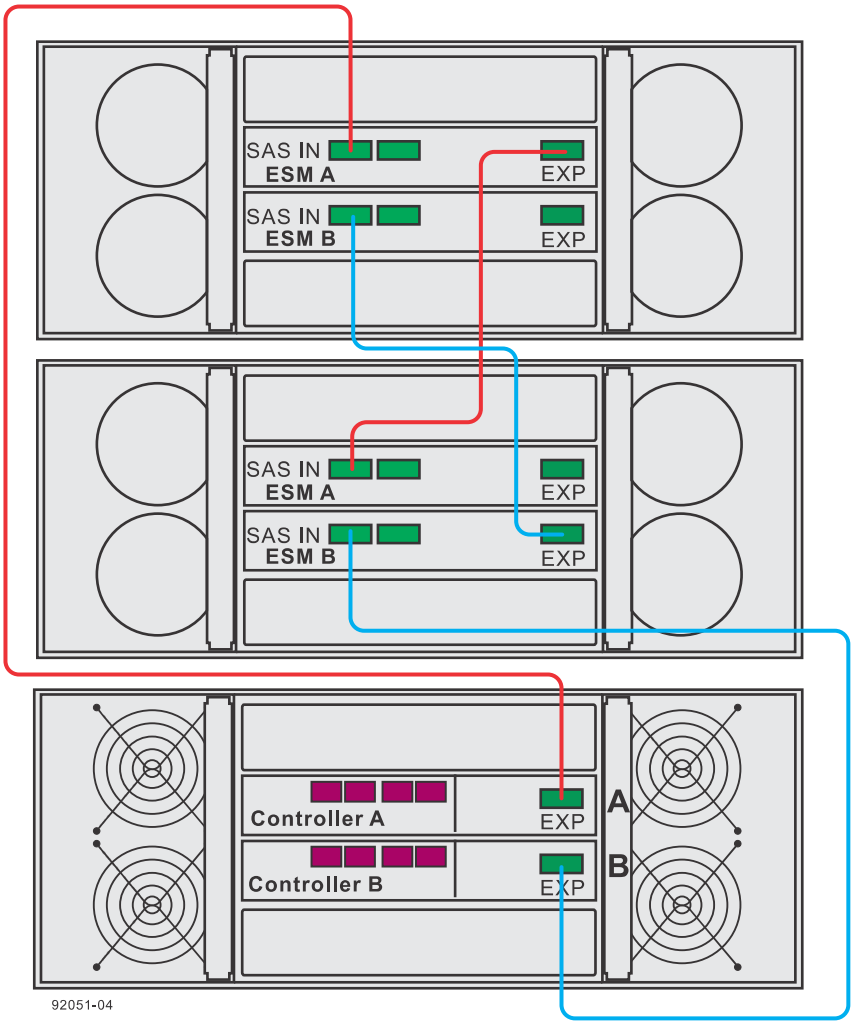


1.	ESM A
2.	ESM B
3.	SAS IN Port
4.	SAS IN Port
5.	SAS Expansion Ports

One E5460 controller-drive tray and one DE6600 drive tray



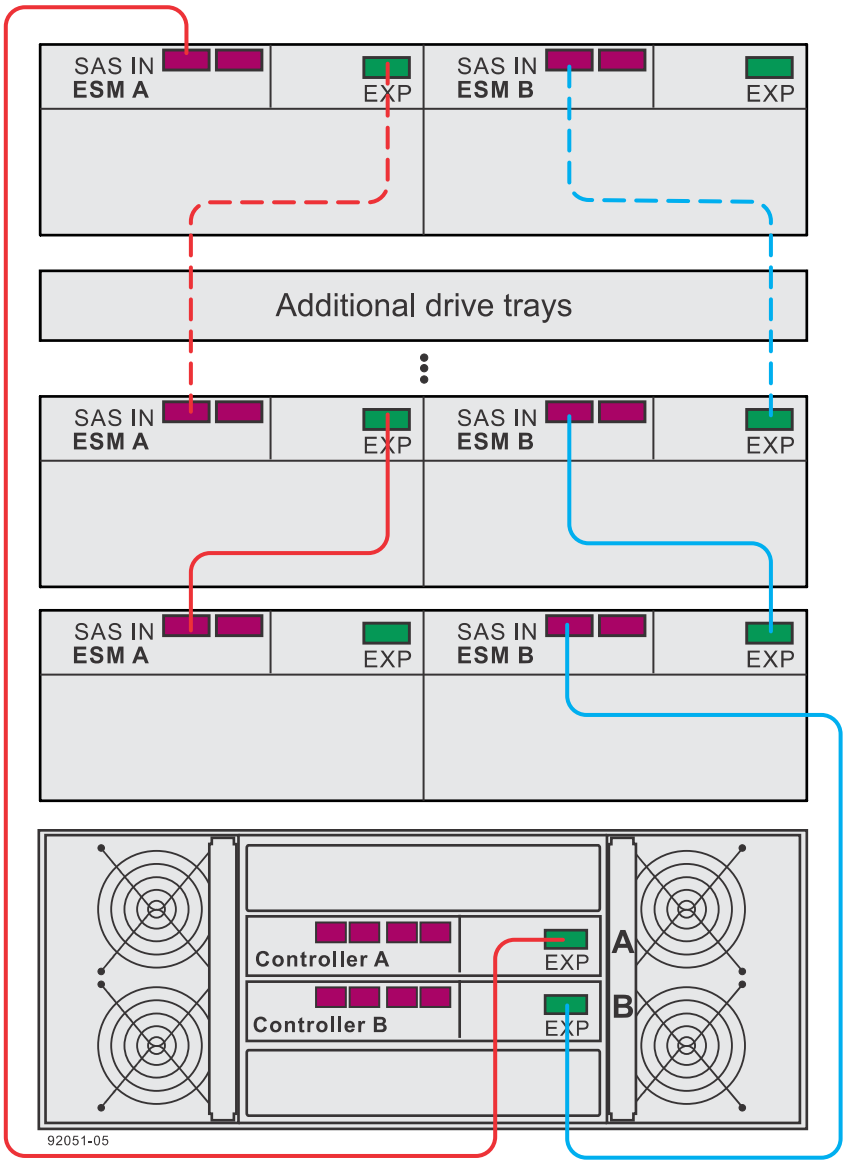
One E5460 controller-drive tray and two DE6600 drive trays



The following figure shows how the cabling pattern can be continued for additional drive trays until the 15 drive tray limit or the limit on the total number of drives in the storage array is reached. The figure uses the schematic representation for DE1600 drive trays or DE5600 drive trays. However, DE6600 drive trays can be included in the storage array as long as the same cabling pattern, connecting SAS Expansion ports to SAS IN ports, is followed.

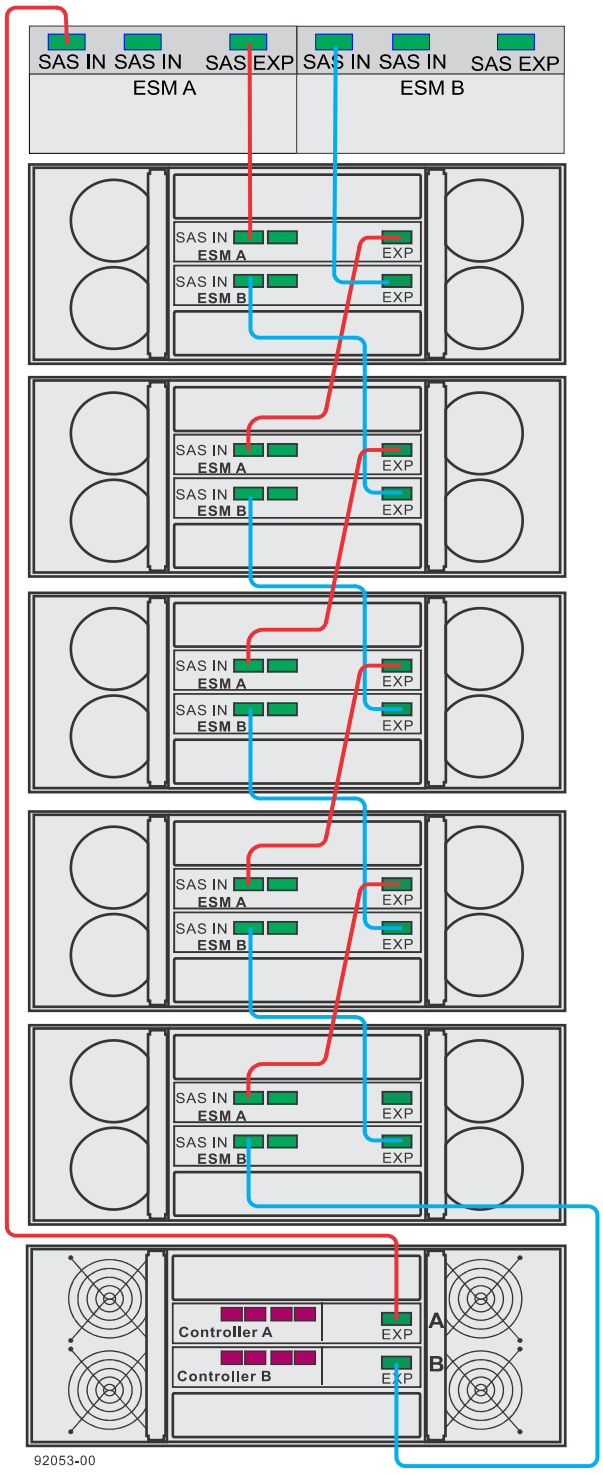
Note: The cabling pattern is independent of the physical location of the trays in the cabinet. If the storage array includes DE6600 drive trays, install those drive trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

One E5460 controller-drive tray and seven or more DE6600 drive trays



The following figure shows cabling for a storage array with the capacity for 384 drives, the maximum number. The storage array consists of a E5460 controller-drive tray with five DE6600 drive trays and one DE5600 drive tray. The maximum capacity also can be achieved by replacing the DE5600 drive tray in this example with two DE1600 drive trays.

A storage array with the capacity for 384 drives using a E5460 controller-drive tray



Drive cabling topologies for the E2800 controller shelves

This section provides examples of drive shelf cabling topologies for the E2800 controller shelves. The E2800 controller shelf models are the E2812, E2824, and E2860. The total number of drive bays in the storage array, including the drive bays in the controller shelf and those in the drive shelves, must not exceed 180. The total number of shelves (controller shelves and drive shelves) in a storage array must not exceed four.

You can cable E2800 controller shelves to SAS-3 drive shelves (DE212C, DE224C, or DE460C), SAS-2 drive trays (DE1600, DE5600, or DE660) or combinations of SAS-2 and SAS-3 drive shelves. Use cables with mini-SAS HD (SFF-8644) connectors to connect SAS-3 drive shelves. Use cables with a mini-SAS (SFF-8088) connector on one end and a mini-SAS HD connector on the other end to connect SAS-2 drive shelves to the controller shelf. Use cables with a mini-SAS connector on both ends for connections between SAS-2 drive shelves.

Note: When you install SAS cables, make sure that the blue tabs on the SAS cables face the bottom of the tray or shelf and that each connector clicks into place.

You should cable both expansion ports on each controller for maximum throughput. You might cable both ports on a controller to the same IOM in the same drive shelf (single-stack configuration). Alternatively, you might cable each port on a controller to a different IOM in a different drive shelf (dual-stack configuration).

Note: Simplex systems do not provide redundant connections to drive shelves. If a connection or an IOM fails, all drive shelves that connect to the controller shelf indirectly through the failed connection or drive shelf become inaccessible.

When you cable a mix of SAS-2 and SAS-3 drive shelves to the same controller shelf, you should use a dual-stack configuration. Put all of the SAS-3 drive shelves in one stack and all of the SAS-2 drive shelves in the other stack.

In dual-stack configurations where all of the drive shelves have the same connection type (SAS-2 or SAS-3), the number of drive shelves in each stack should be as balanced as possible. If the total number of drive shelves is even, the number in one stack should be the same as the number in the other. If the total number of drive shelves is odd, the number in one stack should differ from the number in the other by one.

Drive channel redundancy for the E2800 controller shelves

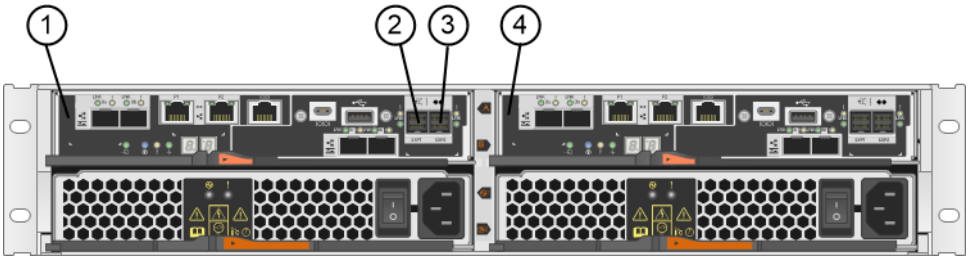
Learn the physical features of the E2800 controller shelves that support drive cabling to minimize the risk of losing access to data.

Controller shelves

Each controller in an E2812, E2824, or E2860 controller shelf has two drive ports. On each controller, the two drive ports connect to the same drive channel (SAS domain). When a controller shelf has two controllers, the drive channel on controller A and the drive channel on controller B form a redundant pair.

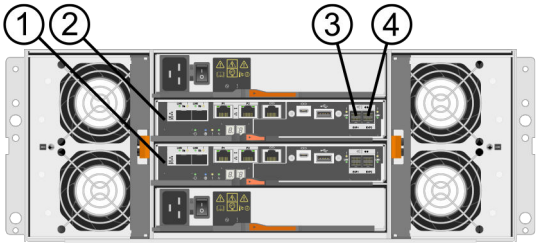
Note: To maintain data access in the event of the failure of a controller, an ESM/IOM, or a drive channel, each drive tray must have a direct connection or an indirect connection (through other drive trays) to at least one drive port on each controller in a dual-controller configuration.

The following figure shows the drive ports (SAS expansion ports) on a dual-controller configuration for the E2812 or E2824 controller shelf. The controllers occupy the top half of each shelf. The drive ports are at the far right of each controller.



1.	Controller A
2.	SAS port 1
3.	SAS port 2
4.	Controller B

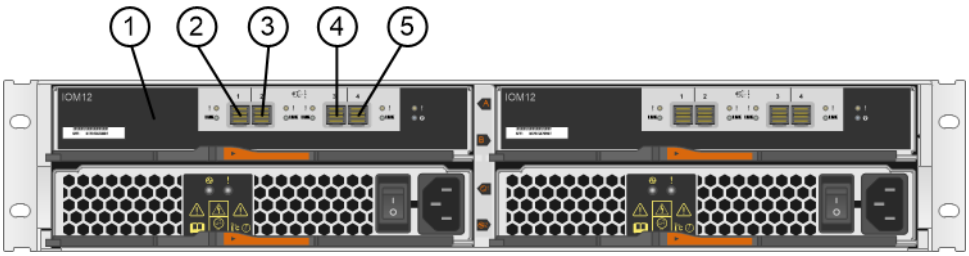
The following figure shows the drive ports (SAS expansion ports) on a dual-controller configuration for the E2860 controller shelf. The drive ports are at the far right of each controller.



1.	Controller A
2.	Controller B
3.	SAS port 1
4.	SAS port 2

Drive shelves

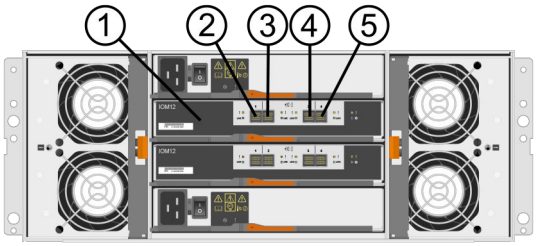
The following figures show the SAS ports on a DE212C drive shelf or a DE224C drive shelf. The I/O modules (IOMs) occupy the top half of the shelf. Each IOM has four SAS-3 expansion ports. You can connect these ports to SAS-3 expansion ports on another drive shelf or drive tray or to SAS expansion ports on a controller shelf or controller-drive tray.



1.	IOM A
2.	SAS port 1

3.	SAS port 2
4.	SAS port 3
5.	SAS port 4

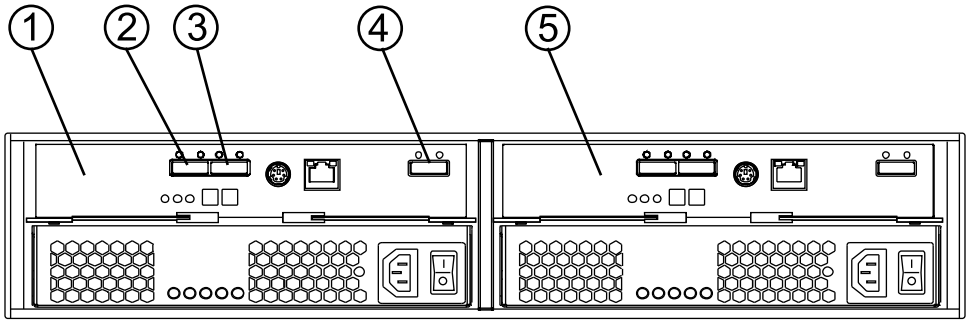
The following figure shows the SAS ports on a DE460C drive shelf. The I/O modules (IOMs) occupy the middle positions in the shelf Each IOM has four SAS-3 expansion ports. You can connect these ports to SAS-3 expansion ports on another drive shelf or to SAS expansion ports on a controller shelf.



1.	IOM A
2.	SAS port 1
3.	SAS port 2
4.	SAS port 3
5.	SAS port 3

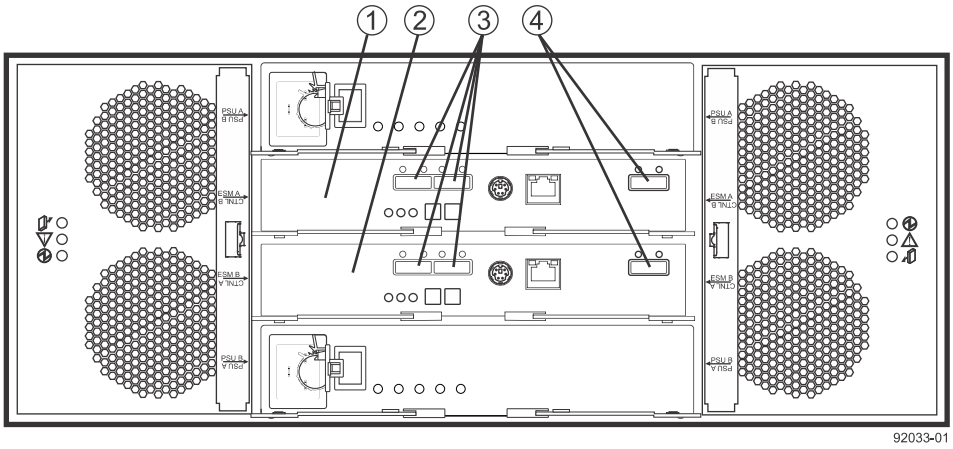
Drive trays

The following figure shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. Each environmental services module (ESM) has two SAS-2 in ports and one SAS-2 expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray.



1.	ESM A
2.	SAS in - port 1
3.	SAS in - port 2
4.	SAS out (expansion) port
5.	ESM B

The following figures show the SAS ports on a DE6600 drive tray. Each environmental services module (ESM) has two SAS in ports and one SAS expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray. Follow the cabling pattern shown in the figures in this topic.



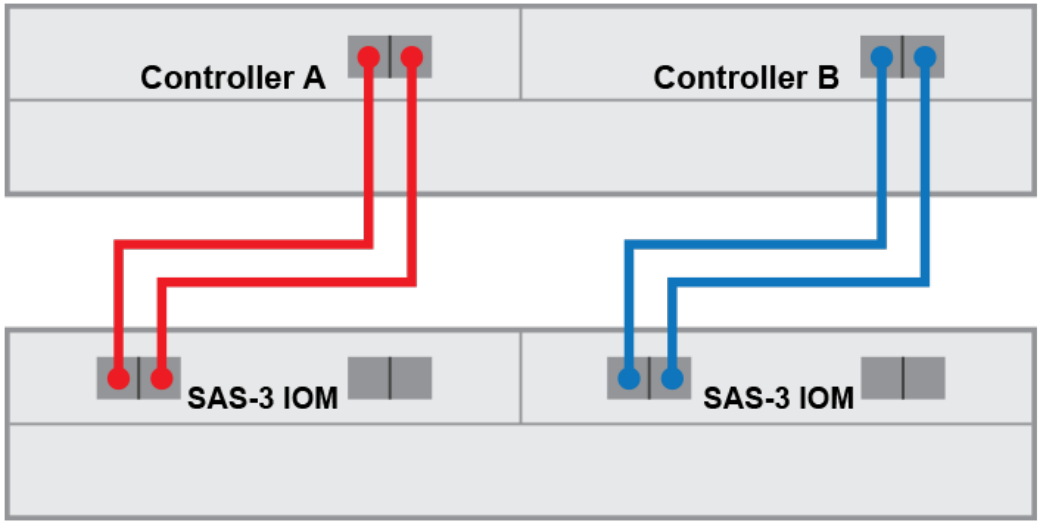
1.	ESM A
2.	ESM B
3.	SAS in ports
4.	SAS out (expansion) port

Drive cabling topologies for the E2824 controller shelf and the E2812 controller shelf

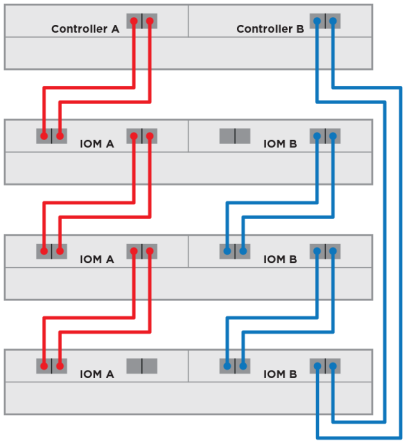
Depending on the number and type of drive shelves that you need to connect, see the applicable figure for a cabling topology. Each example shows a duplex controller shelf configuration with redundant paths to the drive shelves. Several options for cabling might be possible for a given drive shelf configuration.

Note: For simplex controller shelf configurations, use the cabling topology shown for controller A in the other figures in this section as a pattern for cabling.

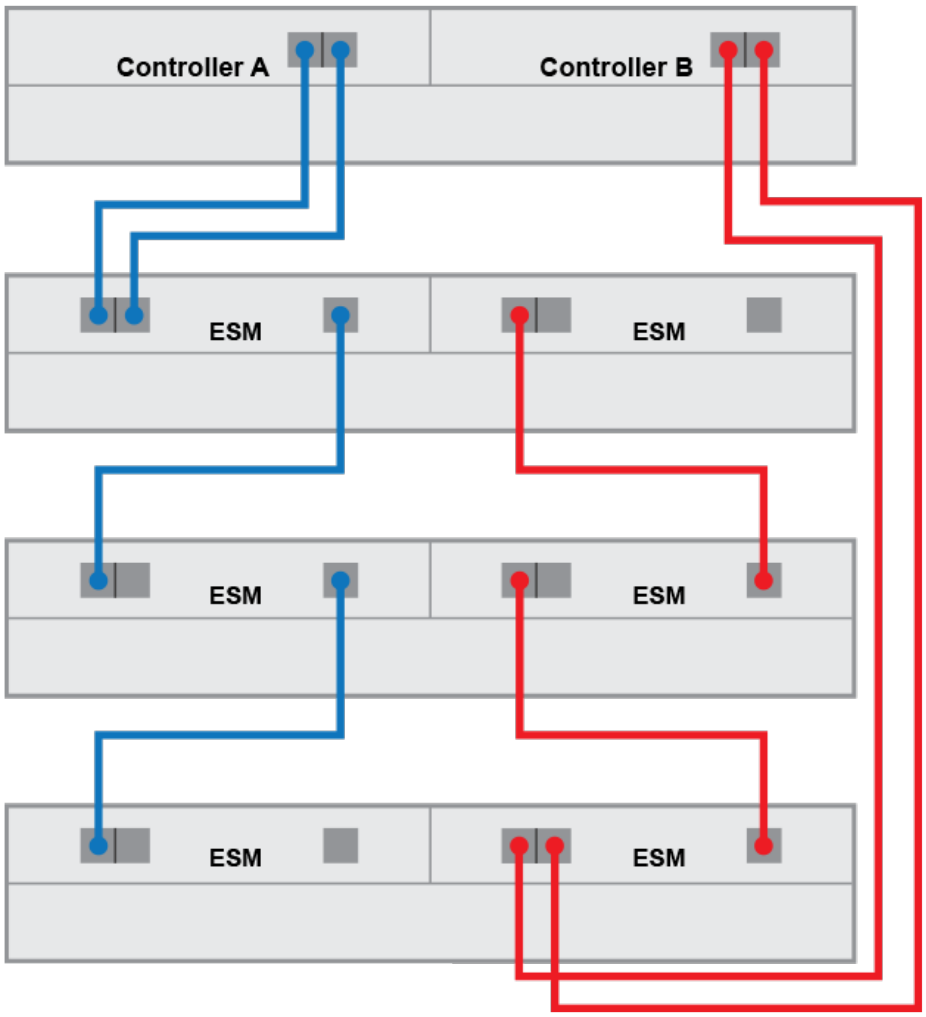
One E2800 controller shelf and one SAS-3 drive shelf



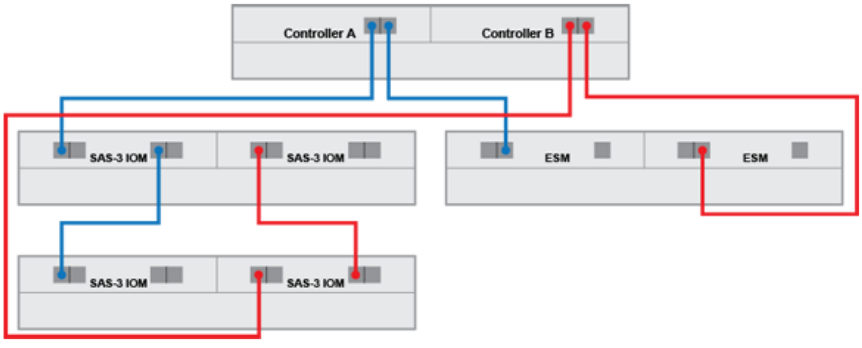
One E2800 controller shelf and a single stack of SAS-3 drive shelves



One E2800 controller shelf and a single stack of SAS-2 drive shelves



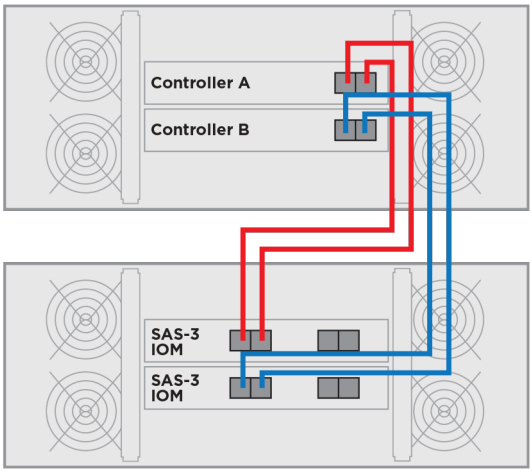
One E2800 controller shelf and dual stacks with a mix of SAS-2 and SAS-3 drive shelves



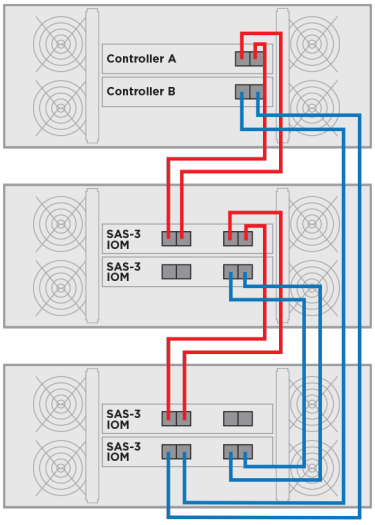
Drive cabling topologies for the E2860 controller shelf

Depending on the number and type of drive shelves that you need to connect, see the applicable figure for a cabling topology. Each example shows an E2860 controller shelf configuration with redundant paths to the drive shelves. Several options for cabling might be possible for a given drive shelf configuration.

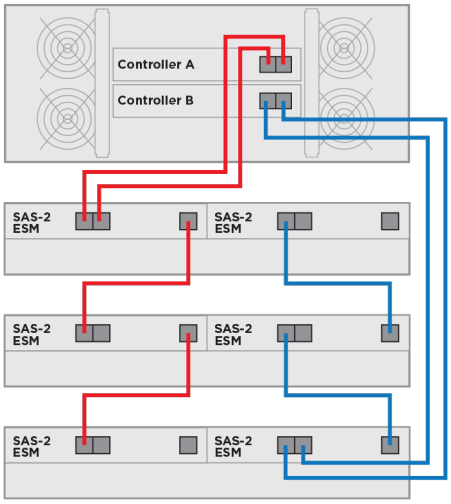
One E2860 controller shelf and one SAS-3 drive shelf



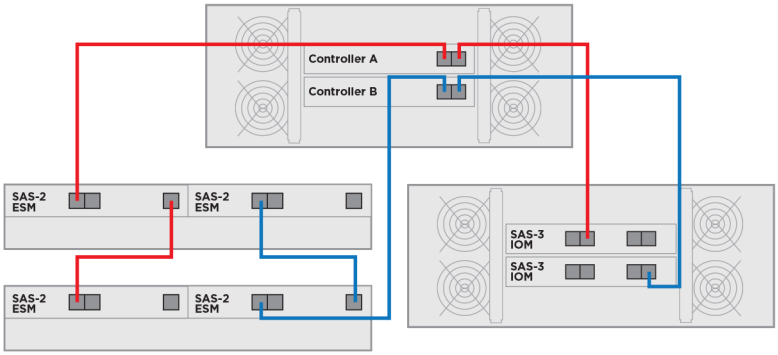
One E2860 controller shelf and a single stack of SAS-3 drive shelves



One E2860 controller shelf and a single stack of SAS-2 drive shelves



One E2860 controller shelf and dual stacks with a mix of SAS-2 and SAS-3 drive shelves



Drive tray cabling topologies for the E2700 controller-drive trays

This section provides examples of drive tray cabling topologies for the E2700 controller-drive trays. The E2700 controller-drive tray models are: the E2712, the E2724 and the E2760. The total number of drive slots in the storage array, including the drive slots in the controller-drive tray and those in the drive trays, must not exceed 192.

Note: Simplex systems do not provide redundant connections to drive trays. If a connection or an environmental services module (ESM) fails, all drive trays that connect to the controller-drive tray indirectly through the failed connection or drive tray becomes inaccessible.

Drive channel redundancy for the E2700 controller-drive trays

Learn the physical features of the E2700 controller trays that support drive cabling to minimize the risk of losing access to data.

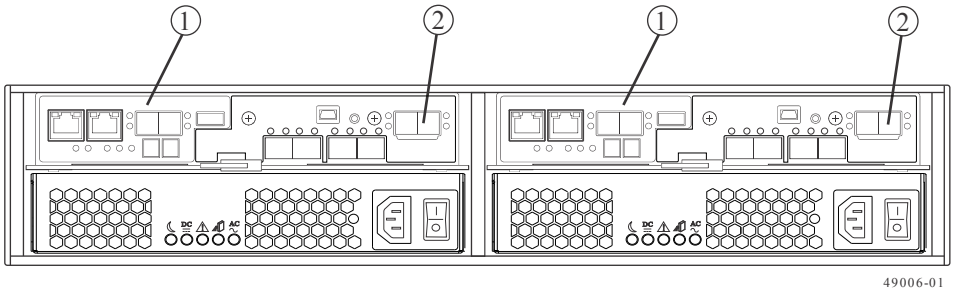
Controller-drive trays

Each controller in an E2712 or an E2724 controller-drive tray has two drive ports. On each controller, the two drive ports connect to the same drive channel (SAS domain). When a controller-drive tray has two controllers, the drive channel on controller A and the drive channel on controller B form a redundant pair.

Note: To maintain data access in the event of the failure of a controller, an ESM/IOM, or a drive channel, each drive tray must have a direct connection or an indirect connection (through other drive trays) to at least one drive port on each controller in a dual-controller configuration.

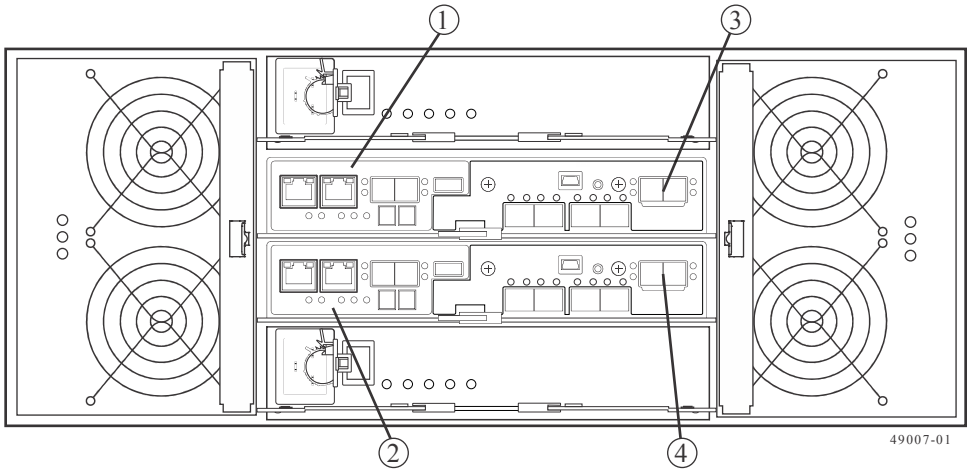
The following figure shows the drive ports on a dual-controller configuration.

Redundant path pairs on the E2712 and E2724 controller-drive trays



1.	Controller Canisters
2.	Drive Expansion Connectors

Redundant path pairs on the E2760 controller-drive tray

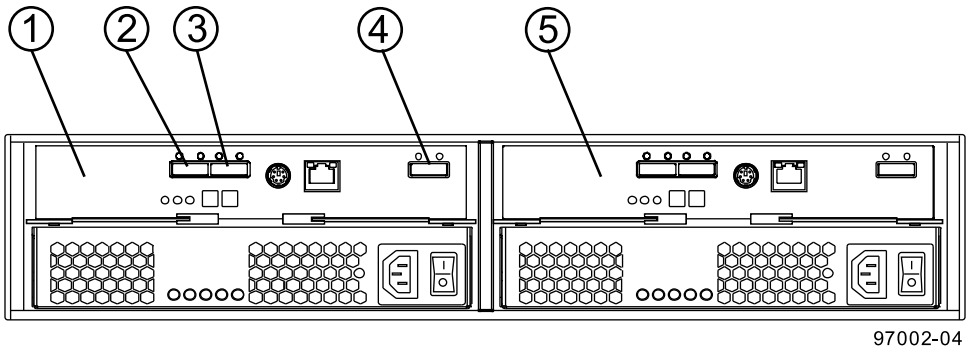


1.	Controller A
2.	Controller B
3.	SAS Drive Expansion Connector

4.	SAS Drive Expansion Connector

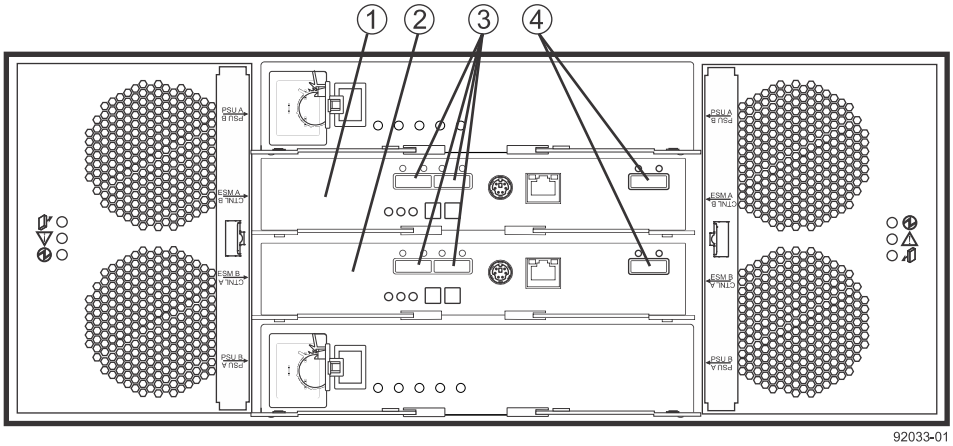
Drive trays

The following figure shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. Each environmental services module (ESM) has two SAS-2 in ports and one SAS-2 expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray.



1.	ESM A
2.	SAS in - port 1
3.	SAS in - port 2
4.	SAS out (expansion) port
5.	ESM B

The following figures show the SAS ports on a DE6600 drive tray. Each environmental services module (ESM) has two SAS in ports and one SAS expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray. Follow the cabling pattern shown in the figures in this topic.

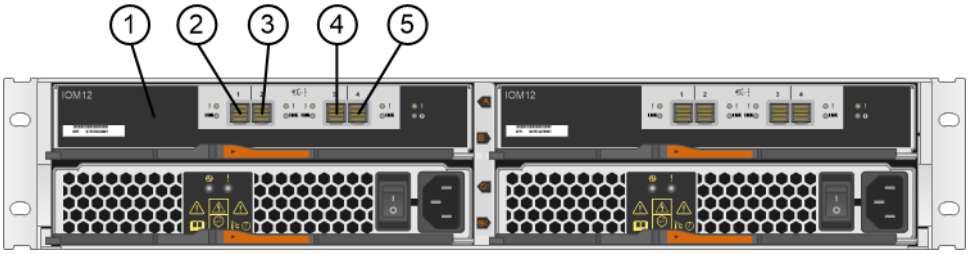


1.	ESM A
2.	ESM B
3.	SAS in ports

4.	SAS out (expansion) port

Drive shelves

The following figures show the SAS ports on a DE212C drive shelf or a DE224C drive shelf. The I/O modules (IOMs) occupy the top half of the shelf. Each IOM has four SAS-3 expansion ports. You can connect these ports to SAS-3 expansion ports on another drive shelf or drive tray or to SAS expansion ports on a controller shelf or controller-drive tray.



1.	IOM A
2.	SAS port 1
3.	SAS port 2
4.	SAS port 3
5.	SAS port 4

Drive tray cabling topologies for the E2712 controller-drive tray and the E2724 controller-drive tray

Depending on the number of drive trays that you need to connect, see the applicable figure for a cabling topology. Each example shows a duplex controller-drive tray configuration with redundant paths to the drive trays. Several options for cabling might be possible for a given drive tray configuration. You should cable both expansion ports on each controller for maximum throughput.

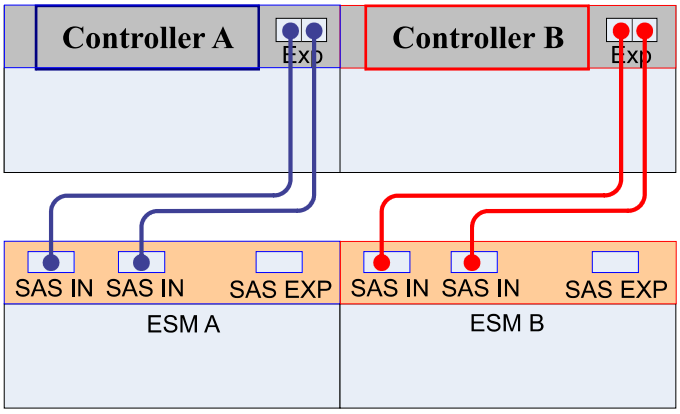
Dual-stack cabling is recommended for better performance if your storage array includes more than one expansion drive tray. In dual-stack cabling configurations, the number of drive trays in each stack should be as balanced as possible. Each stack should have the same number of drive trays for an even total number of drive trays or the number of drive trays in each stack should differ by one for an odd total number of drive trays. For a simplex controller-drive tray configurations, do not use the cabling pattern shown in the figure "One E2700 controller-drive tray and one drive tray (recommended cabling for maximum throughput)." Use the cabling topology shown for controller A in the other figures in this section as a pattern for cabling with a simplex controller-drive tray.

These controller-drive trays can be cabled to SAS-2 drive trays (DE1600, DE5600, and DE6600), or various combinations of those three models of drive tray. For any one controller-drive tray, you must not exceed the limit of 15 connected drive trays or the limit for the total number of drive slots in the storage array.

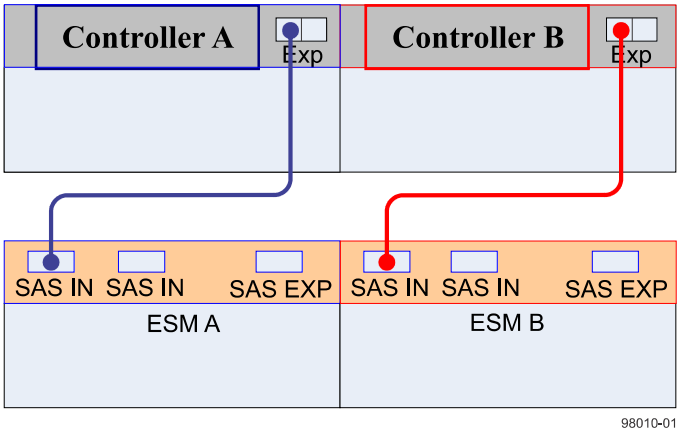
If your configuration has a mix of SAS-2 and SAS-3 drive trays, use a dual-stack configuration. Group the SAS-3 drive trays together in one stack and the SAS-2 drive trays in the other stack. Use cables with a mini-SAS connector on one end and a mini-SAS HD connector on the other end to connect a SAS-2 drive tray to the controllers. The mini-SAS HD connectors attach to the controllers while the mini-SAS connectors attach to the ESMs in SAS-2 drive trays. Use cables with mini-SAS HD connectors on both ends between the controllers and a SAS-3 drive trays as well as between SAS-3 drive trays. Use cables with mini-SAS connectors on both ends between SAS-2 drive trays.

Note: The following figures shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. You can connect either of the SAS ports labeled SAS 1 and SAS 2 to the SAS Expansion port on another drive tray or on a controller-drive tray. You should not make connections to both the SAS 1 port and the SAS 2 port on the same ESM.

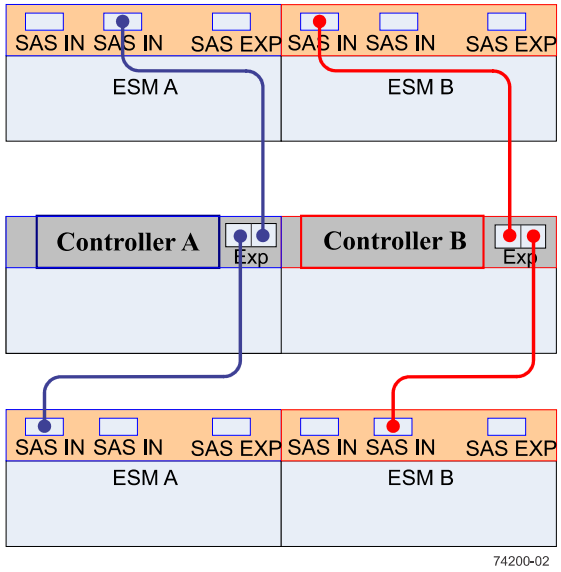
One E2700 controller-drive tray and one drive tray (recommended cabling for maximum throughput)



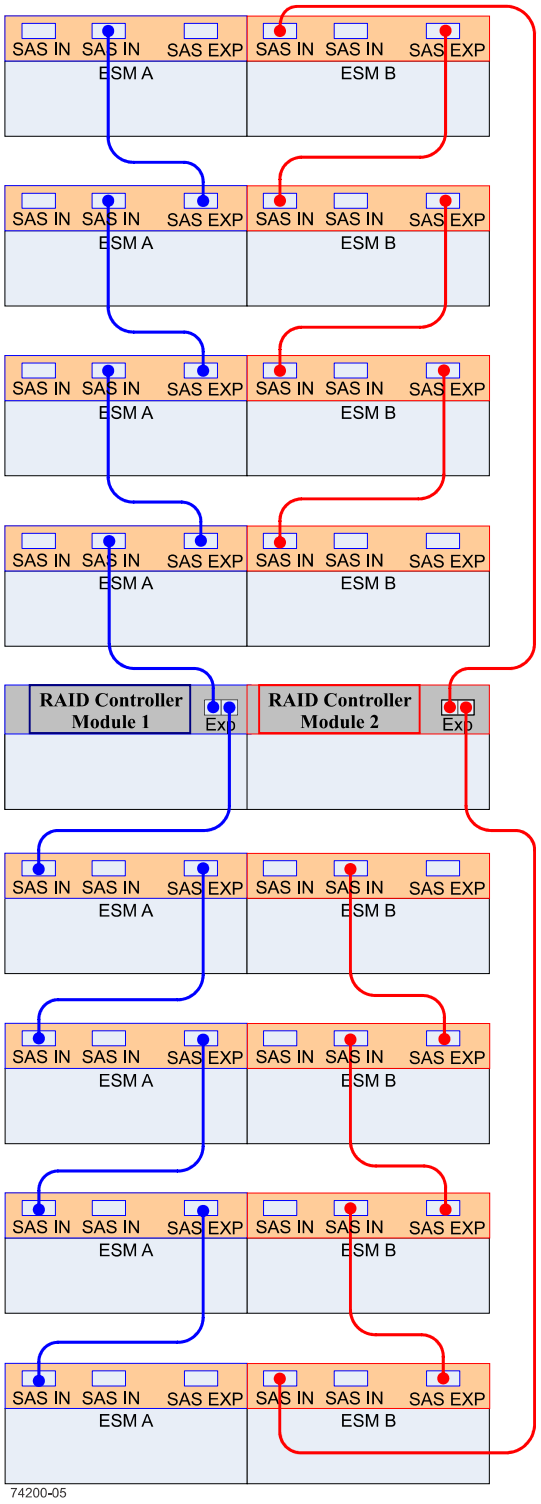
One E2700 controller-drive tray and one drive tray



One E2700 controller-drive tray and two drive trays (dual stack configuration)



One E2700 controller-drive tray and eight drive trays (dual stack configuration)



The pattern shown can be extended to include additional drive trays as long as neither the limit on maximum number of drive slots nor the limit on maximum number of trays is exceeded.

Drive tray cabling topologies for the E2760 controller-drive tray

This section provides examples of drive tray cabling topologies for the E2760 controller-drive tray. The E2760 controller-drive tray can be cabled only to DE6600 drive trays. The total number of drives in the storage array, including the drives in the controller-drive tray and those in the drive trays, must not exceed 192.

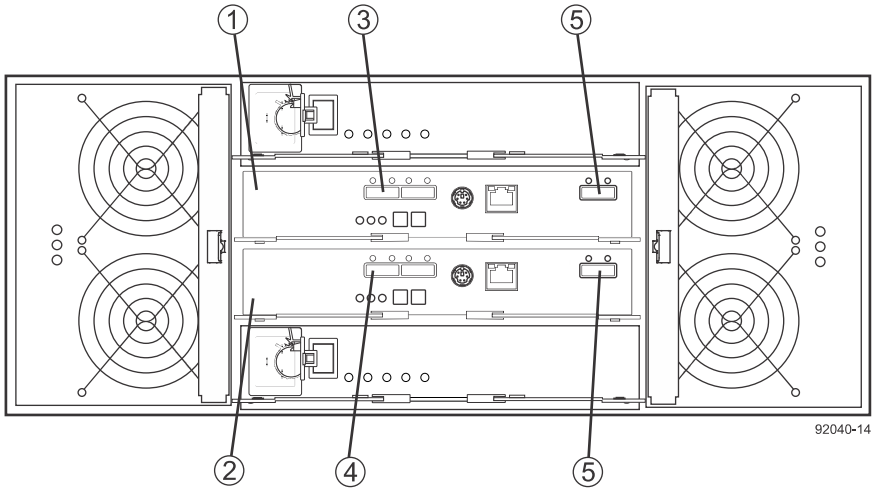
Depending on the number of drive trays that you need to connect, see the applicable figure for a cabling topology. Each example shows a duplex controller-drive tray configuration with redundant paths to the drive trays.

Warning: Risk of bodily injury – An empty tray weighs approximately 56.7 kg (125 lb). Three persons are required to safely move an empty tray. If the tray is populated with components, a mechanized lift is required to safely move the tray.

Note: Install trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

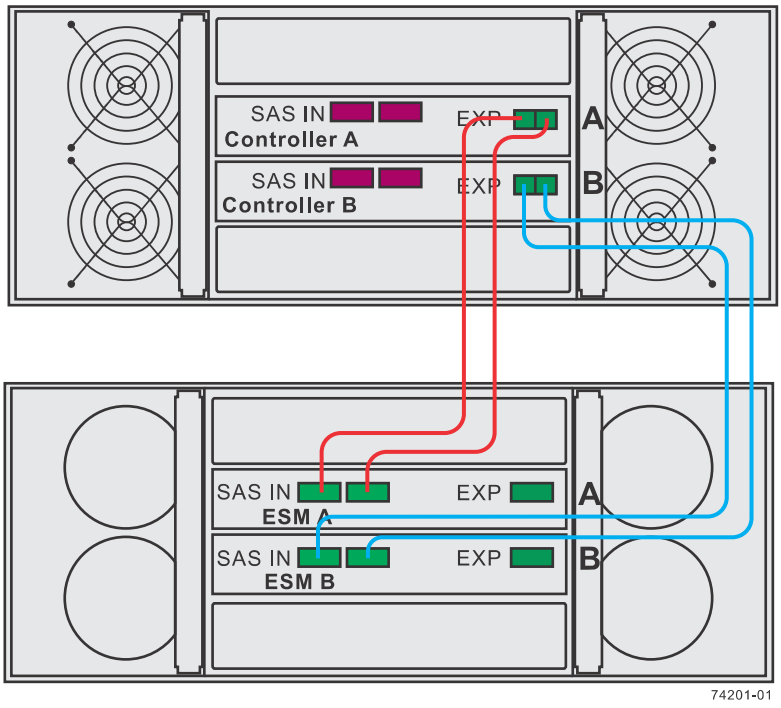
The following figures show the SAS ports on a DE6600 drive tray. You can connect any of the SAS ports to the SAS Expansion port on another drive tray or on a controller-drive tray.

SAS ports on a DE6600 drive tray

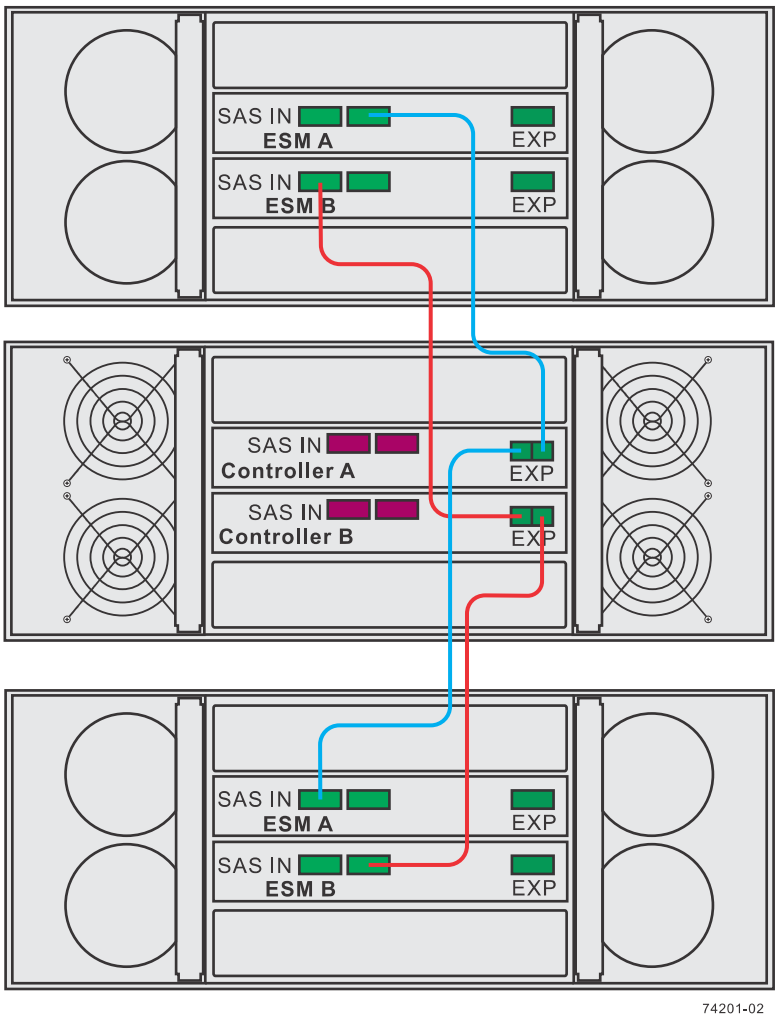


1.	ESM A
2.	ESM B
3.	SAS in port
4.	SAS in port
5.	SAS expansion ports

One E2760 controller-drive tray and one drive tray



One E2760 controller-drive tray and two drive trays (dual stack)



Drive tray cabling topologies for the E2600 controller-drive trays

Learn the physical features of the E2600 controller trays that support drive cabling to minimize the risk of losing access to data.

This section provides examples of drive tray cabling topologies for the E2600 controller-drive trays. The E2600 controller-drive tray models are: the E2612, the E2624, and the E2660. The total number of drive slots in the storage array, including the drive slots in the controller-drive tray and those in the drive trays, must not exceed 192.

Note: Simplex systems do not provide redundant connections to drive trays. If a connection or an environmental services module (ESM) fails, all drive trays that connect to the controller-drive tray indirectly through the failed connection or drive tray become inaccessible.

Drive channel redundancy for the E2612 and E2624 controller-drive trays

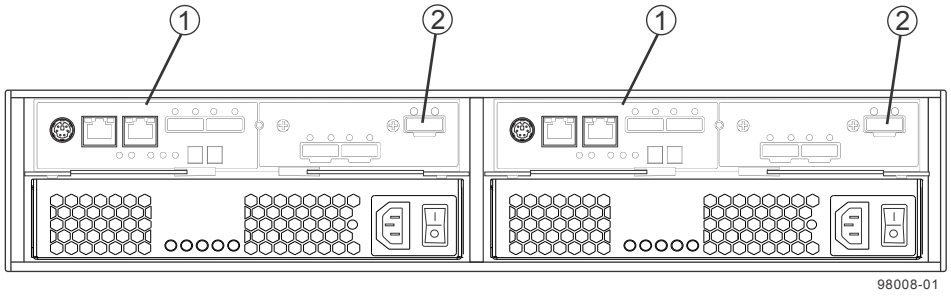
Controller-drive trays

Each controller in an E2612 or E2624 controller-drive tray has one drive port. When a controller-drive tray has two controllers, the drive port on controller A and the drive port on controller B form a redundant pair.

Note: To maintain data access in the event of the failure of a controller, an ESM, or a drive channel, you must connect a drive tray or a string of drive trays to both drive ports on a dual-controller configuration.

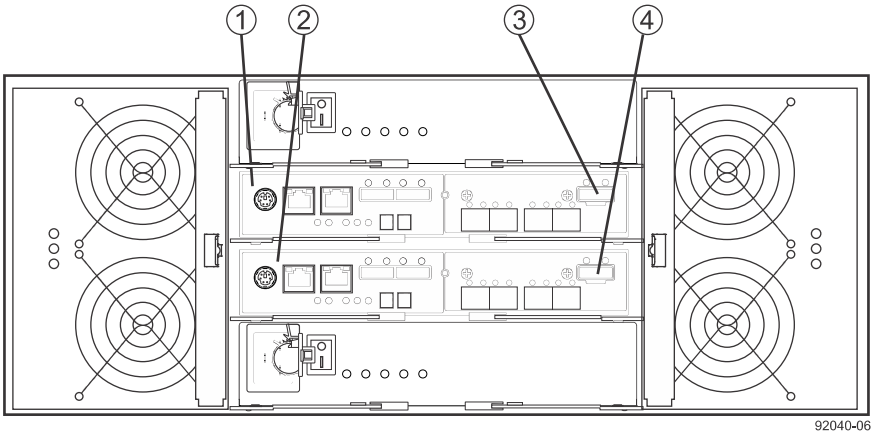
The following figures show the drive ports on dual-controller configurations.

Drive channel redundancy on the E2612 and E2624 controller-drive trays



1.	Controller canisters
2.	Drive expansion connectors (rredundant path pair)

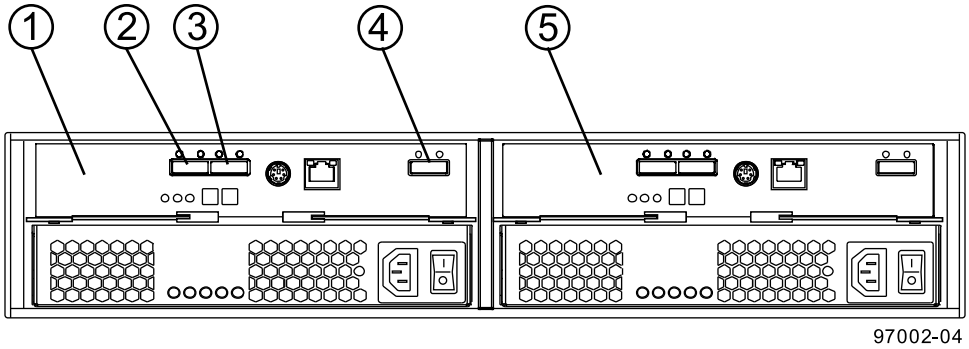
Drive channel redundancy on the E2660 controller-drive tray



1.	Controller A
2.	Controller B
3.	SAS drive expansion connector (connectors 3 and 4 comprise a redundant path pair)
4.	SAS drive expansion connector (connectors 3 and 4 comprise a redundant path pair)

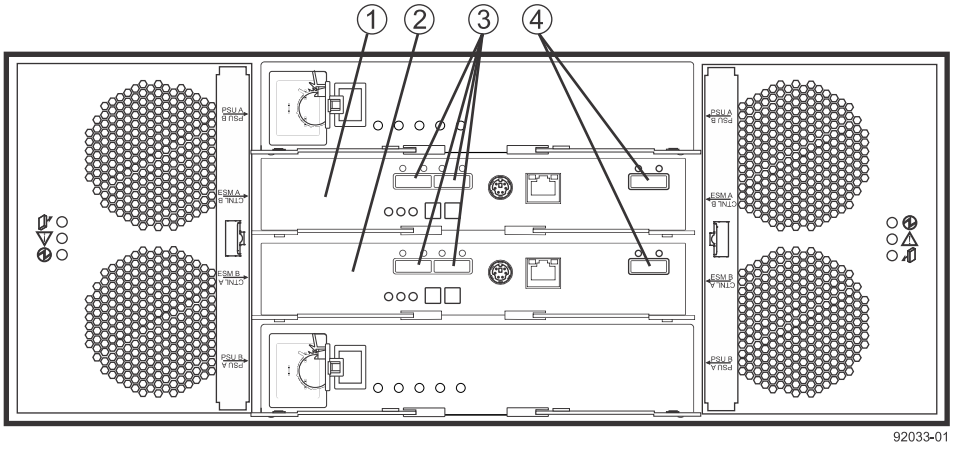
Drive trays

The following figure shows the SAS ports on a DE1600 drive tray or a DE5600 drive tray. Each environmental services module (ESM) has two SAS-2 in ports and one SAS-2 expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray.



1.	ESM A
2.	SAS in - port 1
3.	SAS in - port 2
4.	SAS out (expansion) port
5.	ESM B

The following figures show the SAS ports on a DE6600 drive tray. Each environmental services module (ESM) has two SAS in ports and one SAS expansion (out) port. You can connect the SAS in ports to the SAS expansion port on another drive tray or to the SAS expansion port on a controller-drive tray. Follow the cabling pattern shown in the figures in this topic.



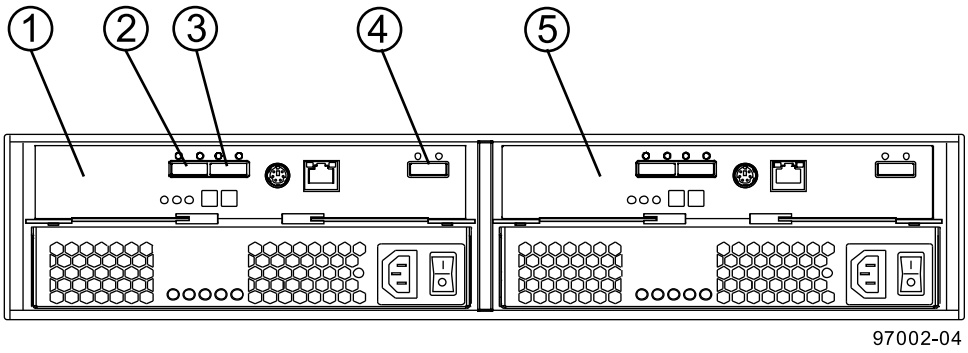
1.	ESM A
2.	ESM B
3.	SAS in ports
4.	SAS out (expansion) port

Drive tray cabling topologies for the E2612 controller-drive tray and the E2624 controller-drive tray

Depending on the number of drive trays that you need to connect, see the applicable figure for a cabling topology. Each example shows a duplex controller-drive tray configuration with redundant paths to the drive trays. For a simplex controller-drive tray configuration, use the cabling topology shown for controller A in the applicable figure.

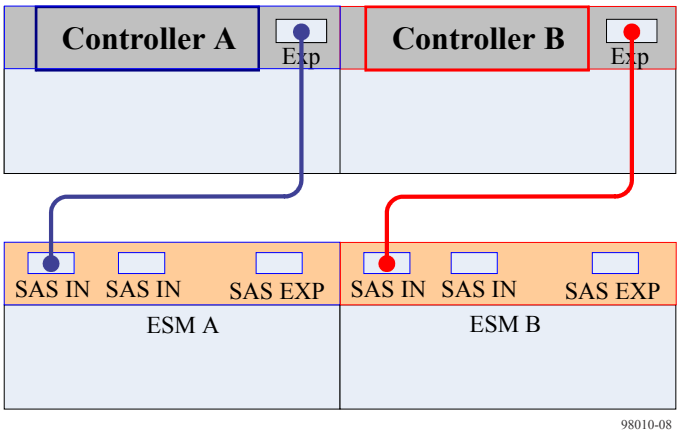
Note: The following figures show the SAS ports on a DE1600 drive tray or a DE5600 drive tray. You can connect either of the SAS ports labeled SAS 1 and SAS 2 to the SAS expansion port on another drive tray or on a controller-drive tray. You should not make connections to both the SAS 1 port and the SAS 2 port on the same ESM.

SAS ports on a DE1600 drive tray or a DE5600 drive tray

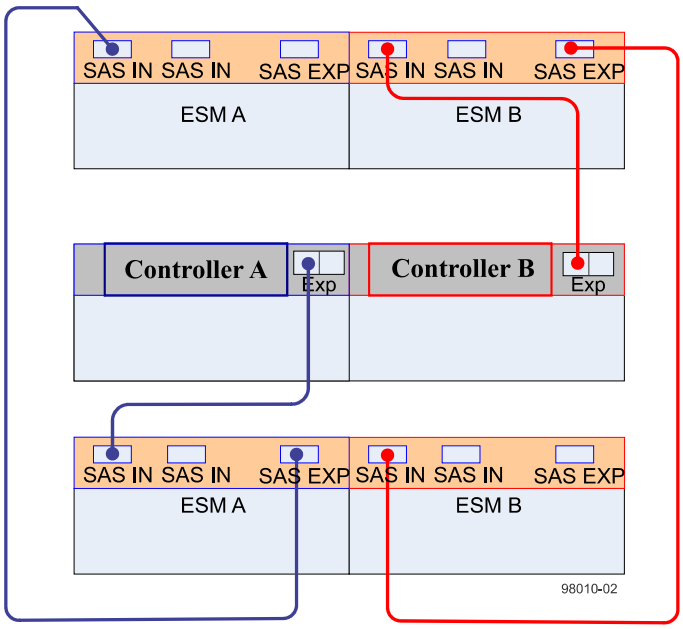


1.	ESM A
2.	SAS in port 1
3.	SAS in port 2
4.	SAS out (expansion) port
5.	ESM B

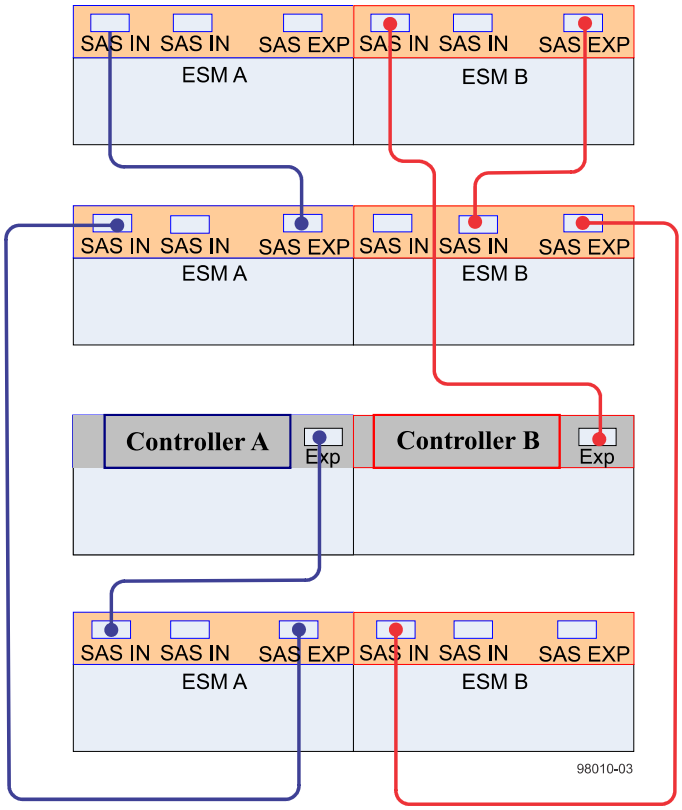
One E2600 controller-drive tray and one drive tray



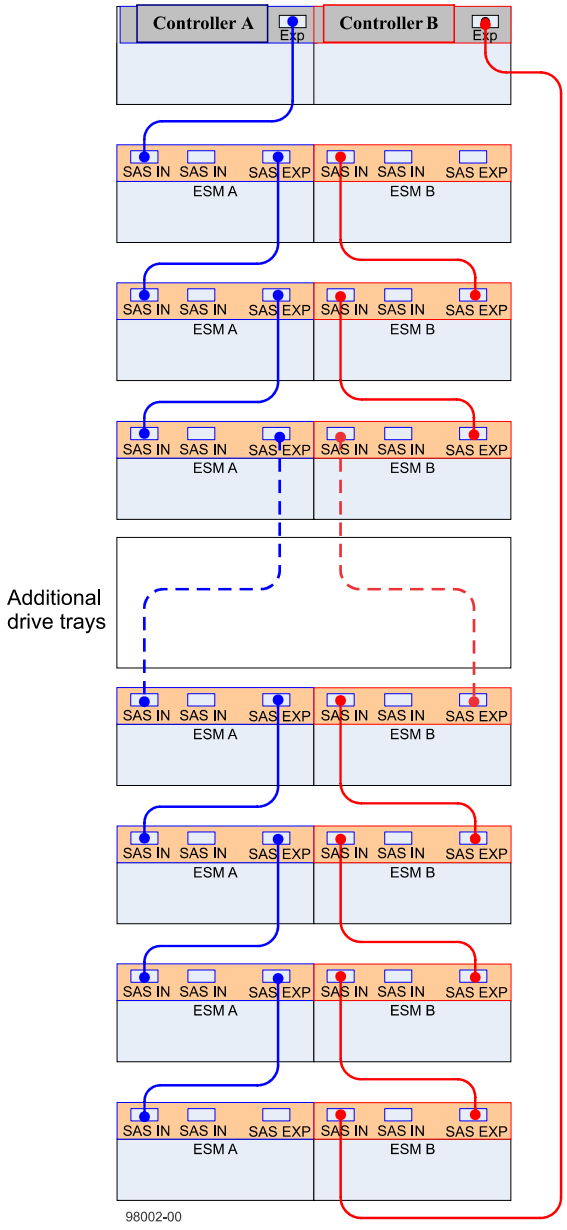
One E2600 controller-drive tray and two drive trays



One E2600 controller-drive tray and three drive trays



One E2600 controller-drive tray and eight drive trays



Drive cabling topologies for the E2660 controller-drive tray with DE6600 drive trays

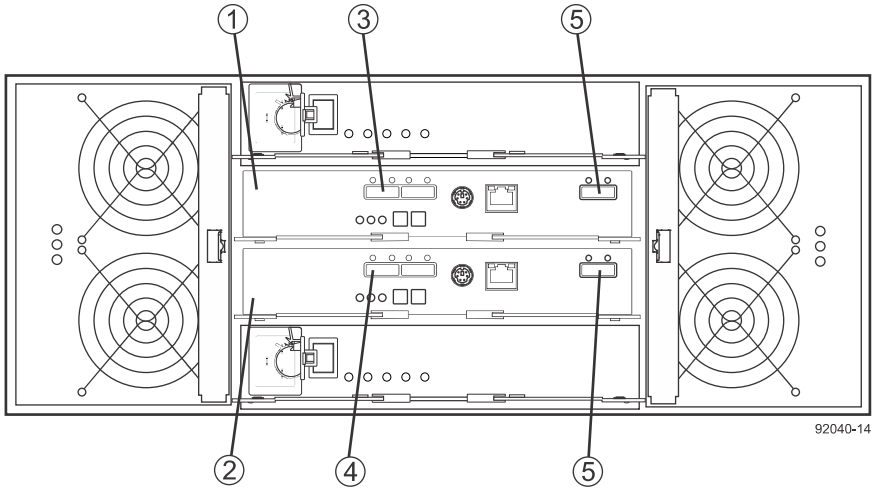
Depending on the number of drive trays that you need to connect, see the applicable figure for a cabling topology. Each example shows a duplex controller-drive tray configuration with redundant paths to the drive trays. For a simplex controller-drive tray configuration, use the cabling topology shown for controller A in the applicable figure.

Warning: Risk of bodily injury – An empty tray weighs approximately 56.7 kg (125 lb). Three persons are required to safely move an empty tray. If the tray is populated with components, a mechanized lift is required to safely move the tray.

Note: Install trays beginning from the bottom of the cabinet so that the cabinet does not become top-heavy. A top-heavy cabinet has a greater risk of falling over.

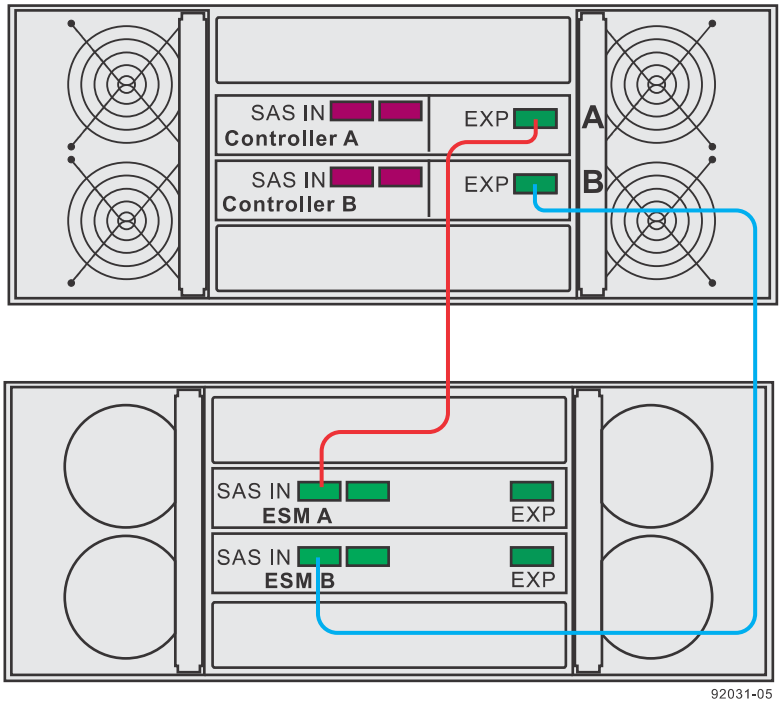
The following figures show the SAS ports on a DE6600 drive tray. You can connect either of the SAS ports labeled SAS 1 and SAS 2 to the SAS Expansion port on another drive tray or on a controller-drive tray. Do not make connections to both the SAS 1 port and the SAS 2 port on the same ESM.

SAS ports on a DE6600 drive tray

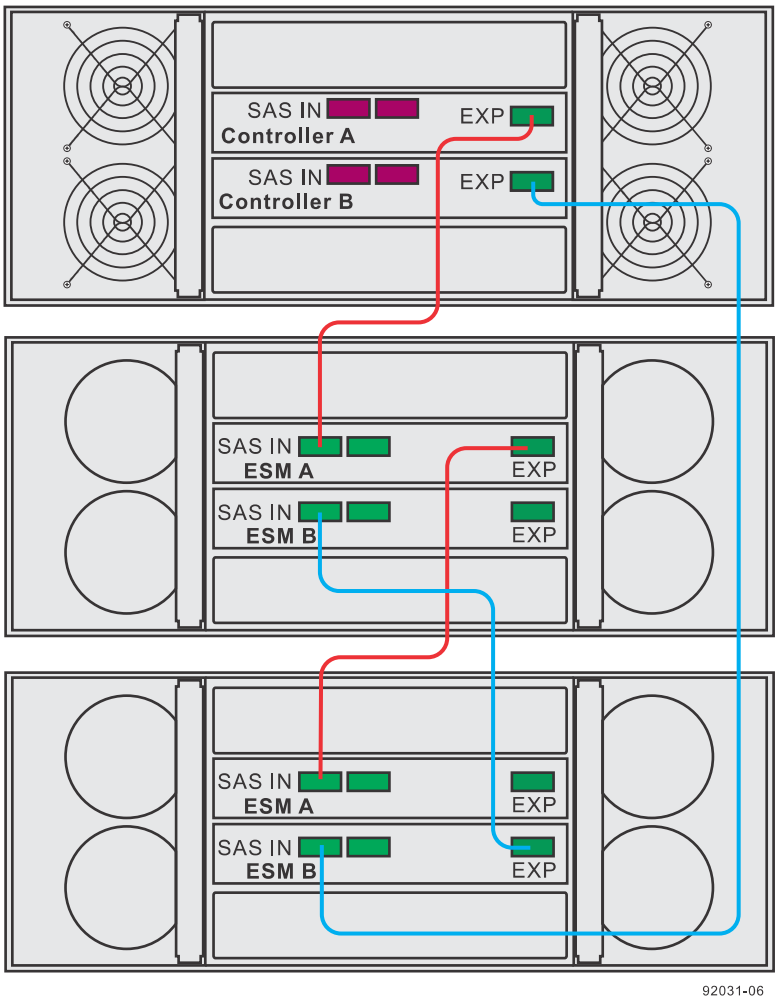


1.	ESM A
2.	ESM B
3.	SAS in port
4.	SAS in port
5.	SAS expansion ports

One E2660 controller-drive tray and one drive tray



One E2660 controller-drive tray and two drive trays



Using SANtricity Storage Manager to add a drive tray to an existing storage array

If you manage your storage array with SANtricity Storage Manager, use the tasks in this section to add a new drive tray to your storage array. If you manage your storage array with SANtricity System Manager, use the tasks in *Using SANtricity System Manager to add a drive shelf to an existing storage array* on page 129 to add a new drive tray to your storage array.

You can add a new drive shelf (drive tray) while power is still applied to the other components of the storage array. You can 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 shelves are added to or removed from your storage array. System integrity is maintained throughout the process of adding and reconfiguring your storage array.

Note: If the drive shelf you are adding to the storage array has been previously installed in a different storage array, contact technical support for assistance and instructions on reinitializing the disks in the drive shelf for use in the new storage array.

Preparing to add a drive tray

Steps for preparing to add a new drive shelf (drive tray) while power is still applied to the other components of a storage array.

Before you begin

Make sure that the power source for your storage array can accommodate the power requirements of the new drive shelf (drive tray). Refer to the power specification for your drive shelf in the *Storage Systems Site Preparation Guide*. Make sure that the cabling pattern for the existing storage array matches one of the applicable schemes shown in this guide.

Steps

1. Select **Monitor > Health > View Health (Recovery Guru)** from the Array Management Window (AMW).
2. Select **Monitor > Health > Collect Support Data** from the AMW, complete the dialog box, and select **Start**.

   Support data is saved to the file that you specify in the dialog box. The data is not automatically sent to technical support.
3. From the AMW navigation bar, select **Monitor > Reports > EventLog** .
4. In the **Event Log** window, select **View Only Critical Events.**
5. Review the system critical events for events that have occurred in the last two to three weeks, and verify that any recent critical events have been resolved or otherwise addressed.

   Note: If unresolved critical events have occurred within the previous two to three weeks, stop the shelf hot-add procedure and contact technical support. Continue this procedure only when the issue is resolved.
6. Select the **Hardware** tab in the **AMW**.
7. For each drive tray in the storage array, select the View Tray Components link.
8. Select **ESM Canisters** from the **Overall Component Information** pane.
9. Confirm that the number of ESMs/IOMs detected matches the number of ESMs/IOMs installed in the system and that for each drive shelf, both of the ESMs/IOMs show that communication is OK.

Installing the drive tray and applying power

Steps for adding a new drive shelf (drive tray) while power is still applied to the other components of a storage array.

Steps

1. Determine which of the following options applies, and then perform the described action.

Option	Description
To install a drive tray that has previously been installed in a storage array. (If the installation history of the drive tray that you are installing is unknown, you should assume that it has been previously installed in a storage array.)	Remove the drives before you continue with step *2* on page 127. The drives must be installed one at a time later in this procedure.
To install a new drive tray and drives that have never previously been installed in a storage array.	Continue with step *2* on page 127.

2. Install the new drive tray in the rack that holds the storage array components.

   Attention: See the installation instructions for your model for the full procedure for physical installation and power cabling. The installation instructions for your model includes notes and warnings that you must take into account to safely install a drive tray.

3. Power on the new drive tray and confirm that no amber warning LEDs are illuminated on the drive tray. Resolve any fault conditions indicated by the LEDs before you continue with this procedure.

Connecting the drive tray

Perform these steps to connect a new drive shelf (drive tray) while power is still applied to the other components of a storage array.

About this task

You may add a new drive tray while power is still applied to the other components of the storage array so that access to data is not interrupted. Refer to the examples of drive cabling topology earlier in this chapter that apply to the hardware of your storage array. If your storage array did not previously have a drive tray, you will cable the new drive tray as shown for the examples of a storage array with one drive tray. If your storage array already has one or more drive trays, this procedure describes how to change the cabling of the drive tray that was previously the last in a stack to connect to the new drive tray as the last in that stack. (You can add the new drive tray before the first drive tray in an existing stack. In that case you must modify this procedure accordingly.)

For E2800 storage arrays with a mix of SAS-2 and SAS-3 drive shelves and drive trays, the SAS-2 drive trays are all in one stack while the SAS-3 drive shelves are in the other. When you add a new tray, be sure that the other trays in the stack where you add it are of the same type (SAS-2 or SAS-3).

Note: If you are adding the new drive tray to a storage array using a dual-stack cabling, the resulting configuration should have an equal number of drive trays in each stack, or, at most, one more drive tray in one stack than the other.

Note: If you are adding the new drive tray to a storage array with one controller (simplex configuration), modify the steps in this procedure as necessary to cable only the controller A drive channel. Multiple connections between a controller and an environmental services module (ESM) are not supported in a simplex configuration.

Note: If you are adding a DE6600 drive tray to the storage array, the drives in the front four bays in each of the five drawers must be installed before you begin this procedure. The drives in the remaining open drive bays are installed later in this procedure.

Connect the cables in the order given in the following steps.

Steps

1. Choose one of the following options:

Option	Description
The new drive tray is the only drive tray in a storage array with an E2600 controller-drive tray or an E5400 controller-drive tray. (non-E2800)	Attach a cable between the SAS expansion port on controller A of the controller-drive tray and a SAS IN port on ESM A of the new drive tray.
The new drive tray is the only drive tray in a storage array with an E2700 controller-drive tray.	Attach a cable between one of the SAS expansion ports on controller A of the controller-drive tray and a SAS IN port on ISM/ESM A of the new drive shelf (or drive tray).
The new drive tray is the only drive tray in a storage array with an E5500 or E5600 controller-drive tray or an EF550 or EF560 flash array.	Attach a cable between the SAS expansion port labeled **Ch 1** on controller A of the controller-drive tray and a SAS IN port on IOM/ESM A of the new drive shelf (or drive tray) and then attach a cable between the SAS expansion port labeled **Ch 1** on controller B of the controller-drive tray and the other SAS IN port on IOM/ESM A.

2. Navigate to the AMW **Hardware** tab, scroll down to view the new drive tray, and select **View Tray Components**. If the new drive tray is not displayed in the drive tray tab, resolve the connection issue.

   Note: The AMW **Recovery Guru** displays a loss of redundancy error. At this point in the procedure, you have only one active path to the controller-drive tray.

3. After the new drive tray is connected, monitor the AMW throughout the rest of this procedure to make sure that the new drive tray does not overheat.

   Note: With the bezel removed and the disk bays empty, the chassis does not achieve efficient air flow. As a result, the installation process must proceed to completion without significant delays.

4. From the **Component Information** window, expand **Overall Component Information**, select **ESM Canisters**, and verify the following:

   - Both ESM A and ESM B are listed.
   - Current data ratefor ESM A is 12Gb/s (for E2800 controllers with DE212C or DE224C drive shelves) or 6Gb/s.
   - Card communications is OK.

5. Choose one of the following options:

Option	Description
The new drive tray is the only drive tray in a storage array with an E2600 controller-drive tray or an E5400 controller-drive tray	Attach a new cable between the SAS Expansion port on controller B in the controller-drive tray and the SAS IN port on ESM B of the new drive tray. Skip to Step *6* on page 129.
The new drive tray is the only drive tray in a storage array with an E2700 controller-drive tray.	Attach a cable between one of the SAS expansion ports on controller B of the controller-drive tray and the SAS IN port on IOM/ESM B of the new drive shelf (or drive tray). Skip to Step *6* on page 129.

Option	Description
The new drive tray is the only drive tray in a storage array with an E5500 or E5600 controller-drive tray or an EF550 or EF560 flash array.	Attach a cable between the SAS expansion port labeled **Ch 2** on controller A of the controller-drive tray and a SAS IN port on ESM B of the new drive tray and then attach a cable between the SAS expansion port labeled **Ch 2** on controller B of the controller-drive tray and the other SAS IN port on ESM B. Skip to Step *6* on page 129.

6. Navigate to the AMW **Hardware** tab, scroll down to view the new drive tray, and select the **View Tray Components** link.
7. From the **Component Information** window, expand **Overall Component Information**, select **ESM Canisters**, and verify that Card communications is OK.
8. From the AMW navigation bar of the target storage array, select **Monitor > Health > View Health (Recovery Guru)**, and verify that the Recovery Guru returns no faults. Resolve any faults indicated in the Recovery Guru before you proceed.
9. From the AMW **Hardware** tab, scroll down to view the newly added drive tray.
10. For drives that were previously installed in a different storage array, add one drive to the newly installed drive tray and allow that drive to be recognized and displayed in the **Tray Components** pane before inserting the next drive.

    Note: When you install drives in the DE6600 or DE460C drive tray, the drives in the front four bays in each of the five drawers must be installed before the drives in the remaining open drive bays are installed. Start installing drives by opening drawer one, but leave drawers two through five in the closed position. After the front four drives (bays one, four, seven, and ten) are installed in drawer one, close drawer one and open drawer two. Repeat this pattern until the front four drive bays are filled in each of the five drawers. Open drawer one again, fill the drive bays, and securely latch the drawer. Repeat this activity for the remaining drawers until all of the available drive bays have been filled.

11. Repeat the previous step until all of the drives are installed.
12. In the Array Management Window, select **Upgrade > View Firmware Inventory**, and check which versions of the ESM firmware and the drive firmware are installed on the new drive tray. If necessary, upgrade the firmware to the most current version.

    See the *SANtricity System Manager 11.30 Upgrade Guide* for the upgrade procedures.

Using SANtricity System Manager to add a drive shelf to an existing storage array

If you manage your storage array with SANtricity System Manager, use the tasks in this section to add a new drive shelf to your storage array. If you manage your storage array with SANtricity Storage Manager, use the tasks in *Using SANtricity Storage Manager to add a drive tray to an existing storage array* on page 125 to add a new drive tray to your storage array.

You can add a new drive shelf (drive tray) while power is still applied to the other components of the storage array. You can 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 shelves are added to or removed from your storage array. System integrity is maintained throughout the process of adding and reconfiguring your storage array.

Note: If the drive shelf you are adding to the storage array has been previously installed in a different storage array, contact technical support for assistance and instructions on reinitializing the disks in the drive shelf for use in the new storage array.

Preparing to add a drive shelf or drive tray

Perform the following steps to prepare to add a new drive shelf (drive tray) using SANtricity System Manager while power is still applied to the other components of a storage array.

Before you begin

- The power source for your storage array must be able to accommodate the power requirements of the new drive shelf (drive tray). Refer to the power specification for your drive shelf in the *Storage Systems Site Preparation Guide* document.
- The cabling pattern for the existing storage array must match one of the applicable schemes shown in this guide.

Steps

1. From the **Home** page of SANtricity System Manager, select **Support > Support Center > Diagnostics**.
2. Select **Collect Support Data**.

   The Collect Support Data dialog box appears.
3. Click **Collect**.

   The file is saved in the Downloads folder for your browser with the name `support-data.7z`. The data is not automatically sent to technical support.
4. Select **Support > Event Log**.

   The Event Log dialog box appears.
5. Select the heading of the **Priority** column to sort critical events to the top of the list.
6. Review the system critical events for events that have occurred in the last two to three weeks, and verify that any recent critical events have been resolved or otherwise addressed.

   Note: If unresolved critical events have occurred within the previous two to three weeks, stop the hot-add procedure and contact technical support. Continue this procedure only when the issue is resolved.
7. Select **Hardware**.
8. Select the **IOMs (ESMs)** icon.

   The Shelf Component Settings dialog box appears with the **IOMs (ESMs)** tab selected.
9. Make sure that the status shown for each IOM/ESM is *Optimal*.
10. Click **Show more settings**.
11. Confirm that the number of ESMs/IOMs detected matches the number of ESMs/IOMs installed in the system and that for each drive shelf, both of the ESMs/IOMs show that communication is OK and that the data rate is 12Gb/s for DE212C and DE224C drive shelves or 6 Gb/s other drive trays.

Installing the drive shelf or drive tray and applying power

Perform these steps for add a new drive shelf (drive tray) using SANtricity System Manager while power is still applied to the other components of a storage array.

Steps

1. Choose one of the following options:
   - If you are installing a drive shelf that has previously been installed in a storage array, remove the drives before you continue with Step *2* on page 127. The drives must be installed one at a time later in this procedure. If the installation history of the drive tray that you are installing is unknown, you should assume that it has been previously installed in a storage array.
   - If you are installing a new drive shelf and drives that have never previously been installed in a storage array, continue with Step *2* on page 127.
2. Install the drive shelf in the rack that holds the storage array components.

   Attention: See the installation instructions for your model for the full procedure for physical installation and power cabling. The installation instructions for your model includes notes and warnings that you must take into account to safely install a drive tray.
3. Power on the new drive shelf, and confirm that no amber attention LEDs are illuminated on the drive shelf. If possible, resolve any fault conditions before you continue with this procedure.

Connecting the drive shelf

Perform the following steps to connect a newly added drive shelf (drive tray) using SANtricity System Manager while power is still applied to the other components of a storage array.

About this task

You can add a new drive shelf while power is still applied to the other components of the storage array so that access to data is not interrupted. Refer to the examples of drive cabling topology earlier in this chapter that apply to the hardware of your storage array. If your storage array did not previously have a drive shelf, you will cable the new drive shelf as shown for the examples of a storage array with one drive shelf. If your storage array already has one or more drive shelves, this procedure describes how to change the cabling of the drive shelf that was previously the last in the stack to connect to the new drive shelf as the last in the stack. (You can add the new drive shelf between the first drive shelf in an existing stack and the controller shelf. In that case you must modify this procedure accordingly.)

Note: If your storage array has a mix of SAS-3 drive shelves and SAS-2 drive trays, you should use a two-stack configuration with all of the SAS-3 shelves in one stack and all of the SAS-2 drive trays in the other. Be sure to add the new drive shelf or drive tray to the appropriate stack.

Note: If you are adding the new drive shelf to a storage array with one controller (simplex configuration), modify the steps in this procedure as necessary to cable only one controller A drive channel. Connections between one controller and two IOMs/ESMs are not supported in a simplex configuration.

Connect the cables in the order given in the following steps.

Steps

1. Choose one of the following options:

- If the new drive shelf or drive tray is the only drive shelf in the storage array, attach a cable between one of the SAS expansion ports on controller A of the controller shelf and a SAS expansion port 1 on IOM/ESM A of the new drive shelf.
- If the storage array already has one or more drive shelves or drive trays in a single-stack configuration and the new drive shelf or drive tray has the same type of SAS interface (SAS-2 or SAS-3) as the existing shelves or trays, connect a cable between the SAS expansion port on IOM/ESM A of the drive shelf or drive tray that was previously the last in the stack and SAS expansion port 1 on IOM/ESM A of the new drive shelf or drive tray.
- If the storage array already has two or more drive shelves or drive trays in a dual-stack configuration, connect the new drive shelf or drive tray to the stack of trays or shelves whose SAS interface (SAS-2 or SAS-3) matches that of the new drive tray or drive shelf. Connect a cable between the SAS expansion port on IOM/ESM A of the drive shelf or drive tray that was previously the last in the stack and SAS expansion port 1 on IOM/ESM A of the new drive shelf or drive tray.
- If the storage array already has one or more drive shelves or drive trays in a single-stack configuration and the new drive shelf or drive tray has a different type of SAS interface (SAS-2 or SAS-3) than the existing shelves or trays, you must re-cable the storage array to a dual-stack configuration. Locate the cable between SAS expansion port 2 on controller A and IOM/ESM A in the first drive tray or drive shelf in the existing stack. Disconnect that cable from IOM/ESM A of the tray or shelf in the existing stack and then reconnect it to IOM/ESM A on the new drive shelf or drive tray. Locate the cable between SAS expansion port 2 on controller B and IOM/ESM B in the last drive tray or drive shelf in the existing stack. Disconnect that cable from IOM/ESM B of the tray or shelf in the existing stack and then reconnect it to IOM/ESM B on the new drive shelf or drive tray.

2. In SANtricity System Manager, click **Hardware**.

   Note: At this point in the procedure, you have only one active path to the controller shelf.

3. Scroll down, as necessary, to see all the of the drive shelves in the new storage array. If the new drive shelf is not displayed, resolve the connection issue.
4. Select the **EOMs/ISMs** icon for the new drive tray.

   The **Shelf Component Settings** dialog box appears.

5. If it is not already selected, select the **EOMs/ISMs** tab in the **Shelf Component Settings** dialog box.
6. Select **Show more options**. Verify the following:
   - Both IOM/ESM A and IOM/ESM B are listed.
   - Current data rate is 12Gb/s for a SAS-3 drive shelf or 6Gb/s for a SAS-2 drive shelf.
   - Card communications is OK.
7. Choose one of the following options:
   - If the new drive shelf is the only drive shelf in the storage array, attach a cable between one (or both) of the SAS expansion ports on controller B of the controller shelf and the SAS expansion port 1 (or port 1 and port 2) on IOM/ESM B of the new drive shelf.
   - If the storage array already has one or more drive shelves or drive trays in a single-stack configuration and the new drive shelf or drive tray has the same type of SAS interface (SAS-2 or SAS-3) as the existing shelves or trays, identify the cable (or cables) that run from controller B to the drive shelf that was previously the last drive shelf in the stack. Disconnect that cable (or those cables) from te SAS expansion port (or ports) of IOM/ESM B on the original drive shelf and re-connect them to the SAS expansion port (or ports) on IOM/ESM B

of the new drive shelf. Connect SAS expansion port 1 on IOM/ESM B of the new drive shelf to the SAS expansion port 1 on the drive shelf that was previously the last in the stack.

- If the storage array already has one or more drive shelves or drive trays in a single-stack configuration and the new drive shelf or drive tray has a different type of SAS interface (SAS-2 or SAS-3) than the existing shelves or trays, you have already fully connected the new drive tray or drive shelf in step 1.

8. If it is not already selected, select the **EOMs (ESMs)** tab in the **Shelf Component Settings** dialog, and then select **Show more settings**. Verify that Card communications is YES.

   Note: Optimal status indicates that the loss of redundancy error associated with the new drive shelf of drive tray has been resolved and the storage system is stabilized.

9. In the SANtricity System Manager, click **Home**.

10. Click the link labeled **Recover from problems** at the center top of the window. Resolve any faults indicated in the Recovery Guru before you proceed.

11. In the SANtricity System Manager, click **Hardware**, and scroll down, as necessary, to see the newly added drive shelf.

12. For drives that were previously installed in a different storage array, add one drive at time to the newly installed drive shelf. Wait for each drive to be recognized before you insert the next drive.

    When a drive is recognized by the storage array, the representation of the drive slot in **Hardware** window shows a blue rectangle.

13. Select **Support > Support Center Inventory > Support Resources tab**.

14. Click the **Software and Firmware Inventory** link, and check which versions of the IOM/ESM firmware and the drive firmware are installed on the new drive shelf.

    Note: You might need to scroll down the page to locate this link.

15. If necessary, upgrade the drive firmware.

    IOM/ESM firmware automatically upgrades to the latest version unless you have disabled the upgrade feature. See the for the manual upgrade procedures.

Cabling for out-of-band management

This chapter provides examples of how to connect your storage array to an Ethernet network for out-of-band storage array management. If you plan to use in-band storage array management, Ethernet cabling might not be necessary for management connections.

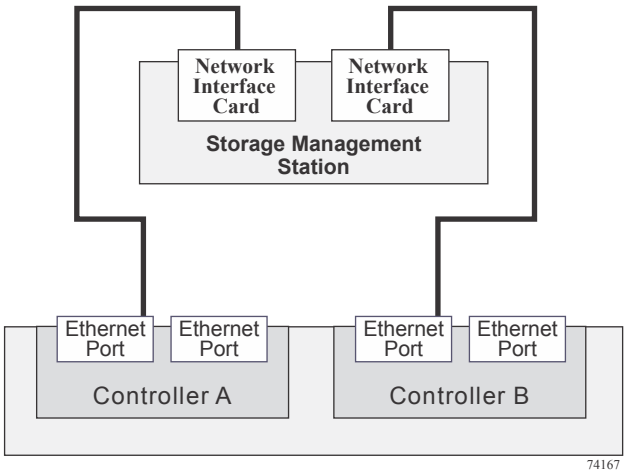
For illustrations showing the Ethernet port locations on the specific controller-drive tray model that you are installing, see the topics under *Component locations* on page 21.

Attention: Possible loss of data access – If you use out-of-band management, connect the Ethernet ports on the controller-drive tray to a private network segment behind a firewall. If the Ethernet connection is not protected by a firewall, your storage array might be at risk of being accessed from outside of your network.

Direct out-of-band Ethernet topology

The following figure shows storage array management connections from a controller shelf or controller-drive tray to an Ethernet network.

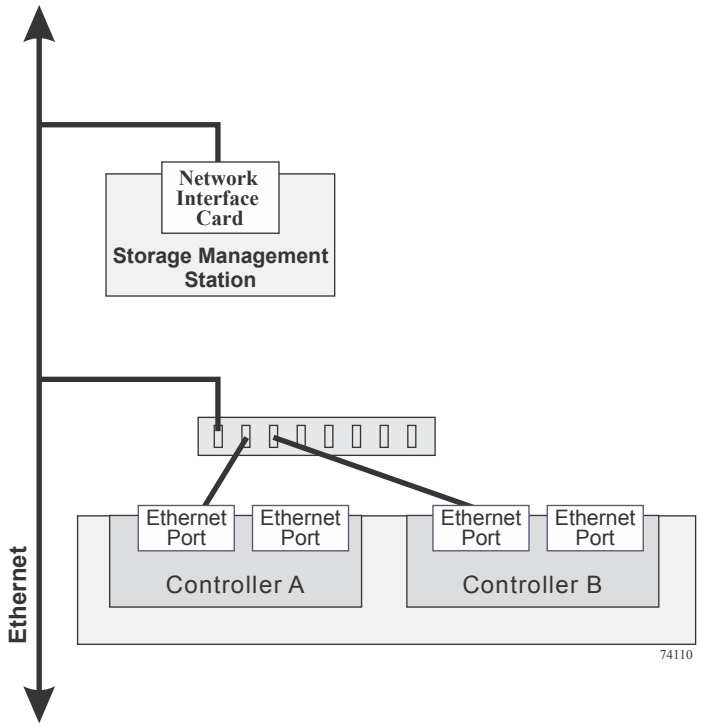
The following figure shows an example of direct out-of-band Ethernet topology.



Fabric out-of-band Ethernet topology

The following figure shows two storage array management connections from the controller-drive tray to two ports on an Ethernet switch. In this topology, the storage management station where the client software resides requires a NIC or some other Ethernet interface. You must use Ethernet cables for all storage array management connections.

The following figure shows and example of fabric out-of-band topology.



Note: Connect management port 1 on each controller for out-of-band management and leave port 2 available for access to the storage array by technical support.

Hardware installation for Synchronous Mirroring and Asynchronous Mirroring

The Asynchronous Mirroring feature uses a remote point-in-time replication method. Asynchronous Mirroring differs from Synchronous Mirroring in one essential way: it captures the state of the source volume at a particular point in time and includes just the data that has changed since the last image capture. With Asynchronous Mirroring, the remote storage array is not fully synchronized with the local storage array, so if the operation needs to transition to the remote storage array due to a loss of the local storage array, some transactions could be lost.

The Synchronous Mirroring feature is also used for online, real-time data replication between storage arrays over a remote distance. The storage array controllers manage the mirror operation. You create one or more mirrored pairs consisting of a primary volume at the local site and a secondary volume at a secondary, remote site. However, instead of batching the synchronization process using point-in-time snapshot images like in Asynchronous Mirroring, the primary volume copies all of the data from the primary volume to the secondary volume in a single operation. This full synchronization process takes longer to complete, but creates a complete copy of the mirrored data. While this process is ideal for certain operations, make sure you fully understand both data mirror options before selecting one over the other.

See to the online help system for more information about the Synchronous Mirroring feature and the Asynchronous Mirroring feature, and for software-related procedures to set the configuration of these features and use them.

Planning and site preparation

The Asynchronous Mirroring feature can be used with either Fibre Channel or iSCSI host connections. Asynchronous Mirroring requires a duplex controller configuration. The Synchronous Mirroring feature can be used only with Fibre Channel connections. For Fibre Channel connections, you *must* have Fibre Channel switches to create a fabric environment for data replication. For iSCSI connections, switches are optional. The following restrictions apply to connections for Asynchronous Mirroring or Synchronous Mirroring.

- SAS and InfiniBand connections are not supported.
- If an E5400 controller-drive tray has an InfiniBand HIC, it cannot have connections for mirroring.
- iSCSI connections must use a host-connect port and not the management Ethernet port.

With the Asynchronous Mirroring feature, the following considerations apply for combining Fibre Channel and iSCSI connections:

- If two storage arrays are connected through both Fibre Channel and iSCSI connections, only one connection type is used for a given asynchronous mirror group. However, if there are multiple asynchronous mirror groups, some asynchronous mirror groups can use Fibre Channel connections while others use iSCSI connections.
- Failover from a Fibre Channel connection to an iSCSI connection (or vice versa) is not supported.

Switches require only minimal additional site preparation beyond basic storage array operation. For additional site preparation considerations for switches, including power requirements and physical dimensions, refer to the documentation that is provided by the switch manufacturer.

iSCSI connections for Asynchronous Mirroring

You can use iSCSI connections for the Asynchronous Mirroring feature. Connect one iSCSI port on each controller of the local (primary) storage array to the corresponding controller on the remote (secondary) storage array. You can make connections through a switched fabric or directly between controllers. During asynchronous mirror group creation, the source storage array attempts to connect to the target storage array. The source storage array scans the IPv4 iSCSI ports in order until it finds a connection. If the source storage array fails to find an IPv4 connection, it repeats the process using IPv6.

Note: To improve performance, connect the lowest numbered iSCSI port on each controller of the local storage array to the corresponding controller on the remote storage array. This reduces delay in asynchronous mirror group creation.

Note: Make sure that Internet Control Message Protocol (ICMP) response is enabled on storage arrays used with the Asynchronous Mirroring feature. See the SANtricity online help topic "Set Storage Array ICMP Response."

Fibre Channel configurations overview

Because of possible restrictions at the host level, the supported Synchronous Mirroring and Asynchronous Mirroring configurations contain Fibre Channel switches. These Fibre Channel switches are zoned so that a single host adapter can access only one controller per storage array. Additionally, all configurations use a separate zone for the ports that are reserved for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

Note: You cannot use the base Fibre Channel ports on an E5400 controller-drive tray or a EF540 flash array to make a connection for Asynchronous Mirroring if the controller-drive tray uses an InfiniBand host interface card for host connections.

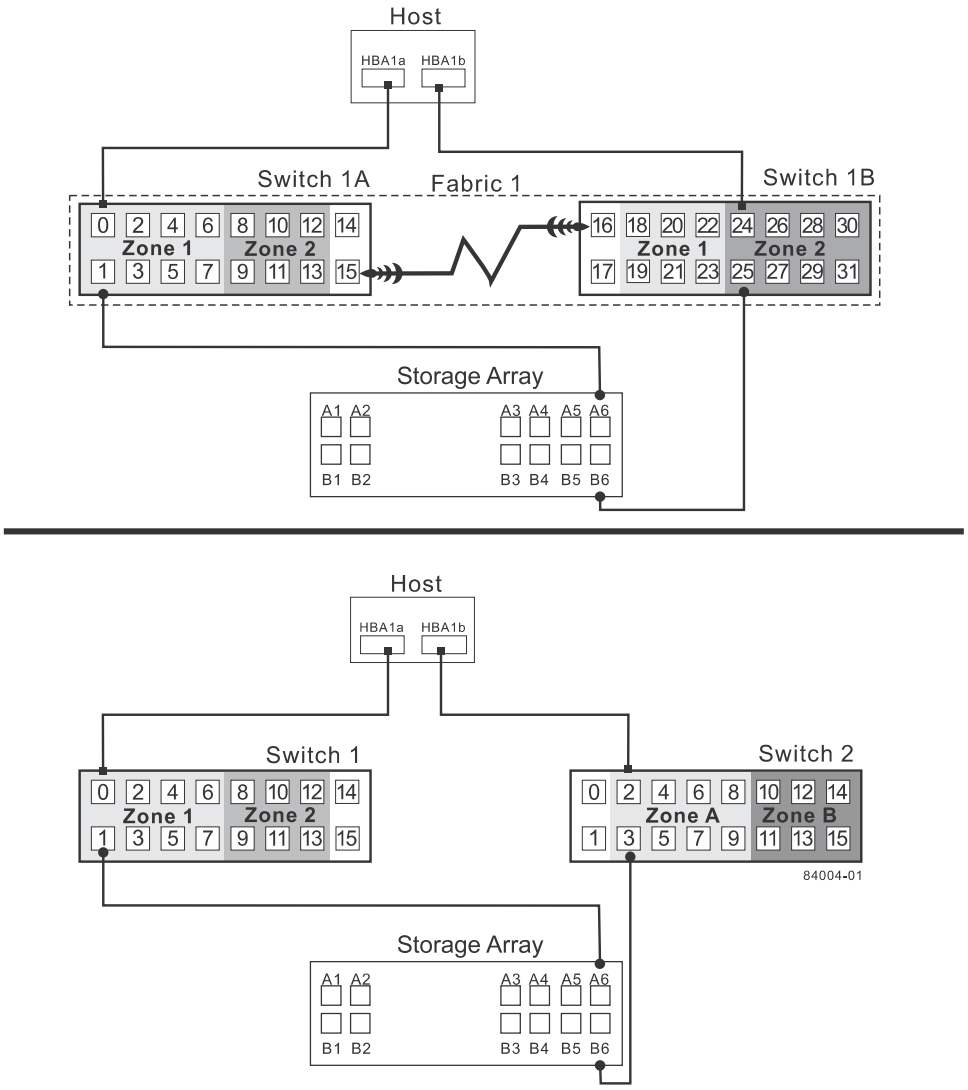
Note: Do not zone the uplink port (E_port) that connects (cascades) switches within a fabric.

Switch zoning configurations are typically set up by using the switch management software that is provided by the manufacturer of the Fibre Channel switch. This software should have been included with the materials that are provided when the switch was purchased.

When two or more Fibre Channel switches are cascaded together, the switch management software combines the ports for all of the switches that are linked. For example, if two 16-port Fibre Channel switches are cascaded with a physical connection using a Fibre Channel cable, the switch management software shows ports 0 through 31 participating in the fabric rather than two switches each with ports 0 through 15. Therefore, a zone that is created containing any of these ports can exist on multiple cascaded switches.

The following figure shows both cascaded and non-cascaded switches. The top-half of the figure shows a set of cascaded switches that are on the same network. Therefore, Zone 1 is the same zone on Switch 1A as Zone 1 is on Switch 1B. In a single-mode Fibre Channel environment, the two switches are connected by a single port on each switch that is designated as an E_port, which is not in a zone.

The set of switches in the bottom half of the following figure is on the same network but is not cascaded. Although both sets contain a Zone 1 (shown as Zone A in Switch 2), these zones are independent of each other.



For more information about Fibre Channel switch zoning or setting up a zone configuration, refer to the manufacturer's documentation that is provided with the switch.

Because of the varying Synchronous Mirroring configurations, the switch zone settings are presented preceding each configuration in this appendix.

Select one of the following configuration options to connect and configure one or more storage arrays for use with the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

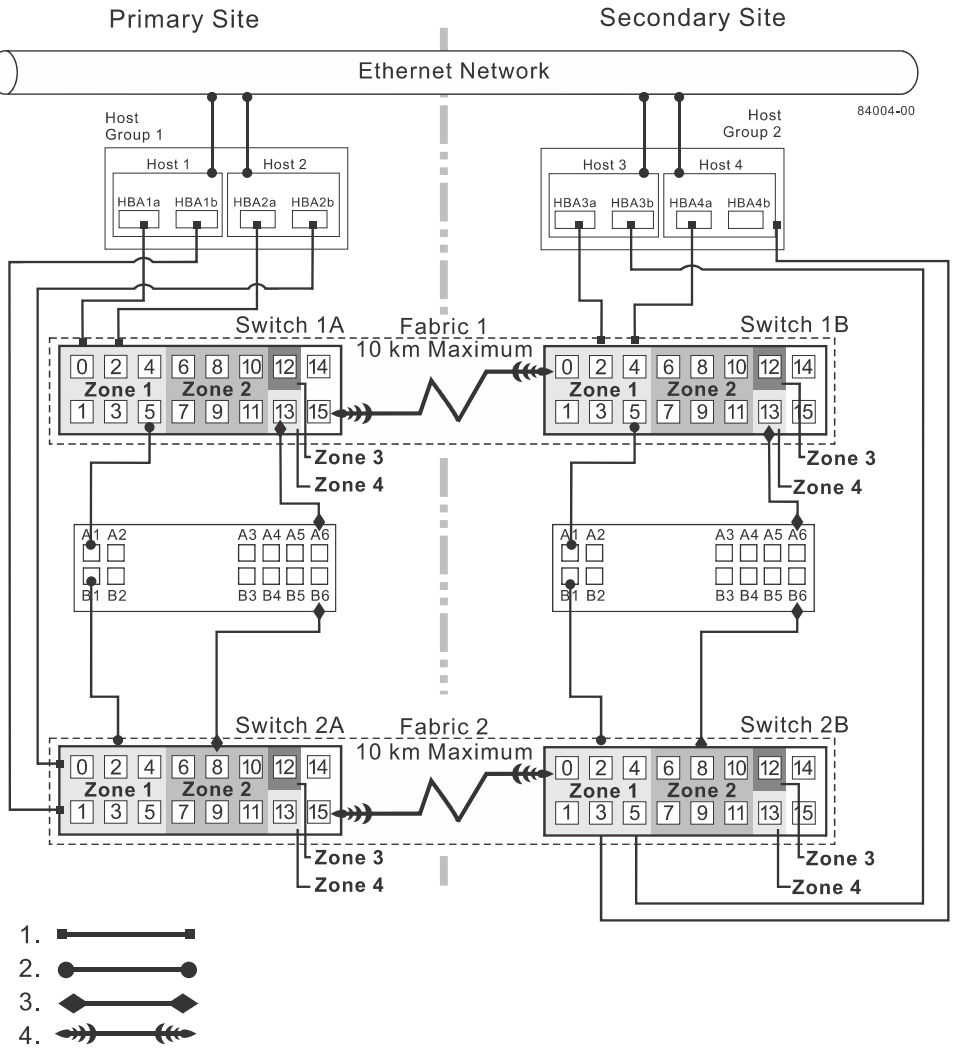
Configuration	Description
Highest availability campus configuration (recommended)	This configuration has the greatest redundancy. It is the most stable of the three configurations. • Two Fibre Channel switches (for a total of four) at both the primary site and the secondary site provide for complete failover and redundancy in the Fibre Channel switches and fabrics, in addition to all storage array components and hosts. • A single point of failure does not exist in this configuration, and it is the recommended configuration. See *Highest availability campus configuration recommended* on page 139.
Campus configuration	The campus configuration is a lower-cost configuration than the highest availability campus configuration. Only one Fibre Channel switch at the primary site and one at the secondary site exist, for a total of two switches. This configuration essentially allows the minimum required components to successfully operate between two sites. • The number of Fibre Channel switches is reduced from four to two and the number of fabrics from two to one. • This configuration is redundant for host bus adapters, controllers, and Synchronous Mirroring ports, but it has a single point of failure for switches and fabric. • A switch failure does not usually result in a loss of data, but it does affect data synchronization until the error is corrected. Therefore, the highest availability campus configuration is the recommended configuration, because data synchronization can continue for any single switch failure. See *Campus configuration* on page 145.
Intra-site configuration	The intra-site configuration is the lowest-cost configuration of all three configurations. It is used in environments where a long-distance fabric is not required because of the close proximity of the hosts and storage arrays. • Because the intra-site configuration only has two switches, it is similar to the campus configuration. However, multiple-switch fabrics do not exist in this configuration. • The configuration is redundant for host bus adapters, controllers, Synchronous Mirroring ports, and switches but is a single point of failure for the site because all of the equipment can be destroyed by the same disaster. • The highest availability campus configuration is the recommended configuration, because it is fully redundant, which makes disaster recovery easier. See *Intra-site configuration* on page 150.

Highest availability campus configuration recommended

Note: The highest availability campus configuration is the recommended Fibre Channel configuration for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

This configuration has two Fibre Channel switches at the primary site and two Fibre Channel switches at the secondary site (four switches total), which provide for complete failover and redundancy. Failures could involve Fibre Channel switches, Fibre Channel cables, and any host or storage array. Two Fibre Channel switches at each site also provide redundancy to the local site in addition to a fully redundant remote configuration. No single point of failure exists in the hardware components.

The following figure shows the highest availability campus configuration. The controller-drive trays are shown schematically with four host ports on each of two controllers in each controller-drive tray. In this configuration, use the A4 connection and the B4 connection for remote mirroring traffic instead of the A2 connection and the B2 connection. You can use controller ports A2, A3, B2, and B3 for additional host access if needed.



1.	Host Fibre Channel cable
2.	Storage array Fibre Channel cable
3.	Fibre Channel cable dedicated for mirroring
4.	Fabric uplink cable

Switch zoning for highest availability campus configuration

The highest availability campus configuration provides a separate zone for each reserved port for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

The switches do not need to be zoned exactly as presented in this configuration. However, you must meet the following requirements when zoning switches for the highest availability campus configuration.

There are a total of four zones in this configuration.

- Zone 1 and zone 3 are on fabric 1 (switch 1A at the primary site, and switch 1B at the secondary site).
- Zone 2 and zone 4 are on fabric 2 (switch 2A at the primary site, and switch 2B at the secondary site).

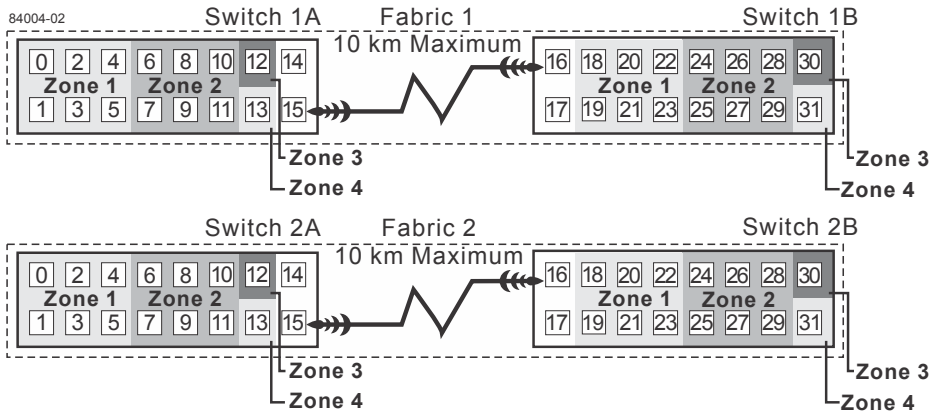
Configure the zones on the switch so that there is one port per zone for a storage array connection and one port per zone for each host. Switches are zoned so that a single host bus adapter port can access only one controller per storage array.

Switches are zoned so that a single host bus adapter port can access only one controller for each storage array.

Note: Do not zone the uplink ports (E_ports) on any of the Fibre Channel switches.

The following figure shows how the four switches are zoned for the highest availability campus configuration.

The switches have 16 ports each, which leaves unused ports on each switch when following the preceding requirements. The remaining ports can be distributed among the other zones. It is recommended, however, that most of the remaining ports be assigned to the zones containing the host connections: zone 1 and zone 2. This port assignment allows easy setup for additional hosts to connect to the environment.



Before you proceed, review the requirements listed in this section and the zoning shown in the figure to make sure that all four switches are correctly zoned. For more information, see the *Fibre Channel configurations overview* on page 137.

Cabling for the highest availability campus configuration

After the four Fibre Channel switches are correctly zoned, set up the highest availability campus configuration for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

About this task

Note: Start the installation at the primary site. Repeat these steps for the secondary site when instructed to do so.

After the four Fibre Channel switches are correctly zoned, set up the highest availability campus configuration for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

Complete all connections by using Fibre Channel cables of the correct length.

Steps

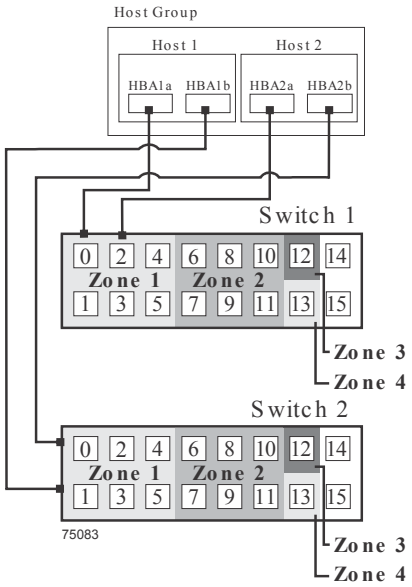
1. Determine whether you adding equipment to an existing storage array environment.
   - If so, stop I/O activity from all hosts before proceeding. Go to Step *2* on page 142.
   - If not, the storage array installation is new. Go to Step *3* on page 142.

   Attention: Possible hardware damage – DC-powered controller-drive trays have special power procedures that you *must* follow beyond the procedures for AC-powered trays. To get specific power-off and power-on procedures, refer to the installation instructions for your storage array.
2. Turn off the power to all storage arrays, hosts, Fibre Channel switches, and any other equipment in the storage array environment.
3. Make sure that cabling between all of the controller-drive trays and the drive trays is complete.

   #### Example

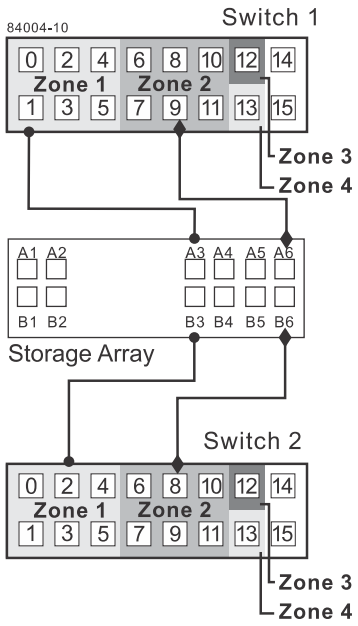
   Note: Depending on which site is being configured, switch 1 represents switch 1A for the primary site and switch 1B for the secondary site. This representation applies to switch 2 as well.
4. Connect the primary host bus adapter for each local host to an available port in zone 1 of switch 1.

   The following figure shows the cabling that is described in Step *4* on page 142 and Step *5* on page 143.



5. Connect the secondary host bus adapter for each host at this site to an available port in zone 1 of switch 2.
6. Connect controller port A1 of the storage array to an available port in zone 1 of switch 1.

   The figure following Step *9* on page 143 shows the cabling for E2700 controller-drive trays.
7. Connect controller port B1 of the storage array to an available port in zone 1 of switch 2.
8. Connect controller port A2 of the storage array to an available port in zone 2 of switch 1. In a four-host-port system, connect controller port A4 to an available port in zone 2 of switch 1.
9. Connect controller port B2 of the storage array to an available port in zone 2 of switch 2. In a four-host-port system, connect controller port B4 to an available port in zone 2 of switch 2.



Note: Controller port A2 and controller port B2 are reserved for mirror relationship synchronization upon activation of the Synchronous Mirroring feature. In a four-host-port system, controller port A4 and controller port B4 are reserved.

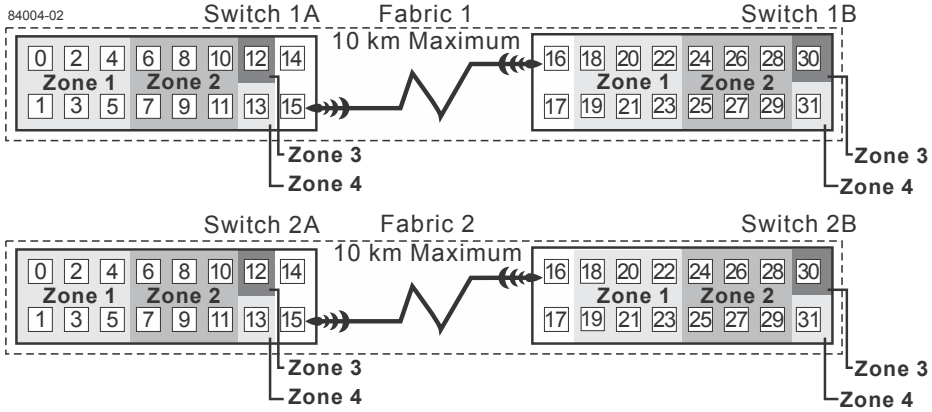
The primary site cabling is now complete.

10. Determine whether the secondary site cabling complete.

- If not, repeat Step *1* on page 142 through Step *9* on page 143 for the secondary site.
- If so, go to Step *11* on page 144.

11. Complete the fabric environment for switch 1 by connecting switch 1A to switch 1B.

The following figure shows the cabling that is described in Step *11* on page 144 and Step *12* on page 145.



12. Repeat Step *11* on page 144 for switch 2A and switch 2B to complete the fabric environment for switch 2.

    Cabling for the highest availability campus configuration is complete.

13. Repeat Step *4* on page 142 through Step *10* on page 144 for other storage arrays that exist in the same cabinet that use the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

    Attention: Possible hardware damage – DC-powered controller-drive trays have special power procedures that you *must* follow beyond the procedures for AC-powered trays. To get specific power-off and power-on procedures, refer to the installation instructions for your storage array.

14. Turn on the power to all of the storage array hosts, Fibre Channel switches, and any other hardware at both sites where the power was turned off.

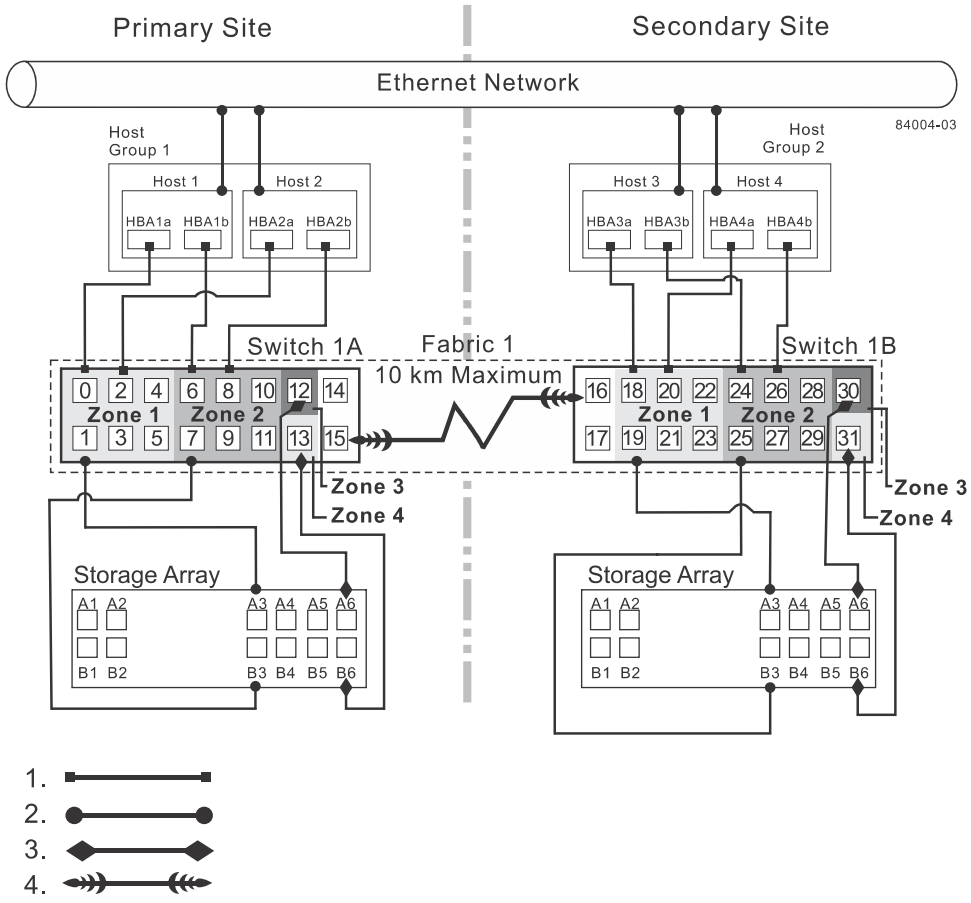
Result

The hardware installation is complete. To configure the storage management software to support mirror relationships, refer to the online help topics.

Campus configuration

The campus configuration offers the same functionality as the highest availability campus configuration, but the campus configuration contains only one switch at each site, rather than two. The configuration is still redundant for host bus adapters, controllers, and remote mirroring ports, but the configuration has a single point of failure for switches. If a switch at either site fails, the Synchronous Mirroring feature or the Asynchronous Mirroring feature cannot operate. For this reason, the highest availability campus configuration is highly recommended for total environment redundancy.

The following figure shows a complete campus configuration. The controller-drive trays are shown schematically with four host ports on each of two controllers in each controller-drive tray.



1.	Host Fibre Channel cable
2.	Storage array Fibre Channel cable
3.	Fibre Channel cable dedicated for mirroring
4.	Fabric uplink cable

Switch zoning for the campus configuration

The campus configuration allows for a separate zone for each reserved port for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

The switches do not need to be zoned exactly as presented in this configuration. However, you must meet the following requirements when you zone switches for the campus configuration.

Note: Do not zone the uplink ports (E_ports) on any of the Fibre Channel switches.

You must have a total of four zones in this configuration.

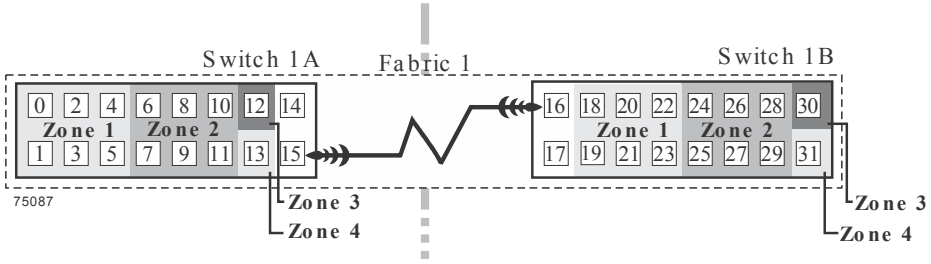
- All zones exist on fabric 1 (switch 1A at the primary site, and switch 1B at the secondary site).
- Zone 3 and zone 4 are reserved for the dedicated Synchronous Mirroring feature connections.

You must configure the zones on the switches so that there is one port per zone for a storage array connection and one port per zone for each host.

You must zone the switches so that a single host adapter can access only one controller per storage array.

The switches in the following figure contain 16 ports each, which leaves many unused ports per switch. The remaining ports can be distributed among the other zones. However, it is recommended that most remaining ports be assigned to the zones that contain the host connections (zone 1). This setup allows connections for additional hosts.

The following figure shows how the two switches are zoned for the campus configuration.



Review the requirements in this section and the zoning example in the figure above to make sure that both switches are correctly zoned before proceeding. For more information, see *Fibre Channel configurations overview* on page 137.

Cabling for the campus configuration

After both Fibre Channel switches are correctly zoned, set up the campus configuration for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

About this task

Start the installation at the primary site. Repeat these steps for the secondary site when instructed to do so.

Note: Complete all connections by using Fibre Channel cables of the correct length.

Steps

1. Determine whether you adding equipment for mirroring to an existing storage array environment.
   - If so, stop I/O activity from all hosts before proceeding. Go to Step *2* on page 148.
   - If not, this is a new storage array installation. Go to Step *3* on page 148.

   Attention: Possible hardware damage – DC-powered controller-drive trays have special power procedures that you *must* follow beyond the procedures for AC-powered trays. To get specific power-off and power-on procedures, see the installation instructions for your storage array.

2. Turn off the power to all storage arrays, hosts, Fibre Channel switches, and any other equipment in the storage array environment.

3. Make sure that basic cabling between all of the controller-drive trays and the drive trays on both storage arrays is complete.

   Note: Depending on which site is being configured, switch 1 represents switch 1A for the primary site and switch 1B for the secondary site.

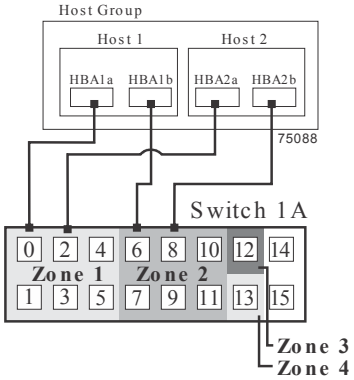
   Note: You can connect the cables to any port in the correct zone of the switch.

4. Connect the primary host bus adapter for each host at this site to an available port in zone 1 of switch 1A.

   The following figure shows the cabling that is described in Step *4* on page 148 and Step *5* on page 148.

5. Connect the secondary host bus adapter for each host at this site to an available port in zone 2 of switch 1A.

   The following figure shows connections between a host bus adapter and a Fibre Channel switch.



6. Connect controller port A1 of the storage array to an available port in zone 1 of switch 1A.

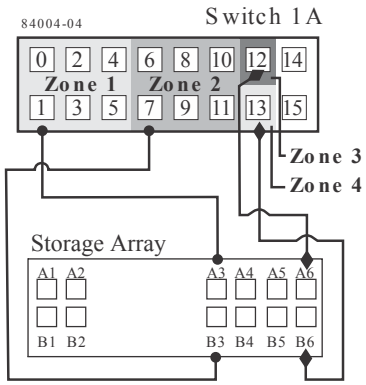
   The first figure following Step *9* on page 149 shows the storage array connected to Fibre Channel switches that is described in Step *6* on page 148 through Step *9* on page 149. The second figure

following Step *9* on page 149 shows the cabling configuration schematically with four host ports on each of two controllers in each controller-drive tray.

7. Connect controller port B1 of the storage array to an available port in zone 2 of switch 1A.
8. Connect controller port A2 of the storage array to an available port in zone 3 of switch 1A. In a four-host-port system, connect controller port A4.
9. Connect controller port B2 of the storage array to an available port in zone 4 of switch 1A. In a four-host-port system, connect controller port B4.

   Note: Controller ports A2 and B2 are reserved for mirror relationship synchronization upon activation of the Synchronous Mirroring feature or the Asynchronous Mirroring feature. In a four-host-port system, controller port A4 and controller port B4 are reserved.

   The following figure shows connections between a storage array and a Fibre Channel switch.



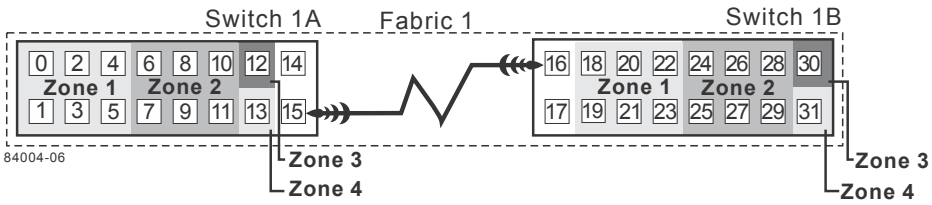
1.
2.

   The primary site cabling is now complete.

10. Determine whether the secondary site cabling complete.
    - If not, repeat Step *1* on page 148 through Step *9* on page 149 for the secondary site.
    - If so, go to Step *11* on page 149.
11. Complete fabric 1 by connecting switch 1A to switch 1B.

    The following figure shows the cabling that is described in this step.

    The following figure shows connections between remote switches to complete the switched fabric.



Cabling for the campus configuration is complete.

12. Repeat Step *4* on page 148 through Step *10* on page 149 for any additional storage arrays that exist in the same cabinet that will use the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

    Attention: Possible hardware damage – DC-powered controller-drive trays have special power procedures that you *must* follow beyond the procedures for AC-powered trays. To get specific power-off and power-on procedures, see the installation instructions for your storage array.

13. Turn on the power to all storage arrays, hosts, Fibre Channel switches, and any other hardware at both sites where the power was turned off.

Result

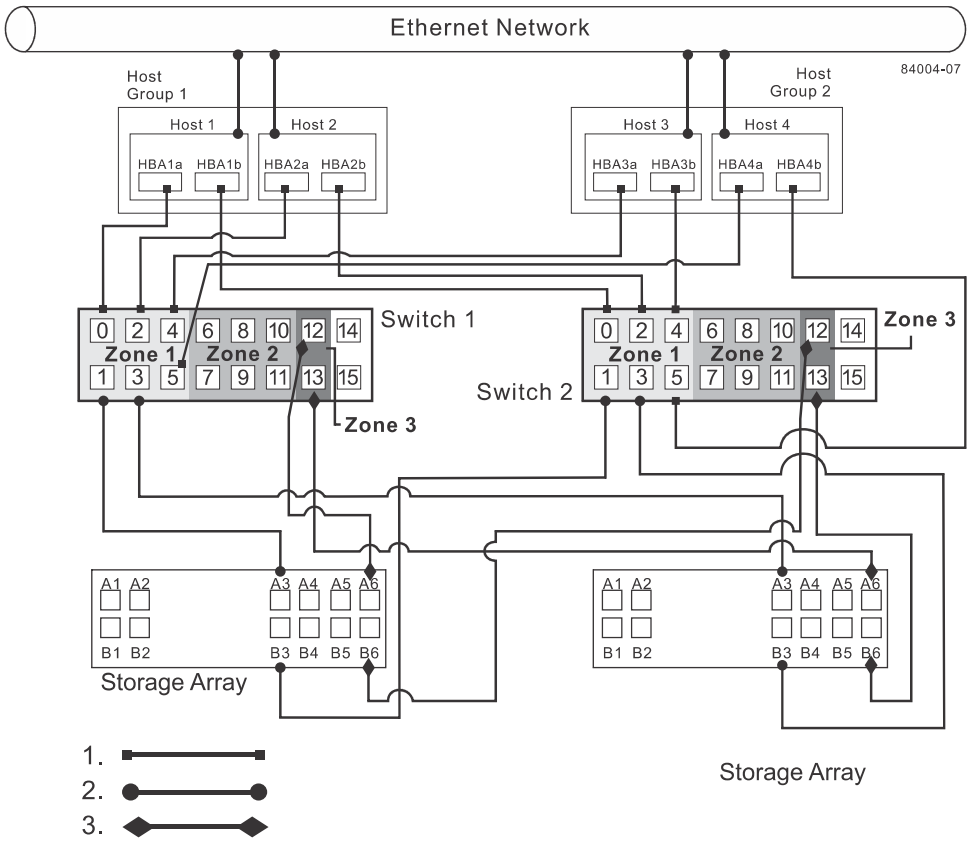
Hardware installation is complete. See the online help topics for procedures to configure the storage management software to support mirror relationships.

Intra-site configuration

The intra-site configuration is used in environments where a long-distance fabric is not required because of the close proximity of the hosts and storage arrays. The configuration is still redundant for host bus adapters, controllers, remote mirroring ports, and switches, but the configuration is a single point of failure for the site because all of the equipment can be destroyed by the same disaster. For this reason, the highest availability campus configuration is highly recommended for total environment redundancy.

The following figure shows a complete installation of the intra-site configuration.

Note: A switch failure in this configuration does not affect data access; however, as a result, an Unsynchronized state might occur for all of the mirror relationships on both the primary storage arrays and the secondary storage arrays.



1.	Host Fibre Channel cable
2.	Storage array Fibre Channel cable
3.	Fibre Channel cable dedicated for mirroring

Switch zoning for the intra-site configuration

The intra-site configuration provides switch redundancy, but the switches are not cascaded and are independent of each other.

Note: The switches do not need to be zoned exactly as presented in this configuration. However, you must meet the following requirements when zoning switches for the intra-site configuration.

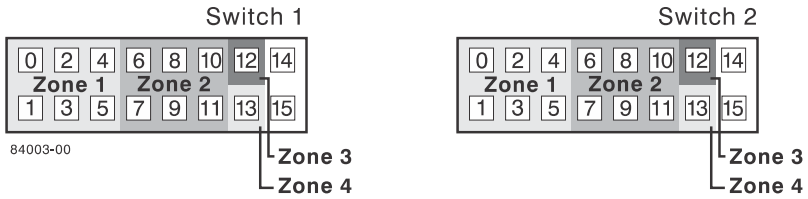
You must have a total of four zones on each controller in this configuration.

You must configure the zones on the switch so that there is one port per zone for a storage array connection and one port per zone for each host.

You must zone the switches so that a single host adapter can only access one controller per storage array.

The switches in the following figure contain 16 ports each, which leaves many unused ports per switch. The remaining ports can be distributed among the other zones. However, make sure that most of the remaining ports are assigned to the zones that contain the host connections: zone 1 and zone 2. This assignment allows for easy setup for connecting additional hosts.

For simplicity, in this example, the switches use one-half of the ports for each zone, although zone 3 and zone 4 require fewer ports.



Before proceeding, review the requirements in this section and the zoning example in the figures to make sure that both switches are correctly zoned. For more information, see *Fibre Channel Configurations Overview* on page 137.

Cabling for the intra-site configuration

After both Fibre Channel switches are correctly zoned, set up the intra-site configuration for the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

About this task

Note: Complete all connections by using Fibre Channel cables of the correct length.

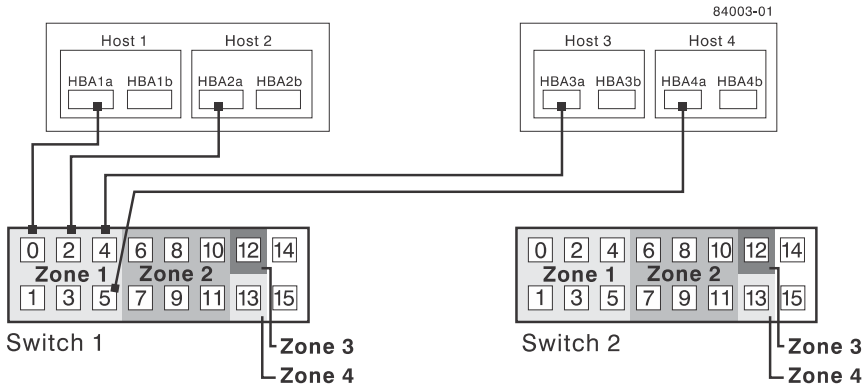
Steps

1. Determine whether you are adding equipment for the Synchronous Mirroring feature or the Asynchronous Mirroring feature to an existing storage array environment.
   - If so, stop I/O activity from all hosts before proceeding. Go to Step *2* on page 152.
   - If not, this is a new storage array installation. Go to Step *3* on page 152.

   Attention: Possible hardware damage – DC-powered controller-drive trays and drive trays have special power procedures that you *must* follow beyond the procedures for AC-powered trays. To get specific power-off and power-on procedures, see the installation guide for your storage array.
2. Turn off the power to all storage arrays, hosts, Fibre Channel switches, and any other equipment in the storage array environment.
3. Make sure that basic cabling between all of the controller trays or controller-drive trays and the drive trays is complete on both storage arrays as described in this document.
4. Connect the primary host bus adapter for each host to an available port in zone 1 of switch 1.

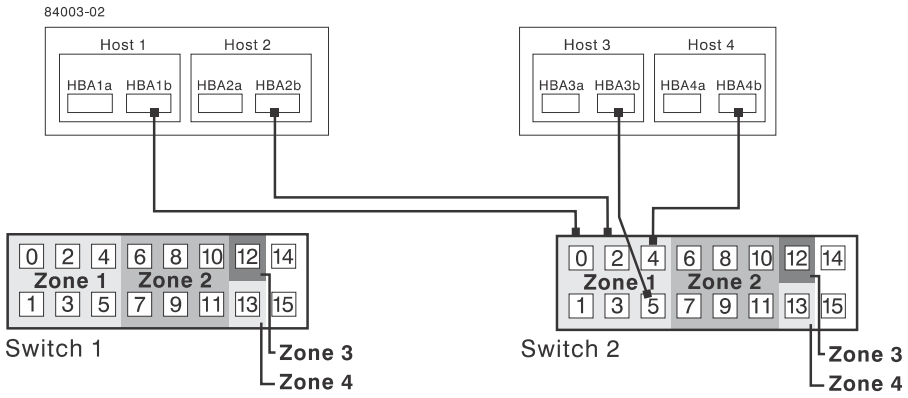
   The following figure shows the cabling that is described in Step *4* on page 152.

   Note: You can connect the cables to any port in the correct zone of the switch.



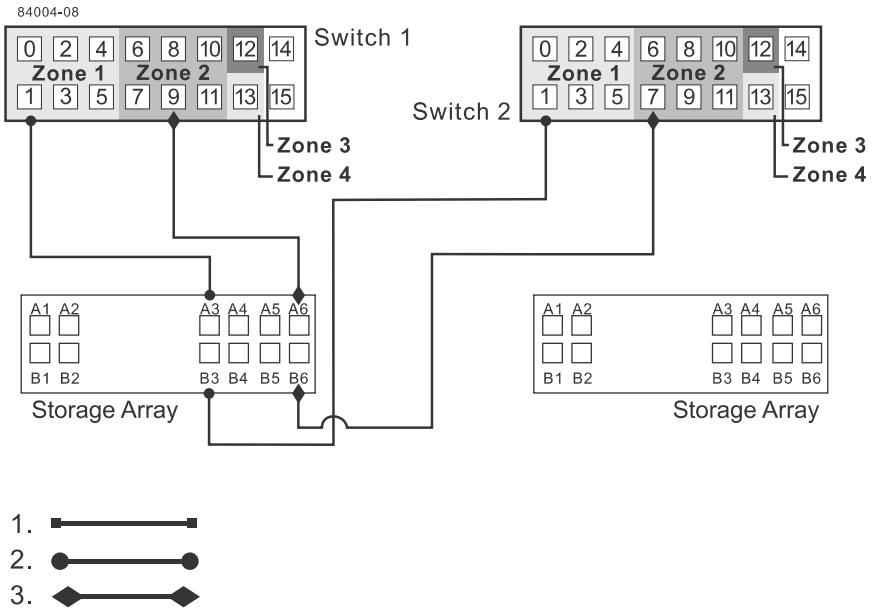
5. Connect the secondary host bus adapter for each host to an available port in zone 1 of switch 2.

   The following figure shows the cabling that is described in this step.



6. Connect controller port A1 of the primary storage array to an available port in zone 1 of switch 1.

The following figure shows the cabling that is described in Step *6* on page 153 through Step *9* on page 154.



1.	Host Fibre Channel cable
2.	Storage array Fibre Channel cable
3.	Fibre Channel cable dedicated for mirroring

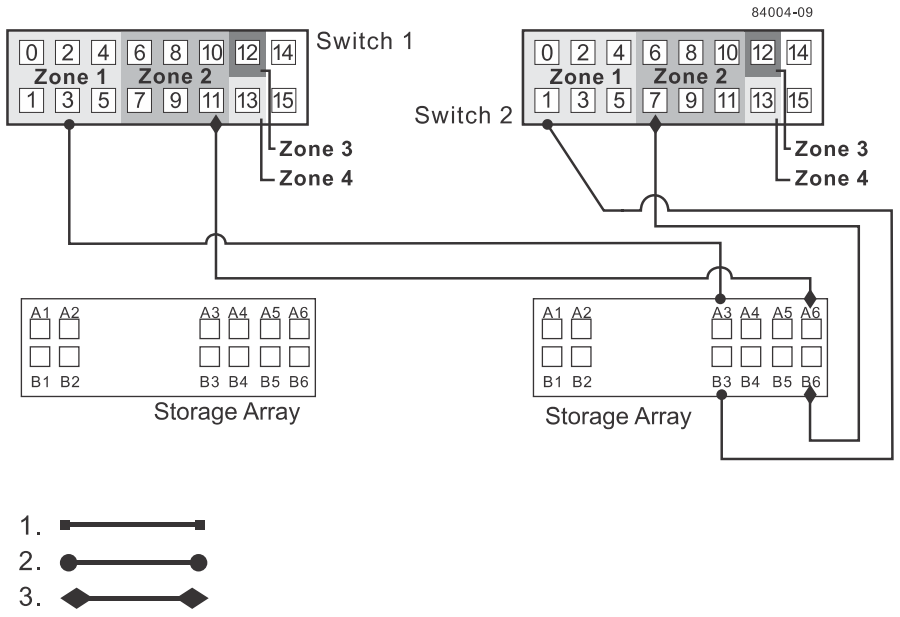
7. Connect controller port B1 of the primary storage array to an available port in zone 3 of switch 2.
8. Connect controller port A2 of the primary storage array to an available port in zone 2 of switch 1. In a four-host-port system, connect controller port A4 to an available port in zone 2 of switch 1.
9. Connect controller port B2 of the primary storage array to an available port in zone 4 of switch 2. In a four-host-port system, connect controller port B4 to an available port in zone 4 of switch 2.

   Note: Upon activation of the Synchronous Mirroring feature or the Asynchronous Mirroring feature, controller port A2 and controller port B2 are reserved for mirror relationship synchronization. In a four-host-port system, controller port A4 and controller port B4 are reserved.

10. Connect controller port A1 of the secondary storage array to an available port in zone 1 of switch 1.

    The figure following Step *13* on page 154 shows the cabling described in Step *6* on page 153 through Step *9* on page 154.

11. Connect controller port B1 of the secondary storage array to an available port in zone 3 of switch 2.
12. Connect controller port A2 of the secondary storage array to an available port in zone 2 of switch 1. In a four-host-port system, connect controller port A4 to an available port in zone 2 of switch 1.
13. Connect controller port B2 of the secondary storage array to an available port in zone 4 of switch 2. In a four-host-port system, connect controller port B4 to an available port in zone 4 of switch 2.



1.	Host Fibre Channel cable
2.	Storage array Fibre Channel cable
3.	Fibre Channel cable dedicated for mirroring

Cabling for the intra-site configuration is complete.

14. Repeat Step *4* on page 152 through Step *13* on page 154 for any additional storage arrays that exist in the same cabinet that will use the Synchronous Mirroring feature or the Asynchronous Mirroring feature.

    Attention: Possible hardware damage – DC-powered controller-drive trays and drive trays have special power procedures that you *must* follow beyond the procedures for AC-powered trays. To get specific power-off and power-on procedures, see the installation guide for your storage array.

15. Turn on the power to all storage arrays, hosts, Fibre Channel switches, and any other hardware where power was turned off.

Result

The hardware installation is complete. See the online help topics for procedures to configure the storage management software to support mirror relationships.

Installing and using mirroring with a wide area network

When installing and using the Synchronous Mirroring feature or the Asynchronous Mirroring feature over a wide area network (WAN), keep these guidelines in mind:

- If you are setting up an FCIP router to perform mirroring, go to the Compatibility Matrix. Select **Router-FCIP** in the **Product** field, and select the release of the storage management software that you use in the **Software Release** field. Verify that the maximum latency and distance are supported by referring to the vendor specifications for your router and by checking the NetApp Interoperability Matrix Tool (IMT) site at *http://mysupport.netapp.com/matrix*.
- FCIP router vendors and telecommunication vendors are responsible for setting up routing.

- The smaller the bandwidth on the WAN, the longer it takes a mirror to synchronize.
- If the bandwidth does not exceed the average rate, you might not be able to synchronize the data at all. For example, if the system writes at 1 Mb/s, it needs 2 Mb/s of bandwidth available.
- If the mirroring is lagging far behind during production hours, suspend the mirror. During off-peak hours, resume the mirror.
- If you need to keep the Synchronous Mirroring on at all times, keep the mirror physically as close as possible to the production site.
- To determine the average write rate, you should use the available system utilities and should take measurements during peak times.
- If you anticipate adding any applications, determine the bandwidth needs for any future applications.
- Acceptable lag times vary depending on the environment and should be determined on an individual basis.

Line capacities

Line type	Capacity in Mb/s	Speed in MB/s
T-1	1.544	0.193
T-3	43.232	5.404
OC-3	155.6352	19.454
OC-12	622.5408	77.8176
OC-48	2490.1632	311.27
OC-192	9960.6528	1245.085

The following table shows average write operations in Mb/s with corresponding line capacity calculations. When the line capacity calculation is below 50 percent, the result is an adequate response-time performance and a limited need for delta logging (when the mirror lags behind the data). When the line capacity calculation is above 50 percent, the mirror can never catch up. Any transfers above 50 percent will start to lag.

Average write time in Mb/s	T-1	T-3	OC-3	OC-12	OC-18	OC-192
0.01	5.2%	0.2%	0.1%	0.0%	0.0%	0.0%
0.1	51.8%	1.9%	0.5%	0.1%	0.0%	0.0%
1	518.1%	18.5%	5.1%	1.3%	0.3%	0.1%
10	5181.3%	185.3%	51.4%	12.9%	3.2%	0.8%

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