

Dell™ PowerVault™ MD3000

RAID Enclosure

Hardware Owner's Manual

Notes, Notices, and Cautions



NOTE: A NOTE indicates important information that helps you make better use of your computer.



NOTICE: A NOTICE indicates either potential damage to hardware or loss of data and tells you how to avoid the problem.



CAUTION: A CAUTION indicates a potential for property damage, personal injury, or death.

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About Your System

The Dell™ PowerVault™ MD3000 is a 3U rack-mounted external Redundant Array of Independent Disks (RAID) enclosure capable of accommodating up to 15 3.0-Gbps, Serial-Attached SCSI (SAS) disks. The RAID enclosure can be daisy-chained with up to two additional MD1000 expansion units, providing access to a maximum of 45 disks in the entire storage array. Connectivity between the RAID enclosure and the host server is provided by Dell SAS 5/E Host Bus Adapters (HBAs).

Overview

The RAID enclosure is designed for high availability, offering redundant access to data storage. It features dual active/active RAID controller modules, redundant power supplies, and redundant fans. The RAID enclosure is designed for high-performance environments: two-node clusters or multi-host storage access for up to four servers.

Storage management can be either in-band through the SAS connection, or out-of-band using an Ethernet connection.



NOTE: Dell recommends that you configure your MD3000 to use both in-band and out-of-band management paths. Establishing all management connections to a RAID enclosure provides additional paths in the case of a management connection failure.

Enclosure Features

Features include:

- Direct-connect support for fully redundant, two-node Microsoft® Windows® Clusters
- Support for up to four Windows, SUSE®, or Red Hat® Linux® host servers
- U chassis for rack mounting
- Two redundant, hot-pluggable RAID controller modules in one of two supported configurations:
 - Dual RAID controller modules with single SAS In port connectors on each controller
 - Dual RAID controller modules with dual SAS In port connectors on each controller
- Two redundant, hot-pluggable power supply/fan modules
- 512 MB of mirrored cache on each RAID controller module
- Battery backup unit in each RAID controller module that protects against cache data loss for up to 72 hours
- Support for up to 45 3.5" SAS physical disks
- Support for up to 255 virtual disks

- Up to 2 TB (2036 GB) storage on a single virtual disk
- Support for up to two PowerVault MD1000 expansion enclosures through SAS Out port connectors on the RAID controller modules



NOTE: These numbers represent maximum theoretical performance based on system architecture. Actual performance depends on customer environment and application usage.

- Online firmware updates (without taking the enclosure offline) for the following components:
 - RAID controller modules
 - NVSRAM
 - Expansion enclosure management modules (EMMs)
 - Physical disks



NOTICE: When updating physical disk firmware, you should stop all I/O activity to the array to prevent data loss.

- Task-based configuration software
- Optional snapshot virtual disk (premium feature), up to four snapshots per virtual disk and 128 snapshots per array
- Optional virtual disk copy (premium feature), up to 255 virtual disk copies per array
- Continuous background event monitoring for critical problems, such as impending physical disk failure or failed RAID controller modules
- Host-based, multipath failover software for redundant configurations to automatically reroute I/O activity from a failed, offline, or removed RAID controller module to its alternate RAID controller module (or from a failed HBA to its peer HBA). This capability maintains a data path between the host and the storage array.

Modular Disk Storage Manager

The Modular Disk (MD) Storage Manager software is a graphic interface with wizard-guided tools and a task-based management structure designed to reduce the complexity of installation, configuration, management, and diagnostic tasks. MD Storage Manager can be used on any server attached to the storage array, as well as on storage management stations connected to the same subnetwork as the RAID enclosure, to create and manage multiple storage arrays.

For more information, see the *MD Storage Manager User's Guide*.

Other Information You May Need



CAUTION: The *Product Information Guide* provides important safety and regulatory information. Warranty information may be included within this document or as a separate document.

- The *Rack Installation Guide* or *Rack Installation Instructions* included with your rack solution describes how to install your enclosure into a rack.

- The *Getting Started Guide* provides an overview of enclosure features, setting up your enclosure, and technical specifications.
- *Setting Up Your PowerVault MD3000* provides an overview of setting up and cabling your storage array.
- The *PowerVault MD3000 Installation Guide* provides installation and configuration instructions for both software and hardware.
- The *PowerVault MD Storage Manager CLI Guide* provides information about using the command line interface (CLI).
- The Dell PowerVault MD3000 *Resource CD* provides documentation for configuration and management tools, as well as the full documentation set included here.
- Dell PowerVault MD1000 Documentation is available at support.dell.com for users who incorporate MD1000 expansion enclosures.
- Dell PowerEdge Cluster Documentation is available at support.dell.com. A link to clustering documentation is also included on the *Resource CD* under **Product Documentation**.
- Updates are sometimes included to describe changes to the enclosure, software, and/or documentation.



NOTE: Always check for updates on support.dell.com and read the updates first because they often supersede information in other documents.

- Release notes or readme files are included to provide last-minute updates to the enclosure or documentation or advanced technical reference material intended for experienced users or technicians.

Hardware Features

The remainder of this section describes the hardware features available on the RAID enclosure, including:

- Indicators on the enclosure bezel
- Front-panel and back-panel indicators and features
- Power supply and cooling fan modules

Indicators on the Enclosure Bezel

An optional locking bezel can be installed on the front of the enclosure to limit access. Figure 1-1 illustrates the indicators and components on the bezel. Table 1-1 lists conditions indicated by the lights on the bezel. For information on installing and removing the bezel, see "Removing and Replacing the Front Bezel" on page 55.

Figure 1-1. LEDs on the Front Bezel

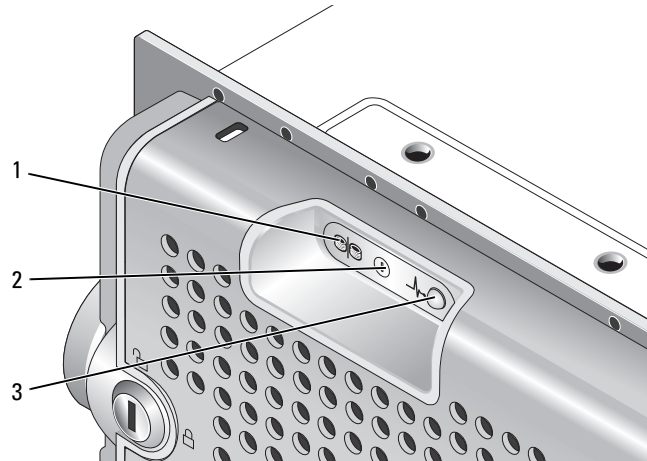





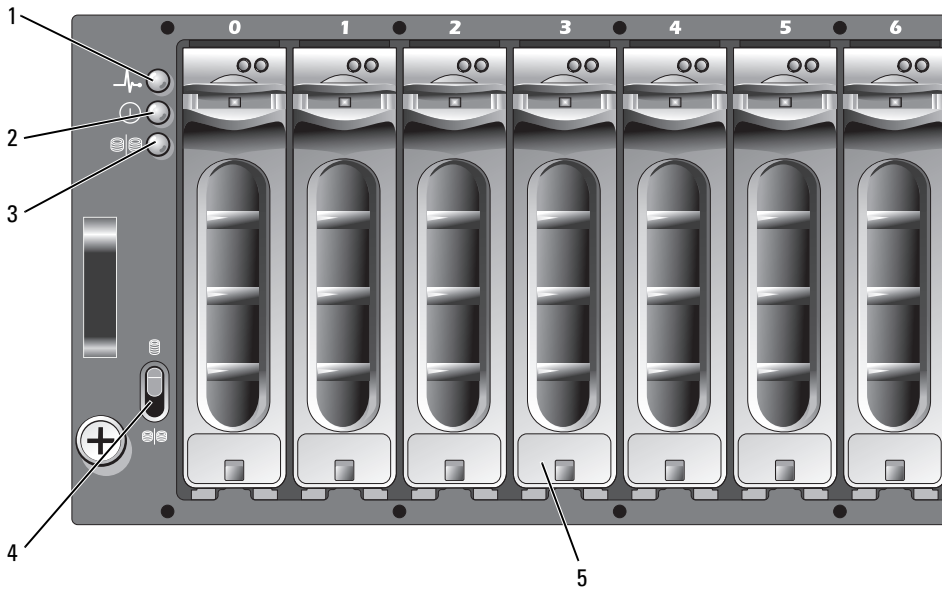
Table 1-1. Front Bezel Indicators

| Item | LED Indicator | LED Icon | Condition |
|------|-------------------------------|---|---|
| 1 | Split mode (green) |  | Because this mode is unused in the system, this LED should always be unlit. |
| 2 | Power (green) |  | When lit, at least one power supply is supplying power to the enclosure. |
| 3 | Enclosure status (blue/amber) |  | <p>Steady amber: Power is on and enclosure is in reset state.</p> <p>Steady blue: Power is on and enclosure status is OK.</p> <p>Flashing blue: Enclosure LED is being blinked by MD Storage Manager.</p> <p>Flashing amber: Enclosure is in fault state.</p> |

Front-Panel Indicators and Features

Figure 1-2 shows the LED indicators and components on the enclosure's front panel (optional locking bezel not shown). Table 1-2 lists the conditions and functions indicated by each.

Figure 1-2. Front-Panel Features




- 1 enclosure status LED
- 2 power LED
- 3 split mode LED (unused)
- 4 enclosure mode switch (unused)
- 5 physical disks (15)

Table 1-2. Front-Panel Components

| Component | Icon | Condition |
|-----------------------------------|------|--|
| Enclosure status LED (blue/amber) | | Steady amber: Power is on and enclosure is in reset state. Steady blue: Power is on and enclosure status is OK. Flashing blue: Host server is identifying the enclosure. Flashing amber: Enclosure is in fault state. |
| Power LED (green) | | When lit, at least one power supply is supplying power to the enclosure. |
| Split mode LED (green) | | Because this mode is unused in the system, this LED should always be unlit. |

Table 1-2. Front-Panel Components (continued)

| Component | Icon | Condition |
|-----------------------|---|------------------------|
| Enclosure mode switch |  | Unused in this system. |

NOTICE: This system does not support user-customizable operating modes. Therefore, the split mode LED and enclosure mode switch are not functional. However, if additional expansion enclosures are daisy chained to your system, the enclosure mode switch on the RAID array enclosure must be in single-mode position. For more information, see "Cabling Your RAID Enclosure" on page 21.

Physical Disk Carrier LED Indicators

Each physical disk carrier in your enclosure has two LEDs: an activity LED (green) and a bicolor (green/amber) status LED (see Figure 1-3). The activity LED flashes whenever the physical disk is accessed. Table 1-3 lists the flash patterns for the status LED.

Figure 1-3. Physical Disk Carrier LED Indicators

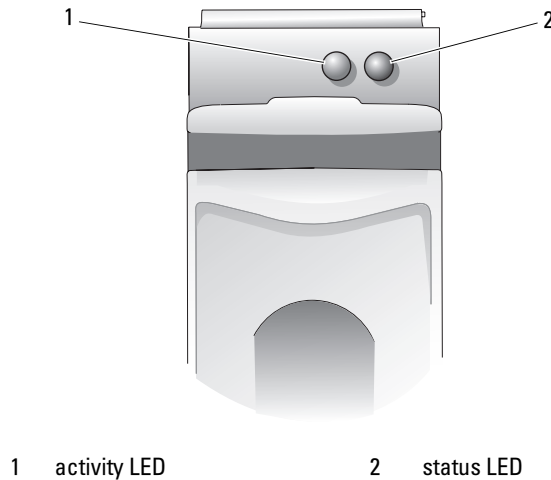


Table 1-3. Physical Disk Carrier Status LEDs

| Status LED | Description |
|--------------|--|
| Off | Physical disk not yet discovered by server or an unsupported disk is present |
| Steady green | Physical disk is online |

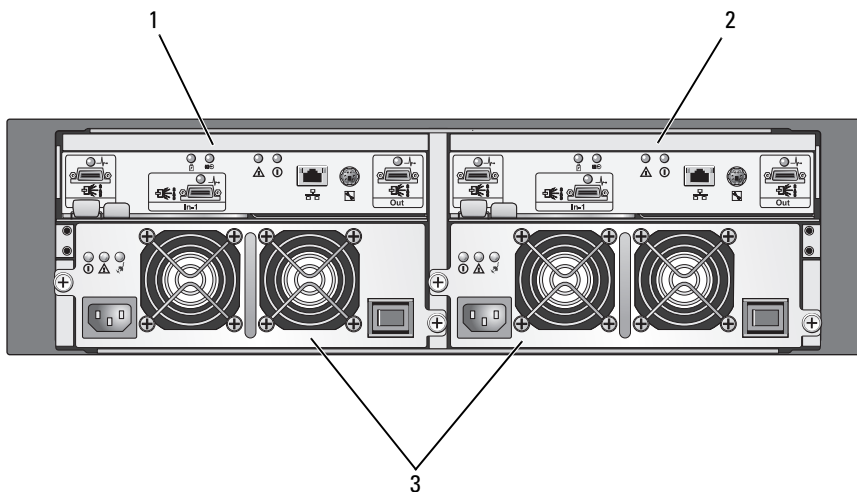
Table 1-3. Physical Disk Carrier Status LEDs (continued)

| Status LED | Description |
|--|---|
| Green flashing (250 milliseconds [ms]) | Physical disk is being identified |
| Green flashing On 400 ms Off 100 ms | Physical disk rebuilding |
| Amber flashing (125 ms) | Physical disk failed |
| Flashing green, amber, and off | Physical disk failure predicted (SMART) |
| Green 3 seconds, amber 3 seconds, and off 3 seconds | Physical disk rebuild aborted |

Back-Panel Indicators and Features

Figure 1-4 shows the back-panel features of the enclosure. Two RAID controller modules and two power supply/cooling fan modules must be installed for the enclosure to operate properly. However, the enclosure can run temporarily on one power supply/cooling fan module. For more information, see "Power Supply and Cooling Fan Features" on page 18.

Figure 1-4. Back-Panel Features



- 1 RAID controller module 0
- 2 RAID controller module 1
- 3 power supply/cooling fan modules (2)

RAID Controller Modules

The RAID controller modules provide high-performance, advanced virtual disk configuration, and fault-tolerant disk subsystem management. Each RAID controller module contains 512 MB of cache that is mirrored with the other controller's cache for high availability and protected by a battery for up to 72 hours.

Each RAID controller module provides data path and enclosure management functions for your enclosure, including:

- Monitoring and controlling enclosure environment elements (temperature, fans, power supplies, and enclosure LEDs)
- Controlling access to the physical disks
- Communicating enclosure attributes and states to the host server



NOTE: Two RAID controller modules must be installed in the enclosure; a configuration with fewer than two RAID controller modules installed is not supported.

Depending on which model you choose, the RAID controller module has either single or dual ports for host access. Various configurations can be utilized to connect the storage enclosure to hosts, depending on specific redundancy needs. For example:

- **Single-port controller** - Both RAID controller modules contain a single SAS host port. With a single-port model, you can connect either:
 - A single host with redundant data paths to each RAID controller module
 - Two hosts with a single, nonredundant data path to one RAID controller module
- **Dual-port controller** - Both RAID controller modules contain two SAS host ports. A dual-port model can connect either:
 - One or two hosts with redundant data paths to each RAID controller module
 - Up to four hosts with a single, nonredundant data path between each host to one RAID controller module

For detailed information on cabling, see "Cabling Your RAID Enclosure" on page 21.

RAID Controller Module Connectors and Features

Figure 1-5 shows a single RAID controller module as it appears from the rear of the enclosure. RAID controller module connectors and components shown include:

- Up to two SAS In port connectors (second SAS In port is optional)
- Ethernet connector



NOTE: The RAID controller module network configuration can be assigned using a DHCP server (the default setting). If a DHCP server is not available (time-out is 10 seconds) then the RAID controller modules uses the static IP addresses of 192.168.128.101 for controller 0 and 192.168.128.102 for controller 1.

- Nine LEDs (three SAS link, two Ethernet link/speed, Battery Fault, Cache Active, Controller Fault, and Controller Power)

- One SAS Out port connector
- Debug port (Dell support only)

For a description of each component on the front panel of the RAID controller module, see Table 1-4. For an explanation of how to connect the enclosure using the RAID controller module ports, see "Cabling Your RAID Enclosure" on page 21.

Figure 1-5. RAID Controller Module External Panel (front view)

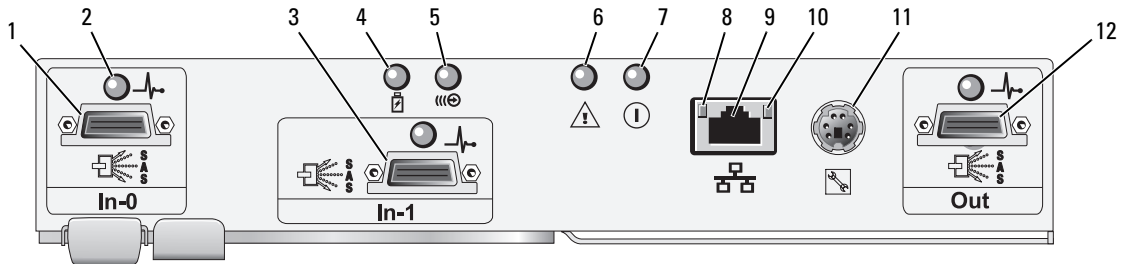


Table 1-4. RAID Controller Module Component Functions








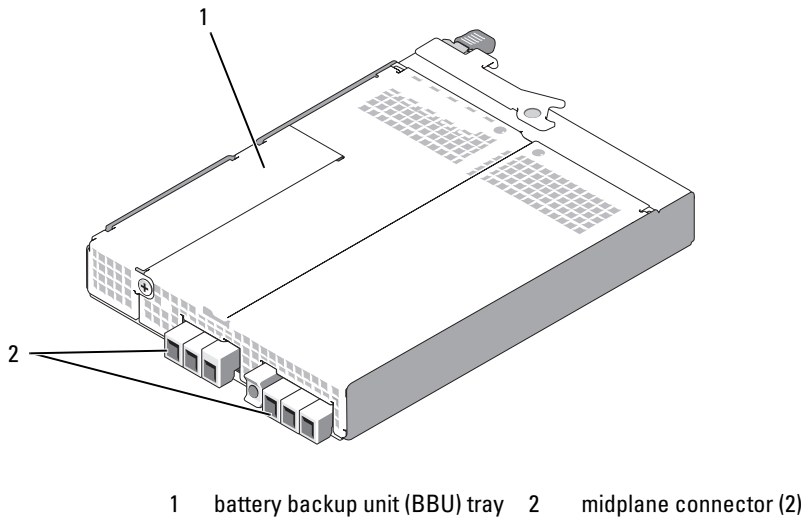
| Item | Component | Icon | Function |
|------|---------------------------------|---|---|
| 1 | SAS In Port 0 | In-0 | Provide host-to-controller SAS connection. |
| 2 | SAS LED (each SAS port) |  | Green: All links in port connected. Amber: Between one and four links disconnected. Off: All links in port disconnected or cable disconnected. |
| 3 | SAS In Port 1 (if available) | In-1 | Provide host-to-controller SAS connection. |
| 4 | Battery Fault LED (amber) |  | Amber: Battery backup unit or battery has failed. Amber flashing: Battery is charging or is in startup self test. Off: Battery backup unit and battery is operating normally. |
| 5 | Cache Active LED (green) |  | Green: On-board controller memory contains data. Off: On-board controller memory is empty. |
| 6 | Controller Fault LED (amber) |  | Amber: Controller fault detected. Off: Controller is operating normally. |
| 7 | Controller Power LED (green) |  | Green: Controller power is on. Off: Controller is not powered. |

Table 1-4. RAID Controller Module Component Functions (continued)

| Item | Component | Icon | Function |
|------|----------------------------|---|--|
| 8 | Ethernet Link LED (green) | | Green: Ethernet connection is active. Off: Ethernet connection is not active. |
| 9 | Ethernet Connector |  | Provide a 10/100 Mbps Ethernet connection for out-of-band management of the enclosure. |
| 10 | Ethernet Speed LED (green) | | Green: Ethernet connection is operating at 100BASE-T. Off: Ethernet connection is operating at 10BASE-T or is not active. |
| 11 | Debug Port |  | Dell support only. |
| 12 | SAS Out Port | Out | Provides SAS connection for cabling to the next downchain expansion enclosure. |

The RAID controller module connects to the enclosure midplane via the two midplane connectors on its internal (rear) panel. The RAID controller module is shown in Figure 1-6.

Figure 1-6. RAID Controller Module



Battery Backup Unit

Each RAID controller contains a three-cell lithium-ion battery backup unit (BBU) that powers the controller's cache memory and preserves the cache contents in the event of a power outage of up to 72 hours. The RAID controller firmware performs a test of the BBU at startup and will illuminate the battery fault LED if the battery is not operating within specified ranges, or if the battery is missing. For a description of the battery fault LED, see Table 1-5. For information on removing and installing the BBU, see "Removing and Installing a RAID Controller Module Backup Battery Unit" on page 60.



NOTE: For virtual disks, the RAID controller firmware changes the data cache setting based on the state of the battery. If the battery is missing or does not have sufficient charge, the controller flushes the cache and sets the write cache attribute to Write Through for all virtual disks. When the battery is replaced, Write Back is reenabled.

The RAID controller module logs the age of the battery and issues a replacement reminder message approximately six weeks before expiration. After replacing the battery, you must use MD Storage Manager to reset the battery age.

RAID Enclosure Thermal Shutdown

Enclosure management provides a feature that automatically shuts down the enclosure when the temperature within the storage enclosure exceeds a safe threshold. Thermal shutdown protects the data on the physical disks from corruption in the event of cooling system failure. It is not necessary to shut down any expansion enclosures attached to the storage enclosure.

The enclosure temperature probe's Nominal Failure Threshold and Maximum Failure Threshold determine the temperature at which shutdown occurs. These thresholds are default settings that cannot be changed. If the temperature sensors on the backplane or RAID controller module detect a temperature exceeding the Nominal Failure Threshold, a critical event is set; if the Maximum Failure Threshold is hit, shutdown of the enclosure power supplies occurs within 5 seconds.

Cache Functions and Features

Cache Mirroring


The cache mirroring function copies accepted host-write data from the primary controller to the partner controller. This action ensures that host-write data is safely mirrored to the partner controller before successful completion status is returned to the host. If a controller fails, the surviving controller safely retains all mirrored data. Cache mirroring is enabled by default.

Write-Back Cache

Write-back cache is a caching strategy whereby write operations result in a completion signal being sent to the host operating system as soon as the cache receives the data to be written. The target physical disk will receive the data at a more appropriate time in order to increase controller performance. In dual-active controller configurations with write-back caching enabled, the write data is always copied to the cache of the second controller before completion status is issued to the host initiator. Write Back is enabled by default.


Write-Through Cache

Write-through cache is a caching strategy whereby data is written to the physical disk before completion status is returned to the host operating system. Write-through cache is considered more secure than write-back cache, since a power failure is less likely to cause loss of data. The RAID controller automatically switches to write-through if cache mirroring is disabled or if the battery is missing or has a fault condition. Write-through cache results in lower performance.

 **NOTE:** Cache mirroring and write cache settings are not user-configurable.

Power Supply and Cooling Fan Features

Your RAID enclosure supports two integrated, hot-pluggable power supply/cooling fan modules. Both modules must be installed to ensure proper cooling. Each module contains two separate cooling fans. The enclosure requires at least three of the cooling fans to operate to avoid overheating.

 **CAUTION:** A power supply/cooling fan module can be removed from a powered-on enclosure for a maximum period of no more than 5 minutes. Beyond that time, the enclosure may automatically shut down to prevent damage to the enclosure and/or enclosure components.

A power supply/cooling fan module can be replaced without powering down the enclosure. For information on removing and replacing the modules, see "Removing and Installing the Power Supply/Cooling Fan Module" on page 62.

Figure 1-7 shows the power supply/cooling fan module features and LED indicators. Table 1-5 lists the LED indicator descriptions.

Figure 1-7. Power Supply and Cooling Fan Module LED Features and Indicators

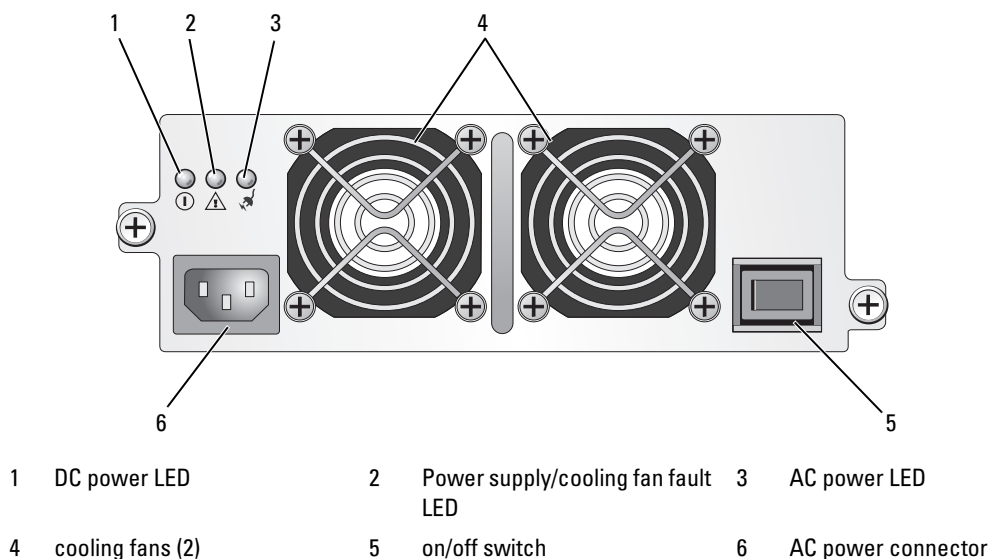


Table 1-5. Power Supply/Cooling Fan Module LED Indicators

| Type | Color | Icon | Function |
|--------------------------------|-------|------|---|
| DC power | Green | ① | On: DC output voltages are within specifications. Off: No power or voltages not within specifications. |
| Power supply/cooling fan fault | Amber | ⚠ | On: DC output voltages are not within specifications or one (or both) fans are in fault. Off: No fault condition is present. |
| AC power | Green | ⚡ | On: AC input voltage is within specifications. Off: No power or voltages not within specifications. |

Cabling Your RAID Enclosure

This section provides the following information:

- Procedures for connecting your RAID enclosure to a host system
- A description of redundant, nonredundant, and clustering configurations, including cabling diagrams for each

Before You Begin

Before connecting your RAID enclosure, ensure that the following are available:

- The components that shipped with your RAID enclosure, including:
 - Power cords (2)
 - SAS interconnect cables
 - *MD3000 Resource CD*
 - Rail kit
- Any relevant documentation, including:
 - *Getting Started Guide*
 - *Rack Installation Guide* or *Rack Installation Instructions*
 - *Product Information Guide* (for important safety, regulatory, and warranty information)
 - Readme files
- #2 Phillips screwdriver

About the Enclosure Connections

The RAID array enclosure is connected to a host via two hot-pluggable RAID controller modules. The RAID controller modules are identified as RAID controller module 0 and RAID controller module 1 (see Figure 1-4).

Each RAID controller module has at least one SAS In port connector that provides the direct connection to the host or node. A second SAS In port connector is available on the optional dual-port RAID controller. SAS In port connectors are labeled **In-0** and, if using the optional controller, **In-1** (see Figure 1-5).



NOTE: When you cable from a host server to an MD3000 SAS In port connector, either Out port of the server's HBA can be used.

Each MD3000 RAID controller module also contains a SAS Out port connector. This port allows you the option to connect the RAID enclosure to an expansion enclosure.

Cabling the Enclosure

You can cable your enclosure to up to four hosts and up to two expansion enclosures. The configuration that you choose depends on the number of hosts you have, whether you are connecting to a standalone host or a cluster node, and the level of data redundancy that you need.

The figures that follow are grouped according to the number of SAS In port connectors available on the MD3000. Single SAS In port configurations and dual SAS In port configurations each support redundant and nonredundant cabling.

Redundancy vs. Nonredundancy

Nonredundant configurations, configurations that provide only a single data path from a host to the RAID enclosure, are recommended only for non-critical data storage. Path failure from a failed or removed cable, a failed host bus adapter, or a failed or removed RAID controller module results in loss of host access to storage on the RAID enclosure.

Redundancy is established by installing separate data paths between the host and the storage array, in which each path is to different RAID controller modules. Redundancy protects the host from losing access to data in the event of path failure, because both RAID controllers can access all the disks in the storage array.

Single SAS In-Port Configurations

Figure 2-1 through Figure 2-5 show supported nonredundant and redundant cabling configurations to MD3000 RAID controller modules with a single SAS In port connector. Each diagram shows the maximum number of optional expansion enclosures attached.

Figure 2-1 through Figure 2-3 show one and two hosts, each connected to only one RAID controller module that is subsequently expanded to two more storage enclosures. The hosts can share storage space but without redundant paths, if one path were to fail, the server on that path would be disconnected from the storage array.

Figure 2-1. Cabling One Host with Nonredundant Data Paths

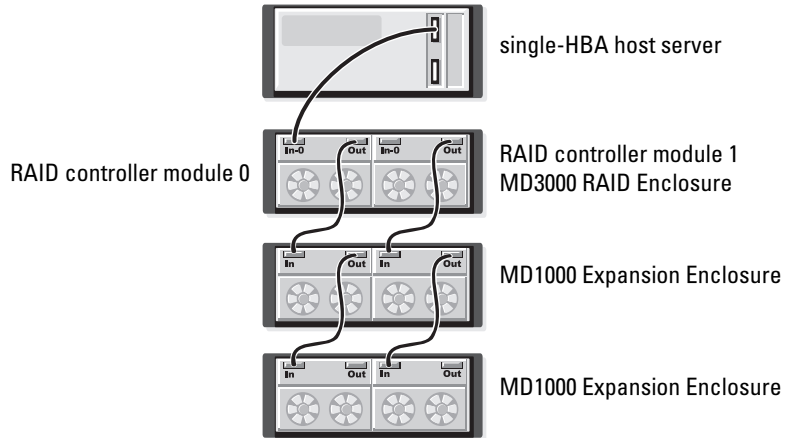


Figure 2-2. Cabling Two Hosts with Nonredundant Data Paths

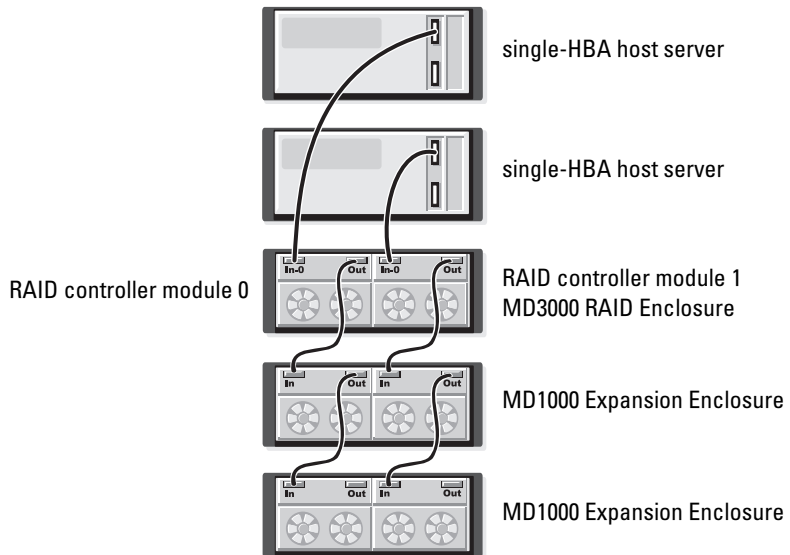


Figure 2-3. Cabling a Two-Node Cluster (Single HBA, Nonredundant Data Paths from Each Node)

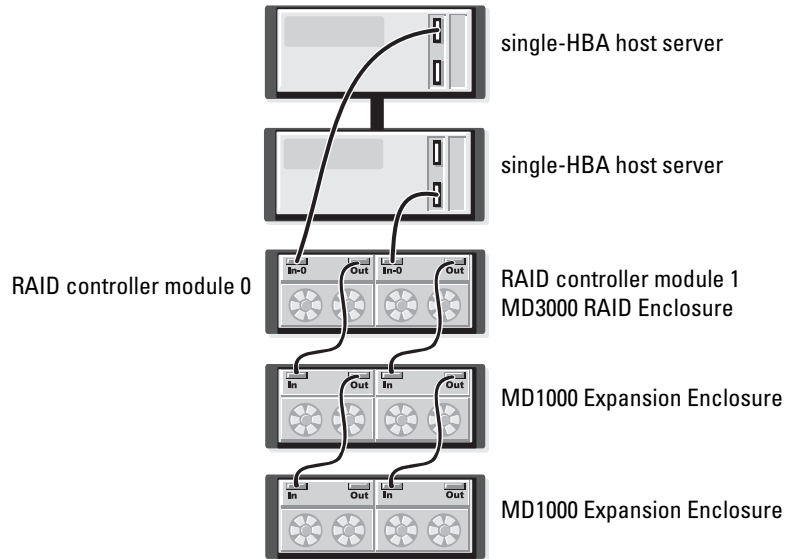


Figure 2-4 and Figure 2-5 show redundant, high-availability cabling configurations for one and two hosts. If any one path fails, at least one HBA is still connected to one RAID controller.

Figure 2-4. Cabling a Single Host (Dual HBA with Two Cable Connections) Using Redundant Data Paths

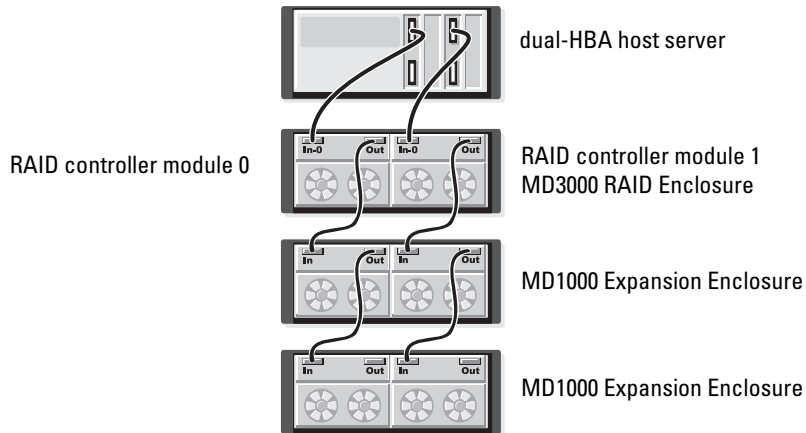
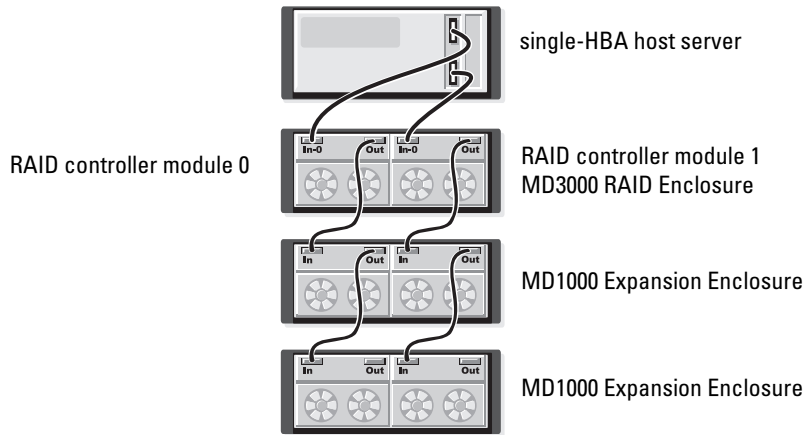


Figure 2-5. Cabling a Single Host (Single-HBA) Using Redundant Data Paths



Dual SAS In-Port Configurations

Figure 2-6 through Figure 2-12 show supported nonredundant and redundant cabling configurations to MD3000 RAID controller modules with two SAS In port connectors. Each diagram shows the maximum number of optional expansion enclosures attached.

Figure 2-6 shows how one, two, three, and four hosts can each be connected to a RAID controller module nonredundantly. The RAID controller module is subsequently expanded to two more storage enclosures. The hosts can share storage space but without redundant paths, if one path were to fail, the server on that path would be disconnected from the storage array.

Figure 2-6. Cabling Up to Four Hosts with Nonredundant Data Paths

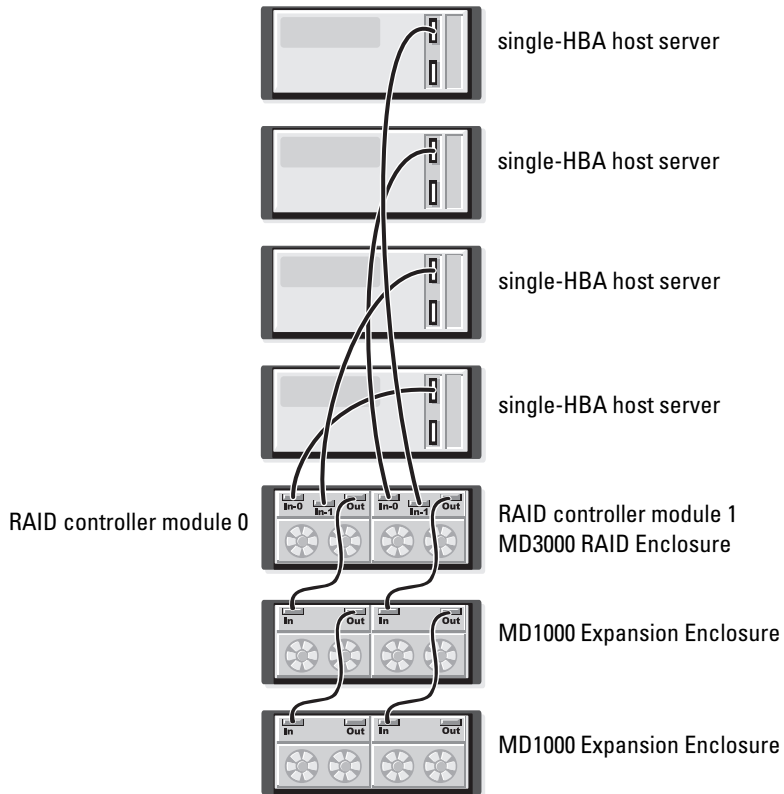


Figure 2-7 through Figure 2-10 show redundant, high-availability cabling configurations for one and two hosts. If any one path fails, at least one HBA is still connected to one RAID controller.

Figure 2-7. Cabling a Single Host (Dual HBA with Four Cable Connections) Using Redundant Data Paths

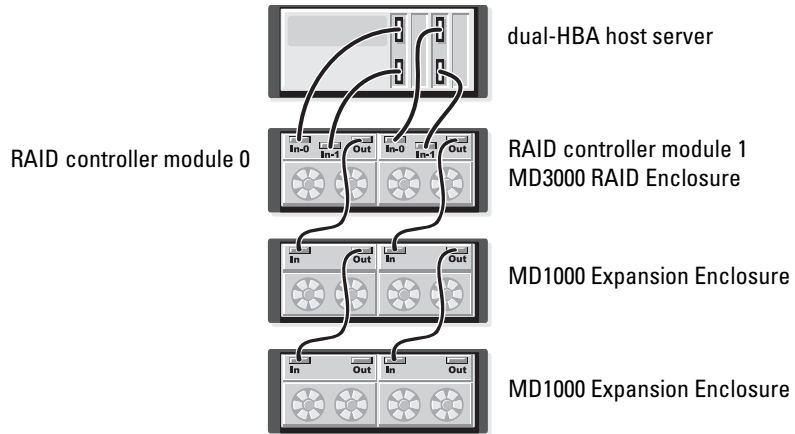


Figure 2-8. Cabling a Single Host (Single HBA) Using Redundant Data Paths

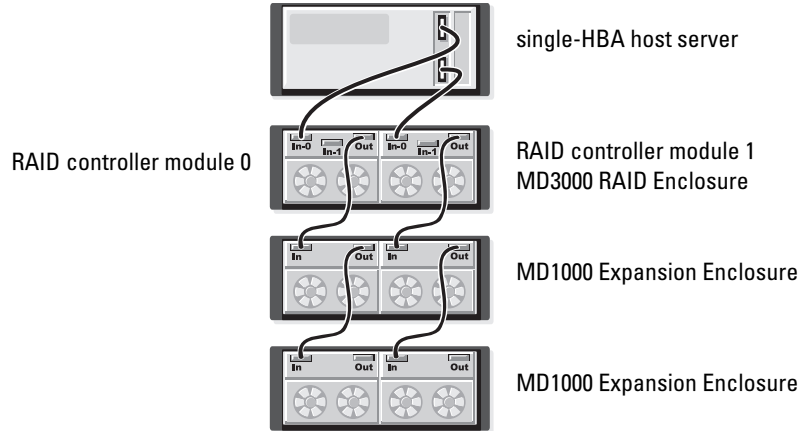


Figure 2-9. Cabling Two Hosts (with Dual HBAs) Using Redundant Data Paths

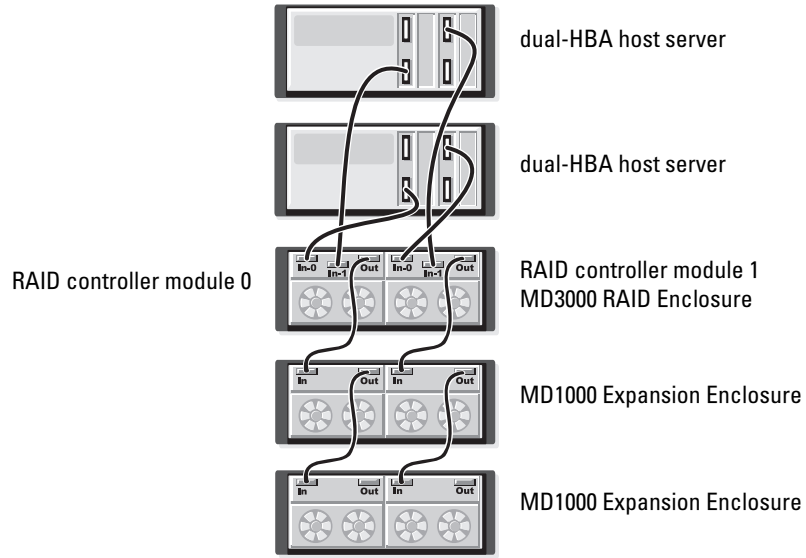


Figure 2-10. Cabling Two Hosts (with Single HBAs) Using Redundant Data Paths

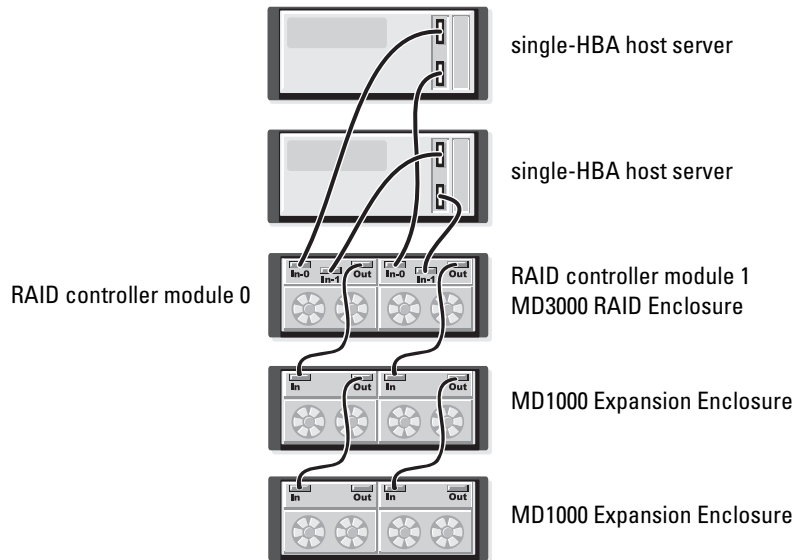


Figure 2-11 through Figure 2-12 show redundant, two-node cluster configurations using a single RAID enclosure that is subsequently expanded to two more storage enclosures.

Figure 2-11. Cabling a Two-Node Cluster (Single HBA, Redundant Data Paths from Each Node)

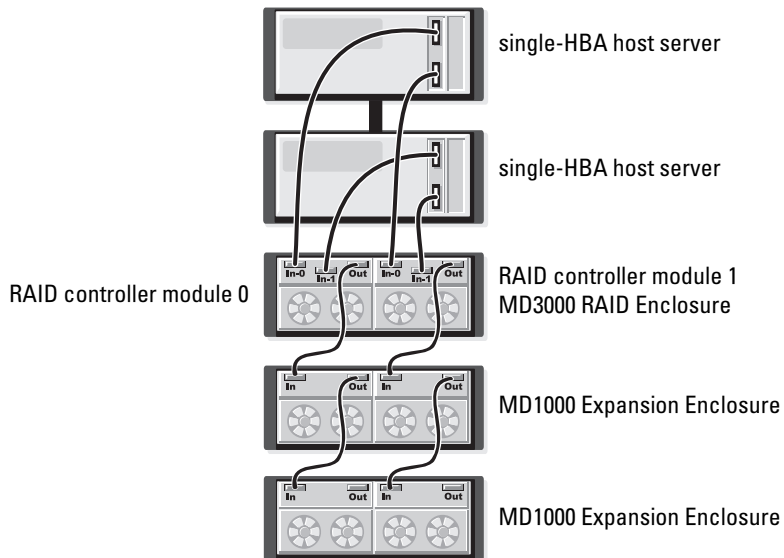
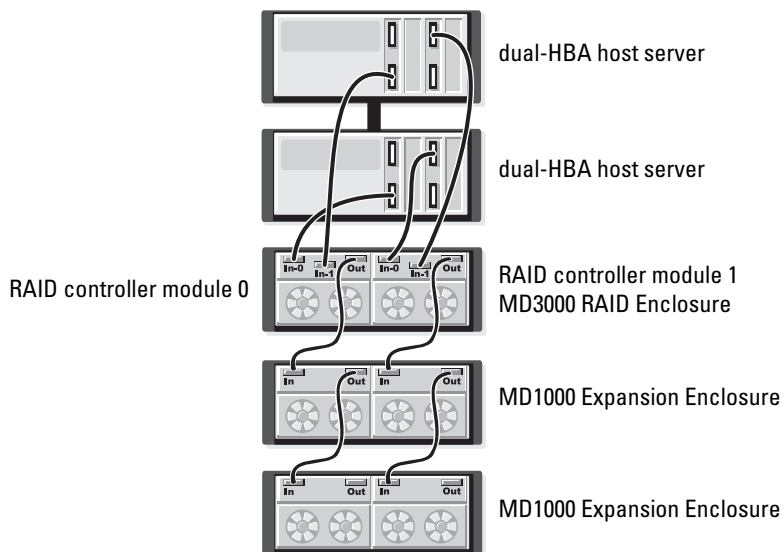


Figure 2-12. Cabling a Two-Node Cluster (Dual HBA, Redundant Data Paths from Each Node)




For a more detailed discussion of redundancy and nonredundancy, as well as alternate path software, see "Hardware Redundancy and Failover" on page 49.

Attaching MD1000 Expansion Enclosures


One of the features of the MD3000 is the ability to add up to two MD1000 expansion enclosures for additional capacity. This expansion increases the maximum physical disk pool to 45 3.5" SAS physical disks.

As described in the following sections, you can expand with either a new MD1000 or an MD1000 that has been previously configured in a direct-attach solution with a PERC 5/E system.

 **NOTICE:** Ensure that all MD1000 expansion enclosures being connected to the MD3000 are updated to the latest Dell MD1000 EMM Firmware from support.dell.com. Dell MD1000 EMM Firmware version A00 is not supported in an MD3000 array; attaching an MD1000 with unsupported firmware causes an uncertified condition to exist on the array. See the following procedure for more information.

Expanding with Previously Configured MD1000 Enclosures

Use this procedure if your MD1000 is currently directly attached to and configured on a Dell PERC 5/E system. Data from virtual disks created on a PERC 5 SAS controller cannot be directly migrated to an MD3000 or to an MD1000 expansion enclosure connected to an MD3000.

 **NOTICE:** If an MD1000 that was previously attached to PERC 5 SAS controller is used as an expansion enclosure to an MD3000, the physical disks of the MD1000 enclosure will be reinitialized and data will be lost. All MD1000 data must be backed up before attempting the expansion.

Perform the following steps to attach previously configured MD1000 expansion enclosures to the MD3000:

- 1 Back up all data on the MD1000 enclosure(s).
- 2 While the enclosure is still attached to the PERC 5 controller, upgrade the MD1000 firmware to an A03 or higher configuration. Windows systems users can reference the **DUP.exe** package; for Linux kernels, users can reference the **DUPbin** package.
- 3 Before adding the MD1000 enclosure(s), make sure the MD3000 software is installed and up to date. For more information, refer to the *Dell PowerVault Compatibility Matrix* available on support.dell.com.
 - a Install or update the SAS driver and firmware. For Windows systems users, use the update package. For Linux systems users, use the DKMS package.
 - b Install or update (to the latest version available on support.dell.com) the MD Storage Manager on each host server. Refer to the *PowerVault MD3000 Installation Guide* for detailed information.
 - c Install or update (to the latest version available on support.dell.com) the multipath drivers on each host server. The multipath drivers are bundled with Modular Disk Storage Management install. On Windows systems, the drivers are automatically installed when a Full or Host selection is made.

- d Using the MD Storage Manager, update the MD3000 RAID controller firmware to the latest version available on support.dell.com (Support→ Download Firmware→ Download RAID Controller Module Firmware) and the NVSRAM (Support→ Download Firmware→ Download RAID Controller Module NVSRAM).
- 4 Stop I/O and turn off all systems:
 - a Stop all I/O activity to the array and turn off affected host systems attached to the MD3000.
 - b Turn off the MD3000.
 - c Turn off any MD1000 enclosures in the affected system.
 - 5 Referencing the applicable configuration for your rack (Figure 2-1 through Figure 2-12), cable the MD1000 enclosure(s) to the MD3000.
 - 6 Turn on attached units:
 - a Turn on the MD1000 expansion enclosure(s). Wait for the expansion status LED to light blue.
 - b Turn on the MD3000 and wait for the status LED to indicate that the unit is ready:
 - If the status LEDs light a solid amber, the MD3000 is still coming online.
 - If the status LEDs are blinking amber, there is an error that can be viewed using the MD Storage Manager.
 - If the status LEDs light a solid blue, the MD3000 is ready.
 - c After the MD3000 is online and ready, turn on any attached host systems.
 - 7 After the MD1000 is configured as the expansion enclosure to the MD3000, restore the data that was backed up in step 1.

After they are online, the MD1000 enclosures are available for use within the MD3000 system.

Expanding with New MD1000 Enclosures

Perform the following steps to attach new MD1000 expansion enclosures to the MD3000:

- 1 Before adding the MD1000 enclosure(s), make sure the MD3000 software is installed and up to date. For more information, refer to the *Dell PowerVault Compatibility Matrix* available on support.dell.com.
 - a Install or update the SAS driver and firmware. For Windows systems users, use the update package. For Linux systems users, use the DKMS package.
 - b Install or update (to the latest version available on support.dell.com) the MD Storage Manager on each host server. Refer to the *PowerVault MD3000 Installation Guide* for detailed information.
 - c Install or update (to the latest version available on support.dell.com) the multipath drivers on each host server. The multipath drivers are bundled with Modular Disk Storage Management install. On Windows systems, the drivers are automatically installed when a Full or Host selection is made.

- d** Using the MD Storage Manager, update the MD3000 RAID controller firmware (**Support**→**Download Firmware**→**Download RAID Controller Module Firmware**) and the NVSRAM (**Support**→**Download Firmware**→**Download RAID Controller Module NVSRAM**).
- 2** Stop I/O and turn off all systems:
 - a** Stop all I/O activity to the array and turn off affected host systems attached to the MD3000.
 - b** Turn off the MD3000.
 - c** Turn off any MD1000 enclosures in the affected system.
- 3** Referencing the applicable configuration for your rack (Figure 2-1 through Figure 2-12), cable the MD1000 enclosure(s) to the MD3000.
- 4** Turn on attached units:
 - a** Turn on the MD1000 expansion enclosure(s). Wait for the expansion status LED to light blue.
 - b** Turn on the MD3000 and wait for the status LED to indicate that the unit is ready:
 - If the status LEDs light a solid amber, the MD3000 is still coming online.
 - If the status LEDs are blinking amber, there is an error that can be viewed using the MD Storage Manager.
 - If the status LEDs light a solid blue, the MD3000 is ready.
 - c** After the MD3000 is online and ready, turn on any attached host systems.
- 5** Using the MD Storage Manager, update all attached MD1000 firmware:
 - a** Select **Support**→**Download Firmware**→**Download Environmental (EMM) Card Firmware**.
 - b** Check the **Select All** check box so that all attached MD1000 enclosures are updated at the same time (each takes approximately 8 minutes to update).

Using Your RAID Enclosure

This section covers the following information:

- Basic concepts of a RAID solution including physical disks, virtual disks, and disk groups
- RAID levels supported by MD Storage Manager
- Hot spare operations and rebuilds
- Media errors and unreadable sectors
- RAID operations and features
- Advanced RAID features
- Hardware redundancy and failover including cabling
- Updating enclosure firmware

Physical Disks, Virtual Disks, and Disk Groups

Physical disks in your RAID array provide the physical storage capacity for your data. Before you can begin writing data to the storage array, you must configure the physical storage capacity into logical components, called *disk groups* and *virtual disks*.

A disk group is a set of physical disks upon which multiple virtual disks are created. The maximum number of physical disks supported in a disk group is 30. You create disk groups from unconfigured capacity on your storage array.

A virtual disk is a partition in a physical disk group that is made up of contiguous data segments of the physical disks in the disk group. A virtual disk consists of data segments from all physical disks in the disk group. All virtual disks in a disk group support the same RAID level. The RAID enclosure supports up to 255 virtual disks that can be assigned to hosts. Each virtual disk is assigned a Logical Unit Number (LUN) that is recognized by the host operating system.

Physical Disks

Only Dell-supported 3.0-Gbps SAS physical disks are supported in the storage array. If the RAID controller module detects unsupported physical disks, it marks the disk as unsupported and the drive becomes unavailable for all operations.



NOTE: The MD3000 enclosure must contain at least two disk drives for proper operation. This is necessary because the disks are used to store configuration information.

Physical Disk States

The RAID controller module recognizes the physical disk states (*mode* and *status* reported in MD Storage Manager) described in Table 3-1.

Table 3-1. RAID Controller Physical Disk States

| Status | Mode | Description | Physical Disk Status LED Indication |
|-----------------|--|--|--|
| Optimal | Unassigned | The physical disk in the indicated slot is unused and available to be configured. | Steady Green |
| Optimal | Assigned | The physical disk in the indicated slot is configured as part of a disk group. | Steady Green |
| Optimal | Hot Spare Standby | The physical disk in the indicated slot is configured as a hot spare. | Steady Green |
| Optimal | Hot Spare In Use | The physical disk in the indicated slot is in use as a hot spare within a disk group. | Steady Green |
| Failed | Assigned, Unassigned, Hot Spare In Use, or Hot Spare Standby | The physical disk in the indicated slot has been failed because of an unrecoverable error, an incorrect drive type or drive size, or by its operational state being set to failed. | Amber flashing (125 ms) |
| Replaced | Assigned | The physical disk in the indicated slot has been replaced and is ready to be, or is actively being, configured into a disk group. | Green flashing (On 400 ms, Off 100 ms) |
| Pending Failure | Assigned, Unassigned, Hot Spare In Use, or Hot Spare Standby | A SMART error has been detected on the physical disk in the indicated slot. | Flashing Green, Amber, and off |
| (none) | (none) | The indicated slot is empty, or the array cannot detect the physical disk. | Off |

If a disk drive rebuild fails because of a source drive failure or because the drive is too small, the user interface reports a failure of the physical disk even though the LED state on the drive indicates the rebuild was aborted.


Self-Monitoring Analysis and Reporting Technology (SMART)

Self-Monitoring Analysis and Reporting Technology (SMART) monitors the internal performance of all physical disk components to detect faults indicating the potential for physical disk failure. SMART uses this information to report whether failure is imminent so that a physical disk can be replaced before failure occurs. The RAID controller monitors all attached drives and notifies users when a predicted failure is reported by a physical disk.

Virtual Disks and Disk Groups

When configuring a storage array, you would normally proceed in this order:

- Organize the physical disks into disk groups.
- Create virtual disks within these disk groups.
- Determine which hosts you want to grant access to which virtual disks, then create mappings to associate the virtual disks with the hosts.

 **NOTE:** Host access must be created prior to mapping virtual disks to them.

Disk groups are always created in the unconfigured capacity of a storage array; virtual disks are created within the free capacity of a disk group. *Unconfigured* capacity is comprised of the available physical disk space that is not already assigned in the storage array. *Free* capacity is the space in a disk group that has not been assigned to a virtual disk.

Creating a Virtual Disk

To create a virtual disk, use one of the following methods:

- Create a new disk group from unconfigured capacity. You can define the RAID level and capacity (the number of physical disks) for the disk group, then define the parameters for the first virtual disk in the new disk group.
- Create a new virtual disk in the free capacity of an existing disk group. You only need to specify the parameters for the new virtual disk.

Virtual Disk States

The RAID controller module recognizes the following virtual disk states.

Table 3-2. RAID Controller Virtual Disk States

| State | Description |
|----------|--|
| Optimal | The virtual disk contains physical disks that are all online. |
| Degraded | The virtual disk with a redundant RAID level contains an inaccessible physical disk. The system can still work properly, but performance may be affected and additional disk failures may result in data loss. |
| Offline | A virtual disk with one or more member disks in an inaccessible (failed, missing, or offline) state. Data on the virtual disk is no longer accessible. |

Supported RAID Levels

RAID levels determine the way in which data is written to physical disks. Different RAID levels provide different levels of accessibility, redundancy, and capacity.

Using multiple physical disks has several advantages over using a single physical disk, including:

- Placing data on multiple physical disks, called *striping*, means that input/output (I/O) operations can occur simultaneously and improve performance.
- Storing redundant data on multiple physical disks using *mirroring* or *parity* supports reconstruction of lost data if an error occurs, even if that error is the failure of a physical disk.

Each RAID level provides different performance and protection. You should select a RAID level based on the type of application, access, fault tolerance, and data you are storing.

The storage array supports RAID levels 0, 1, 5, and 10.

RAID 0

RAID 0 uses disk striping to provide high data throughput, especially for large files in an environment that requires no data redundancy. RAID 0 breaks the data down into segments and writes each segment to a separate physical disk. I/O performance is greatly improved by spreading the I/O load across many physical disks. Although it offers the best performance of any RAID level, RAID 0 lacks data redundancy (fault tolerance). Choose this option only for non-critical data, because failure of just one physical disk will result in the loss of all data.

RAID 1

RAID 1 uses disk mirroring so that data written to one physical disk is simultaneously written to another physical disk. This is recommended for small databases or other applications that do not require large capacity. RAID 1 provides full data redundancy, meaning that if one disk fails, the mirrored disk automatically maintains throughput with no data loss.

RAID 5

RAID 5 uses parity and striping data across all physical disks (distributed parity) to provide high data throughput and data redundancy, especially for small random access. RAID 5 is the most versatile RAID level and is suited for multi-user environments where typical I/O size is small and there is a high proportion of read activity.

RAID 10

RAID 10, a combination of RAID 1 and RAID 0, uses disk striping across mirrored disks. It provides high data throughput and complete data redundancy. Utilizing an even number of physical disks (four or more) creates a RAID level 10 disk group and/or virtual disk. Because RAID levels 1 and 10 use disk mirroring, half of the capacity of the physical disks is utilized for mirroring. This leaves the remaining half of the physical disk capacity for actual storage. RAID 10 is automatically used when a RAID level of 1 is chosen with four or more physical disks.

RAID Level Usage

To ensure best performance, you should select an optimal RAID level when you create a system physical disk. The optimal RAID level for your disk array depends on a number of factors, including:

- Number of physical disks in the disk array
- Capacity of the physical disks in the disk array
- Need for redundant access to the data (fault tolerance)
- Disk performance requirements

RAID 0 is best used for video editing, image editing, prepress applications, or any application requiring high bandwidth.

RAID 1 offers fast performance and the best data availability, but also the highest disk overhead. It is best used for accounting, payroll, or financial applications.

RAID 5 is best used for file, application, database, web, e-mail, news, and intranet servers.

RAID 10 works well for medium-sized databases or any environment that requires high performance and fault tolerance and moderate-to-medium capacity.

Segment Size

Disk striping enables data to be written across multiple physical disks. Disk striping enhances performance because striped disks are accessed simultaneously.

The segment size or stripe element size specifies the size of data in a stripe written to a single disk. The MD3000 supports stripe element sizes of 8, 16, 32, 64, 128, 256, and 512 KB. The default stripe element size is 128 KB.

Stripe width, or depth, refers to the number of disks involved in an array where striping is implemented. For example, a four-disk disk group with disk striping has a stripe width of four.



NOTE: Although disk striping delivers excellent performance, striping alone does not provide data redundancy.

Hot Spares and Rebuild

A valuable strategy to protect data is to assign available physical disks in the storage array as *hot spares*. A hot spare adds another level of fault tolerance to the storage array.

A hot spare is an idle, powered-on, stand-by physical disk ready for immediate use in case of disk failure. If a hot spare is defined in an enclosure in which a redundant virtual disk experiences a physical disk failure, a rebuild of the degraded virtual disk is automatically initiated by the RAID controller modules. If no hot spares are defined, the rebuild process will be initiated by the RAID controller modules when a replacement physical disk is inserted into the storage array.

Global Hot Spares

The MD3000 supports global hot spares. A global hot spare can replace a failed physical disk in any virtual disk with a redundant RAID level as long as the capacity of the hot spare is equal to or larger than the size of the configured capacity on the physical disk it replaces, including its metadata.

Hot Spare Operation

When a physical disk fails, the virtual disk automatically rebuilds using an available hot spare. When a replacement physical disk is installed, data from the hot spare is copied back to the replacement physical disk. This function is called copy back. By default, the RAID controller module automatically configures the number and type of hot spares based on the number and capacity of physical disks in your system.


A hot spare may have the following states:

- A *standby hot spare* is a physical disk that has been assigned as a hot spare and is available to take over for any failed physical disk.
- An *in-use hot spare* is a physical disk that has been assigned as a hot spare and is currently replacing a failed physical disk.

Rebuild

If a disk fails in a fault-tolerant disk group (RAID 1, RAID 5, and RAID 10) and a hot spare is available, the RAID software automatically attempts to rebuild the data to restore redundancy. If no hot spares are available, an automatic rebuild occurs when a new physical disk is installed. You can use MD Storage Manager to specify a physical disk to rebuild.

The requirements for a replacement physical disk are the same as those for a hot spare: the capacity should be equal to or larger than the size of the configured capacity on the physical disk it replaces, including its metadata.


 **NOTE:** For a stripe set of mirrors (RAID 10), it is possible for multiple disks to fail without a virtual disk failure.

Media Errors and Unreadable Sectors

If the RAID controller detects a media error while accessing data from a physical disk that is a member of a disk group with a redundant RAID level (RAID 1, RAID 5 or RAID 10), the controller will try to recover the data from peer disks in the disk group and will use recovered data to correct the error. If the controller encounters an error while accessing a peer disk, it is unable to recover the data and affected sectors are added to the unreadable sector log maintained by the controller.

Other conditions under which sectors are added to the unreadable sector log include:

- A media error is encountered when trying to access a physical disk that is a member of a nonredundant disk group (RAID 0 or degraded RAID 1, RAID 5 or RAID 10).
- An error is encountered on source disks during rebuild.

 **NOTE:** Data on an unreadable sector is no longer accessible.

RAID Operations and Features

This section details the following RAID operations and features supported by your enclosure or RAID controller:

- Virtual disk operations
- Disk group operations
- RAID background operations priority
- Virtual disk migration and roaming

Virtual Disk Operations

Virtual Disk Initialization

Every virtual disk must be initialized. Up to four concurrent initializations can occur for the same RAID controller module.

Background Initialization

The RAID controller module executes a background initialization when the virtual disk is created to establish parity, while allowing full host access to the virtual disks. Background initialization does not run on RAID 0 virtual disks.

The background initialization rate is controlled by MD Storage Manager. You must stop an ongoing background initialization before you change the rate, or the rate change will not take effect. After you stop background initialization and change the rate, the rate change will take effect when the background initialization restarts automatically.



NOTE: Unlike initialization of virtual disks, background initialization does not clear data from the physical disks.

Foreground Initialization

The RAID controller module firmware supports full foreground initialization for virtual disks. All access to the virtual disk is blocked during the initialization process. During initialization, zeros (0x00) are written to every sector of the virtual disk. The virtual disk is available after the initialization is completed without requiring a RAID controller module restart.

Consistency Check

A consistency check verifies the correctness of data in a redundant array (RAID levels 1, 5, and 10). For example, in a system with parity, checking consistency means computing the data on one physical disk and comparing the results to the contents of the parity physical disk.

A consistency check is similar to a background initialization. The difference is that background initialization cannot be started or stopped manually, while consistency check can.



NOTE: Dell recommends that you run data consistency checks on a redundant array at least once a month. This allows detection and automatic replacement of unreadable sectors. Finding an unreadable sector during a rebuild of a failed physical disk is a serious problem, since the system does not have the redundancy to recover the data.

Media Verification

Another background task performed on the RAID controller module is media verification of all configured physical disks in a disk group. The RAID controller module uses the Read operation to perform verification on the space configured in virtual disks and the space reserved by the controller for the metadata.

Cycle Time

The media verification operation runs only on selected disk groups, independent of other disk groups. *Cycle time* is how long it takes to complete verification of the metadata region of the disk group and all virtual disks in the disk group for which media verification is configured. The next cycle for a disk group starts automatically when the current cycle completes. You can set the cycle time for a media verification operation between 1 and 30 days. The firmware throttles the media verification I/O accesses to disks based on the cycle time.

The RAID controller module tracks the cycle for each disk group independent of other disk groups on the controller and creates a checkpoint. If the media verification operation on a disk group is preempted or blocked by another operation on the disk group, the firmware resumes after the current cycle. If the media verification process on a disk group is stopped due to a RAID controller module restart, the firmware resumes the process from the last checkpoint.

Virtual Disk Operations Limit

The maximum number of active, concurrent virtual disk processes per controller is four. This limit is applied to the following virtual disk processes: background initialization, foreground initialization, consistency check, rebuild, and copy back.

If a redundant controller fails with existing virtual disk processes, the processes on the failed controller are transferred to the peer controller. A transferred process is placed in a suspended state if there are four active processes on the peer controller. The suspended processes are resumed on the peer controller when the number of active processes falls below four.

Disk Group Operations

RAID Level Migration

Over time, you might determine that characteristics of the initial RAID level you set initially are no longer appropriate for your enterprise. For example, you can add fault-tolerant characteristics to a stripe set (RAID 0) by converting it to a RAID 5 set. Select the virtual disk that you want to change and select the type of RAID level to which you want to migrate. MD Storage Manager provides information about RAID attributes to assist you in selecting the appropriate level. You can perform a RAID level migration while the system is still running and without rebooting, which maintains data availability.

Segment Size Migration

Segment size refers to the amount of data (in kilobytes) that the RAID controller module writes on a single physical disk in a virtual disk before writing data on the next physical disk. Valid values for the segment size are 8, 16, 32, 64, 128, 256, and 512 KB.

Dynamic segment size migration enables the segment size of a given virtual disk to be changed. A default segment size was set when the virtual disk was created, based on such factors as the RAID level and expected usage. You can change the default value if actual usage does not match your needs.

When considering a segment-size change, two scenarios illustrate different approaches to the limitations:

- If I/O activity stretches beyond the segment size, you can increase it to reduce the number of disks required to satisfy a single I/O. Using a single physical disk for a single request frees other disks to service other requests, especially when you have multiple users accessing a database or storage environment.
- If you are using the virtual disk in a single-user, large I/O environment (such as for multimedia application storage), performance can be optimized when a single I/O request is serviced with a single data stripe (the segment size multiplied by the number of physical disks in the disk group used for data storage). In this case, multiple disks are used for the same request, but each disk is only accessed once.

Virtual Disk Capacity Expansion

When you configure a virtual disk, you select a capacity based on the amount of data you expect to store. For example, if a disk group will contain a virtual disk that stores larger multimedia files and another virtual disk that stores smaller text files, the multimedia file virtual disk will obviously require more capacity.

However, you might need to eventually increase the virtual disk capacity for a standard virtual disk by adding free capacity to the disk group. This creates more unused space for you to create new virtual disks, or to expand your existing virtual disks.

Disk Group Expansion

Because the storage array supports hot pluggable physical disks, you can add two physical disks at a time for each disk group while the storage array remains online. Data remains accessible on virtual disk groups, virtual disks, and physical disks throughout the entire modification operation. The data and increased unused free space are dynamically redistributed across the disk group. RAID characteristics are also reapplied to the disk group as a whole.


Disk Group Defragmentation

Defragmenting consolidates the free capacity in the disk group into one contiguous area. Defragmentation does not change the way in which the data is stored on the virtual disks.

Disk Group Operations Limit

The maximum number of active, concurrent disk group processes per controller is one. This limit is applied to the following disk group processes: virtual disk RAID level migration, segment size migration, virtual disk capacity expansion, disk group expansion, and disk group defragmentation.


If a redundant controller fails with an existing disk group process, the process on the failed controller is transferred to the peer controller. A transferred process is placed in a suspended state if there is an active disk group process on the peer controller. The suspended processes is resumed when the active process on the peer controller completes or is stopped.

 **NOTE:** If you try to start a disk group process on a controller that does not have an existing active process, the start attempt will fail if the first virtual disk in the disk group is owned by the other controller and there is an active process on the other controller.

RAID Background Operations Priority

The controller supports a common configurable priority for the following RAID operations: background initialization, rebuild, copy back, virtual disk capacity expansion, RAID level migration, segment size migration, disk group expansion, and disk group defragmentation.

The priority of each of these operations can be changed to address performance requirements of the environment in which the operations are to be executed.

 **NOTE:** Setting a high priority level will impact storage array performance. It is not advisable to set priority levels at the maximum level. Priority should also be assessed in terms of impact to host access and time to complete an operation. For example, the longer a rebuild of a degraded virtual disk takes, the greater the risk for potential secondary disk failure.

Virtual Disk Migration and Disk Roaming


Virtual disk migration is moving a virtual disk or a hot spare from one array to another by detaching the physical disks and re-attaching them to the new array. *Disk roaming* is moving a physical disk from one slot to another on the same array.


Disk Migration

You can move virtual disks from one array to another without taking the target array offline. However, the disk group being migrated must be offline prior to performing the disk migration. If the disk group is not offline prior to migration, the source array holding the physical and virtual disks within the disk group will mark them as missing. However, the disk groups themselves will still be migrated to the target array.

An array can import a virtual disk only if it is in an optimal state. You can move virtual disks that are part of a disk group only if all members of the disk group are being migrated. The virtual disks automatically become available after the target array has finished importing all the disks in the disk group.


When you migrate a physical disk or a disk group from one MD3000 array to another, the MD3000 you migrate to will recognize any data structures and/or metadata you had in place on the migrating MD3000. However, if you are migrating from a non-PV controller, the MD3000 array will not recognize the migrating metadata. In this case, the RAID controller will initialize the physical disks and mark them as unconfigured capacity.

 **NOTE:** Only disk groups and associated virtual disks with all member physical disks present can be migrated from one storage array to another. Dell recommends that you only migrate disk groups that have all their associated member virtual disks in an optimal state.

 **NOTE:** The number of physical disks and virtual disks that a storage array supports limits the scope of the migration.


Use either of the following methods to move disk groups and virtual disks:

- Hot virtual disk migration — Disk migration with the destination storage array power turned on.
- Cold virtual disk migration — Disk migration with the destination storage array power turned off.


 **NOTE:** To ensure that the migrating disk groups and virtual disks are correctly recognized when the target storage array has an existing physical disk, use hot virtual disk migration.

When attempting virtual disk migration, follow these recommendations:


- Moving physical disks to the destination array for migration — When inserting drives into the destination storage array during hot virtual disk migration, wait for the inserted physical disk to be displayed in the MD Storage Manager before inserting the next physical disk.

 **NOTICE:** Without the delay between drive insertions, the storage array can become unstable and manageability is temporarily lost.

- Migrating virtual disks from multiple storage arrays into a single storage array — When migrating virtual disks from multiple, different storage arrays into a single destination storage array, move all of the physical disks from the same storage array as a set into the new destination storage array. Ensure that all of the physical disks from a storage array are migrated to the destination storage array before starting migration from the next storage array.

 **NOTE:** If the drive modules are not moved as a set to the destination storage array, the newly relocated disk groups might not be accessible.


- Migrating virtual disks to a storage array with no existing physical disks — When migrating disk groups or a complete set of physical disks from a storage array to another storage array that has no existing physical disks, turn off the destination storage array. After the destination storage array has been turned on and has successfully recognized the newly migrated physical disks, migration operations can continue.

 **NOTE:** Disk groups from multiple storage arrays should not be migrated at the same time to a storage array that has no existing physical disks. Use cold virtual disk migration for the disk groups from one storage array.

- Enabling premium features before migration — Before migrating disk groups and virtual disks, enable the required premium features on the destination storage array. If a disk group is migrated from a storage array that has a premium feature enabled and the destination array does not have this feature enabled, an Out of Compliance error message can be generated. For specific procedures to correct the error, refer to the Recovery Guru.

Disk Roaming


Moving physical disks within an array is called *disk roaming*. The RAID controller module automatically recognizes the relocated physical disks and logically places them in the proper virtual disks that are part of the disk group. Disk roaming is permitted whether the RAID controller module is either online or powered off.

 **NOTE:** The disk group must be offline before moving the physical disks.

Advanced Features


The RAID enclosure supports several advanced features:

- Storage Partitioning, including host-to-virtual disk mapping
- Virtual Disk Snapshots
- Virtual Disk Copy

 **NOTE:** Virtual Disk Snapshot and Virtual Disk Copy are premium features that must be activated separately. If you have purchased these features, an activation card is supplied that contains instructions for enabling this functionality.

Storage Partitions

Storage partitioning enables hosts to share access to virtual disks in a storage array. A storage partition is a logical entity consisting of one or more virtual disks that can be accessed by a single host or shared among hosts that are part of a host group. To create a storage partition, you first define a host or host group, then define a host-to-virtual disk mapping.

 **NOTE:** You must create a storage partition for each type of host.

Storage partitions give multiple hosts or host groups access to the same host-to-virtual disk mappings. With these mappings, you can control which host or host group may have access to a virtual disk in your storage array.

The first time you map a virtual disk to a specific host or host group, a storage partition is created. Any subsequent mappings to that host or host group do not create new storage partitions.


Under the following conditions, only a single storage partition is required:

- You have only one attached host that will access all of the virtual disks in the storage array. A single host can be attached to only one partition.

- You plan to have all attached hosts share access to all virtual disks on the storage array. When you choose this type of configuration, all of the hosts must have the same operating system and must have special software (such as clustering software) to manage virtual disk sharing and accessibility.

If either of the following is true, you *must* use more than one storage partition:

- You want specific hosts to access specific virtual disks in the storage array.
- You have hosts with different operating systems attached to the same storage array.

 **NOTE:** The storage array can support up to four storage partitions.

Host-to-Virtual Disk Mapping

The host server attached to a storage array accesses various virtual disks on the storage array through its host ports. Specific virtual disk-to-LUN mappings to an individual host can be defined. In addition, the host can be part of a host group that shares access to one or more virtual disks.

You can manually configure a host-to-virtual disk mapping. When you configure host-to-virtual disk mapping, consider these guidelines:

- You can define one host-to-virtual disk mapping for each virtual disk in the storage array.
- Host-to-virtual disk mappings are shared between RAID controller modules in the storage array.
- A unique LUN must be used by a host group or host to access a virtual disk.
- Not every operating system will have the same number of LUNs available for use.

Host Types

Generally, a host is a server that accesses a storage array, is mapped to the virtual disks, and uses one or more HBA ports. In general, hosts have the following attributes:

- **Host name** — A name that uniquely identifies the host.
- **Host group** (used in Cluster solutions only) — Two or more hosts associated together to share access to the same virtual disks.

A host group is a group of two or more hosts that share access to specific virtual disks on the storage array. This is a logical entity you can create in MD Storage Manager. All hosts in a host group must be running the same operating system.

- **Host type** — The operating system running on the host.
- **HBA host port** — A physical connection on the host base adapter installed in the host.

HBA host ports are automatically detected by the host agent and can be identified by an alias assigned by the user.

Snapshot Virtual Disks

A snapshot is a point-in-time image of a virtual disk. The snapshot provides an image of the virtual disk at the time the snapshot was created. Typically, you create a snapshot so that an application (for example, a backup application) can access the snapshot and read the data while the source virtual disk remains online and user-accessible. When the backup is completed, the snapshot virtual disk is no longer needed. Another potential use would be to experiment with a few different configurations until you determine which one is the best. You can create up to four snapshots per virtual disk.

Snapshots are used to recover previous versions of files that have changed since the snapshot was taken. Snapshots are implemented using a copy-on-write algorithm. Data on a virtual disk is copied to the snapshot repository before it is modified.

Snapshots are instantaneous and take up less overhead than a full physical copy process.

For further details on using snapshot virtual disks, see the *MD Storage Manager User's' Guide*.

Snapshot Repository Virtual Disk

When you create a snapshot virtual disk, it automatically creates a snapshot repository virtual disk. A snapshot repository is a virtual disk created in the storage array as a resource for a snapshot virtual disk. A snapshot repository virtual disk contains snapshot virtual disk metadata and copy-on-write data for a particular snapshot virtual disk. The repository supports one snapshot only.

You cannot select a snapshot repository virtual disk as a source virtual disk or as a target virtual disk in a virtual disk copy. If you select a Snapshot source virtual disk as the target virtual disk of a virtual disk copy, you must disable all snapshot virtual disks associated with the source virtual disk.



NOTICE: Before using the Snapshot Virtual Disks Premium Feature in a Windows Clustered configuration, you must map the snapshot virtual disk to the cluster node that owns the source virtual disk. This ensures that the cluster nodes correctly recognize the snapshot virtual disk.

Mapping the snapshot virtual disk to the node that does not own the source virtual disk before the Snapshot enabling process is completed can result in the operating system misidentifying the snapshot virtual disk. This, in turn, can result in data loss or an inaccessible snapshot.

For details on mapping the snapshot virtual disk to the secondary node, refer to the *Dell PowerEdge Cluster SE600W Systems Installation and Troubleshooting Guide* on support.dell.com.


Virtual Disk Service

The Microsoft Virtual Disk Service (VDS) is supported on your RAID storage array. Microsoft VDS is a set of application programming interfaces (APIs) that provides a single interface for managing disks and other storage hardware, including creating volumes on those disks.

The Microsoft VDS installer service for storage provisioning is available on the MD3000 Resource CD in the `\windows\VDS_VSS` directory. For more information on VDS, see www.microsoft.com.

Volume Shadow-Copy Service

The Microsoft Volume Shadow-copy Service (VSS) is a storage management interface for Microsoft Windows Server® 2003. VSS enables your storage array to interact with third-party applications that use the VSS Application Programming Interface. Microsoft VSS is included in the Windows Server 2003 installation.

 **NOTE:** A volume is another term for virtual disk.

VSS attaches to the service and uses it to coordinate the creation of snapshot virtual disks on the storage array. VSS-initiated snapshot virtual disks can be triggered through backup tools, known as *requestors*. The VSS Provider Configuration Tool makes available the following configuration options:

- **Snapshot Repository Virtual Disk Properties** — This section contains a drop-down list for the RAID level and a field for entering source virtual disk capacity percentage for snapshot repositories.
- **Snapshot Repository Virtual Disk Location** — This section contains a list of preferences for the location of the snapshot repository virtual disk. These preferences are honored whenever conditions permit.

The Microsoft VSS installer service for storage provisioning is available on the MD3000 Resource CD in the `\windows\VDS_VSS` directory.

Storage Management VSS Hardware Provider Tips:


- The number of snapshot virtual disks that can be created using a single snapshot set varies with the I/O load on the RAID controller modules. Under little or no I/O load, the number of virtual disks in a snapshot set should be limited to eight. Under high I/O loads, the limit should be three.
- The snapshot virtual disks created in the storage management software are differential snapshots. Plex snapshots are not supported.
- Virtual disks to be used as source virtual disks for VSS snapshots should have names no longer than 16 characters. The VSS hardware provider uses the base virtual disk name as a prefix for the snapshot and repository virtual disk names. The resulting snapshot and repository names will be too long if the source virtual disk name exceeds 16 characters.

Virtual Disk Copy

Virtual Disk Copy is a premium feature you can use to back up data, copy data from disk groups that use smaller-capacity physical disks to disk groups using greater capacity physical disks, or restore snapshot virtual disk data to the source virtual disk. Virtual Disk Copy generates a full copy of data from the source virtual disk to the target virtual disk in a storage array.

Source Virtual Disk — When you create a virtual disk copy, a copy pair consisting of a source virtual disk and a target virtual disk is created on the same storage array. When a virtual disk copy is started, data from the source virtual disk is copied completely to the target virtual disk.

Target Virtual Disk — When you start a virtual disk copy, the target virtual disk maintains a copy of the data from the source virtual disk. You can choose whether to use an existing virtual disk or create a new virtual disk as the target virtual disk. If you choose an existing virtual disk as the target, all data on the target is overwritten. A target virtual disk can be a standard virtual disk or the source virtual disk of a failed or disabled snapshot virtual disk.

 **NOTE:** The target virtual disk capacity must be equal to or greater than the source virtual disk capacity.

When you begin the disk copy process, you must define the rate at which the copy is completed. Giving the copy process top priority will slightly impact I/O performance, while giving it lowest priority will make the copy process take longer to complete. You can modify the copy priority while the disk copy is in progress.

You can find more details on using the virtual disk copy feature in the *MD Storage Manager User's Guide*.

Virtual Disk Recovery

You can use the **Edit host-to-virtual disk mappings** feature to recover data from the backup virtual disk. This functionality enables you to unmap the original source virtual disk from its host, then map the backup virtual disk to the same host.

Ensure that you record the LUN used to provide access to the source virtual disk. You will need this information when you define a host-to-virtual disk mapping for the target (backup) virtual disk. Also, be sure to stop all I/O activity to the source virtual disk before beginning the virtual disk recovery procedure.

Using Snapshot and Disk Copy Together

You can use the Snapshot Virtual Disk and Virtual Disk Copy premium features together to back up data on the same storage array, or to restore the data on the snapshot virtual disk to its original source virtual disk.

You can copy data from a virtual disk in one of two ways:


- By taking a point-in-time snapshot of the data
- By copying the data to another virtual disk using a virtual disk copy

You can select a snapshot virtual disk as the source virtual disk for a virtual disk copy. This configuration is one of the best ways you can apply the snapshot virtual disk feature, since it enables complete backups without any impact to the storage array I/O.

You cannot, however, use a snapshot repository virtual disk as a source virtual disk or as a target virtual disk in a virtual disk copy. If you select the source virtual disk as the target virtual disk of a virtual disk copy, you must disable all snapshot virtual disks associated with the source virtual disk.

Hardware Redundancy and Failover

This section provides basic information that will help you determine how to connect a host to the RAID controller modules in a RAID enclosure in order to achieve redundancy and failover.

 **NOTE:** The best practice for ensuring data access is to avoid a configuration with a single point of failure. A single point of failure is any component or path that is not duplicated (redundant) or whose failure can cause loss of data access.

Redundancy and Non-Redundancy


Redundancy means that a storage array has duplicate components, or alternate ways to provide essential services. This redundancy ensures access to the virtual disks in case of a failure of a single component.

In a typical RAID configuration, most of the components are redundant; however, the configuration itself might not be fully redundant. For example, there might be components whose individual failure would cause loss of access to the virtual disks. In a fully redundant storage array, all components must be duplicated. In addition, the storage array must be configured in such a way as to ensure that duplicate components can be accessed in case of a failure. The manner in which the storage array is cabled is an essential component of creating a successfully configured redundant storage array.

Multi-Path Software

Multi-path software (also referred to as the failover driver) is software resident on the host server that provides management of the redundant data path between the server and the RAID enclosure. For the multi-path software to correctly manage a redundant path, the configuration must provide for redundant HBAs and cabling.

The multi-path software identifies the existence of multiple paths to a virtual disk and establishes a preferred path to that disk. If any component in the preferred path fails, the multi-path software automatically re-routes I/O requests to the alternate path so that the storage array continues to operate without interruption.

 **NOTE:** Multi-path software is included with MD Storage Manager.

Preferred and Alternate Controllers and Paths

A *preferred* controller is a RAID controller module designated as the owner of a virtual disk or disk group. The preferred controller is automatically selected by MD Storage Manager when a virtual disk is created. You can change the preferred RAID controller module owner of a virtual disk after it is created.

Ownership of a virtual disk is moved from the preferred controller to the second controller (also called the *alternate controller*) when the preferred controller is:


- Physically removed
- Updating firmware
- Involved in a fatal event that caused failover over to the alternate controller

Paths used by the preferred controller to access either the disks or the host are called the *preferred paths*; redundant paths are called the *alternate paths*. If a failure causes the preferred path to become inaccessible, the storage array automatically uses the alternate path to access data.

Host Bus Adapters

Each cable connection from a host to a RAID controller module is made through an HBA. The HBA is installed in the host and provides an interface to the internal bus of the host. To configure for highest redundancy, you must use more than one HBA in a single host. You can connect each HBA to the RAID controller modules (preferred and alternate) to ensure that the server data will be accessible even if one HBA fails.

Selecting Host Bus Adapters for Redundancy

 **NOTE:** For maximum redundancy, you must select all HBA host ports connected to the array when manually defining host topology or setting up host mapping.

You can have multiple SAS HBA host ports-to-array connections for each host. When setting up host mapping, you must select the HBA host ports from the list of **Known HBA host ports** in MD Storage Manager. Add all of the HBA host ports to the list of **Selected HBA host port identifiers/aliases** for the host for which you are defining the LUN mapping.

For example, a host might have two HBAs, each with two HBA host ports connected to the array. For this host, you would select all four HBA host ports.

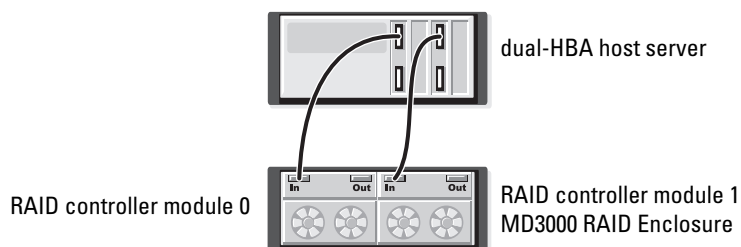
Host Cabling for Redundancy

To make sure that the RAID storage array remains accessible to the host, establish a minimum of two physical paths from each host to the RAID controller modules. The following examples show host cabling for redundancy.

One Host with Two Cable Connections

Figure 3-1 shows a single host with two HBAs. Both HBAs have two ports, but use only a single port. Each HBA is connected to one RAID controller module in the RAID enclosure. Each RAID controller module has one port.

Figure 3-1. One Host with Two Cable Connections

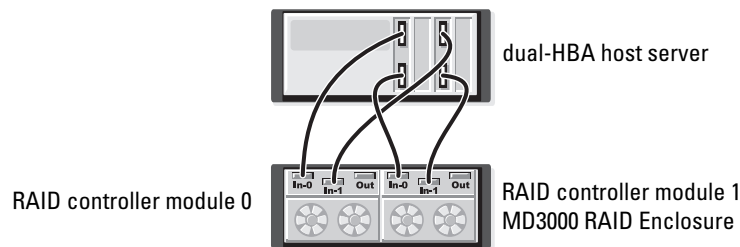


This cabling topology, when used with alternate path software, ensures a redundant path from the host server to the virtual disks. If the connection from In-0 on the RAID controller to the host port becomes unavailable, the alternative path software will transfer I/O activity on RAID controller module 0 to RAID controller module 1. While RAID controller module 0 is unavailable, the host can access all virtual disks through RAID controller module 1.

One Host with Four Cable Connections

Figure 3-2 shows one host with two HBAs. Both HBAs have two ports. Each HBA port is connected to one of the RAID controller modules in the RAID enclosure. Each RAID controller module has two ports.

Figure 3-2. One Host with Four Cable Connections



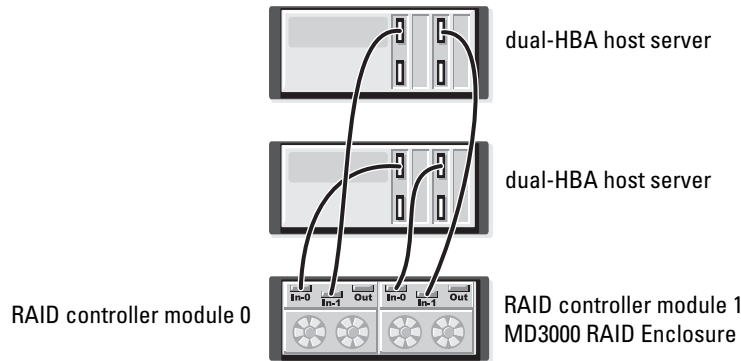
This cabling topology, when used with alternate path software, ensures a redundant path from the host to the virtual disks. If any component (HBA, HBA port, cable, RAID controller module port, or RAID controller module) fails, the host can still access the virtual disks through an alternate path.

NOTE: This configuration is the most redundant for one host directly connected to a single array module.

Two Hosts, Each with Two Cable Connections

Figure 3-3 shows two hosts. Each host has two HBAs. (Both HBAs may have two ports, but in this figure use only a single port.) Each HBA is connected to one RAID controller module in the RAID enclosure. Each RAID controller module has two ports.

Figure 3-3. Two Hosts, each with Two Cable Connections



This cabling topology, when used with alternate path software, ensures a redundant path from the host to the virtual disks. If any component (HBA, HBA port, cable, RAID controller module port, or RAID controller module) fails, a host can still access the virtual disks through an alternate path.

NOTE: This configuration is the most redundant for two hosts directly connected to a single RAID enclosure.

When a RAID Controller Module Is Replaced or Removed

When one RAID controller module fails, or is removed from the RAID enclosure, failover software on the host directs the alternate RAID controller module to assume all controller responsibilities for the storage array. The virtual disks owned by the failed or removed RAID controller module are failed over to the surviving controller and no data is lost.

NOTE: For Linux kernels, stop and then restart the SMagent after moving a controller offline, replacing a controller, or removing SAS cables from (or attaching SAS cables to) Red Hat® Enterprise Linux® (version 4), SUSE Linux Enterprise Server 9 (x86_64), or SUSE Linux Enterprise Server 10 (x86_64) host servers.

Because host-based multi-path software is configured for automatic failback, the data paths and virtual disks are restored to their original RAID controller module after the RAID controller module is replaced.

Automatic failback occurs under the following conditions:

- Data is protected by dual redundant paths to the host.
- The host has multi-path failover software installed, and it is configured for auto failback.
- Failover occurred due to either RAID controller module lockdown, replacement, or path failover.

NOTE: Clustering requires simultaneous access from cluster nodes to shared storage. If you have clustering software installed on the host, automatic failback should be disabled to prevent "ping-pong" with single-path failure. For more information on clustering, a link to clustering documentation is included on the *MD3000 Resource CD* under Product Documentation.

For more information on failover, see "Cabling the Enclosure" on page 22.

RAID Controller Failover Modes

Failover provides redundant access to the virtual disks owned by either RAID controller module on the storage array. Failover happens automatically (and transparently). As a result, the host(s) never loses access through the preferred controller which owns the virtual disk.

Two failover modes are supported:

- Host-based Multi-Path I/O (MPIO) for Windows or MPP for Linux
- Controller-based Auto Virtual Disk Transfer (AVT)

Host-based uses a multi-path driver installed on the host server to access the storage array. If required, the multi-path driver will issue an explicit command to transfer ownership from the RAID controller module that owns the virtual disk to its peer RAID controller module.

AVT is used only in single-port cluster solutions (see Figure 2-3). I/O access to the Logical Unit Number (LUN) of a virtual disk causes failover. In AVT mode, firmware transfers ownership of a virtual disk to the online RAID controller module. The alternate or backup node in a cluster takes over and issues I/O to the peer controller and moves the virtual disk to itself.



NOTE: Clustering requires simultaneous access from cluster nodes to shared storage. If you have clustering software installed on the host, automatic failback should be disabled to prevent "ping-pong" with single-path failure. For more information on clustering, a link to clustering documentation is included on the *MD3000 Resource CD* under Product Documentation.



NOTE: If setting up a cluster host, the **MD3000 Stand Alone to Cluster.reg** file entry must be merged into the registry of each node. If re-configuring a cluster node to a standalone host, the **MD3000 Cluster to Stand Alone.reg** file must be merged into the host registry. These registry files, which set up the host for correct failback operation, are in the `windows\utility` directory of the *MD3000 Resource CD*.

RAID Enclosure Thermal Shutdown

Enclosure management provides a feature which automatically shuts down the enclosure when the temperature within the RAID enclosure reaches dangerous extremes. Thermal shutdown protects the data on the physical disks from corruption in the event of a cooling system failure.

The temperature at which shutdown occurs is determined by the enclosure temperature probe's Nominal Failure Threshold and the Maximum Failure Threshold. These thresholds are default settings that cannot be changed. If the temperature sensors on the backplane or RAID controller module detect a temperature exceeding the Nominal Failure Threshold, a critical event is set; if the Maximum Failure Threshold is hit, shutdown of the enclosure power supplies will occur within 5 seconds.



NOTE: If an MD1000 expansion enclosure reaches critical internal temperatures, the enclosure will be shut down automatically via a thermal shutdown command issued by the EMM firmware.

Updating Enclosure Firmware

You can use MD Storage Manager to upgrade the firmware for the RAID controller module, the controller NVSRAM, and the physical disks. In a redundant configuration, the RAID controller module firmware can be upgraded with no interruption to data access.

RAID Controller Module Firmware

The RAID controller module firmware and NVSRAM files are needed to properly use MD Storage Manager and all of its features.

Before you download the RAID controller module firmware or NVSRAM files, ensure that the multi-path driver (for example, MPP for Linux or MPIO for Windows) is running on the host. In a redundant configuration, the multi-path driver maintains data access through one RAID controller module while the other RAID controller module's firmware is upgraded. Also check the MD Storage Manager to see if it lists both RAID controller modules as optimal. Downloading firmware when either or both controllers are non-optimal may result in unsynchronized firmware and cause you to have to run the download again after restoring the RAID controller module(s) to optimal condition.

If a RAID controller is replaced and its firmware does not match the version on the non-replaced RAID controller, the non-replaced controller will automatically flash the replacement controller with its firmware version to ensure that both controllers have the same firmware version.

NVSRAM Update

NVSRAM packages specify the internal settings for the storage array RAID controller modules. These internal settings cannot be modified except by an NVSRAM update. You can download RAID controller module firmware and NVSRAM packages separately or together using MD Storage Manager.

Physical Disk Firmware



NOTE: Dell recommends stopping all I/O to the array when downloading physical disk firmware.

You can also download physical disk packages containing the latest firmware files. Ensure that the firmware files you select are compatible with the physical disks.

Before downloading firmware, you should back up all your data. In addition, do not make any configuration changes to the storage array, such as creating virtual disks or defining hosts, during the download. Doing so could cause the firmware download to fail and prevent access to the physical disks.

Expansion Enclosure Firmware

You can download firmware updates for your MD1000 expansion enclosures using the MD Storage Manager.

Installing Enclosure Components

This section explains how to install the following components:

- Front bezel (optional)
- Physical disks and disk carriers
- RAID controller modules
- Battery backup unit
- Power supplies
- Control panel
- Enclosure midplane

Recommended Tools

The procedures in this section require the use of one or more of the following tools:

- #2 Phillips-head screwdriver
- Torx T10 driver
- Wrist grounding strap, as explained in the safety instructions found in your *Product Information Guide*

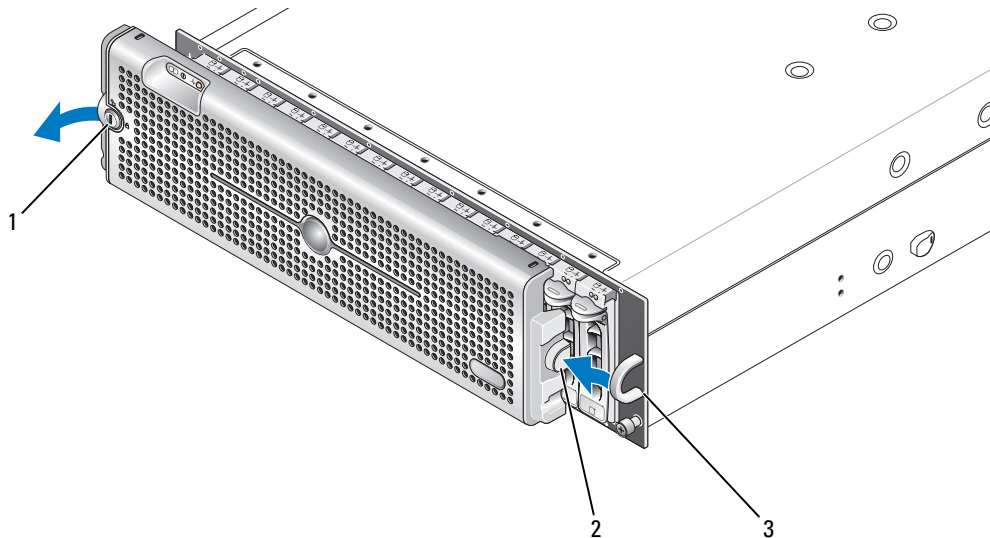
Removing and Replacing the Front Bezel

To access the physical disks in your enclosure, you must remove the optional front enclosure bezel. If your enclosure does not have this bezel, skip this section.

To remove the bezel:

- 1 If the bezel is locked, insert the bezel locking key in the bezel lock. If the bezel is unlocked, go to step 3.
- 2 Turn the key to the left to unlock the bezel.
- 3 Push inward on the release tab on the bezel and lift it away from the enclosure front (see Figure 4-1).

Figure 4-1. Installing and Removing the Front Bezel



- 1 bezel lock 2 release tab/interlocking notch 3 U-shaped handle

- 4 To replace the bezel, insert the interlocking notch into the U-shaped handle on the side of the front enclosure panel.
- 5 Snap the left side of the bezel into place in the U-shaped handle on the left side of the enclosure.
- 6 To lock the bezel, insert the key and turn to the right.

Removing and Installing Physical Disks

Your enclosure supports up to 15 SAS 3.0-Gbps physical disks, each one contained in its individual disk carrier. Physical disks are connected directly to the enclosure midplane and are hot-pluggable, allowing you to remove and insert disks without shutting down your enclosure.

This section describes how to remove and install physical disks in your storage array.

- ➔ **NOTICE:** Extra care must be taken when handling and storing the physical disks. The carriers provide some protection, but the disks and carrier connectors can be damaged by rough handling. When removing the physical disks from the enclosure, place them on a padded surface. Never drop the disks.

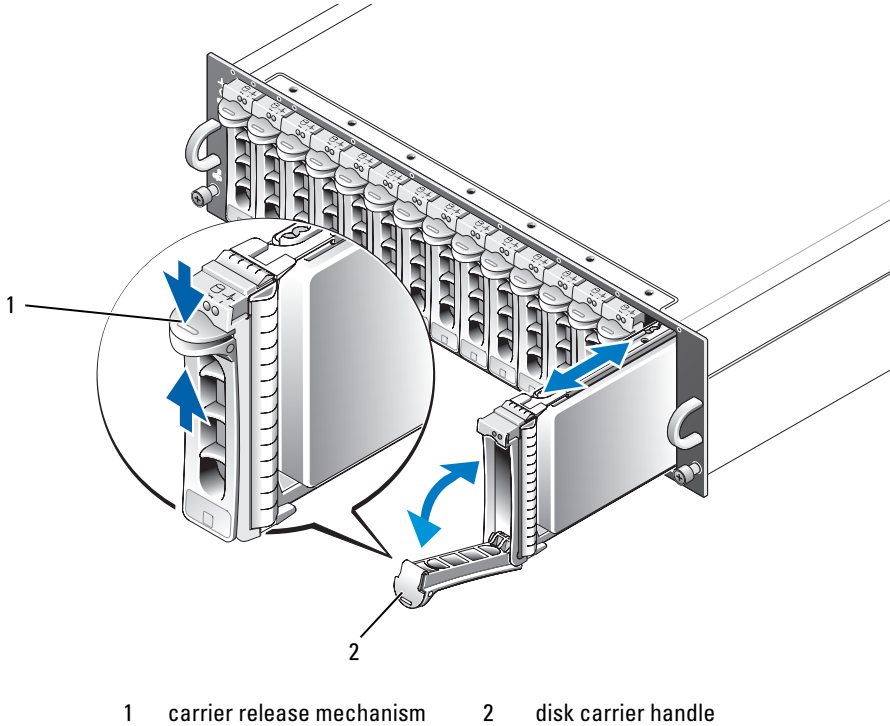
Removing Physical Disks from the Enclosure

- ➔ **NOTICE:** To avoid damage, never leave a physical disk carrier partially removed from the enclosure. Rotating a carrier handle next to an unseated disk carrier will result in serious damage to the unseated disk carrier.
- ➔ **NOTICE:** To avoid data loss when removing a physical disk, Dell recommends that you verify with MD Storage Manager that the appropriate disk is being removed. Removing an Assigned physical disk could result in data loss.

⚠ CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components.

- 1 Wait until the LED indicators on the physical disk carrier stop flashing.
- 2 Squeeze the release mechanism on the front of the physical disk carrier (see Figure 4-2).

Figure 4-2. Installing and Removing Physical Disks



- 3 Open the physical disk carrier handle by rotating it downward.
- 4 Gently but firmly pull the physical disk carrier from its slot while supporting the weight of the disk from the bottom.

Installing SAS Physical Disks in the Enclosure

➡ NOTICE: To ensure proper airflow for enclosure cooling, each slot should contain either an active physical disk or a disk blank.

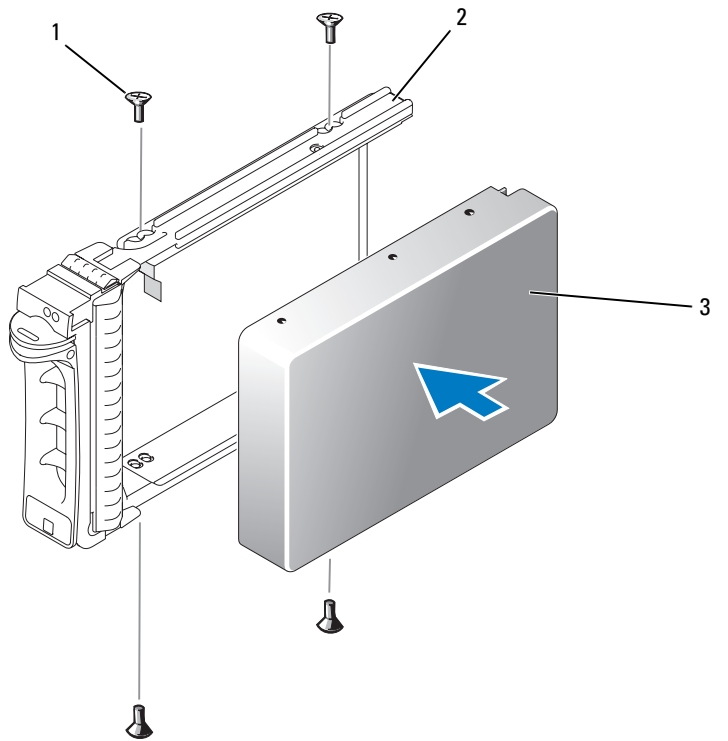
⚠ CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components.

1 Perform the following steps to install the new physical disk into the carrier:

📌 NOTE: Data from virtual disks created on a PERC 5 SAS controller cannot be migrated to an MD3000 or to an MD1000 expansion enclosure connected to an MD3000.

- a** If you are replacing a physical disk in the carrier, remove the four screws that secure the disk to its carrier and remove the disk (see Figure 4-3).
- b** Position the replacement physical disk into the disk carrier with the disk's controller board facing the rear of the carrier.
- c** From the rear of the carrier, slide the physical disk into the carrier until it contacts the stop tab at the front of the carrier.
- d** Secure the physical disk to the carrier using the four screws removed earlier. To avoid damaging the carrier, do not overtighten.

Figure 4-3. Installing a SAS Physical Disk in the Carrier



1 screws (4)

2 physical disk carrier

3 physical disk

- 2 With the physical disk carrier handle open, carefully align the channel on the disk carrier guide rail with the appropriate disk slot keying feature on the chassis face plate, and insert the disk (see Figure 4-2).
- 3 Push the physical disk carrier into the slot until the bottom of the open carrier handle makes contact with the chassis face plate.
- 4 Rotate the carrier handle to the closed position while continuing to push the carrier into the slot.
The status LED indicator (see Table 1-3 for description) will display a steady green if the physical disk is inserted properly. If the indicator is not illuminated, see "Troubleshooting SAS Physical Disks" on page 72.



NOTE: At least two physical disks must be installed in the enclosure.

Removing and Installing a RAID Controller Module

The enclosure contains two RAID controller modules. Both are hot-pluggable and can be removed and installed independently without shutting down the enclosure.



NOTICE: Removing a module is not recommended while data traffic involving that module is occurring. Although RAID controller modules are hot-pluggable, data loss could result from removing a module involved in data traffic.



CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components. See your *Product Information Guide* for safety information.

Removing a RAID Controller Module


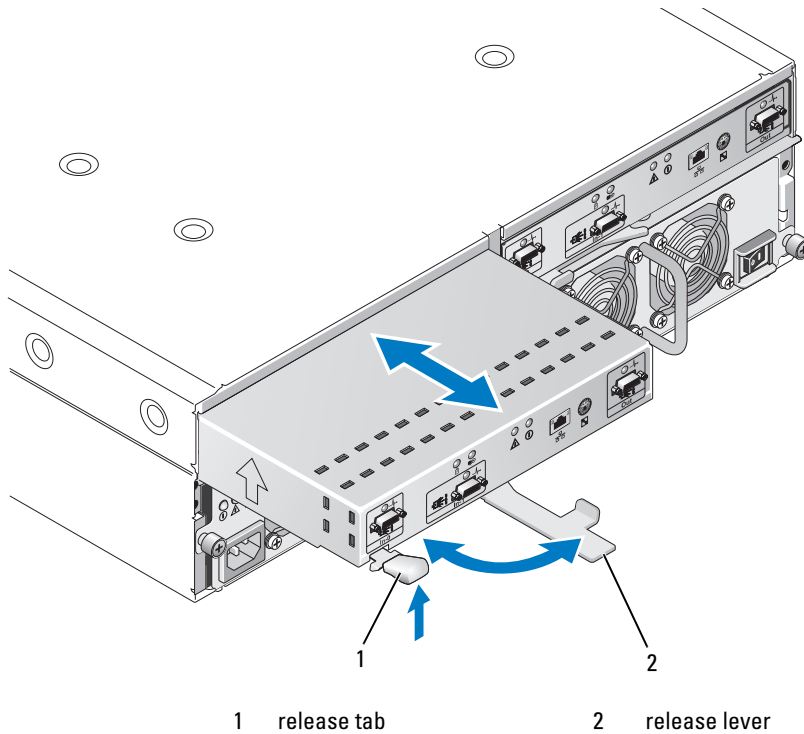
- 1 Push up on the release tab on the left side of the module (see Figure 4-4).
 - 2 At the same time, pull out on the release lever. When the lever is pulled out, the controller module partially ejects from the enclosure.
 - 3 Remove the module from the enclosure and place it on a flat, secure surface.
-  **NOTICE:** To avoid damage to the sensitive EMI contacts on the bottom of the controller module, do not stack or place it on a hard surface.

Figure 4-4. Removing and Installing a RAID Controller Module



Installing a RAID Controller Module

- 1 Carefully insert the RAID controller module into the empty module slot.
- 2 Push the module to the back of the slot until it is firmly seated in the backplane connector (see Figure 4-4).
- 3 Push the release lever in (towards the enclosure) until the module is retracted into the slot and is secure.

For information on controller connections and cabling, see "Cabling Your RAID Enclosure" on page 21.

Removing and Installing a RAID Controller Module Backup Battery Unit

Each RAID controller module has a battery unit that provides backup power for the data cache memory. The battery unit is mounted inside the RAID controller module and connects to the controller circuit board. This section describes how to remove and replace the battery unit.

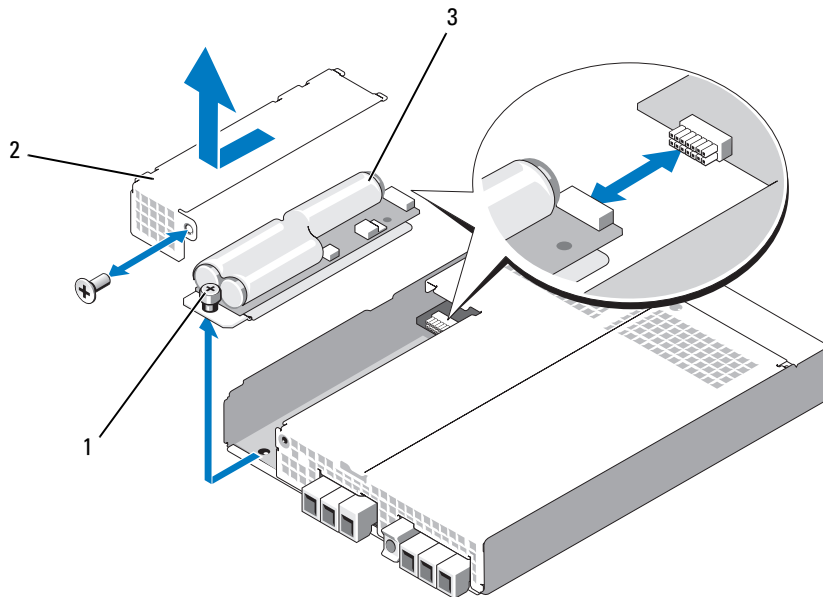
CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

NOTICE: RAID controller modules are hot-pluggable and can be removed and installed without shutting down the enclosure. However, removing a controller module while data traffic is occurring that involves that controller could cause data loss and is not recommended. Use the MD Storage Manager to take the RAID controller module off line before removal.

CAUTION: Always wear a wrist grounding strap when handling equipment with static-sensitive components. See your *Product Information Guide* for safety information.

- 1 Use MD Storage Manager to place the RAID controller module offline. See the MD Storage Manager documentation for more information.
- 2 Remove the RAID controller module (see "Removing and Installing a RAID Controller Module" on page 59).
- 3 Remove the screws holding the battery cover and remove the cover (see Figure 4-5).

Figure 4-5. Removing and Installing a RAID Controller Module Backup Battery Unit



1 thumbscrew

2 battery cover


3 battery unit

- 4 Unscrew the thumbscrew holding the battery unit to the controller module.


- 5 Disconnect the battery unit from the connector by sliding it towards the back of the controller, then remove it from the controller module.
- 6 Place the replacement battery unit into the controller module tray and push the battery unit into the connector on the RAID controller circuit board.
- 7 Tighten the thumbscrew to secure the battery unit to the controller.
- 8 Reinstall the battery cover.
- 9 Reinstall the RAID controller module (see "Installing a RAID Controller Module" on page 60).
- 10 Reset the battery installation date using MD Storage Manager.


Removing and Installing the Power Supply/Cooling Fan Module

Your enclosure supports two separate modules containing an integrated power supply and two cooling fans per module. While the enclosure can operate temporarily with only one functional power supply, both cooling modules (with two fans each) must be present for proper cooling. Three of the four fans must be operational for the enclosure to avoid overheating.

 **NOTICE:** A single power supply/cooling module can be removed from a powered-on enclosure for a maximum period of 5 minutes. Beyond that time, the enclosure may automatically shut down to prevent damage.

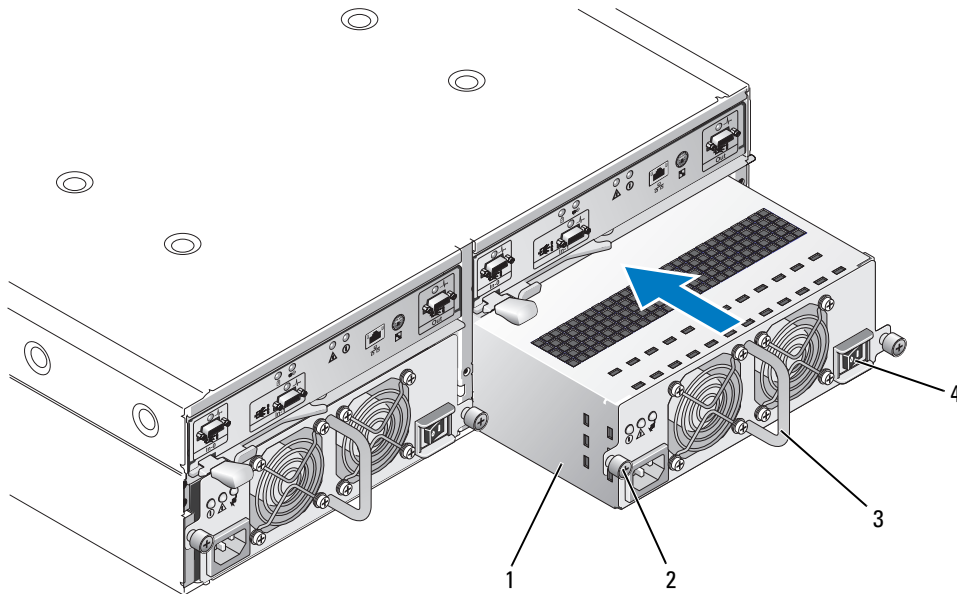
Removing a Power Supply/Cooling Fan Module

 **NOTICE:** Power supply/cooling fan modules are hot-pluggable. Provided one power supply/cooling fan module is functioning normally, you can remove or replace the other while the enclosure is powered on.

 **NOTE:** If you remove a fully functioning power supply/cooling fan module, the fan speed in the remaining module will increase significantly to provide adequate cooling. The fan speed will decrease gradually when a new power supply/cooling fan module is installed.

- 1 Turn off the power supply you intend to remove using the on/off switch.
- 2 Using a Phillips-head screwdriver, loosen the two captive screws securing the power supply/cooling fan module in the bay (see Figure 4-6).

Figure 4-6. Replacing the Power Supply



- 1 power supply
- 2 captive screws (2)
- 3 handle
- 4 on/off switch

⚠ CAUTION: The power supply/cooling fan modules are heavy. Use both hands when removing.

3 Grasp the handle on the power supply and carefully pull the module out of the bay (see Figure 4-6).

➡ NOTICE: The power-supply handle is provided to ease the task of pulling the module from the bay. Do not use this handle to carry the module.

Installing a Power Supply/Cooling Fan Module

- 1** Carefully slide the new power supply/cooling fan module approximately two-thirds of the way into the empty bay.
- 2** Gently push the module all the way to the back of the bay until it is firmly seated in the backplane connector.

The power supply is seated when its front plate is even with the front plate of the adjacent power supply.

🔧 NOTE: If the enclosure is powered on, the power-supply fault indicator (see Figure 1-7) remains illuminated until you connect the AC power cable to the power supply and turn on the on/off switch.

- 3** Tighten the two captive screws to secure the new power supply/cooling fan module in the bay.
- 4** Connect the AC power cable to the new power supply and to an electrical outlet.
- 5** Turn on the on/off switch on the new power supply.

Removing and Installing the Control Panel

The control panel powers the LED indicators on the front panel of the system enclosure. It is connected to the backplane and cannot be removed or replaced unless the system is powered down.



CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

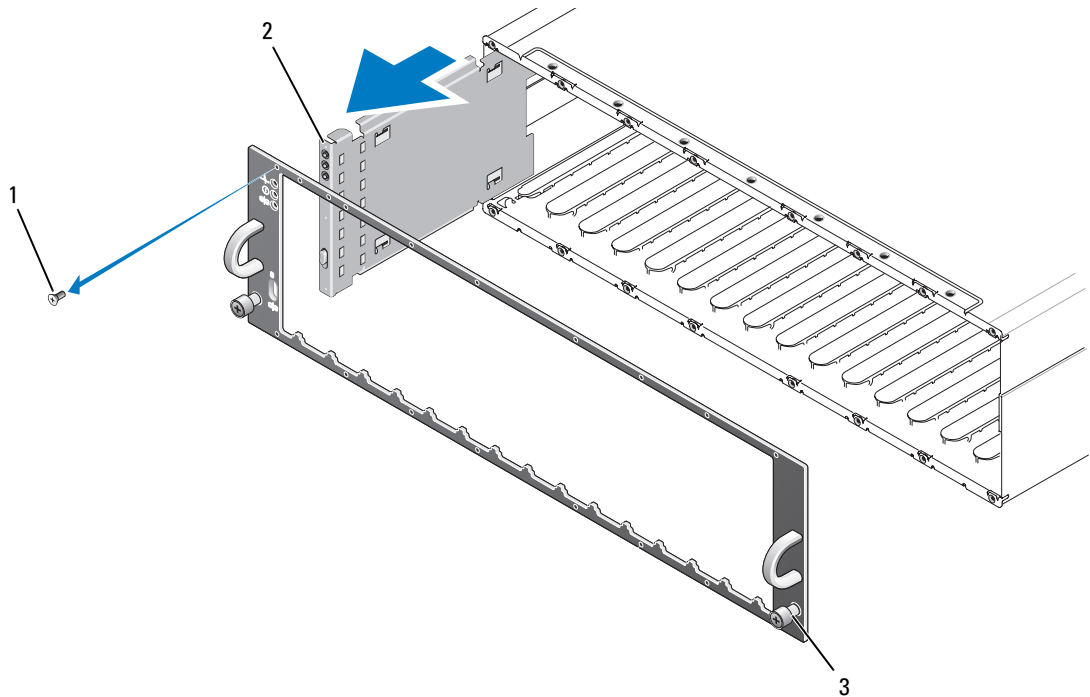
Removing the Control Panel

- 1 Power down your host server.
- 2 Power down your enclosure.
- 3 Disconnect all power cables to the enclosure.
- 4 Loosen the two thumbscrews on the front of the enclosure panel and pull the enclosure approximately six inches out from the rack (see Figure 4-7).
- 5 Remove all the physical disks from the enclosure (see "Removing and Installing Physical Disks" on page 56).



NOTE: To avoid confusion when re-installing the disks, mark each one with its slot position as you remove it.

Figure 4-7. Removing and Replacing the Control Panel



- 1 faceplate screws (16) 2 control panel 3 thumbscrews


- 6 Using a Torx T10 driver, remove all 16 screws from the front faceplate of the enclosure as shown in Figure 4-7.
- 7 Remove the front faceplate from the enclosure and place it on a flat, secure surface.
- 8 Slide the control panel assembly straight out from its connector on the backplane (see Figure 4-7).

Installing the Control Panel

- 1 Align the top and bottom tabs on the control panel with the insert slots on the edge of the chassis (see Figure 4-7).
- 2 Slide the control panel fully into the slot, making sure that its connector engages into the matching backplane connector (see Figure 4-7). Also, make sure the guide tab on the control panel is fully inserted into the mounting slot on the backplane.
- 3 Replace the front faceplate and re-attach the 16 screws that hold it in place.
- 4 Re-install any physical disks you removed (see "Removing and Installing Physical Disks" on page 56).
- 5 Push the enclosure all the way back into the rack and tighten the thumbscrews.

- 6 Reconnect power cables to the enclosure and power it back on.
- 7 Power on the host server.

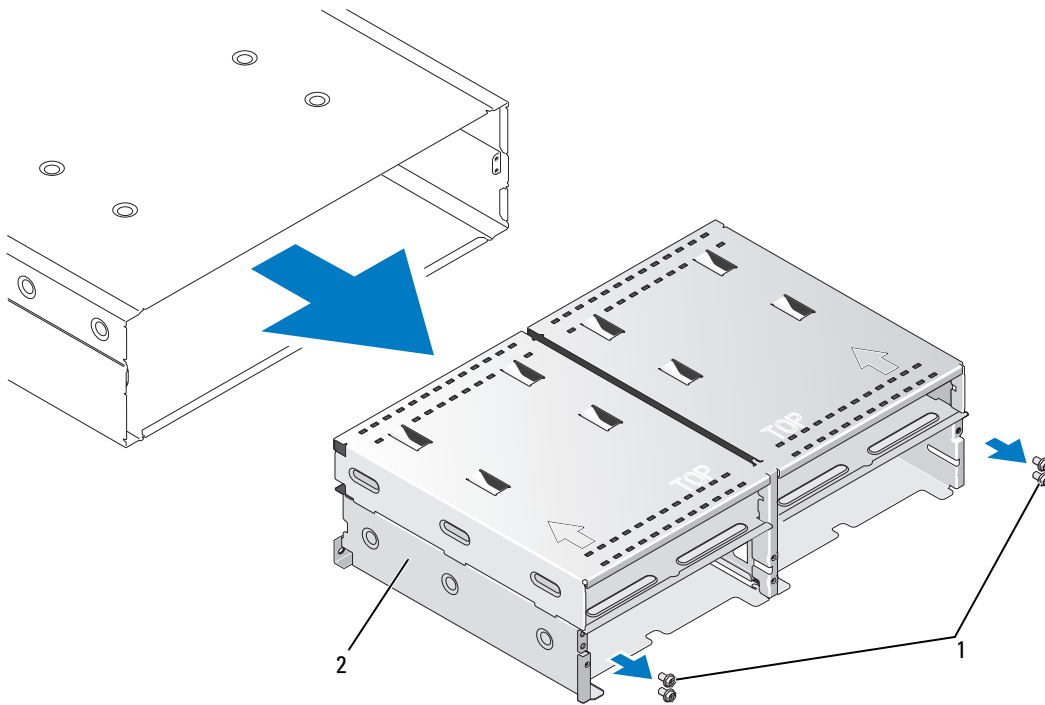
Removing and Installing the Midplane

 **CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.**

The enclosure midplane contains the connectors for the physical disks, RAID controller module, control panel, and power supply/cooling modules.

- 1 Complete the "Removing the Control Panel" on page 64 steps as shown in "Removing and Installing the Control Panel" on page 64.
- 2 Remove the RAID controller modules from the enclosure. (See "Removing and Installing a RAID Controller Module" on page 59.)
- 3 Remove both power supply/cooling modules from the enclosure. (See "Removing and Installing the Power Supply/Cooling Fan Module" on page 62.)
- 4 Remove the four Phillips screws holding the controller/power supply cage in the enclosure (see Figure 4-8).

Figure 4-8. Removing and Replacing the Controller/Power Supply Cage

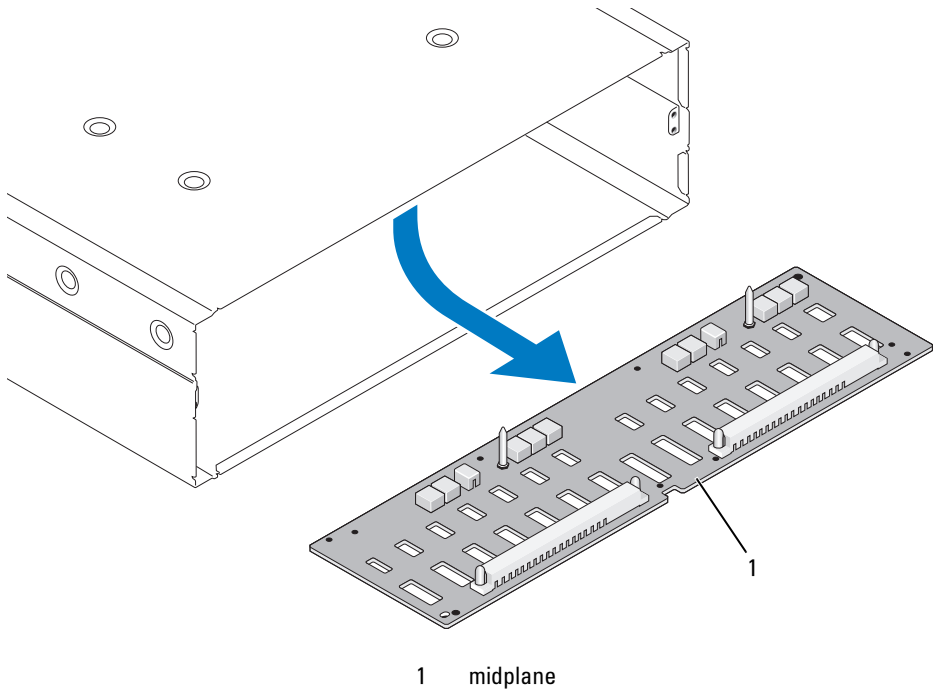


1 Phillips screws (4)

2 controller/power supply cage

- 5 Slide the controller/power supply cage out of the enclosure and place it aside.
- 6 Reaching into the enclosure chassis from the back, carefully disconnect the midplane from the control panel and lift it out of the enclosure (see Figure 4-9).
- 7 To re-install the midplane, reverse the previous steps.


Figure 4-9. Removing and Installing the Midplane



Troubleshooting Your Enclosure

Safety First—For You and Your Enclosure

To perform certain procedures in this document, you must work inside the enclosure. While working inside the enclosure, do not attempt to perform service except as explained in this guide and elsewhere in your documentation.

 **CAUTION:** Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

Start-Up Routine

Look and listen during the enclosure's start-up routine for the indications described in Table 5-1. For a description of the front- and back-panel indicators, see "About Your System" on page 7.

Table 5-1. Start-Up Routine Indications

| Look/listen for: | Action |
|--|--|
| Alert messages. | See your storage management documentation. |
| An unfamiliar constant scraping or grinding sound when you access a physical disk. | See "Getting Help" on page 77. |

 **NOTE:** At least two physical disks must be installed in the enclosure.

Troubleshooting External Connections

Loose or improperly connected cables and bent pins are the most likely source of problems. Ensure that all external cables are securely attached to the external connectors on your system and that none of the connectors are damaged. See "Back-Panel Indicators and Features" on page 13 for the back-panel connectors on your enclosure.

Troubleshooting a Wet Enclosure

Problem

- Liquid spilled on the enclosure.
- Excessive humidity.

Action



CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

- 1 Turn off the enclosure and disconnect all power.
- 2 Remove all the physical disks from the enclosure. See "Removing and Installing Physical Disks" on page 56.
- 3 Remove the RAID controller modules from the enclosure. See "Removing and Installing a RAID Controller Module" on page 59.
- 4 Remove the power supply/cooling fan modules from the enclosure. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 62.
- 5 Remove the enclosure midplane. See "Removing and Installing the Midplane" on page 66.
- 6 Let the enclosure dry thoroughly for at least 24 hours.
- 7 Reinstall all the components you removed in the previous steps.
- 8 Reconnect the enclosure to the electrical outlet and turn on the enclosure.
If the enclosure does not start properly, see "Getting Help" on page 77.

Troubleshooting a Damaged Enclosure

Problem

- Enclosure was dropped or damaged.

Action



CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

- 1 Ensure that the following components are properly installed:
 - All physical disks (both in their carriers and connected to the enclosure midplane)
 - Power supply/cooling fan modules

- RAID controller modules
 - Enclosure midplane
- 2 Ensure that all cables are properly connected and that there are no bent pins in the connector. If problems are encountered, see "Getting Help" on page 77.

Troubleshooting Power Supplies

Problem

- Enclosure-status indicators show a problem.
- Power-supply fault indicators are lit.

Action



CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

- 1 Check that at least two physical disks are present in the enclosure. A minimum of two physical disks must be installed. If they are not, install the minimum number of physical disks. If the problem persists, go to step 2.
- 2 Turn off the enclosure and attached peripherals, and disconnect the enclosure from the electrical outlet.
- 3 Locate the faulty power supply.

If the power supply's fault indicator is lit, see "Power Supply and Cooling Fan Features" on page 18.



NOTICE: Power supply/cooling fan modules are hot-pluggable. The enclosure can operate on a single functioning power supply; however, both modules must be installed to ensure proper cooling. A single power supply/cooling fan module can be removed from the enclosure for up to 5 minutes, provided the other module is functioning properly. After 5 minutes, the enclosure will overheat and may cause an automatic thermal shutdown.

- 4 Ensure that the power supply is properly installed by removing and re-installing it. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 62.



NOTE: After installing a power supply, allow several seconds for the enclosure to recognize the power supply and determine if it is working properly.

- 5 If the problem is resolved, skip the rest of this procedure.
If the problem persists, remove the faulty power supply. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 62.
- 6 Install a new power supply. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 62.
If the problem persists, see "Getting Help" on page 77.

Troubleshooting Enclosure Cooling Problems

Problem

- Systems management software issues a fan-related error message.

Action

Ensure that none of the following conditions exist:

- Ambient temperature is too high.
- External airflow is obstructed.
- A power supply/cooling fan module has failed. See "Troubleshooting a Fan" on page 72.

Troubleshooting a Fan

Problem

- Enclosure-status indicator is amber.
- Systems management software issues a fan-related error message.
- Fan status indicator indicates a problem with the fan.

Action



CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.




CAUTION: The cooling fans are hot-pluggable. To maintain proper cooling while the system is on, replace only one fan at a time.

- 1 Locate the malfunctioning fan.
- 2 Ensure that the faulty power supply/cooling fan module is properly connected to the enclosure midplane.
- 3 If the problem is not resolved, install a new power supply/cooling fan module. See "Removing and Installing the Power Supply/Cooling Fan Module" on page 62.
If the replacement fan does not operate, see "Getting Help" on page 77.

Troubleshooting SAS Physical Disks



CAUTION: Only trained service technicians are authorized to remove the enclosure cover and access any of the components inside the enclosure. Before performing any procedure, see your *Product Information Guide* for complete information about safety precautions, working inside the enclosure and protecting against electrostatic discharge.

 **NOTICE:** This procedure can destroy data stored on the physical disks. Before you continue, back up all files on the disk.

Problem

- A single physical disk is not seen in MD Storage Manager.

Action

- 1 Remove the physical disk from the enclosure. See "Removing and Installing Physical Disks" on page 56.
- 2 Inspect the physical disk and midplane connectors for obvious damage.
- 3 Re-install the physical disk in its original bay. See "Removing and Installing Physical Disks" on page 56. If the problem persists, see "Getting Help" on page 77.

Problem

- Physical disk status LED is flashing amber.

Action

- 1 Review MD Storage Manager for possible recovery actions.



NOTE: If a physical disk rebuild is under way, allow the rebuild to complete.

- 2 Remove the physical disk from the enclosure. See "Removing and Installing Physical Disks" on page 56.
- 3 Inspect the disk and midplane connectors for obvious damage.
- 4 Re-install the disk in its original bay. See "Removing and Installing Physical Disks" on page 56. If the problem persists, see "Getting Help" on page 77.

Problem

- Multiple physical disks are not seen in MD Storage Manager.

Action

- 1 Make sure that all cables are attached correctly according to the enclosure mode you selected. For more information on enclosure modes, see "Cabling Your RAID Enclosure" on page 21.
- 2 Verify that the SAS port link status LED is solid green for each port that is connected to a cable. If it is not, see "Back-Panel Indicators and Features" on page 13.
- 3 If you reseated cables, reboot the host server. If the problem persists, see "Getting Help" on page 77.

Troubleshooting Enclosure Connections

Problem

- Enclosure is not seen by attached host controller.

Action

- Inspect RAID controller module cables for connectivity problems, such as damaged or disconnected cables and poor connections. For detailed cabling instructions, see "Cabling Your RAID Enclosure" on page 21.

Hard Controller Failures and Lockdown Conditions

Certain events can cause a RAID controller module to fail and/or shut down. Unrecoverable ECC memory or PCI errors, or critical physical conditions can cause lockdown. If your RAID storage array is configured for redundant access and cache mirroring, the surviving controller can normally recover without data loss or shutdown.

Typical hard controller failures are detailed in the following sections.

Invalid Enclosure

The RAID controller module is supported only in a Dell-supported enclosure. Upon installation in the enclosure, the controller performs a set of validation checks. The enclosure status LED is lit with a steady blue color while the RAID controller module completes these initial tests and after the controller is found to be working properly. If the RAID controller module detects a non-Dell supported enclosure, the controller aborts startup. The RAID controller module will not generate any events to alert you in the event of an invalid enclosure, but the enclosure status LED will blink amber to indicate a fault state.

For full details on the LEDs and their interpretation, see "Back-Panel Indicators and Features" on page 13.

ECC Errors

RAID controller firmware can detect ECC errors and can recover from a single-bit ECC error whether the RAID controller module is in a redundant or nonredundant configuration. A storage array with redundant controllers can recover from multi-bit ECC errors as well because the peer RAID controller module can take over, if necessary.

The RAID controller module will failover if it experiences up to 10 single-bit errors, or up to three multi-bit errors.

PCI Errors

The storage enclosure firmware can detect and only recover from PCI errors when the RAID controller modules are configured for redundancy. If a virtual disk uses cache mirroring, it fails over to its peer RAID controller module, which initiates a flush of the dirty cache.

Critical Conditions

The storage array will generate a critical event if the RAID controller module detects a critical condition that could cause immediate failure of the enclosure and/or loss of data. The storage array is in a critical condition if one of the following occurs:

- More than one fan has failed
- Any backplane temperature sensors in the critical range
- Backplane/power supply failure
- Two or more temperature sensors are unreadable
- Failure to detect or unable to communicate with peer in duplex configuration



NOTE: If both RAID controller modules fail simultaneously, the enclosure cannot issue critical or noncritical event alarms for any enclosure component.

When the enclosure is under critical condition, its enclosure status LED blinks amber.

Noncritical Conditions

A noncritical condition is an event or status that will not cause immediate failure, but must be corrected to ensure continued reliability of the storage array. Examples of noncritical events include the following:

- One power supply has failed
- One cooling fan has failed
- One RAID controller module in a redundant configuration has failed
- A battery has failed or has been removed
- A physical disk in a redundant virtual disk has failed

When the enclosure is under non-critical condition, its enclosure status LED shows steady amber.

Getting Help


Obtaining Assistance


 **CAUTION:** If you need to remove the system cover, first disconnect the power and modem cables from all electrical outlets.

- 1 Complete the procedures in "Troubleshooting Your Enclosure" on page 69.
- 2 Review the storage array status in MD Storage Manager and record any information provided.
- 3 Use Dell's extensive suite of online services available at Dell Support (support.dell.com) for help with installation and troubleshooting procedures.

For more information, see "Online Services" on page 77.


- 4 If the preceding steps have not resolved the problem, call Dell for technical assistance.

 **NOTE:** Call the support service from a phone near or at the system so that the support staff can assist you with any necessary procedures.

 **NOTE:** Dell's Express Service Code system may not be available in all countries.

When prompted by Dell's automated telephone system, enter your Express Service Code to route the call directly to the proper support personnel. If you do not have an Express Service Code, open the **Dell Accessories** folder, double-click the **Express Service Code** icon, and follow the directions.

For instructions on using the support service, see "Support Service" on page 79 and "Before You Call" on page 80.

 **NOTE:** Some of the following services are not always available in all locations outside the continental U.S. Call your local Dell representative for information on availability.

Online Services

You can access Dell Support at support.dell.com. Select your region on the **WELCOME TO DELL SUPPORT** page, and fill in the requested details to access help tools and information.

You can learn about Dell products and services on the following websites:

www.dell.com/

www.dell.com/ap/ (Asian/Pacific countries only)

www.dell.com/jp/ (Japan only)

www.euro.dell.com (Europe only)

www.dell.com/la (Latin American countries)

www.dell.ca (Canada only)

You can access Dell Support through the following websites and e-mail addresses:

- Dell Support websites
support.dell.com
support.jp.dell.com (Japan only)
support.euro.dell.com (Europe only)
- Dell Support e-mail addresses
mobile_support@us.dell.com
support@us.dell.com
la-techsupport@dell.com (Latin America and Caribbean countries only)
apsupport@dell.com (Asian/Pacific countries only)
- Dell Marketing and Sales e-mail addresses
apmarketing@dell.com (Asian/Pacific countries only)
sales_canada@dell.com (Canada only)
- Anonymous file transfer protocol (FTP)
ftp.dell.com/
Log in as user: `anonymous`, and use your e-mail address as your password.

AutoTech Service

Dell's automated support service—AutoTech—provides recorded answers to the questions most frequently asked by Dell customers about their portable and desktop computer systems.

When you call AutoTech, use your touch-tone telephone to select the subjects that correspond to your questions.

The AutoTech service is available 24 hours a day, 7 days a week. You can also access this service through the support service. See the contact information for your region.

Automated Order-Status Service

To check on the status of any Dell™ products that you have ordered, you can go to support.dell.com, or you can call the automated order-status service. A recording prompts you for the information needed to locate and report on your order. See the contact information for your region.

Support Service

Dell's support service is available 24 hours a day, 7 days a week, to answer your questions about Dell hardware. Our support staff use computer-based diagnostics to provide fast, accurate answers.

To contact Dell's support service, see "Before You Call" on page 80 and then see the contact information for your region or go to support.dell.com.

Dell Enterprise Training

Dell enterprise training is available; see www.dell.com/training for more information. This service may not be offered in all locations.

Problems With Your Order

If you have a problem with your order, such as missing parts, wrong parts, or incorrect billing, contact Dell for customer assistance. Have your invoice or packing slip available when you call. See the contact information for your region.

Product Information

If you need information about additional products available from Dell, or if you would like to place an order, visit the Dell website at www.dell.com. For the telephone number to call to speak to a sales specialist, see the contact information for your region.

Returning Items for Warranty Repair or Credit


Prepare all items being returned, whether for repair or credit, as follows:

- 1 Call Dell to obtain a Return Material Authorization Number, and write it clearly and prominently on the outside of the box.
For the telephone number to call, see the contact information for your region.
- 2 Include a copy of the invoice and a letter describing the reason for the return.
- 3 Include a copy of any diagnostic information indicating the tests you have run and any error messages reported by the system diagnostics.
- 4 Include any accessories that belong with the item(s) being returned (such as power cables, media such as CDs and diskettes, and guides) if the return is for credit.
- 5 Pack the equipment to be returned in the original (or equivalent) packing materials.


You are responsible for paying shipping expenses. You are also responsible for insuring any product returned, and you assume the risk of loss during shipment to Dell. Collect-on-delivery (C.O.D.) packages are not accepted.

Returns that are missing any of the preceding requirements will be refused at our receiving dock and returned to you.

Before You Call

 **NOTE:** Have your Express Service Code ready when you call. The code helps Dell's automated-support telephone system direct your call more efficiently.

If possible, turn on your system before you call Dell for technical assistance and call from a telephone at or near the computer. You may be asked to type some commands at the keyboard, relay detailed information during operations, or try other troubleshooting steps possible only at the computer system itself. Ensure that the system documentation is available.


 **CAUTION:** Before servicing any components inside your computer, see your *Product Information Guide* for important safety information.


Contacting Dell

To contact Dell electronically, you can access the following websites:


- www.dell.com
- support.dell.com (support)

For specific web addresses for your country, find the appropriate country section in the table below.

 **NOTE:** Toll-free numbers are for use within the country for which they are listed.

 **NOTE:** In certain countries, support specific to Dell™ XPS™ computers is available at a separate telephone number listed for participating countries. If you do not see a telephone number listed that is specific for XPS computers, you may contact Dell through the support number listed and your call will be routed appropriately.

When you need to contact Dell, use the electronic addresses, telephone numbers, and codes provided in the following table. If you need assistance in determining which codes to use, contact a local or an international operator.

 **NOTE:** The contact information provided was deemed correct at the time that this document went to print and is subject to change.

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|--|
| Anguilla | Website: www.dell.com.ai E-mail: la-techsupport@dell.com General Support | toll-free: 800-335-0031 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|---|---|
| Antigua and Barbuda | Website: www.dell.com.ag E-mail: la-techsupport@dell.com General Support | 1-800-805-5924 |
| Aomen | Technical Support (Dell™ Dimension™, Dell Inspiron™, Dell OptiPlex™, Dell Latitude™, and Dell Precision™) Technical Support (servers and storage) | 0800-105 0800-105 |
| Argentina (Buenos Aires) International Access Code: 00 Country Code: 54 City Code: 11 | Website: www.dell.com.ar E-mail: la-techsupport@dell.com E-mail for desktop and portable computers: la-techsupport@dell.com E-mail for servers and EMC® storage products: la_enterprise@dell.com Customer Care Technical Support Technical Support Services Sales | toll-free: 0-800-444-0730 toll-free: 0-800-444-0733 toll-free: 0-800-444-0724 0-810-444-3355 |
| Aruba | Website: www.dell.com.aw E-mail: la-techsupport@dell.com General Support | toll-free: 800-1578 |
| Australia (Sydney) International Access Code: 0011 Country Code: 61 City Code: 2 | Website: support.ap.dell.com E-mail: support.ap.dell.com/contactus Technical Support (XPS) General Support | toll-free: 1300 790 877 13DELL-133355 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Austria (Vienna) | Website: support.euro.dell.com | |
| International Access Code: 900 | E-mail: tech_support_central_europe@dell.com | |
| Country Code: 43 | Home/Small Business Sales | 0820 240 530 00 |
| City Code: 1 | Home/Small Business Fax | 0820 240 530 49 |
| | Home/Small Business Customer Care | 0820 240 530 14 |
| | Preferred Accounts/Corporate Customer Care | 0820 240 530 16 |
| | Support for XPS | 0820 240 530 81 |
| | Home/Small Business Support for all other Dell computers | 0820 240 530 17 |
| | Preferred Accounts/Corporate Support | 0820 240 530 17 |
| | Switchboard | 0820 240 530 00 |
| Bahamas | Website: www.dell.com.bs | |
| | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 1-866-874-3038 |
| Barbados | Website: www.dell.com/bb | |
| | E-mail: la-techsupport@dell.com | |
| | General Support | 1-800-534-3142 |
| Belgium (Brussels) | Website: support.euro.dell.com | |
| International Access Code: 00 | Tech Support for XPS | 02 481 92 96 |
| Country Code: 32 | Tech Support for all other Dell computers | 02 481 92 88 |
| City Code: 2 | Tech Support Fax | 02 481 92 95 |
| | Customer Care | 02 713 15 65 |
| | Corporate Sales | 02 481 91 00 |
| | Fax | 02 481 92 99 |
| | Switchboard | 02 481 91 00 |
| Bermuda | Website: www.dell.com/bm | |
| | E-mail: la-techsupport@dell.com | |
| | General Support | 1-877-890-0751 |
| Bolivia | Website: www.dell.com/bo | |
| | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 800-10-0238 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|---|---|
| Brazil | Website: www.dell.com/br | |
| International Access Code: 00 | E-mail: BR-TechSupport@dell.com | |
| Country Code: 55 | Customer Care and Tech Support | 0800 90 3355 |
| City Code: 51 | Technical Support Fax | 51 2104 5470 |
| | Customer Care Fax | 51 2104 5480 |
| | Sales | 0800 722 3498 |
| British Virgin Islands | General Support | toll-free: 1-866-278-6820 |
| Brunei | Technical Support (Penang, Malaysia) | 604 633 4966 |
| Country Code: 673 | Customer Care (Penang, Malaysia) | 604 633 4888 |
| | Transaction Sales (Penang, Malaysia) | 604 633 4955 |
| Canada (North York, Ontario) | Online Order Status: www.dell.ca/ostatus | |
| International Access Code: 011 | Website: support.ca.dell.com | |
| | AutoTech (automated Hardware and Warranty Support) | toll-free: 1-800-247-9362 |
| | Customer Service (Home/Home Office) | toll-free: 1-800-847-4096 |
| | Customer Service (small/med./large business, government) | toll-free: 1-800-387-5757 |
| | Customer Service (printers, projectors, televisions, handhelds, digital jukebox, and wireless) | toll-free: 1-800-847-4096 |
| | Hardware Warranty Phone Support (XPS) | toll-free: 1-866-398-8977 |
| | Hardware Warranty Phone Support (Home/Home Office) | toll-free: 1-800-847-4096 |
| | Hardware Warranty Phone Support (small/med./large business, government) | toll-free: 1-800-387-5757 |
| | Hardware Warranty Phone Support (printers, projectors, televisions, handhelds, digital jukebox, and wireless) | 1-877-335-5767 |
| | Sales (Home Sales/Small Business) | toll-free: 1-800-387-5752 |
| | Sales (med./large bus., government) | toll-free: 1-800-387-5755 |
| | Spare Parts Sales & Extended Service Sales | 1 866 440 3355 |
| Cayman Islands | E-mail: la-techsupport@dell.com | |
| | General Support | 1-877-262-5415 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Chile (Santiago) Country Code: 56 City Code: 2 | Website: www.dell.com/cl E-mail: la-techsupport@dell.com Sales and Customer Support | toll-free: 1230-020-4823 |
| China (Xiamen) Country Code: 86 City Code: 592 | Technical Support website: support.dell.com.cn Technical Support E-mail: support.dell.com.cn/email Customer Care E-mail: customer_cn@dell.com Technical Support Fax Technical Support (XPS) Technical Support (Dimension and Inspiron) Technical Support (OptiPlex, Latitude, and Dell Precision) Technical Support (servers and storage) Technical Support (projectors, PDAs, switches, routers, and so on) Technical Support (printers) Customer Care Customer Care Fax Home and Small Business Preferred Accounts Division Large Corporate Accounts GCP Large Corporate Accounts Key Accounts Large Corporate Accounts North Large Corporate Accounts North Government and Education Large Corporate Accounts East Large Corporate Accounts East Government and Education Large Corporate Accounts Queue Team Large Corporate Accounts South Large Corporate Accounts West Large Corporate Accounts Spare Parts | 592 818 1350 toll-free: 800 858 0540 toll-free: 800 858 2969 toll-free: 800 858 0950 toll-free: 800 858 0960 toll-free: 800 858 2920 toll-free: 800 858 2311 toll-free: 800 858 2060 592 818 1308 toll-free: 800 858 2222 toll-free: 800 858 2557 toll-free: 800 858 2055 toll-free: 800 858 2628 toll-free: 800 858 2999 toll-free: 800 858 2955 toll-free: 800 858 2020 toll-free: 800 858 2669 toll-free: 800 858 2572 toll-free: 800 858 2355 toll-free: 800 858 2811 toll-free: 800 858 2621 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|---|--|
| Colombia | Website: www.dell.com/cl E-mail: la-techsupport@dell.com General Support | 01-800-915-4755 |
| Costa Rica | Website: www.dell.com/cr E-mail: la-techsupport@dell.com General Support | 0800-012-0231 |
| Czech Republic (Prague) International Access Code: 00 Country Code: 420 | Website: support.euro.dell.com E-mail: czech_dell@dell.com Technical Support Customer Care Fax Technical Fax Switchboard | 22537 2727 22537 2707 22537 2714 22537 2728 22537 2711 |
| Denmark (Copenhagen) International Access Code: 00 Country Code: 45 | Website: support.euro.dell.com Technical Support for XPS Technical Support for all other Dell computers Customer Care (Relational) Home/Small Business Customer Care Switchboard (Relational) Switchboard Fax (Relational) Switchboard (Home/Small Business) Switchboard Fax (Home/Small Business) | 7010 0074 7023 0182 7023 0184 3287 5505 3287 1200 3287 1201 3287 5000 3287 5001 |
| Dominica | Website: www.dell.com/dm E-mail: la-techsupport@dell.com General Support | toll-free: 1-866-278-6821 |
| Dominican Republic | Website: www.dell.com/do E-mail: la-techsupport@dell.com General Support | 1-800-156-1588 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|---|---|--|
| Ecuador | Website: www.dell.com/ec E-mail: la-techsupport@dell.com General Support (calling from Quito) General Support (calling from Guayaquil) | toll-free: 999-119-877-655-3355 toll-free: 1800-999-119-877-655-3355 |
| El Salvador | Website: www.dell.com/ec E-mail: la-techsupport@dell.com General Support | 800-6132 |
| Finland (Helsinki) International Access Code: 990 Country Code: 358 City Code: 9 | Website: support.euro.dell.com E-mail: fi_support@dell.com Technical Support Customer Care Switchboard Sales under 500 employees Fax Sales over 500 employees Fax | 0207 533 555 0207 533 538 0207 533 533 0207 533 540 0207 533 530 0207 533 533 0207 533 530 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| France (Paris) (Montpellier) | Website: support.euro.dell.com | |
| International Access Code: 00 | Home and Small Business | |
| Country Code: 33 | Technical Support for XPS | 0825 387 129 |
| City Codes: (1) (4) | Technical Support for all other Dell computers | 0825 387 270 |
| | Customer Care | 0825 823 833 |
| | Switchboard | 0825 004 700 |
| | Switchboard (calls from outside of France) | 04 99 75 40 00 |
| | Sales | 0825 004 700 |
| | Fax | 0825 004 701 |
| | Fax (calls from outside of France) | 04 99 75 40 01 |
| | Corporate | |
| | Technical Support | 0825 004 719 |
| | Customer Care | 0825 338 339 |
| | Switchboard | 01 55 94 71 00 |
| | Sales | 01 55 94 71 00 |
| | Fax | 01 55 94 71 01 |
| Germany (Frankfurt) | Website: support.euro.dell.com | |
| International Access Code: 00 | E-mail: tech_support_central_europe@dell.com | |
| Country Code: 49 | Technical Support for XPS | 069 9792 7222 |
| City Code: 69 | Technical Support for all other Dell computers | 069 9792-7200 |
| | Home/Small Business Customer Care | 0180-5-224400 |
| | Global Segment Customer Care | 069 9792-7320 |
| | Preferred Accounts Customer Care | 069 9792-7320 |
| | Large Accounts Customer Care | 069 9792-7320 |
| | Public Accounts Customer Care | 069 9792-7320 |
| | Switchboard | 069 9792-7000 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Greece | Website: support.euro.dell.com | |
| International Access Code: 00 | Technical Support | 00800-44 14 95 18 |
| Country Code: 30 | Gold Service Technical Support | 00800-44 14 00 83 |
| | Switchboard | 2108129810 |
| | Gold Service Switchboard | 2108129811 |
| | Sales | 2108129800 |
| | Fax | 2108129812 |
| Grenada | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 1-866-540-3355 |
| Guatemala | E-mail: la-techsupport@dell.com | |
| | General Support | 1-800-999-0136 |
| Guyana | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 1-877-270-4609 |
| Hong Kong | Website: support.ap.dell.com | |
| International Access Code: 001 | Technical Support E-mail: support.dell.com.cn/email | |
| Country Code: 852 | Technical Support (XPS) | 00852-3416 6923 |
| | Technical Support (Dimension and Inspiron) | 00852-2969 3188 |
| | Technical Support (OptiPlex, Latitude, and Dell Precision) | 00852-2969 3191 |
| | Technical Support (servers and storage) | 00852-2969 3196 |
| | Technical Support (projectors, PDAs, switches, routers, and so on) | 00852-3416 0906 |
| | Customer Care | 00852-3416 0910 |
| | Large Corporate Accounts | 00852-3416 0907 |
| | Global Customer Programs | 00852-3416 0908 |
| | Medium Business Division | 00852-3416 0912 |
| | Home and Small Business Division | 00852-2969 3105 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|---|---|--|
| India | Website: support.ap.dell.com E-mail: india_support_desktop@dell.com india_support_notebook@dell.com india_support_Server@dell.com Technical Support (XPS computers) | 0802 506 8033 or toll-free: 1800 425 2066 |
| | Technical Support (portables, desktops, servers, and storage) | 1600338045 and 1600448046 |
| | Sales (Large Corporate Accounts) | 1600 33 8044 |
| | Sales (Home and Small Business) | 1600 33 8046 |
| Ireland (Cherrywood) International Access Code: 00 Country Code: 353 City Code: 1 | Website: support.euro.dell.com E-mail: dell_direct_support@dell.com Sales Ireland Sales Dell Outlet Online Ordering HelpDesk Customer Care Home User Customer Care Small Business Customer Care Corporate Customer Care Technical Support Technical Support for XPS computers only Technical Support for all other Dell computers General Fax/Sales Fax Switchboard U.K. Customer Care (dial within U.K. only) Corporate Customer Care (dial within U.K. only) U.K. Sales (dial within U.K. only) | 01 204 4444 1850 200 778 1850 200 778 01 204 4014 01 204 4014 1850 200 982 1850 200 722 1850 543 543 01 204 0103 01 204 4444 0870 906 0010 0870 907 4499 0870 907 4000 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Italy (Milan) | Website: support.euro.dell.com | |
| International Access Code: 00 | Home and Small Business | |
| Country Code: 39 | Technical Support | 02 577 826 90 |
| City Code: 02 | Customer Care | 02 696 821 14 |
| | Fax | 02 696 821 13 |
| | Switchboard | 02 696 821 12 |
| | Corporate | |
| | Technical Support | 02 577 826 90 |
| | Customer Care | 02 577 825 55 |
| | Fax | 02 575 035 30 |
| | Switchboard | 02 577 821 |
| Jamaica | E-mail: la-techsupport@dell.com | |
| | General Support (dial from within Jamaica only) | 1-800-440-9205 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|---|---|
| Japan (Kawasaki) | Website: support.jp.dell.com | |
| International Access Code: 001 | Technical Support (XPS) | toll-free: 0120-937-786 |
| Country Code: 81 | Technical Support outside of Japan (XPS) | 044-520-1235 |
| City Code: 44 | XPS Customer Care (if ordered items are missing or have been damaged during shipment) | 044-556-4240 |
| | Technical Support (Dimension and Inspiron) | toll-free: 0120-198-226 |
| | Technical Support outside of Japan (Dimension and Inspiron) | 81-44-520-1435 |
| | Technical Support (Dell Precision, OptiPlex, and Latitude) | toll-free: 0120-198-433 |
| | Technical Support outside of Japan (Dell Precision, OptiPlex, and Latitude) | 81-44-556-3894 |
| | Technical Support (Dell PowerApp™, Dell PowerEdge™, Dell PowerConnect™, and Dell PowerVault™) | toll-free: 0120-198-498 |
| | Technical Support outside of Japan (PowerApp, PowerEdge, PowerConnect, and PowerVault) | 81-44-556-4162 |
| | Technical Support (projectors, PDAs, printers, routers) | toll-free: 0120-981-690 |
| | Technical Support outside of Japan (projectors, PDAs, printers, routers) | 81-44-556-3468 |
| | Faxbox Service | 044-556-3490 |
| | 24-Hour Automated Order Status Service | 044-556-3801 |
| | Customer Care | 044-556-4240 |
| | Business Sales Division (up to 400 employees) | 044-556-1465 |
| | Preferred Accounts Division Sales (over 400 employees) | 044-556-3433 |
| | Public Sales (government agencies, educational institutions, and medical institutions) | 044-556-5963 |
| | Global Segment Japan | 044-556-3469 |
| | Individual User | 044-556-1760 |
| | Switchboard | 044-556-4300 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|---|---|---|
| Korea (Seoul) International Access Code: 001 Country Code: 82 City Code: 2 | E-mail: krsupport@dell.com | |
| | Support | toll-free: 080-200-3800 |
| | Technical Support (XPS) | toll-free: 080-999-0283 |
| | Support (Dimension, PDA, Electronics, and Accessories) | toll-free: 080-200-3801 |
| | Sales | toll-free: 080-200-3600 |
| | Fax | 2194-6202 |
| | Switchboard | 2194-6000 |
| Latin America | Customer Technical Support (Austin, Texas, U.S.A.) | 512 728-4093 |
| | Customer Service (Austin, Texas, U.S.A.) | 512 728-3619 |
| | Fax (Technical Support and Customer Service) (Austin, Texas, U.S.A.) | 512 728-3883 |
| | Sales (Austin, Texas, U.S.A.) | 512 728-4397 |
| | SalesFax (Austin, Texas, U.S.A.) | 512 728-4600 or 512 728-3772 |
| Luxembourg | Website: support.euro.dell.com | |
| | Support | 342 08 08 075 |
| | Home/Small Business Sales | +32 (0)2 713 15 96 |
| | Corporate Sales | 26 25 77 81 |
| | Customer Care | +32 (0)2 481 91 19 |
| | Fax | 26 25 77 82 |
| Macao | Technical Support | toll-free: 0800 105 |
| | Customer Service (Xiamen, China) | 34 160 910 |
| | Transaction Sales (Xiamen, China) | 29 693 115 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Malaysia (Penang) | Website: support.ap.dell.com | |
| International Access Code: 00 | Technical Support (XPS) | toll-free: 1800 885 784 |
| Country Code: 60 | Technical Support (Dell Precision, OptiPlex, and Latitude) | toll-free: 1 800 880 193 |
| City Code: 4 | Technical Support (Dimension, Inspiron, and Electronics and Accessories) | toll-free: 1 800 881 306 |
| | Technical Support (PowerApp, PowerEdge, PowerConnect, and PowerVault) | toll-free: 1800 881 386 |
| | Customer Care | toll-free: 1800 881 306 (option 6) |
| | Transaction Sales | toll-free: 1 800 888 202 |
| | Corporate Sales | toll-free: 1 800 888 213 |
| Mexico | E-mail: la-techsupport@dell.com | |
| International Access Code: 00 | Customer Technical Support | 001-877-384-8979 |
| Country Code: 52 | | or 001-877-269-3383 |
| | Sales | 50-81-8800 |
| | | or 01-800-888-3355 |
| | Customer Service | 001-877-384-8979 |
| | | or 001-877-269-3383 |
| | Main | 50-81-8800 |
| | | or 01-800-888-3355 |
| Montserrat | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 1-866-278-6822 |
| Netherlands Antilles | E-mail: la-techsupport@dell.com | |
| | General Support | 001-800-882-1519 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Netherlands (Amsterdam) | Website: support.euro.dell.com | |
| International Access Code: 00 | Technical Support for XPS | 020 674 45 94 |
| Country Code: 31 | Technical Support for all other Dell computers | 020 674 45 00 |
| City Code: 20 | Technical Support Fax | 020 674 47 66 |
| | Home/Small Business Customer Care | 020 674 42 00 |
| | Relational Customer Care | 020 674 4325 |
| | Home/Small Business Sales | 020 674 55 00 |
| | Relational Sales | 020 674 50 00 |
| | Home/Small Business Sales Fax | 020 674 47 75 |
| | Relational Sales Fax | 020 674 47 50 |
| | Switchboard | 020 674 50 00 |
| | Switchboard Fax | 020 674 47 50 |
| New Zealand | Website: support.ap.dell.com | |
| International Access Code: 00 | E-mail: support.ap.dell.com/contactus | |
| Country Code: 64 | Technical Support (XPS) | toll-free: 0800 335 540 |
| | General Support | 0800 441 567 |
| Nicaragua | E-mail: la-techsupport@dell.com | |
| | General Support | 001-800-220-1377 |
| Norway (Lysaker) | Website: support.euro.dell.com | |
| International Access Code: 00 | Technical Support for XPS | 815 35 043 |
| Country Code: 47 | Technical Support for all other Dell products | 671 16882 |
| | Relational Customer Care | 671 17575 |
| | Home/Small Business Customer Care | 23162298 |
| | Switchboard | 671 16800 |
| | Fax Switchboard | 671 16865 |
| Panama | E-mail: la-techsupport@dell.com | |
| | General Support | 011-800-507-1264 |
| Peru | E-mail: la-techsupport@dell.com | |
| | General Support | 0800-50-669 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Poland (Warsaw) | Website: support.euro.dell.com | |
| International Access Code: 011 | E-mail: pl_support_tech@dell.com | |
| Country Code: 48 | Customer Service Phone | 57 95 700 |
| City Code: 22 | Customer Care | 57 95 999 |
| | Sales | 57 95 999 |
| | Customer Service Fax | 57 95 806 |
| | Reception Desk Fax | 57 95 998 |
| | Switchboard | 57 95 999 |
| Portugal | Website: support.euro.dell.com | |
| International Access Code: 00 | Technical Support | 707200149 |
| Country Code: 351 | Customer Care | 800 300 413 |
| | Sales | 800 300 410 or 800 300 411 or 800 300 412 or 21 422 07 10 |
| | Fax | 21 424 01 12 |
| Puerto Rico | E-mail: la-techsupport@dell.com | |
| | General Support | 1-877-537-3355 |
| St. Kitts and Nevis | Website: www.dell.com/kn | |
| | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 1-866-540-3355 |
| St. Lucia | Website: www.dell.com/lc | |
| | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 1-866-464-4352 |
| St. Vincent and the Grenadines | Website: www.dell.com/vc | |
| | E-mail: la-techsupport@dell.com | |
| | General Support | toll-free: 1-866-464-4353 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|---|---|
| Singapore (Singapore) International Access Code: 005 Country Code: 65 | NOTE: The phone numbers in this section should be called from within Singapore or Malaysia only. Website: support.ap.dell.com | |
| | Technical Support (XPS) | toll-free: 1800 394 7464 |
| | Technical Support (Dimension, Inspiron, and Electronics and Accessories) | toll-free: 1 800 394 7430 |
| | Technical Support (OptiPlex, Latitude, and Dell Precision) | toll-free: 1 800 394 7488 |
| | Technical Support (PowerApp, PowerEdge, PowerConnect, and PowerVault) | toll-free: 1 800 394 7478 |
| | Customer Care | toll-free: 1 800 394 7430 (option 6) |
| | Transaction Sales | toll-free: 1 800 394 7412 |
| | Corporate Sales | toll-free: 1 800 394 7419 |
| Slovakia (Prague) International Access Code: 00 Country Code: 421 | Website: support.euro.dell.com E-mail: czech_dell@dell.com | |
| | Technical Support | 02 5441 5727 |
| | Customer Care | 420 22537 2707 |
| | Fax | 02 5441 8328 |
| | Tech Fax | 02 5441 8328 |
| | Switchboard (Sales) | 02 5441 7585 |
| South Africa (Johannesburg) International Access Code: 09/091 Country Code: 27 City Code: 11 | Website: support.euro.dell.com E-mail: dell_za_support@dell.com Gold Queue | 011 709 7713 |
| | Technical Support | 011 709 7710 |
| | Customer Care | 011 709 7707 |
| | Sales | 011 709 7700 |
| | Fax | 011 706 0495 |
| | Switchboard | 011 709 7700 |
| Southeast Asian and Pacific Countries | Technical Support, Customer Service, and Sales (Penang, Malaysia) | 604 633 4810 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|--|---|
| Spain (Madrid) | Website: support.euro.dell.com | |
| International Access Code: 00 | Home and Small Business | |
| Country Code: 34 | Technical Support | 902 100 130 |
| City Code: 91 | Customer Care | 902 118 540 |
| | Sales | 902 118 541 |
| | Switchboard | 902 118 541 |
| | Fax | 902 118 539 |
| | Corporate | |
| | Technical Support | 902 100 130 |
| | Customer Care | 902 115 236 |
| | Switchboard | 91 722 92 00 |
| | Fax | 91 722 95 83 |
| Sweden (Upplands Vasby) | Website: support.euro.dell.com | |
| International Access Code: 00 | Technical Support for XPS | 0771 340 340 |
| Country Code: 46 | Technical Support for all other Dell products | 08 590 05 199 |
| City Code: 8 | Relational Customer Care | 08 590 05 642 |
| | Home/Small Business Customer Care | 08 587 70 527 |
| | Employee Purchase Program (EPP) Support | 020 140 14 44 |
| | Technical Support Fax | 08 590 05 594 |
| | Sales | 08 590 05 185 |
| Switzerland (Geneva) | Website: support.euro.dell.com | |
| International Access Code: 00 | E-mail: Tech_support_central_Europe@dell.com | |
| Country Code: 41 | Technical Support for XPS | 0848 33 88 57 |
| City Code: 22 | Technical Support (Home and Small Business) for all other Dell products | 0844 811 411 |
| | Technical Support (Corporate) | 0844 822 844 |
| | Customer Care (Home and Small Business) | 0848 802 202 |
| | Customer Care (Corporate) | 0848 821 721 |
| | Fax | 022 799 01 90 |
| | Switchboard | 022 799 01 01 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|---|---|
| Taiwan International Access Code: 002 Country Code: 886 | Website: support.ap.dell.com | |
| | E-mail: support.dell.com.cn/email | |
| | Technical Support (XPS) | toll-free: 0080 186 3085 |
| | Technical Support (OptiPlex, Latitude, Inspiron, Dimension, and Electronics and Accessories) | toll-free: 0080 186 1011 |
| | Technical Support (servers and storage) | toll-free: 0080 160 1256 |
| | Customer Care | toll-free: 0080 160 1250 (option 5) |
| | Transaction Sales | toll-free: 0080 165 1228 |
| Corporate Sales | toll-free: 0080 165 1227 | |
| Thailand International Access Code: 001 Country Code: 66 | Website: support.ap.dell.com | |
| | Technical Support (OptiPlex, Latitude, and Dell Precision) | toll-free: 1800 0060 07 |
| | Technical Support (PowerApp, PowerEdge, PowerConnect, and PowerVault) | toll-free: 1800 0600 09 |
| | Customer Care | toll-free: 1800 006 007 (option 7) |
| | Corporate Sales | toll-free: 1800 006 009 |
| Transaction Sales | toll-free: 1800 006 006 | |
| Trinidad/Tobago | Website: www.dell.com/tt | |
| | E-mail: la-techsupport@dell.com General Support | toll-free: 1-888-799-5908 |
| Turks and Caicos Islands | Website: www.dell.com/tc | |
| | E-mail: la-techsupport@dell.com General Support | toll-free: 1-877-441-4735 |

| Country (City) International Access Code Country Code City Code | Department Name or Service Area, Website and E-Mail Address | Area Codes, Local Numbers, and Toll-Free Numbers |
|--|---|---|
| U.K. (Bracknell) International Access Code: 00 Country Code: 44 City Code: 1344 | Website: support.euro.dell.com E-mail: dell_direct_support@dell.com Customer Care website: support.euro.dell.com/uk/en/ECare/form/home.asp | |
| | Sales | |
| | Home and Small Business Sales | 0870 907 4000 |
| | Corporate/Public Sector Sales | 01344 860 456 |
| | Customer Care | |
| | Home and Small Business Customer Care | 0870 906 0010 |
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| Venezuela | Website: www.dell.com/ve E-mail: la-techsupport@dell.com General Support | 0800-100-4752 |

Glossary

This section defines or identifies technical terms, abbreviations, and acronyms used in your system documents.

A — Ampere(s).

AC — Alternating current.

ACPI — Advanced Configuration and Power Interface. A standard interface for enabling the operating system to direct configuration and power management.

ambient temperature — The temperature of the area or room where the system is located.

ANSI — American National Standards Institute. The primary organization for developing technology standards in the U.S.

application — Software designed to help you perform a specific task or series of tasks. Applications run from the operating system.

ASCII — American Standard Code for Information Interchange.

asset tag — An individual code assigned to a system, usually by an administrator, for security or tracking purposes.

backup — A copy of a program or data file. As a precaution, back up your system's physical disks on a regular basis. Before making a change to the configuration of your system, back up important start-up files from your operating system.

backup battery — A battery that maintains system configuration, date, and time information in a special section of memory when the system is turned off.

beep code — A diagnostic message in the form of a pattern of beeps from your system's speaker. For example, one beep, followed by a second beep, and then a burst of three beeps is beep code 1-1-3.

BIOS — Basic input/output system. Your system's BIOS contains programs stored on a flash memory chip. The BIOS controls the following:

- Communications between the processor and peripheral devices
- Miscellaneous functions, such as system messages

bit — The smallest unit of information interpreted by your system.

blade — A module that contains a processor, memory, and a physical disk. The modules are mounted into a chassis that includes power supplies and fans.

BMC — Baseboard management controller.

boot routine — A program that clears all memory, initializes devices, and loads the operating system when you start your system. Unless the operating system fails to respond, you can reboot (also called *warm boot*) your system by pressing <Ctrl><Alt>. Otherwise, you must restart the system by pressing the reset button or by turning the system off and then back on.

bootable diskette — A diskette that is used to start your system if the system will not boot from the physical disk.

BTU — British thermal unit.

bus — An information pathway between the components of a system. Your system contains an expansion bus that allows the processor to communicate with controllers for the peripheral devices connected to the system. Your system also contains an address bus and a data bus for communications between the processor and RAM.

C — Celsius.

cache — A fast storage area that keeps a copy of data or instructions for quick data retrieval. When a program makes a request to a physical disk for data that is in the cache, the disk-cache utility can retrieve the data from RAM faster than from the physical disk.

CD — Compact disc. CD drives use optical technology to read data from CDs.

cm — Centimeter(s).

cmos — Complementary metal-oxide semiconductor.

component — As they relate to DMI, components include operating systems, computer systems, expansion cards, and peripherals that are compatible with DMI. Each component is made up of groups and attributes that are defined as relevant to that component.

COMn — The device names for the serial ports on your system.

control panel — The part of the system that contains indicators and controls, such as the power button and power indicator.

controller — A chip that controls the transfer of data between the processor and memory or between the processor and a peripheral.

conventional memory — The first 640 KB of RAM. Conventional memory is found in all systems. Unless they are specially designed, MS-DOS® programs are limited to running in conventional memory.

coprocessor — A chip that relieves the system's processor of specific processing tasks. A math coprocessor, for example, handles numeric processing.

CPU — Central processing unit. See *processor*.

DC — Direct current.

DDR — Double-data rate. A technology in memory modules that potentially doubles the output.

device driver — A program that allows the operating system or some other program to interface correctly with a peripheral. Some device drivers—such as network drivers—must be loaded from the **config.sys** file or as memory-resident programs (usually, from the **autoexec.bat** file). Others must load when you start the program for which they were designed.

DHCP — Dynamic Host Configuration Protocol. A method of automatically assigning an IP address to a client system.

diagnostics — A comprehensive set of tests for your system.

DIMM — Dual in-line memory module. See also *memory module*.

DIN — *Deutsche Industrie Norm*.

directory — Directories help keep related files organized on a disk in a hierarchical, "inverted tree" structure. Each disk has a "root" directory. Additional directories that branch off the root directory are called *subdirectories*. Subdirectories may contain additional directories branching off them.

DMA — Direct memory access. A DMA channel allows certain types of data transfer between RAM and a device to bypass the processor.

DMI — Desktop Management Interface. DMI enables the management of your system's software and hardware by collecting information about the system's components, such as the operating system, memory, peripherals, expansion cards, and asset tag.

DNS — Domain Name System. A method of translating Internet domain names, such as **www.dell.com**, into IP addresses, such as 143.166.83.200.

DRAM — Dynamic random-access memory. A system's RAM is usually made up entirely of DRAM chips.

DVD — Digital versatile disc.

ECC — Error checking and correction.

EEPROM — Electronically erasable programmable read-only memory.

EMC — Electromagnetic compatibility.

EMI — Electromagnetic interference.

EMM — Enclosure Management Module.

ERA — Embedded remote access. ERA allows you to perform remote, or "out-of-band," server management on your network server using a remote access controller.

ESD — Electrostatic discharge.

ESM — Embedded server management.

expansion bus — Your system contains an expansion bus that allows the processor to communicate with controllers for peripherals, such as NICs.

expansion card — An add-in card, such as a NIC or SCSI adapter, that plugs into an expansion-card connector on the system board. An expansion card adds some specialized function to the system by providing an interface between the expansion bus and a peripheral.

expansion-card connector — A connector on the system board or riser board for plugging in an expansion card.

F — Fahrenheit.

FAT — File allocation table. The file system structure used by MS-DOS to organize and keep track of file storage. The Microsoft® Windows® operating systems can optionally use a FAT file system structure.

flash memory — A type of EEPROM chip that can be reprogrammed from a utility on diskette while still installed in a system; most EEPROM chips can only be rewritten with special programming equipment.

format — To prepare a physical disk or diskette for storing files. An unconditional format deletes all data stored on the disk.

FSB — Front-side bus. The FSB is the data path and physical interface between the processor and the main memory (RAM).

ft — Feet.

FTP — File transfer protocol.

g — Gram(s).

G — Gravities.

Gb — Gigabit(s); 1024 megabits or 1,073,741,824 bits.

GB — Gigabyte(s); 1024 megabytes or 1,073,741,824 bytes. However, when referring to physical disk capacity, the term is usually rounded to 1,000,000,000 bytes.

graphics mode — A video mode that can be defined as x horizontal by y vertical pixels by z colors.

group — As it relates to DMI, a group is a data structure that defines common information, or attributes, about a manageable component.

guarding — A type of data redundancy in which a set of physical disks stores data and an additional disks stores parity data. See also *mirroring*, *striping*, and *RAID*.

h — Hexadecimal. A base-16 numbering system, often used in programming to identify addresses in the system's RAM and I/O memory addresses for devices. In text, hexadecimal numbers are often followed by *h*.

headless system — A system or device that functions without having a keyboard, mouse, or monitor attached. Normally, headless systems are managed over a network using an Internet browser.

host adapter — A host adapter implements communication between the system's bus and the controller for a peripheral device. (Disk controller subsystems include integrated host adapter circuitry.) To add a SCSI expansion bus to your system, you must install or connect the appropriate host adapter.

hot-pluggable — The ability to remove a system component or attached device without powering down the system. While a component may be "hot-pluggable," you should never remove a component or device while data traffic is occurring that involves the component. For more information, see the documentation for your specific component or device.

Hz — Hertz.

I/O — Input/output. A keyboard is an input device, and a monitor is an output device. In general, I/O activity can be differentiated from computational activity.

ID — Identification.

IDE — Integrated drive electronics. A standard interface between the system board and storage devices.

integrated mirroring — Provides simultaneous physical mirroring of two drives. Integrated mirroring functionality is provided by the system's hardware. See also *mirroring*.

internal processor cache — An instruction and data cache built into the processor.

IP — Internet Protocol.

IPX — Internet package exchange.

IRQ — Interrupt request. A signal that data is about to be sent to or received by a peripheral device travels by an IRQ line to the processor. Each peripheral connection must be assigned an IRQ number. Two devices can share the same IRQ assignment, but you cannot operate both devices simultaneously.

jumper — Small blocks on a circuit board with two or more pins emerging from them. Plastic plugs containing a wire fit down over the pins. The wire connects the pins and creates a circuit, providing a simple and reversible method of changing the circuitry in a board.

K — Kilo-; 1000.

Kb — Kilobit(s); 1024 bits.

KB — Kilobyte(s); 1024 bytes.

Kbps — Kilobit(s) per second.

KBps — Kilobyte(s) per second.

key combination — A command requiring you to press multiple keys at the same time (for example, <Ctrl><Alt>).

kg — Kilogram(s); 1000 grams.

kHz — Kilohertz.

KMM — Keyboard/monitor/mouse.

KVM — Keyboard/video/mouse. KVM refers to a switch that allows selection of the system from which the video is displayed and for which the keyboard and mouse are used.

LAN — Local area network. A LAN is usually confined to the same building or a few nearby buildings, with all equipment linked by wiring dedicated specifically to the LAN.

lb — Pound(s).

LCD — Liquid crystal display.

LED — Light-emitting diode. An electronic device that lights up when a current is passed through it.

Linux — A UNIX-like operating system that runs on a variety of hardware systems. Linux is open source software, which is freely available; however, the full distribution of Linux along with technical support and training are available for a fee from vendors such as Red Hat Software.

local bus — On a system with local-bus expansion capability, certain peripheral devices (such as the video adapter circuitry) can be designed to run much faster than they would with a traditional expansion bus. See also *bus*.

LVD — Low voltage differential.

m — Meter(s).

mA — Milliampere(s).

MAC address — Media Access Control address. Your system's unique hardware number on a network.

mAh — Milliampere-hour(s).

Mb — Megabit(s); 1,048,576 bits.

MB — Megabyte(s); 1,048,576 bytes. However, when referring to physical disk capacity, the term is often rounded to mean 1,000,000 bytes.

Mbps — Megabits per second.

MBps — Megabytes per second.

MBR — Master boot record.

memory address — A specific location, usually expressed as a hexadecimal number, in the system's RAM.

memory module — A small circuit board containing DRAM chips that connects to the system board.

memory — An area in your system that stores basic system data. A system can contain several different forms of memory, such as integrated memory (ROM and RAM) and add-in memory modules (DIMMs).

MHz — Megahertz.

mirroring — A type of data redundancy in which a set of physical disks stores data and one or more sets of additional disks stores duplicate copies of the data. Mirroring functionality is provided by software. See also *guarding*, *integrated mirroring*, *striping*, and *RAID*.

mm — Millimeter(s).

ms — Millisecond(s).

MS-DOS® — Microsoft Disk Operating System.

NAS — Network Attached Storage. NAS is one of the concepts used for implementing shared storage on a network. NAS systems have their own operating systems, integrated hardware, and software that are optimized to serve specific storage needs.

NIC — Network interface controller. A device that is installed or integrated in a system to allow connection to a network.

NMI — Nonmaskable interrupt. A device sends an NMI to signal the processor about hardware errors.

ns — Nanosecond(s).

NTFS — The NT File System option in the Windows 2000 operating system.

NVRAM — Nonvolatile random-access memory. Memory that does not lose its contents when you turn off your system. NVRAM is used for maintaining the date, time, and system configuration information.

parity — Redundant information that is associated with a block of data.

partition — You can divide a physical disk into multiple physical sections called *partitions* with the **fdisk** command. Each partition can contain multiple logical disks. You must format each logical disk with the **format** command.

PCI — Peripheral Component Interconnect. A standard for local-bus implementation.

PDU — Power distribution unit. A power source with multiple power outlets that provides electrical power to servers and storage systems in a rack.

peripheral — An internal or external device, such as a diskette drive or keyboard, connected to a system.

PGA — Pin grid array. A type of processor socket that allows you to remove the processor chip.

physical disk — A hard drive installed in the RAID enclosure.

pixel — A single point on a video display. Pixels are arranged in rows and columns to create an image. A video resolution, such as 640 x 480, is expressed as the number of pixels across by the number of pixels up and down.

POST — Power-on self-test. Before the operating system loads when you turn on your system, the POST tests various system components such as RAM and physical disks.

processor — The primary computational chip inside the system that controls the interpretation and execution of arithmetic and logic functions. Software written for one processor must usually be revised to run on another processor. *CPU* is a synonym for processor.

protected mode — An operating mode that allows operating systems to implement:

- A memory address space of 16 MB to 4 GB
- Multitasking
- Virtual memory, a method for increasing addressable memory by using the physical disk

The Windows 2000 and UNIX® 32-bit operating systems run in protected mode. MS-DOS cannot run in protected mode.

PS/2 — Personal System/2.

PXE — Preboot eXecution Environment. A way of booting a system via a LAN (without a physical disk or bootable diskette).

RAC — Remote access controller.

RAID — Redundant array of independent disks. A method of providing data redundancy. Some common implementations of RAID include RAID 0, RAID 1, RAID 5, RAID 10, and RAID 50. See also *guarding*, *mirroring*, and *striping*.

RAID enclosure — A storage enclosure supporting RAID via a modular controller unit.

RAID array — Collection of storage disks managed under a RAID solution. The RAID array includes any disks attached to the RAID controller, including those contained in a supported expansion enclosure.

RAM — Random-access memory. The system's primary temporary storage area for program instructions and data. Any information stored in RAM is lost when you turn off your system.

RAS — Remote Access Service. This service allows users running the Windows operating system to remotely access a network from their system using a modem.

readme file — A text file, usually shipped with software or hardware, that contains information supplementing or updating the product's documentation.

read-only file — A read-only file is one that you are prohibited from editing or deleting.

ROM — Read-only memory. Your system contains some programs essential to its operation in ROM code. A ROM chip retains its contents even after you turn off your system. Examples of code in ROM include the program that initiates your system's boot routine and the POST.

ROMB — RAID on motherboard.

rpm — Revolutions per minute.

RTC — Real-time clock.

SCSI — Small computer system interface. An I/O bus interface with faster data transmission rates than standard ports.

SDRAM — Synchronous dynamic random-access memory.

sec — Second(s).

serial port — An I/O port used most often to connect a modem to your system. You can usually identify a serial port on your system by its 9-pin connector.

service tag — A bar code label on the system used to identify it when you call Dell for technical support.

simple disk volume — The volume of free space on a single dynamic, physical disk.

SMART — Self-Monitoring Analysis and Reporting Technology. Allows physical disks to report errors and failures to the system BIOS and then display an error message on the screen.

SMP — Symmetric multiprocessing. Used to describe a system that has two or more processors connected via a high-bandwidth link and managed by an operating system, where each processor has equal access to I/O devices.

SNMP — Simple Network Management Protocol. A standard interface that allows a network manager to remotely monitor and manage workstations.

spanning — Spanning, or concatenating, disk volumes combines unallocated space from multiple disks into one logical volume, allowing more efficient use of all the space and all physical disk drive letters on a multiple-disk system.

striping — Disk striping writes data across three or more disks in an array, but only uses a portion of the space on each disk. The amount of space used by a "stripe" is the same on each disk used. A virtual disk may use several stripes on the same set of disks in an array. See also *guarding*, *mirroring*, and *RAID*.

SVGA — Super video graphics array. VGA and SVGA are video standards for video adapters with greater resolution and color display capabilities than previous standards.

system board — As the main circuit board, the system board usually contains most of your system's integral components, such as the processor, RAM, controllers for peripherals, and various ROM chips.

system configuration information — Data stored in memory that tells a system what hardware is installed and how the system should be configured for operation.

system diskette — See *bootable diskette*.

system memory — See *RAM*.

System Setup program — A BIOS-based program that allows you to configure your system's hardware and customize the system's operation by setting features such as password protection. Because the System Setup program is stored in NVRAM, any settings remain in effect until you change them again.

system.ini file — A start-up file for the Windows operating system. When you start Windows, it consults the **system.ini** file to determine a variety of options for the Windows operating environment. Among other things, the **system.ini** file records which video, mouse, and keyboard drivers are installed for Windows.

TCP/IP — Transmission Control Protocol/Internet Protocol.

termination — Some devices (such as the last device at each end of a SCSI cable) must be terminated to prevent reflections and spurious signals in the cable. When such devices are connected in a series, you may need to enable or disable the termination on these devices by changing jumper or switch settings on the devices or by changing settings in the configuration software for the devices.

UNIX — Universal Internet Exchange. UNIX, the precursor to Linux, is an operating system written in the C programming language.

uplink port — A port on a network hub or switch used to connect to other hubs or switches without requiring a crossover cable.

UPS — Uninterruptible power supply. A battery-powered unit that automatically supplies power to your system in the event of an electrical failure.

USB — Universal Serial Bus. A USB connector provides a single connection point for multiple USB-compliant devices, such as mice and keyboards. USB devices can be connected and disconnected while the system is running.

utility — A program used to manage system resources— memory, disk drives, or printers, for example.

UTP — Unshielded twisted pair. A type of wiring used to connect systems in a business or home to a telephone line.

V — Volt(s).

VAC — Volt(s) alternating current.

VDC — Volt(s) direct current.

VGA — Video graphics array. VGA and SVGA are video standards for video adapters with greater resolution and color display capabilities than previous standards.

video adapter — The logical circuitry that provides (in combination with the monitor) your system's video capabilities. A video adapter may be integrated into the system board or may be an expansion card that plugs into an expansion slot.

video driver — A program that allows graphics-mode application programs and operating systems to display at a chosen resolution with the desired number of colors. Video drivers may need to match the video adapter installed in the system.

video memory — Most VGA and SVGA video adapters include memory chips in addition to your system's RAM. The amount of video memory installed primarily influences the number of colors that a program can display (with the appropriate video drivers and monitor capabilities).

video resolution — Video resolution (800 x 600, for example) is expressed as the number of pixels across by the number of pixels up and down. To display a program at a specific graphics resolution, you must install the appropriate video drivers and your monitor must support the resolution.

W — Watt(s).

WH — Watt-hour(s).

win.ini file — A start-up file for the Windows operating system. When you start Windows, it consults the **win.ini** file to determine a variety of options for the Windows operating environment. The **win.ini** file also usually includes sections that contain optional settings for Windows application programs that are installed on the physical disk.

Windows 2000 — An integrated and complete Microsoft Windows operating system that does not require MS-DOS and that provides advanced operating system performance, improved ease of use, enhanced workgroup functionality, and simplified file management and browsing.

Windows Powered — A Windows operating system designed for use on NAS systems. For NAS systems, the Windows Powered operating system is dedicated to file service for network clients.

Windows Server 2003 — A set of Microsoft software technologies that enable software integration through the use of XML Web services. XML Web services are small reusable applications written in XML that allow data to be communicated between otherwise unconnected sources.

XML — Extensible Markup Language. XML is a way to create common information formats and to share both the format and the data on the World Wide Web, intranets, and elsewhere.

ZIF — Zero insertion force.

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