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Implementing Online Storage Controller Recovery Option Under Windows NT

Historically, the effort to improve the reliability of I/O subsystems focused on redundant arrays of independent disks (RAID). RAID protects the data against failure of a disk drive, but offers no protection against mass storage controller failure.

Windows NT provides the option to implement a fully redundant I/O subsystem in a configuration called Disk Duplexing. Disk Duplexing implemented at the software level provides protection against failure of the disk as well as the mass storage controller. However, Disk Duplexing requires complete redundancy of all I/O subsystem components, which makes it very costly to implement and limits the extensibility of the system.

With the introduction of Online Storage Controller Recovery Option, Compaq offers fault tolerance for mass storage controllers implemented at the hardware level, providing increased reliability without requiring complete I/O subsystem redundancy.



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EXECUTIVE OVERVIEW

RAID technology offers improved reliability of disk subsystems by providing a level of fault tolerance for the disk drives. However, RAID technology does not provide redundancy at the mass storage controller level. Though you might have several devices participating in a RAID disk array, the mass storage controller they connect to constitutes a single point of failure for your I/O subsystem.

Compaq Online Storage Controller Recovery Option eliminates this single point of failure by merging two SMART-2 controllers into a controller pair. In such a pair, one controller is active, and the other remains in standby mode. Should a problem occur with the active controller, the device driver switches traffic to the standby controller without loss of data (see Figure 1) or interruption of service.

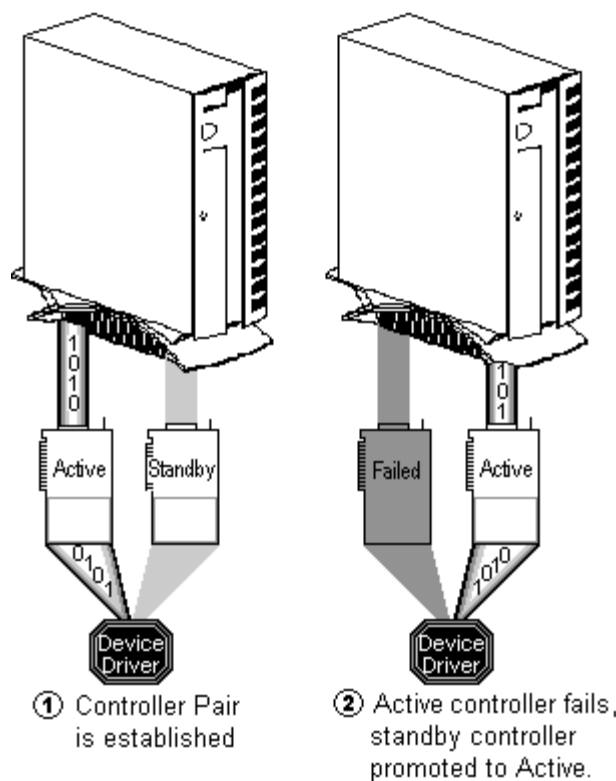


Figure 1 : Online Storage Controller Recovery Option Overview

Previously, implementing mass storage controller redundancy required duplication of the mass storage controllers as well as the disk drives. By pairing Online Storage Controller Recovery Option with RAID 5 arrays, you derive the benefits of Disk Duplexing without the additional costs of complete disk drive redundancy, and without the overhead of a software based solution.

Hardware Requirements

Implementation of Compaq Online Storage Controller Recovery Option involves the following hardware components:

- Compaq ProLiant or ProSignia server
- At least two matched Compaq SMART-2 Array Controllers
- At least one Compaq ProLiant Storage System/U or ProLiant Storage System/F
- Compaq Recovery Server Option (RSO) switch(es)
- Cables to connect SMART-2 Array Controllers to ProLiant Storage System(s)

Online Storage Controller Recovery Option will initially be supported for the single bus versions of the ProLiant Storage System units, in both the tower and rack-mount configurations. Dual bus ProLiant Storage System units and older ProLiant Storage Systems will not be supported.

SOFTWARE REQUIREMENTS

Online Storage Controller Recovery Option software consists of updated device drivers for the mass storage controllers, and the Online Storage Controller Recovery Utility. The utility icon is accessed through Control Panel, and is accessible from the Compaq System Tools folder. These software components are available on the Compaq Support Software Disk (SSD) for Windows NT.

Alternatively, they can be downloaded at no cost from the Compaq Online web site at <http://www.compaq.com/support/files/server/softpaqs/WINNT/NTSSD.html>.

All software required to implement Online Storage Controller Recovery Option under Windows NT 4.0 is included in the Compaq Support Software CD included with the kit. The CD includes the following required components:

- Compaq SSD for Windows NT (version 2.02 or later)
- Compaq Options ROMPaq (version 2.39 or later)

The Compaq SSD for Windows NT includes the following components required to implement Online Storage Controller Recovery Option:

- Compaq Online Storage Controller Recovery Utility
- Updated Compaq SMART-2 Array Controller device driver
- Compaq System Management driver (SYSMGMT.SYS)
- Compaq Remote Monitoring service (CPQRMC.EXE)

The Compaq Options ROMPaq contains the firmware upgrade for the SMART-2 Array Controllers.

TABLE 1 : ROMPAQ AND FIRMWARE VERSIONS COMPARISON

Features Supported	Options ROMPaq	SMART-2 Controller Firmware Revision
Online Storage Controller Recovery Option	2.39	1.94
Ultra SCSI for SMART-2 Array Controllers, Online Storage Controller Recovery Option	2.4x	1.96

Table 1 shows the features supported by the latest releases of the Options ROMPaq. Note that both ROMPaqs support Online Storage Controller Recovery Option, but only the latest version supports Ultra SCSI operations. The latest version of the Options ROMPaq can also be found on the Compaq web site at <http://www.compaq.com/support/files/server/softpaqs/Rompaq/OPTRROM.html>.

Compaq Online Storage Controller Recovery Option also requires the installation of the Remote Procedure Call (RPC) Service, which is part of the Windows NT 4.0 operating system. If the system is to be used to manage remote servers as well, you will also need to install a routable protocol that can be used by the RPC service (such as TCP/IP).

Understanding How The Software Works

The Compaq Online Storage Controller Recovery Utility utilizes Remote Procedure Calls (RPC) as the primary interface mechanism, as shown in Figure 2. Use of RPCs allows the utility to manage controller pairs on the local system and on any system accessible over the network. The utility sends RPCs to the Compaq Remote Management service (CPQRCMC), which in turn forwards the requests to the device driver. The driver reports the state of the devices and the status of the requests to the user interface by way of the System Management driver (SYSMGMT.SYS).

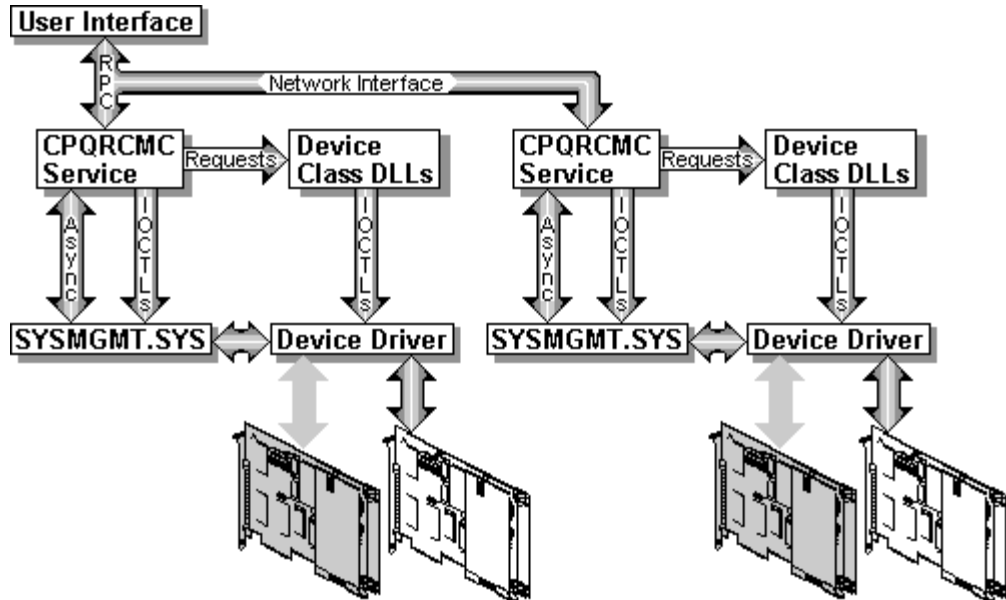


Figure 2 : Online Storage Controller Recovery Software Environment

Implementing the Online Storage Controller Recovery Option software environment with system support code allows Compaq Online Storage Controller Recovery to be deployed on Windows NT 4.0 without modification to the operating system.

CONFIGURATION OPTIONS

This section outlines the configuration guidelines involved in establishing highly reliable I/O subsystems utilizing Online Storage Controller Recovery Option. Table 2 lists the RAID options available and details the requirements and benefits of each option.

TABLE 2: CONFIGURATION OPTIONS

Raid Level	Controller Pairing	Controllers Required	Min. # of Drives	Overhead of Redundancy	Recommended	Comments
0	No	1	1	0%	No	Data unavailable if drive or controller fails.
0	Yes	2	1	0%	No	Data unavailable if drive fails.
1	No	1	2	50%	No	Data unavailable if controller fails.
1	Yes	2	2	50%	Yes	Complete redundancy, high overhead.
5	No	1	3	33% to 7%	No	Data unavailable if controller fails.
5	Yes	2	3	33% to 7%	Yes	Complete redundancy, lowest overhead.

Warning: SMART-2 Array Controllers use different disk geometries than standard SCSI adapters. Be aware that transferring a disk from one type of controller to the other involves reformatting the disk.

SMART-2 Array Controllers implement RAID fault tolerance at the hardware level, eliminating the overhead associated with implementing RAID in the software. Another advantage of implementing RAID at the hardware level is the ability to apply any of the RAID configuration options to the system disk, as indicated in Table 3.

TABLE 3 : SMART-2 ARRAY CONTROLLER CONFIGURATION OPTIONS

RAID Level	Description	Available for System Disk	Comments and Recommendations
0	No Fault Tolerance	Yes	Maximum availability of storage, no protection of data.
1	Drive Mirroring	Yes	Half the space given up for RAID overhead, half of the mirror set can fail without data loss. No system performance overhead, as write operations are performed by hardware. Recommended when data availability is paramount.
5	Distributed Data Guarding	Yes	Lower percentage of space given up to RAID overhead, one device of the stripe set may fail without data loss. System performance may be improved by reducing disk latency. Recommended when data availability, cost and performance are important criteria in I/O subsystem design.

The Compaq Online Storage Controller Recovery Utility combines two matched SMART-2 Array Controllers into a controller pair, eliminating the controller as a potential single point of failure. Using Online Storage Controller Recovery Option with RAID 0 provides protection against controller failure, but does not provide any protection of the data if a disk fails.

The combination of Online Storage Controller Recovery Option and RAID 1 provides all of the advantages of traditional disk duplexing. In addition, this combination provides the advantage of implementing the fault tolerance features at the hardware level, thereby eliminating the overhead associated with implementing fault tolerance in the software.

Combining Online Storage Controller Recovery Option and RAID 5 provides a high degree of fault tolerance for the entire I/O subsystem, while keeping costs down by eliminating the need to duplicate every disk in the subsystem. Previously, implementing mass storage controller redundancy involved duplicating both the mass storage controllers as well as the disks, which effectively doubled the cost of the I/O subsystem. Compaq Online Storage Controller Recovery Option allows you to take advantage of the benefits of mass storage controller redundancy without the need to duplicate the disks. By pairing redundant SMART-2 Array Controllers with RAID 5 disk arrays, you receive the data protection of the RAID implementation and the fault tolerance of redundant controllers.

Single Channel Controller Pair Configuration

The simplest controller pair configuration involves two similar SMART-2 Array Controllers and a single ProLiant Storage System equipped with the Recovery Server Option (RSO) switch. The Compaq Online Storage Controller Recovery Utility is used to merge the independent controllers into a controller pair. One controller is made the active controller, and the other is designated the standby controller. Both controllers are physically wired to the ProLiant Storage System through the RSO switch, as illustrated in Figure 3.

Note: If you already have the Recovery Server Option installed, you must disable that option, upgrade the switch within the ProLiant Storage System, and reconfigure the cabling in order to implement Online Storage Controller Recovery Option.

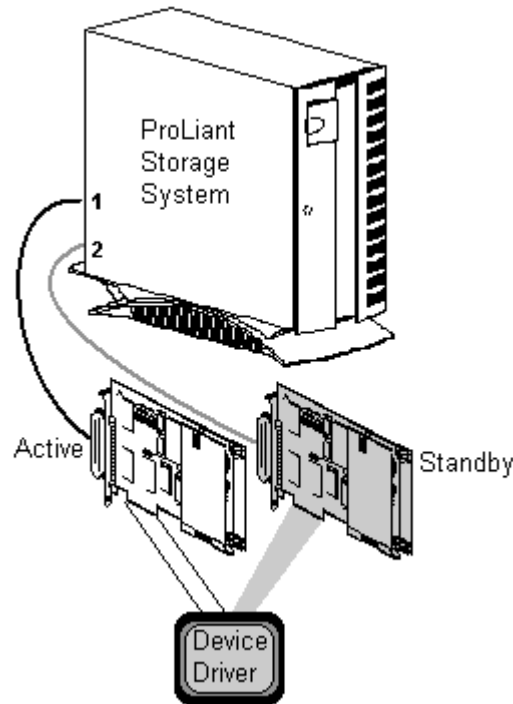


Figure 3 : Single Channel Controller Pair

The single channel configuration provides the foundation for understanding how to implement mass storage controller redundancy. When using single channel controllers, such as the SMART-2SL, the single channel controller pair configuration is the only viable controller pair configuration. Single channel controllers can only be paired with other single channel controllers. Likewise, dual-channel controllers can only be paired with other dual-channel controllers.

Note that in the example shown in Figure 3, the Active controller is connected to the primary port on the ProLiant Storage System. The Active controller should always be connected to the primary port of the ProLiant Storage System to ensure consistent recovery after complete power loss to the server and the storage system. When the power is cycled on the ProLiant Storage System, the RSO switch inside is reset, and the primary port becomes the active port by default. By aligning the primary port of the ProLiant Storage System with the Active controller of the controller pair, the system recovers from a power failure using the power-up defaults.

This configuration rule is especially significant when the system boot device is a member of a controller pair. Because the boot device controller is specified during System Configuration by setting the *Controller Order* to *First*, no other controller can boot the system. Therefore, the boot device controller must be the one that is given default access to the ProLiant Storage System after power is restored.

Dual Channel Controller Pairs

Dual channel controllers, such as the SMART-2DH, SMART-2/P, and the SMART-2/E, are capable of supporting two ProLiant Storage Systems. Therefore, it is possible to configure a controller pair supporting a pair of ProLiant Storage Systems, so long as they are properly cabled. Figure 4 shows a logical diagram of such a configuration.

Note: When forming dual channel controller pairs, both controllers must be dual channel controllers. Do not attempt to utilize a single channel controller, such as the SMART-2SL, in a dual channel configuration.

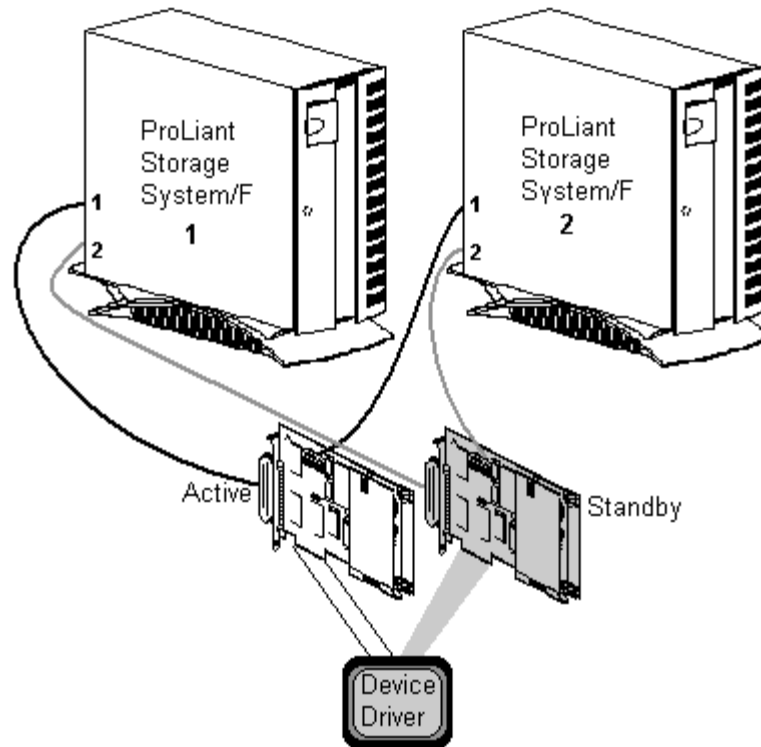


Figure 4 : Dual Channel Controller Pair

The steps involved in assembling this configuration are as follows:

1. Install two dual channel SMART-2 Array Controllers in your server.
2. Locate the knock-out plate(s) on the back of the server where the external wide SCSI connectors will be mounted. If the knock-out plate has no slots, replace it with the knock-out plate included with the Online Storage Controller Recovery Option kit (part #189620-001). Some newer Compaq servers have slots in the case and do not require the knock-out plate.
3. Locate the internal SCSI ribbon cable (part # 199595) that came with the SMART-2 controller. Attach the external end of this cable to the server case using the black mating screws. Attach the other end to the internal connector of the SMART-2 controller (see Figure 5).

Note: Some older ProSignia systems do not have knock-out plates, and therefore are not supported in this configuration.

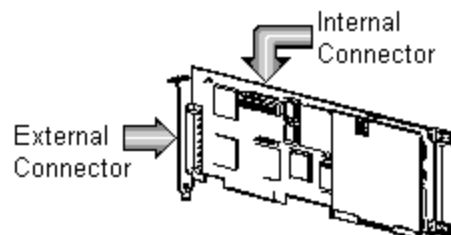


Figure 5 : Dual Channel SMART-2 Controller Connectors

4. Repeat step 3 for the second SMART-2 controller.
5. Decide which of the SMART-2 controllers will be Active and which will be the Standby controller. Label the controllers accordingly, and label their associated secondary ports on the knock-out panel so that it is possible to tell which port belongs to each SMART-2 controller.
6. Locate the four external cables used to connect the server to the ProLiant Storage Systems (part #189646-003).
7. Label both ends of the external cables to avoid confusion in the future.
8. Connect the external connector from the Active SMART-2 controller to the first interface on the primary ProLiant Storage System.
9. Connect the internal interface from the Active controller to the first interface on the secondary ProLiant Storage System.
10. Connect the external connector from the Standby SMART-2 controller to the second interface on the primary ProLiant Storage System.
11. Connect the internal interface from the Standby controller to the second interface on the secondary ProLiant Storage System.

Caution: *It is extremely important that the cables be connected correctly. Incorrect cabling will nullify the effectiveness of Online Storage Controller Recovery Option and may result in data loss or disk unavailability.*

Multiple Controller Pairs

The ability to define multiple controller pairs extends the configurable size of the fault tolerant I/O subsystem. With increased flexibility comes an increased need for planning and care during configuration and installation.

The number of possible controller pairs may be limited by the number of knock-out panels or slots available on the server, as well as the number of available expansion slots for SMART-2 controllers. Some older ProSignia servers contain only one knock-out panel with four slots. Such systems are limited to implementing two Dual-Channel Configurations.

Configuration Errors To Avoid

Setting up Online Storage Controller Recovery Option requires that each member of a controller pair be capable of sharing a single instance of the device driver. For this reason, it is not possible to combine dissimilar controllers into a controller pair. The Online Storage Controller Recovery Utility will not allow you to create a mismatched controller pair.

On-Line Recovery Server and the Standby Recovery Server options are incompatible with Online Storage Controller Recovery Option. If either of the Recovery Server Options is installed, it must be disabled before implementing Online Storage Controller Recovery Option. If your ProLiant Storage System already has the Recovery Server Option switch installed, it must be upgraded to the new RSO switch. In addition, the cabling for Compaq Recovery Server Option and Online Storage Controller Recovery Option are incompatible. If the system already has Compaq Recovery Server Option installed, you must reconfigure the cabling before implementing Online Storage Controller Recovery Option.

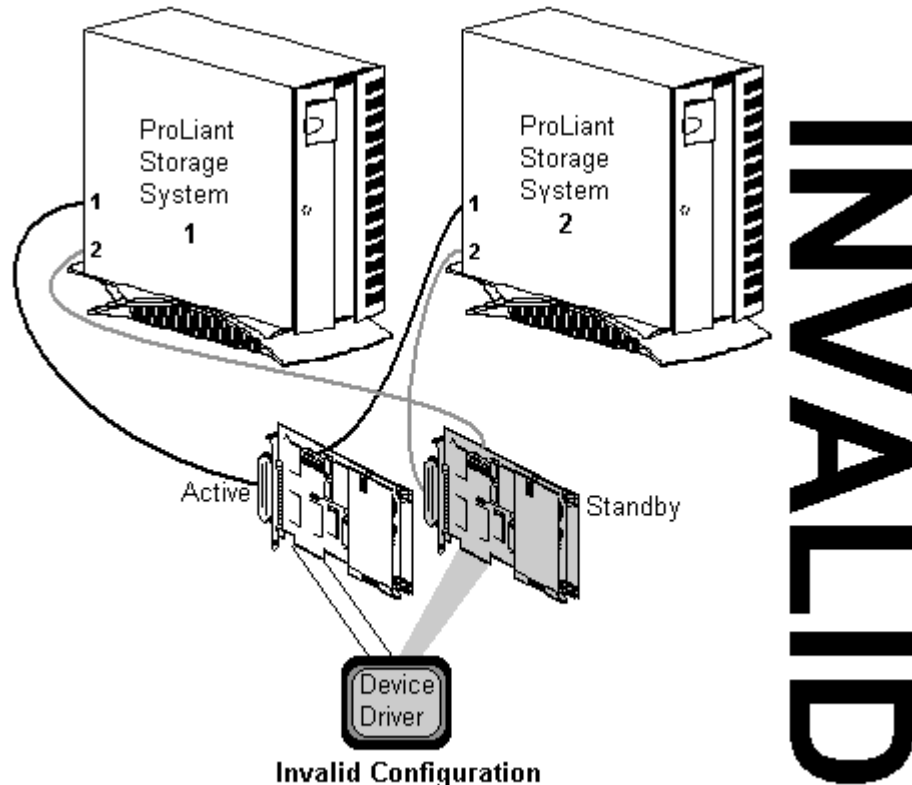
Exercise particular caution when building dual channel SMART-2 controller pairs. Because of the potential complexity of these configurations, it is important to plan how the components will be connected. It is also important to label the components clearly to aid in the execution of the plan and maintenance of the configuration.

Warning: *Attempting to implement Online Storage Controller Recovery Option with an older Recovery Server Option switch will result in a configuration that will be unable to complete a Verify function.*

Caution: The Online Storage Controller Recovery Utility will only detect cross-connected cables when a Verify function is performed. This configuration will not manifest any problems until a switch from the active controller to the standby controller occurs.

Tip: You should always perform a Verify operation after forming a controller pair to ensure that the controller pair is valid and will perform as expected in the event of a controller failure. If the controller pair passes verification, the cables are not cross-connected. Verifying a cross-connected controller pair will result in a failed standby controller, with the active controller remaining functional.

The following examples illustrate configuration errors to avoid.



Invalid Configuration

Do not connect the external port from the active controller with the internal port of the standby controller.

Figure 6 : Invalid Configuration - Cross-connected Cables

In the example shown in Figure 6, the cables are cross-connected such that the external connector from the Active SMART-2 controller is attached to the same ProLiant Storage System as the internal connector of the Standby SMART-2 controller. If active controller fails in this configuration, the system will not be able to locate the disks because their logical SCSI ID numbers will change.

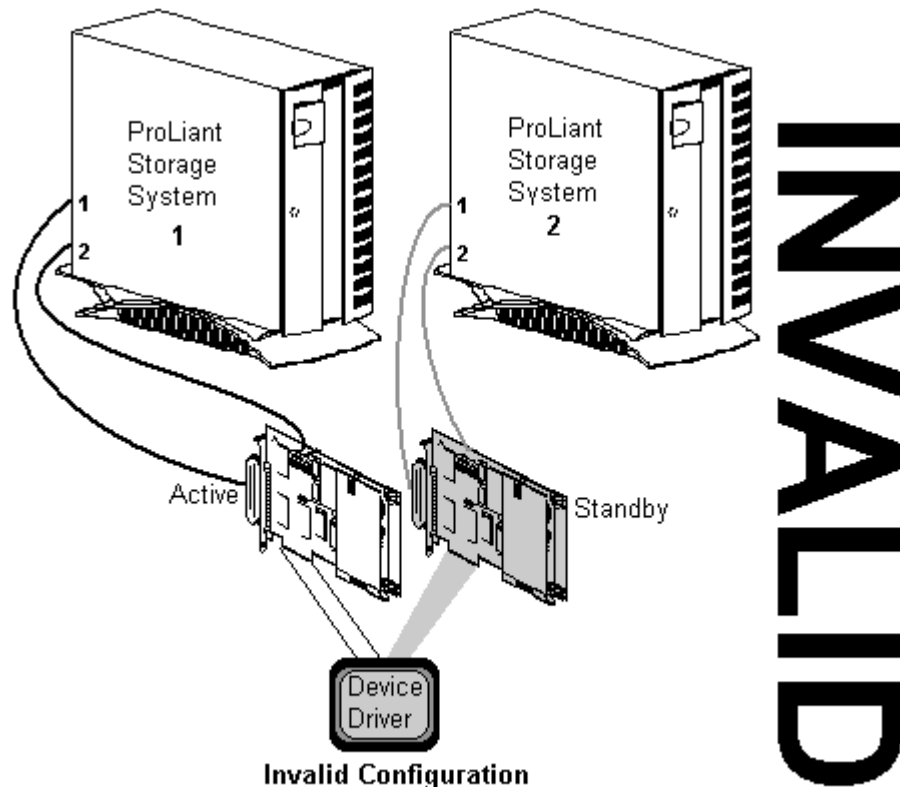
This configuration error demonstrates the need to pay close attention to the cabling of the ProLiant Storage Systems when using dual channel SMART-2 controllers to their full capacity. Cabling errors such as this are most likely to occur when the cables are not labeled properly. Cables should be marked to indicate proper orientation. One example would be to mark the cables and the ports according to the example shown in Table 4.

TABLE 4 : EXAMPLE OF CABLE LABELS

Cable Label	Description
AI-1	Active controller, Internal interface, first controller pair
AX-1	Active controller, External interface, first controller pair
BI-1	Backup controller, Internal interface, first controller pair
BX-1	Backup controller, External interface, first controller pair

In the example shown in Figure 7, both the internal and external cables from the active controller are connected to the same ProLiant Storage System. Likewise, the internal and external cables from the standby controller are connected to the second ProLiant Storage System. If there are drives in both ProLiant Storage Systems, both of the SMART-2 controllers will be attached to active SCSI buses, and the Online Storage Controller Recovery Utility would not allow you to merge the controllers. In the unlikely event that no drives were installed in the second ProLiant Storage System, the utility would not detect an error in the configuration unless you perform a *Verify* operation.

Tip: The erroneous configuration depicted in Figure 7 can be trapped by performing a *Verify* operation once the pair is formed. You should always perform a *Verify* after reconnecting the cables to detect any cabling errors and to ensure that the controller pair will perform as expected if a controller fails.

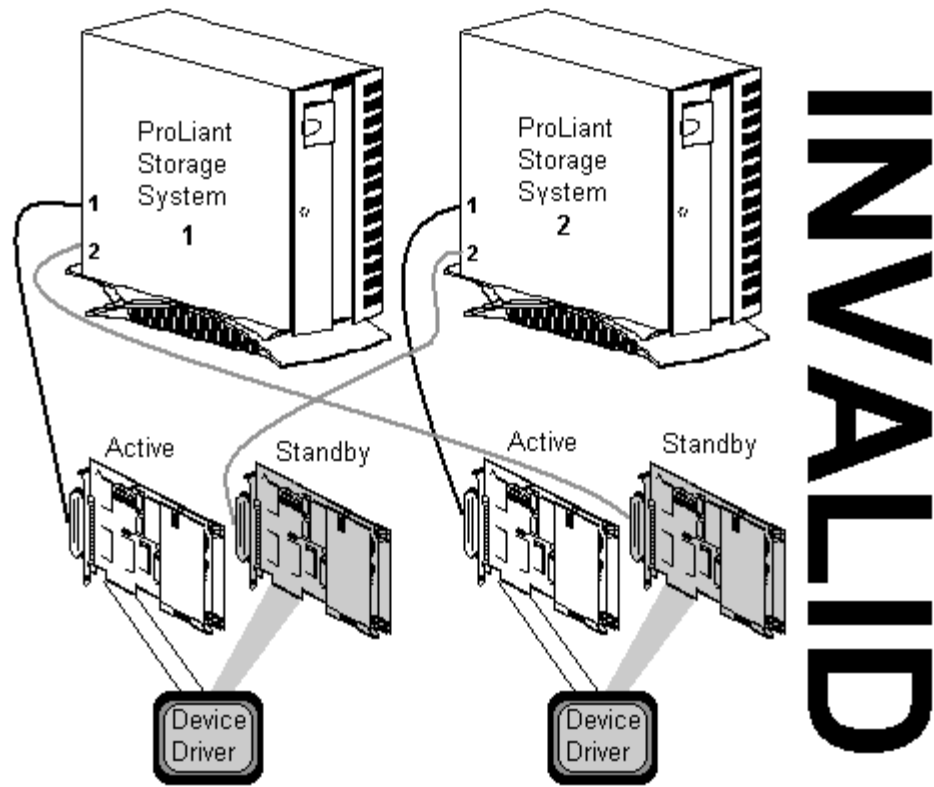


Invalid Configuration

Do not connect both cables from a single SMART-2 controller to the same ProLiant Storage System

Figure 7 : Invalid Configuration - Unilateral Cabling

Since this invalid configuration could only be formed when the second ProLiant Storage System has no disks installed, it would most commonly be caused by a cabling error after the pair was formed. The easiest way to avoid such cabling errors is to concisely label the cables and ports to avoid confusion when connecting the cables.



Invalid Configuration

When forming multiple controller pairs, make sure to connect the Active and Standby controllers to the same ProLiant Storage System(s)

Figure 8 : Invalid Configuration - Mismatched Controller Pairs

Online Storage Controller Recovery Option permits you to form multiple controller pairs within a single server. Each controller pair within the server must conform to the configuration guidelines for single channel and dual channel controller pairs. Figure 8 illustrates an invalid configuration caused by mismatching the cables between two independent controller pairs. Notice in the example that the standby controllers are connected to the secondary (idle) interface of the wrong ProLiant Storage Systems. Because the secondary interfaces are idle, the Online Storage Controller Recovery Utility will permit the controllers to be merged into a controller pair.

As with the other configuration errors, this configuration fault is detected by performing a *Verify* operation. When verification is done on a set of mismatched controller pairs, the effect will temporarily be to disable *both* controller pairs while the verification is being performed. This interruption of the second controller pair is caused by the activation of the standby controller in the first controller pair. When *Verify* detects that the standby controller is not connected to the same ProLiant Storage System as the Active controller, it marks the standby controller as *Failed* and sets the failure status to "Cable - Check Connection", indicating a cabling fault. If you encounter this situation, you must correct the cabling error before the controller pairs can pass verification.

Tip: When using PCI Hot Plug technology a Cable Check error can be cleared by using the PCI Hot Plug utility to cycle power to the PCI slot containing the failed controller. Without PCI Hot Plug technology, the server must be rebooted to clear the Cable Check.

BEFORE SETTING UP A CONTROLLER PAIR

There are a few things to consider before setting up a controller pair on your system. In this section, we will examine those points and consider their implications.

Potential Impact on Unattended Reboot

Installation of the Online Storage Controller Recovery Option effectively sets up a SMART-2 Array Controller. This means that at least one of the SMART-2 controllers on the system will not be connected to an active SCSI bus at boot time. This condition is detected during Power On Self Test (POST). This condition causes the system to prompt for the system administrator to press "F1 to continue or F10 to run system partition utilities". As this prompt does not time out, the prompt will block unattended reboot if the *F1 Boot Prompt* is enabled.

The procedure to disable the *F1 Boot Prompt* is:

1. Boot the system into the System Configuration Utility (version 2.34A or greater). You can download the latest version of the utility from the Compaq On-Line web site at <http://www.compaq.com/support/files/server/softpaqs/Rompag/SYSCONFIG.html>.
2. After passing through the initial screen(s), get to the main menu. Once you see the main menu, press *Ctrl* and *A* simultaneously. A notice will pop up indicating that Advanced Mode is enabled.
3. From the Main Menu select System Configuration.
4. From the System Configuration Menu, select Configure Hardware.
5. Once automatic configuration is complete, you will be given the option to save changes and exit, or review and modify hardware settings. Select "Review or modify hardware settings".
6. From the "Steps in configuring your computer" menu, select "Step 3: View or edit details".
7. Scroll down to the Advanced Features section, select the option labeled "F1 Boot Prompt" and press *Enter* to change it.
8. Select "Disabled - Skip Prompt" and press *Enter*.
9. Press *F10* and save the system settings, then exit the utility.

Following this procedure will disable the *F1 Boot Prompt* until you enable it again.

Boot Device Controller Pairing

Connecting the boot device to a controller pair requires particular care. Only the primary mass storage controller, designated *First* in *Controller Order* by the System Configuration Utility, can act as the boot device controller. When connecting a boot device to a controller pair, the following configuration guidelines must be followed:

- The primary mass storage controller must be the Active controller of the controller pair at boot time.
- The primary mass storage controller must be connected to the port of the ProLiant Storage System that activates immediately after powering up the ProLiant Storage System.

This configuration provides fault tolerance for the boot device controller, which enables the server to continue operating, even if the primary mass storage controller fails.

Tip: It is recommended that the F1 Boot Prompt be disabled in order to facilitate unattended reboots. It is also recommended that the bootable System Configuration disk be retained to facilitate configuration changes.

Array Acceleration Disabled

Implementation of Online Storage Controller Recovery Option automatically disables the Array Accelerator feature of the SMART-2 controller to ensure data integrity in case of a failover. Under no circumstances should array acceleration be enabled on a SMART-2 Array Controller that is a member of a controller pair.

The system performance implications of disabling the array accelerator vary according to the application type and load placed on the system. For example, a system acting primarily as a file and print server will experience no appreciable impact in system performance with array acceleration disabled, due to the fact that Windows NT implements its own form of I/O caching.

On the other hand, a system tuned to produce high I/O throughputs by using the array accelerator feature could be significantly impacted by turning the feature off. In all cases, system performance should be considered when planning to install Online Storage Controller Recovery Option.

Recovery Server Option Incompatibility

Compaq Recovery Server Option consists of the *Standby Recovery Server* and the *On-Line Recovery Server*. As mentioned before, the Online Storage Controller Recovery Option cannot be run in conjunction with the Recovery Server Option because both require hardware connectivity to ProLiant Storage Systems through the same interfaces, and the cabling requirements are not compatible. For this reason, customers must decide which option best serves their needs. For more information on Compaq Recovery Server Options, read the white paper entitled *Compaq Standby Recovery Server* on the Compaq web site at

<http://www.compaq.com/support/techpubs/whitepapers/287a1196.html>, or the white paper entitled *Compaq Online Recovery Server* on the Compaq web site at <http://www.compaq.com/support/techpubs/whitepapers/286a1196.html>.

Operating System Upgrade Issues

Online Storage Controller Recovery Option utilizes updated versions of the SMART-2 device drivers to establish and maintain the controller pair(s). Windows NT upgrades include default versions of device drivers built to be compatible with the version of Windows NT being installed. However, the device drivers included with the operating system may not be the same as those installed under previous versions of Windows NT. For that reason, all controller pairs should be dissolved before installation of a Windows NT upgrade, and re-established after the upgrade.

SETTING UP ONLINE STORAGE CONTROLLER RECOVERY

The software needed to form controller pairs is available on the latest issue of the Compaq SSD for Windows NT (Version 2.02 or later), which can be obtained at no cost from the Compaq On-Line web site at <http://www.compaq.com/support/files/server/softpaqs/WINNT/NTSSD.html>. Complete instructions for loading Compaq SSD for Windows NT are included with the software.

The firmware upgrade for SMART-2 Array Controllers (revision 1.94 or greater) is included with the Online Storage Controller Recovery Option, and is available from Compaq On-Line as a free download at <http://www.compaq.com/support/files/server/softpaqs/Rompaq/OPTRROM.html>. The Options ROMPaq that contains the correct firmware is version 2.39 or later.

Installing Compaq SSD for Windows NT

The initial release of Compaq Online Storage Controller Recovery Option for Windows NT requires installation of the Compaq SSD for Windows NT (version 2.02 or greater). Included on the SSD are updated device drivers for the SMART-2 Array Controllers. The SSD also provides the updated CPQRCMC service and System Management driver, both required for Online Storage Controller Recovery Option functionality.

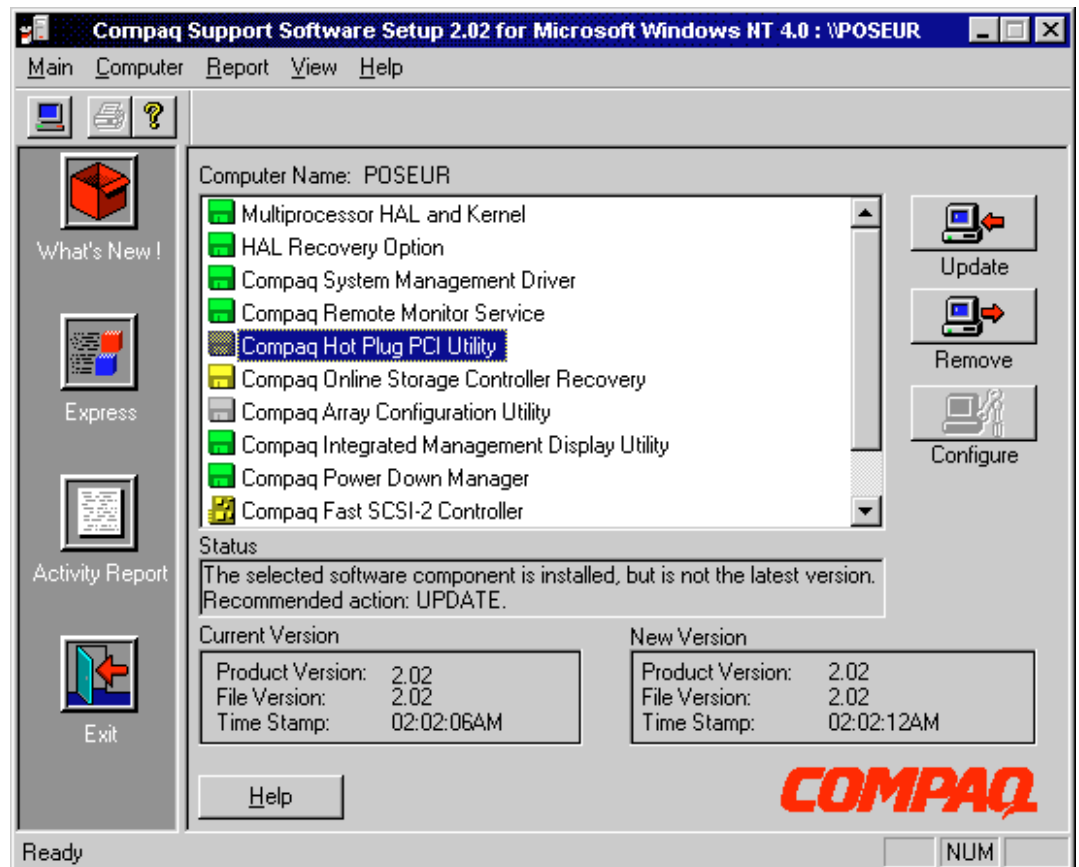


Figure 9 : Compaq SSD for Windows NT Setup

When the Setup Utility for the SSD is run, you are presented with the screen shown in Figure 9. This screen lists the options available from the SSD. Table 5 lists the components provided by Compaq SSD for Windows NT and details which components are required for implementing Online Storage Controller Recovery Option. Select the items you wish to install by clicking on the item name from the displayed list, then click on the *Install* or *Update* button. When all of the required components have been installed, click on the *Exit* button and then reboot your server to allow the updates to take effect.

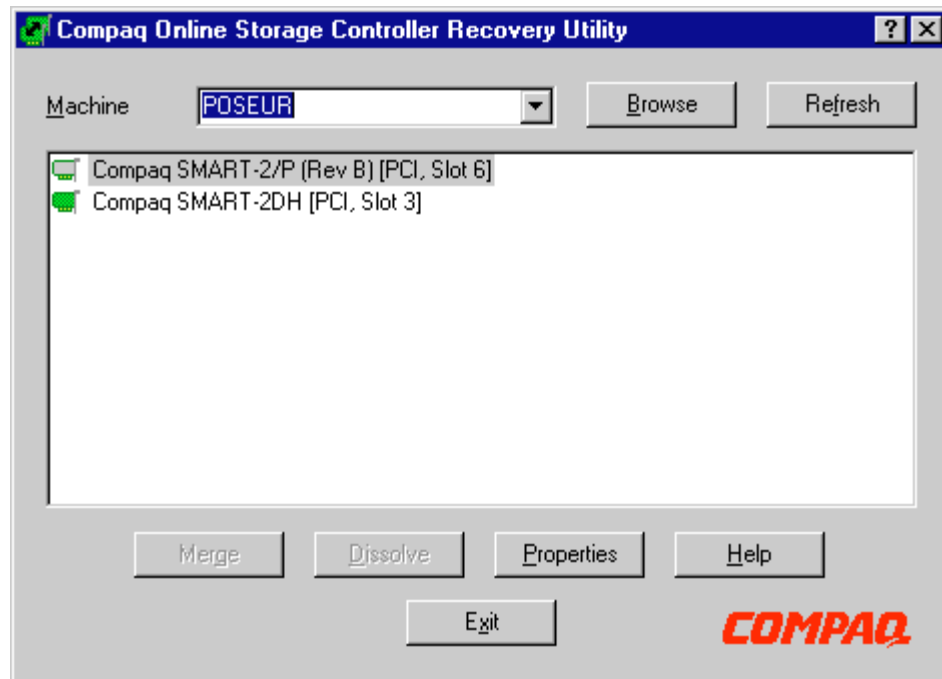
TABLE 5 : COMPAQ SSD FOR WINDOWS NT COMPONENTS

SSD Component	Description
Uniprocessor/Multiprocessor HAL and Kernel	Allows you to upgrade or downgrade the HAL and kernel to match the configuration of the server. This option is not required for online Storage Controller Recovery Option.
HAL Recovery Option	Allows a user with a multiprocessor system to recover from blue-screen traps resulting from mismatched HAL and hardware, mismatched HAL and kernel, and HAL corruption. Not required for Online Storage Controller Recovery Option, but highly recommended for multiprocessor-capable servers.
Compaq System Management Driver	This component is required on the local server when implementing Online Storage Controller Recovery Option. Provides a communications path between the SMART-2 device drivers and the Online Storage Controller Recovery Utility.
Compaq Remote Monitor Service	The CPQRCMC service is required when implementing Online Storage Controller Recovery on the local server or when setting up remote management capability. CPQRCMC acts as the central communications point for the Online Storage Controller Recovery Utility, as well as the PCI Hot Plug Utility.
Compaq PCI Hot Plug	The PCI Hot Plug utility allows you to control the PCI Hot Plug slots on the local system, or on a remote system. This option is not required to implement Online Storage Controller Recovery Option, but is required to implement or manage a PCI Hot Plug environment.
Compaq Online Storage Controller Recovery	The Online Storage Controller Recovery Utility is required to manage the Online Storage Controller Recovery Option on the local system and on remote systems.
Compaq Fast SCSI-2 Controller	Device drivers for Compaq SCSI-2 controllers. These drivers are not required to implement Online Storage Controller Recovery Option.
Compaq SMART-2 Array Controller	Updated device drivers for Compaq SMART-2 Array Controllers are required to implement Online Storage Controller Recovery Option on the local server. These device drivers are not required if you are setting up a remote management station for Online Storage Controller Recovery.
Compaq ProLiant Storage System	Provides support for Compaq ProLiant Storage Systems only when attached to Compaq SCSI-2 controllers. This component is not required for support of Online Storage Controller Recovery Option.
Compaq Netelligent/NetFlex-3 Network Controller(s)	Device drivers for Compaq network controllers. This component is not required for support of Online Storage Controller Recovery Option.



Using the Online Storage Controller Recovery Utility

The Online Storage Controller Recovery Utility is accessed from an applet in Control Panel. As seen in Figure 10, the utility provides a view of the SMART-2 Array Controllers connected to a system. The display shows the controller type, its physical location, and whether or not it is part of a controller pair. In addition, the utility includes a browser, which allows you to configure and manage the SMART-2 controllers on the entire network from a single management station.



Note: Controller pairs must be formed using matched pairs of controllers, as shown in Figure 10.

Figure 10 : Online Storage Controller Recovery Utility

The mass storage controller icons on the left side of the display come in eight varieties, as shown in Table 6. Note that when two mass storage controllers are connected to a ProLiant Storage System through the RSO switch, one should show an active connection (green) while the other shows an inactive connection (gray).

TABLE 6 : MASS STORAGE CONTROLLER ICONS

Controller Icon	Description
	Mass storage controller currently connected to logical drives. Also indicates active controller in controller pair.
	Mass storage controller not currently connected to logical drives. Also indicates standby controller in controller pair.
	Controller pair.
	Mass storage controller is powered off.
	Mass storage controller is not ready, but is connected to logical drives.
	Mass storage controller is not ready, and is not connected to logical drives.
	Failed mass storage controller connected to logical drives.
	Failed mass storage controller that is not connected to logical drives.

Creating a controller pair involves merging an active controller with an inactive controller of the same type. Thus, a controller pair consists of one green and one gray controller icon.

Forming a controller pair consists of the following steps:

1. Confirm that the controllers you want to merge are properly connected to the ProLiant Storage System using the RSO switch. While verifying the connection, make note of the physical slot number of the controllers connected to the ProLiant Storage System to eliminate any possible confusion when performing the merge operation.
2. When you are certain the connections are correct, select one of the two controllers by clicking on it. Depress the *Ctrl* key and click on the second controller. Doing so will highlight both selected controllers and activate the Merge button, as shown in Figure 11.

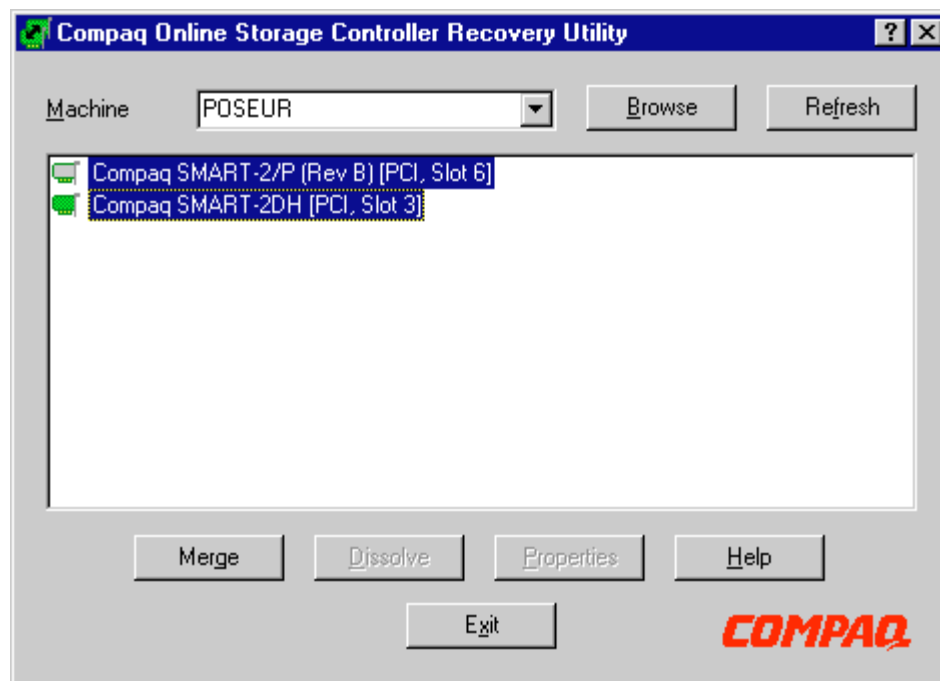


Figure 11 : Merging Two Controllers Into a Controller Pair

3. Click on the *Merge* button to continue the process. The utility will prompt you to confirm your decision to merge the two controllers by displaying the dialog box depicted in Figure 12.



Figure 12 : Merge Confirmation Dialog Box

4. By clicking on the *Yes* button, you complete the merge operation and the controller pair is formed. Figure 13 shows the Online Storage Controller Recovery Utility with an active controller pair.

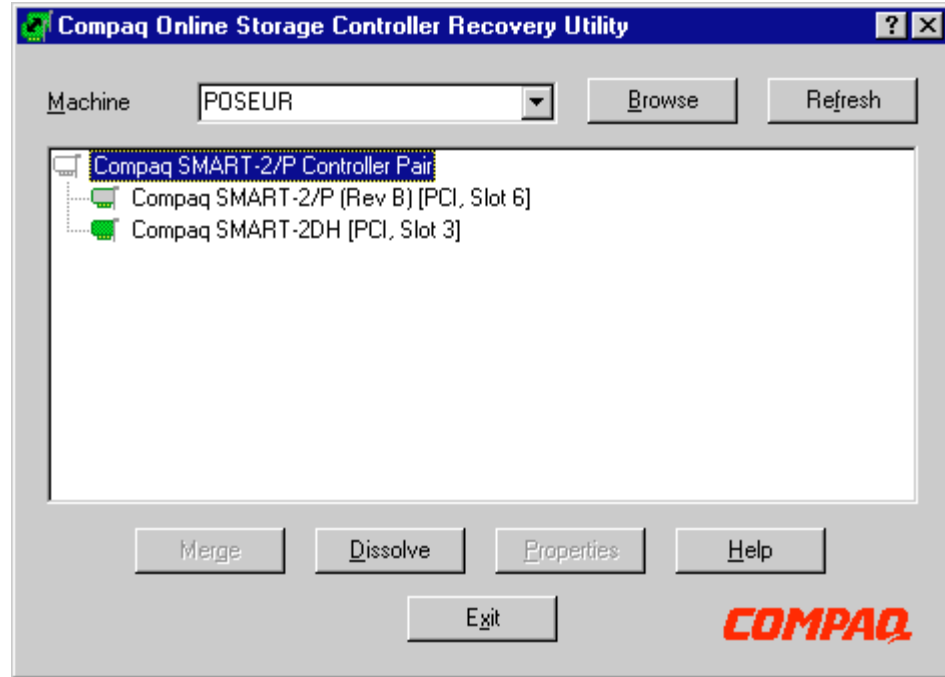


Figure 13 : Merge Completed and Pair Active

Once a controller pair is formed, a new icon is displayed that represents controller pair. The normal controller pair icon is white, as shown in Figure 13. Table 7 shows how the status of the individual controllers affects the status of the icon representing the controller pair.

TABLE 7 : STATUS ICONS FOR CONTROLLER PAIRS

		Status of Controller #1 of Controller Pair			
		Power Off	Failed	Not Ready	Normal
Status of Controller #2 of Controller Pair	Power Off				
	Failed				
	Not Ready				
	Normal				

Important: When dissolving a controller pair, do not reconfigure the cables until the pair is dissolved.

Dissolving a Controller Pair

Dissolving a controller pair involves breaking the controller pair into two independent controllers. The process involves the following steps:

1. Ensure that the controller pair does not contain any failed controllers. Controller pairs that include a failed controller cannot be dissolved until the failed controller is repaired.
2. If the controller pair includes the boot device controller, ensure that the boot device controller is the active controller prior to dissolving the pair. Failure to complete this step would render the system unable to reboot until the RSO switch within the ProLiant Storage System is reset.
3. Highlight the controller pair icon, activating the *Dissolve* button.
4. Click on the *Dissolve* button. A dialog box will appear asking you to confirm that you really want to dissolve the controller pair, as shown in Figure 14.



Figure 14 : Dissolve Confirmation Dialog Box

5. Clicking on the *Yes* button dissolves the controller pair, leaving you with two independent controllers.

Note that one of the two independent controllers should be inactive (gray) after dissolving a controller pair, because it is still connected to an inactive SCSI bus. You should not reconfigure the cabling of the controllers until after the controller pair has been dissolved.

Online Storage Controller Recovery Utility Functions

Table 8 lists the primary functions accessible from the Online Storage Controller Recovery Utility.

TABLE 8 : ONLINE STORAGE CONTROLLER RECOVERY UTILITY FUNCTIONS

Function Name	Description
Refresh	Provides a way to force the utility to update the information display.
Browse	Provides the means for locating other systems on the network and allowing you to manage those systems remotely. You must have a privileged account on the remote node in order to manage the mass storage controllers on that system.
Properties	Provides detailed information about controllers.
Merge	Combines two like controllers into a controller pair.
Dissolve	Splits a controller pair into two independent controllers.
Help	Provides help on use of the utility and configuring controller pairs.

Right-Click Functions

In addition to the primary functions, the Online Storage Controller Recovery Utility provides several secondary functions, available when the right mouse button is used on a selected controller or controller pair. The specific functions offered by the right-click depend on whether the highlighted device is a controller or a controller pair, as shown in Figure 15 and Figure 16. The specific functions are described in Table 9.



Figure 15: Right-Click Functions for Controllers



Figure 16: Right-Click Functions for Controller Pair

TABLE 9: ONLINE STORAGE CONTROLLER RECOVERY UTILITY RIGHT-CLICK FUNCTIONS

Function	Description
Merge	Combines two like controllers into a controller pair. Functionally the same as the <i>Merge</i> button.
Dissolve	Splits a controller pair into two independent controllers. Functionally the same as the <i>Dissolve</i> button.
Fail / Unfail	Used to manually fail or unfail a controller.
Switch	Performs a manual switch, promoting the Standby controller of a controller pair to Active status. This function provides a means for specifying which controller is Active.
Verify	Performs two <i>Switch</i> operations in order to verify that both controllers of the controller pair are capable of becoming active.
Properties	Displays information about the controller selected. This function is not available when the controller pair is selected.

Viewing Device Properties

When a specific mass storage controller is selected, the Properties function provides detailed information about that controller. Properties information is divided between two screens, both accessed through the Properties Function. These screens provide information on General Properties and Status Properties.

The General Properties screen, shown in Figure 17, provides information about the physical and logical locations of the device. Also provided are the board name, device driver name and the physical I/O address.

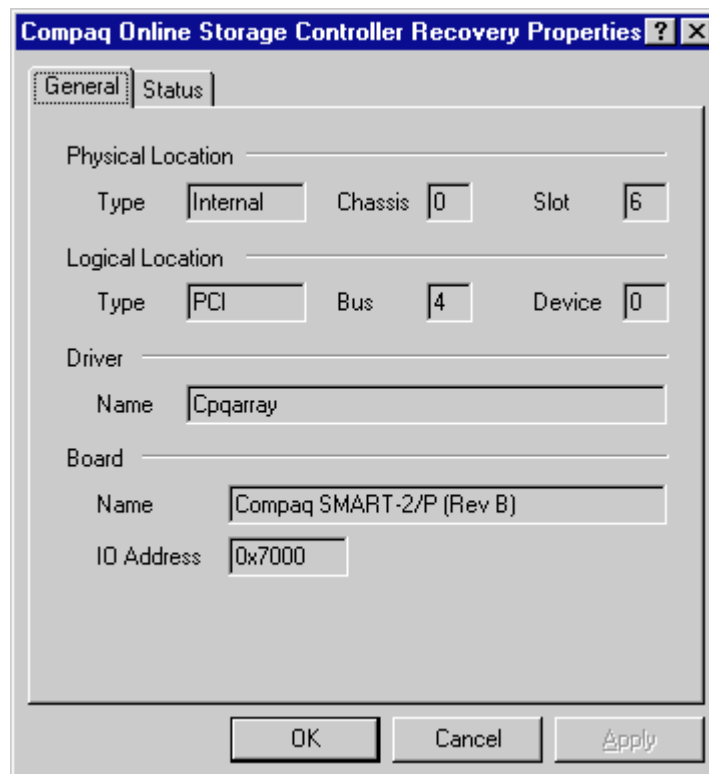


Figure 17: General Properties Screen

The Status Properties page provides information about the status of the PCI hot plug slot (when applicable) and the mass storage controller. Figure 18 shows the Status Properties page of a device that is not plugged into a PCI hot plug slot. The status information includes the indicators described in Table 10.

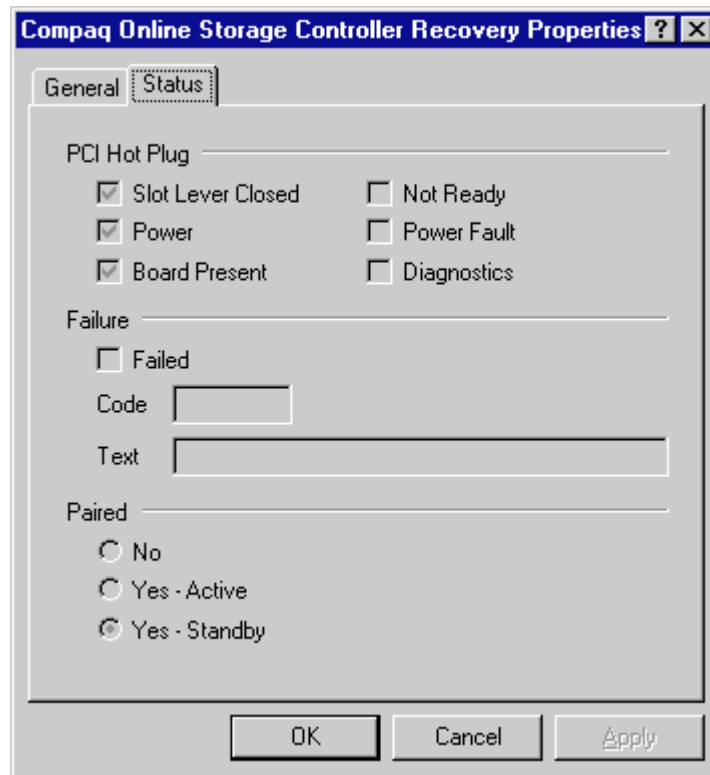


Figure 18 : Status Properties Screen

TABLE 10 : STATUS PROPERTIES INDICATORS

Status Indicator	When Marked	When Clear
Slot Lever Closed	Slot release lever is in the closed position.	Slot release lever is in the open position.
Power	Power to the slot is turned on.	Power to the slot is turned off.
Board Present	A PCI adapter has been detected in the slot.	No PCI adapter was detected in the slot.
Not Ready	The PCI adapter is not ready for software access.	The PCI adapter is ready for software access.
Power Fault	A power fault has occurred on the slot.	No power faults have occurred on the slot.
Diagnostics	Diagnostic tests are being performed on the PCI adapter.	No diagnostics are being run on the PCI device.
Failure: Failed	The PCI adapter has failed.	The PCI adapter is not reporting a failed status.
Failure: Code	Used for debugging device failures.	No failure reported.
Failure: Text	Reason for failure.	No failure reported.
Failure	The PCI adapter has failed.	The PCI adapter is not reporting a failed status.
Paired: No	The PCI adapter is not part of a controller pair.	The PCI adapter is part of a controller pair.
Paired: Yes - Active	The PCI adapter is the active member of a controller pair.	Not the active member of a controller pair.
Paired: Yes - Standby	The PCI adapter is the standby member of a controller pair.	Not the standby member of a controller pair.

RECOVERING FROM CONTROLLER FAILURE

Online Storage Controller Recovery Option enables the server to continue operating in the event that a mass storage controller fails. This section outlines the steps to replace a failed controller and recover the fault tolerant state of the I/O subsystem.

Recovering from Controller Failure Using PCI Hot Plug Technology

PCI Hot Plug technology and Online Storage Controller Recovery Option work together to provide a means for replacing a failed mass storage controller without shutting down the system. The steps involved are:

1. Power off the PCI slot containing the controller using the PCI Hot Plug Utility.
2. Replace the controller.
3. Use the PCI Hot Plug Utility to power on the PCI slot containing the controller.
4. Use the Online Storage Controller Recovery Utility to perform a manual Switch operation, thereby making the controller the Active controller of the controller pair.

Using this procedure, the fault tolerant state of the I/O subsystem is restored without shutting down the system or interrupting the availability of the data, as shown in Figure 19.

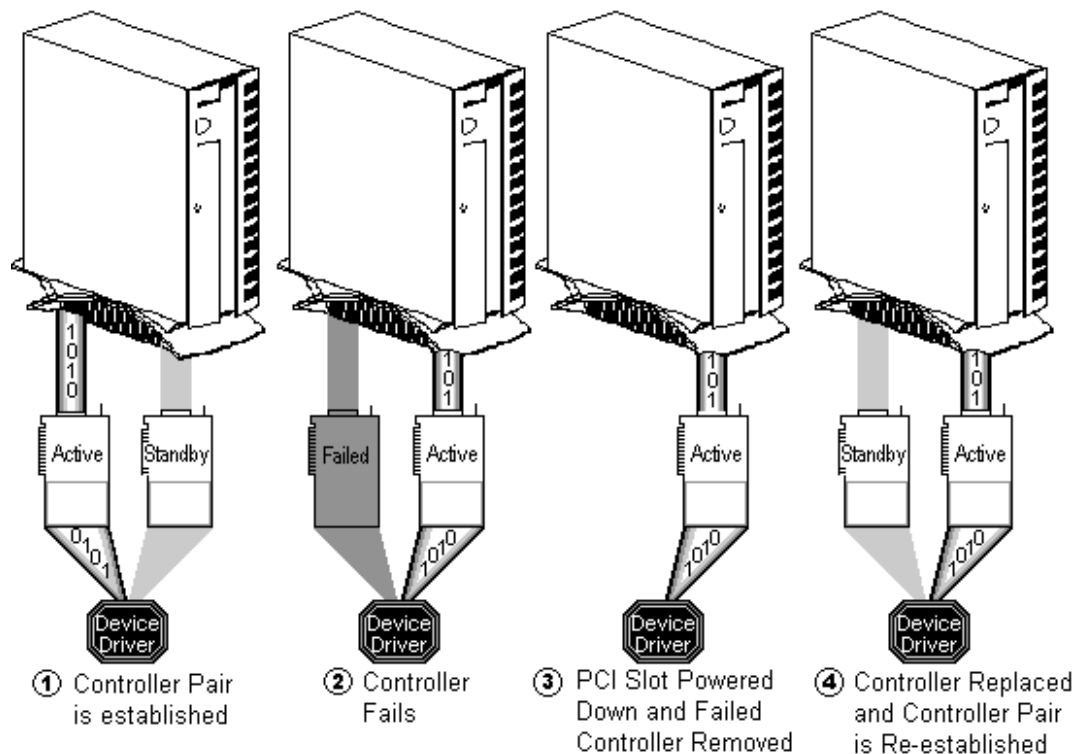


Figure 19 : Compaq PCI Hot Plug and Online Storage Controller Recovery Option

Recovering from Controller Failure Without PCI Hot Plug Technology

The procedure for replacing a failed controller without the aid of PCI Hot Plug technology involves the following steps:

1. Schedule a time when the server can be shut down.
2. Shut down the server at the scheduled time, and turn off the power.
3. Turn off the power on the ProLiant Storage System(s) to reset the RSO switch.
4. Replace the failed controller.
5. Turn on the power for the ProLiant Storage System(s).
6. Reboot the server.

By following this procedure, the mass storage controller is replaced when convenient for the system administrator, restoring the I/O subsystem to a fault tolerant state.

Recovering from Boot Device Controller Failure

A very special case exists that may cause some confusion. The conditions that lead to this special case are as follows:

1. The boot device controller is a member of a controller pair.
2. The boot device controller fails.
3. The backup controller takes over.
4. The server is shut down while the backup controller is acting on behalf of the boot device controller.
5. The boot device controller is NOT repaired while the server is shut down.

If all five of these conditions are met, the server will not be able to find the boot device because the standby controller is not capable of acting as the boot device controller. The problem is avoided by replacing the failed controller during the system downtime. However, if that is not possible, perform the following steps:

1. Turn off the power to the server.
2. Disconnect both cables from the remaining SMART-2 Array Controller.
3. Move the remaining SMART-2 controller into the slot previously occupied by the primary controller. This step promotes the SMART-2 controller to act as the boot device controller by positioning it in the slot designated as *First in Controller Order*.
4. Connect the external and internal cables for the primary controller to the remaining SMART-2 controller.
5. Cycle the power on the ProLiant Storage Systems to ensure that the RSO switches inside are reset.

Performing these steps makes the standby controller become the boot device controller, and ensures its connection to the primary port of the ProLiant Storage System. These steps are necessary to allow the system to recovery cleanly from complete power loss.

SUMMARY

Compaq Online Storage Controller Recovery Option extends the reliability of Windows NT servers by ensuring the continuing operation of the system, even when a mass storage controller fails. The Online Storage Controller Recovery Utility for Windows NT provides a means of managing the SMART-2 controllers of the entire Windows NT network from a single management station.

Compaq Online Storage Controller Recovery Option is a natural partner for Compaq PCI Hot Plug technology. The combination of the two eliminates the need to shut the system down whenever a mass storage controller fails. Online Storage Controller Recovery Option permits the system to continue operating after a controller failure, and PCI Hot Plug technology allows replacement of the failed controller without shutting the system down.

Compaq Online Storage Controller Recovery Option represents another facet of the Compaq commitment to providing customers with the most reliable servers available.