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Deploying PCI Hot Plug on Compaq® Servers in a Microsoft® Windows NT® Environment

This White Paper focuses on integrating Compaq PCI Hot Plug technology with the Microsoft Windows NT 4.0 operating system. This information is intended for system administrators and information technology staff interested in improving fault tolerance and server availability in Windows NT environments.

This white paper provides the following information:

- *Hardware and software required to implement PCI Hot Plug technology*
- *Features and benefits of PCI Hot Plug technology under Windows NT*
- *Using related fault tolerant technologies with PCI Hot Plug technology*
- *Installation and configuration of PCI Hot Plug functionality for Windows NT*

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Deploying PCI Hot Plug in a Microsoft Windows NT Environment
First Edition (July 1997)
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PCI HOT PLUG TECHNOLOGY OVERVIEW

PCI Hot Plug technology defines a new standard for high availability in Compaq servers by allowing removal and replacement of PCI controllers without shutting down the system. PCI Hot Plug technology is being developed as an open standard by the PCI Hot Plug Workgroup of the PCI Special Interest Group. PCI Hot Plug is an extension of the *PCI Local Bus Specification.*

Compaq is building hot plug solutions that consist of hot plug system hardware and hot plug aware software. PCI Hot Plug technology was intentionally designed to use existing industry-standard PCI adapters without requiring hardware changes. Avoiding the need for hardware changes greatly simplifies and accelerates the process of making existing PCI controllers hot plug aware. Standard PCI adapters function normally in a PCI Hot Plug bus.

Compaq PCI Hot Plug hardware isolates each hot plug slot from all other devices on the PCI bus. By offering slot-level control, Compaq provides great flexibility. Slot level isolation eliminates interruption to other components and applications using those components, enabling the system to continue performing useful work throughout the hot replacement.

PCI Hot Plug software for Windows NT includes hot plug aware device drivers, operating system support, and the PCI Hot Plug Utility. Hot plug aware device drivers enable the system to halt operations on a specific controller prior to removing the controller. Compaq provides operating system support for Windows NT through the Compaq Remote Monitoring service and the System Management driver. These operating system support elements enable control of the hot plug hardware using the PCI Hot Plug Utility.

The PCI Hot Plug Utility provides a common point for managing the PCI Hot Plug buses on the local system, as well as on remote systems accessible over the network. Because the PCI Hot Plug Utility works over the network, a single management station can be set up to support all of the hot plug systems in the enterprise. The ability to centrally manage remote PCI Hot Plug servers simplifies the task of supporting distributed computing environments.

Glossary of Terms

PCI	Peripheral Component Interconnect refers to a bus based on the PCI Local Bus Specification, through which industry standard peripheral controllers connect to computer systems.
RPC	Remote Procedure Call is a calling standard that permits client-server applications to communicate over a network. RPC requires the availability of a routable network protocol, such as TCP/IP.
Hot plug slot	A PCI slot capable of being powered down without interfering with the other slots in the system, and without shutting the system down.
Hot plug aware	Indicates that a piece of software, such as a device driver, can take advantage of the PCI Hot Plug capabilities of a system.
Hot replacement	The ability to remove PCI controllers from a system while the system is running and replace them with equivalent PCI controllers, without shutting down the system.
Hot upgrade	The ability to upgrade existing PCI controllers and drivers to next generation controllers and drivers while a system is running, without shutting down the system. Not available in initial release of PCI Hot Plug technology for Windows NT.
Hot expansion	The ability to add new PCI controllers to a system and load the respective device drivers while the system is running, without shutting down the system. Not available in initial release of PCI Hot Plug technology for Windows NT.
Hot plug service	Software (CPQRCMC) which has control of overall hot plug operations.
System Management driver	Software driver (SYSMGMT.SYS) which monitors the health of the system and provides the primary interface between the hot plug service and the hot plug system hardware.

Hot Plug System Hardware

PCI Hot Plug systems, including the Compaq ProLiant 6500 servers, incorporate the following features that differentiate them from conventional systems:

- Advanced system circuitry that permits software control of the PCI Hot Plug slots.
- LED status indicators for each PCI Hot Plug slot that indicate if a slot has power, and if the device driver reported an attention condition.
- Slot release levers that automatically disable power to the hot plug slot when opened.
- Wider PCI slot spacing and dividers between hot plug slots that permit safe insertion and removal of controllers, while avoiding contact with active adjacent PCI options.

TABLE 1 : PCI HOT PLUG COMPATIBILITY AND FUNCTIONALITY

	Non Hot Plug Aware Device Driver	PCI Hot Plug Aware Device Driver
PCI slot	Standard Functionality	Standard Functionality
PCI Hot Plug slot	Standard Functionality	Hot Plug Functionality

Table 1 shows the interoperability between PCI Hot Plug and existing PCI standards. PCI Hot Plug technology is an extension, not a replacement, of the PCI specification, making it compatible with existing PCI standards. This commitment to standards greatly simplifies the process of configuring and supporting Compaq PCI Hot Plug systems.

PCI Hot Plug Software for Windows NT 4.0

Implementation of PCI Hot Plug technology involves a combination of the system hardware and hot plug software. The software components of PCI Hot Plug technology are available at no cost on the Compaq SSD for Windows NT (version 2.00 or greater), which can be accessed on the Compaq Online web site at http://www.compaq.com/support/files/server/softpaqs/WINNT/NTSSD.html. The software components for PCI Hot Plug include the following:

- Compaq PCI Hot Plug Utility
- Compaq Remote Monitor service (CPQRCMC)
- System Management driver (SYSMGMT.SYS)
- Hot plug aware device drivers

The PCI Hot Plug Utility can be loaded on any system running Windows NT 4.0, regardless of whether that system has a PCI Hot Plug bus. Using Remote Procedure Calls (RPC), the PCI Hot Plug Utility manages the PCI Hot Plug slots on either the local system, or any system accessible on the network. The use of RPCs as the primary interface allows management of all the PCI Hot Plug slots in a network from a single management station. Compaq designed PCI Hot Plug technology with ease of management as a primary consideration.

Understanding the Software Environment

As illustrated in Figure 1, the CPQRCMC service is central to the operation of PCI Hot Plug technology. CPQRCMC acts as the connection point for all hot plug communications. By using the CPQRCMC service as the primary interface, Compaq delivers true PCI Hot Plug capability without requiring hot plug support directly in the operating system.

When the user invokes a hot plug function from the PCI Hot Plug Utility, CPQRCMC receives the request and routes it to the appropriate driver. For example, if the request involves action on a hot plug slot, CPQRCMC routes the request to the System Management driver (SYSMGMT.SYS). The PCI Hot Plug Utility receives reports of the success or failure of the request by way of CPQRCMC as well.

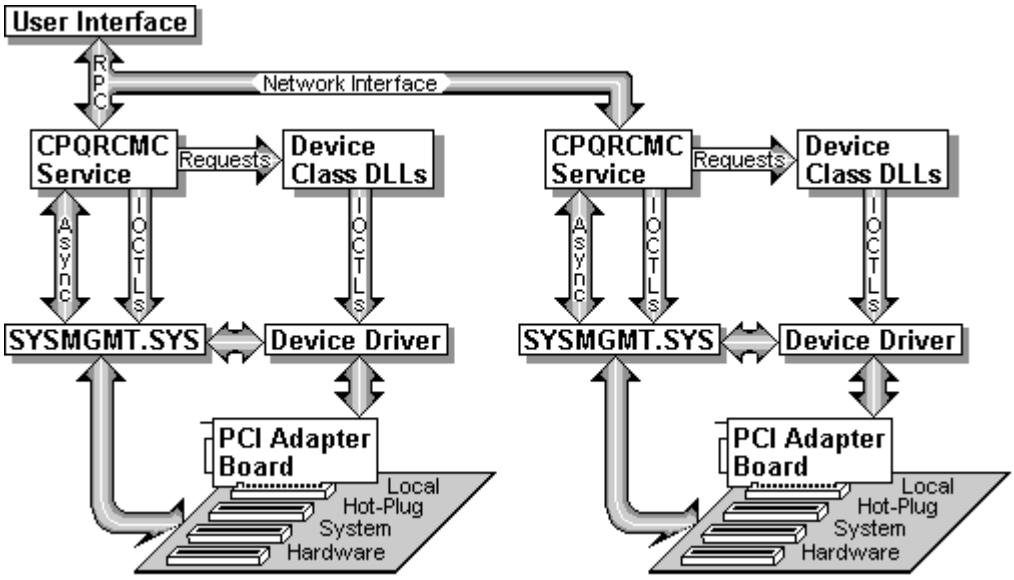


Figure 1: Overview of PCI Hot Plug Technology

If the request coming to CPQRCMC involves direct action to the controller in the hot plug slot, CPQRCMC routes that request to the device-class DLL that supports the controller. These device-class DLLs communicate directly with the device drivers, which in turn manage the functions of the PCI controllers. Status reports of these events flow back to the PCI Hot Plug Utility by way of CPQRCMC.

By default, the CPQRCMC service starts automatically at system startup time using the System Account. Under the Services applet of Control Panel the service name is “Compaq Remote Monitor Service." Without CPQRCMC running, there is no hot plug functionality. Stopping the service disables hot plug functionality until the service restarts. Therefore, the Compaq Remote Monitor Service should not be stopped on hot plug systems for any reason.

Both the CPQRCMC service and the System Management driver install as part of the Compaq SSD for Windows NT.

PCI HOT PLUG TECHNOLOGY IN ACTION

The following examples illustrate how PCI Hot Plug technology solves problems, alone and in concert with fault tolerant technologies. An animated example of the procedure for utilizing PCI Hot Plug technology is available on the *Compaq System Reference Library* CD under the heading *PCI Hot Plug Procedure*.

Replacing an Adapter

PCI Hot Plug technology helps eliminate downtime by resolving controller-level hardware problems with a minimum of impact on system availability. By implementing slot level isolation, PCI Hot Plug technology allows you to power down a single PCI slot without impacting any other PCI slots in the system. An adapter equipped with a hot plug aware device driver can be replaced without shutting down the system, and without causing problems for other PCI adapters. Once an adapter has been replaced, PCI Hot Plug technology enables you to bring the PCI slot back into service without impacting other PCI slots. Single slot isolation gives you a very high degree of control over the hardware environment, extending the support options and improving system availability.

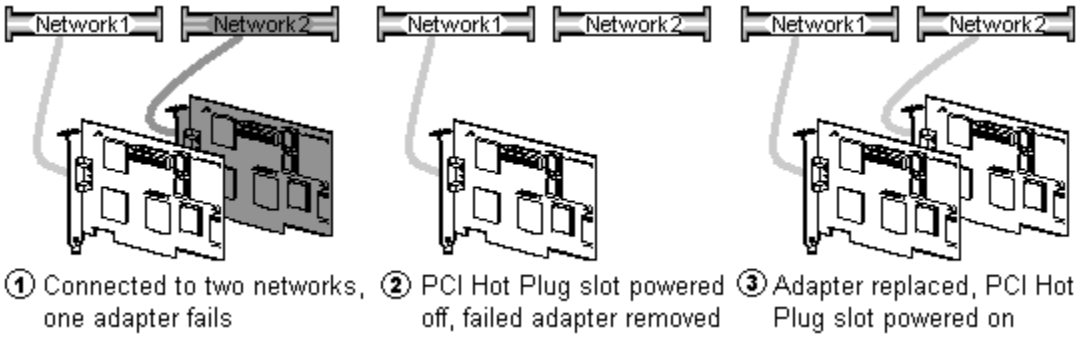


Figure 2 : Replacing a Failed Network Adapter Using PCI Hot Plug Technology

In the example shown in Figure 2, the system contains two network adapters, each connected to a different network. PCI Hot Plug technology offers customers the ability to replace hot plug aware devices without shutting down the system. If a network adapter fails, single slot isolation allows you to replace the adapter without impacting the rest of the system. Once the adapter is replaced, connections to the affected network can be restored quickly and with a minimum of service interruption. Users on the unaffected network never lose connection to the server.

Replacing a Redundant Network Adapter

By combining PCI Hot Plug technology with controller redundancy, the fault tolerance of the system is greatly enhanced. Forming a network controller pair involves setting up two similar network interface controllers so that they share a single instance of the device driver code. One becomes the active controller and the other acts as a standby controller. In this scenario, the driver detects when the active controller or its connection fails and immediately switches all network traffic to the redundant controller, promoting it to active status.

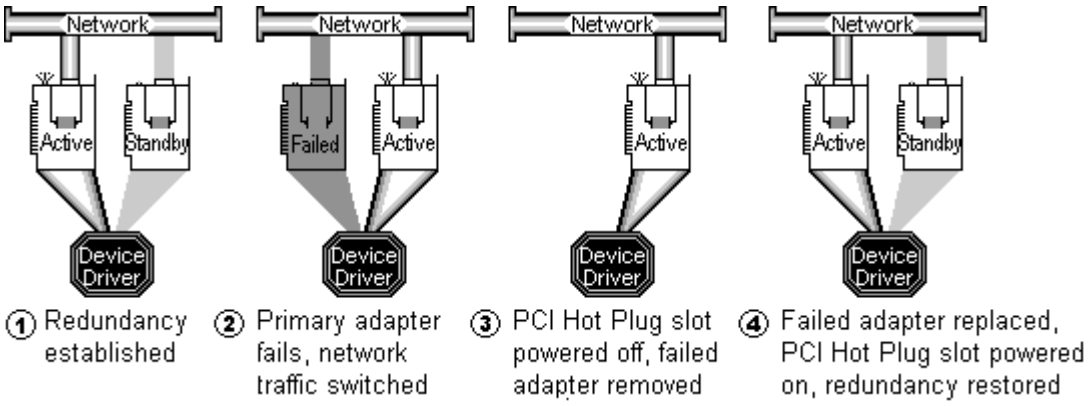
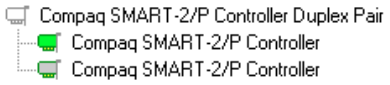


Figure 3: Replacing a Redundant Network Adapter Using PCI Hot Plug Technology

PCI Hot Plug technology and network controller redundancy allow you to replace a failed controller while users continue to communicate with the server, as shown in Figure 3. The affected slot is powered off using the PCI Hot Plug Utility. After replacing the failed module, you simply activate the slot again through the PCI Hot Plug Utility. The device driver automatically detects the presence of the replacement module.

Network interface controller redundancy provides continuous connection to the network, even when one of the network interfaces fails. PCI Hot Plug technology provides the means for replacing a failed network interface while a server is operating, thus maintaining the redundancy of the network interfaces. Together they offer extremely high availability and fault tolerance for network connectivity.

Replacing a Redundant Mass Storage Controller



Compaq Online Storage Controller Recovery Option creates a high level of redundancy in the mass storage subsystem by effectively linking two similar controllers into a cooperative pair. The Compaq Online Storage Controller Recovery Utility makes one controller the active controller, while the other acts as the redundant controller. If the active controller fails, the redundant controller takes over and responds to all requests. Users continue to access their data without interruption of service. Online Storage Controller Recovery Option works with Compaq SMART-2 Array Controllers. For more information about Online Storage Controller Recovery Option for Windows NT, refer to document number 066A/0797 (*Implementing Online Storage Controller Recovery Option Under Windows NT).*

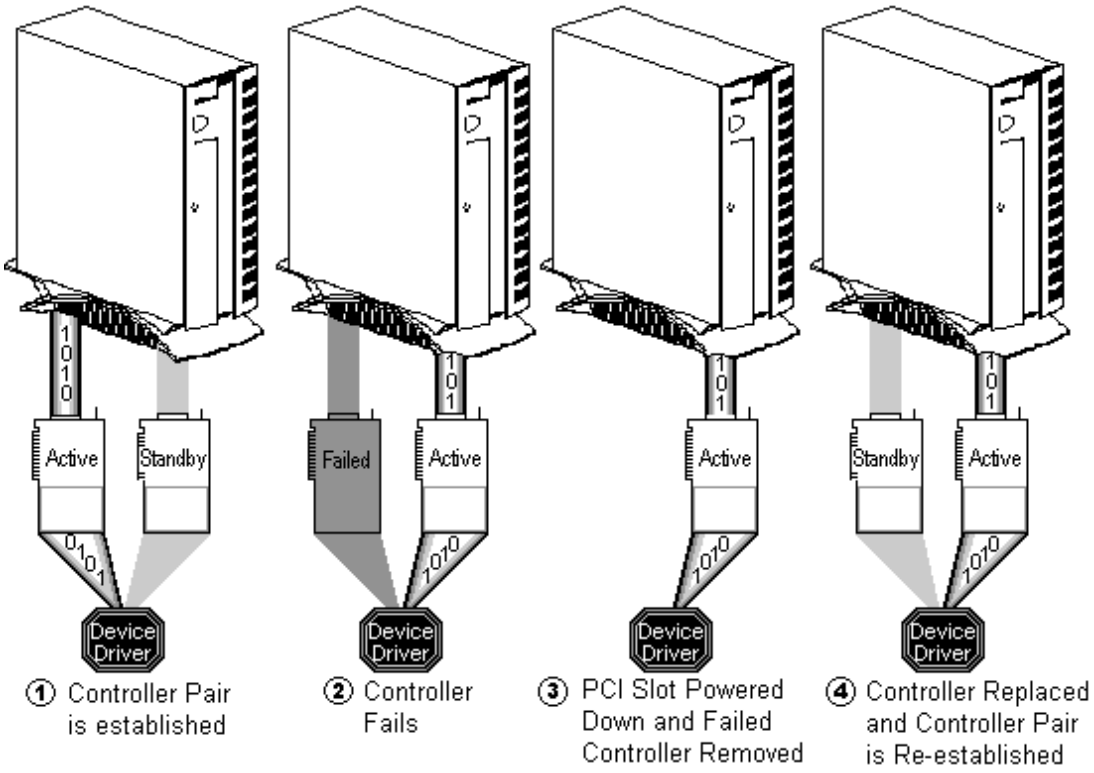


Figure 4: Replacing a Redundant Mass Storage Controller Using PCI Hot Plug Technology

Caution: *When replacing a hot plug aware mass storage controller, connect all cables before applying power to the slot. Some devices will not initialize properly unless fully connected before power-up.*

Hot pluggable disks provide a means of preserving data availability when a disk fails. Previously, if a PCI controller failed, the system required a shutdown to replace the failed device. PCI Hot Plug and Online Storage Controller Recovery Option provide a means for replacing a mass storage controller without shutting down the system. The administrator powers off the PCI slot with the Compaq PCI Hot Plug Utility while the rest of the system remains unaffected. The Hot Plug Service (CPQRCMC) notifies the device driver that the slot will be powered down, allowing it to stop all activity. After replacing the failed controller, the administrator powers on the PCI slot again through the Compaq PCI Hot Plug Utility. The Hot plug Service performs the PCI configuration of the replacement controller, and then notifies the device driver that the device has been replaced. 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 4.

THINGS TO CONSIDER BEFORE INSTALLING WINDOWS NT

This section points out some specific considerations for those installing Windows NT 4.0 on Compaq PCI Hot Plug systems. The information presented here does not constitute a complete pre-installation checklist for Windows NT 4.0. For general pre-installation considerations, refer to the *Windows NT 4.0 Server Installation Guide*.

Planning Hot Plug PCI Slot Usage

The first Compaq PCI Hot Plug system, the ProLiant 6500, comes equipped with a combination of PCI Hot Plug slots and shared PCI/EISA slots. You should plan in advance which controllers require hot plug slots and which will use the PCI/EISA slots.

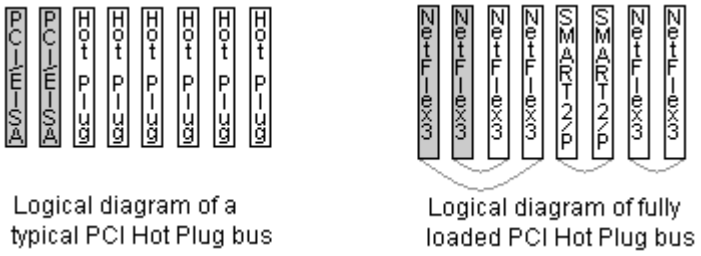


Figure 5 : Example of PCI Hot Plug Slot Usage Planning

Compaq PCI Hot Plug systems accept virtually any combination of PCI options, including hot plug aware options and non-hot plug aware options. If the system contains non-hot plug aware devices, place them in PCI/EISA slots. Reserve the hot plug slots for hot plug aware options when possible.

***Caution**: If the boot disk controller is not part of a controller duplex pair, place that controller in a non hot plug slot to avoid accidentally shutting down access to the system disk and the swap file.*

If the system contains a full complement of hot plug aware PCI adapters, the best configuration under this circumstance involves placement of redundant controllers in the PCI/EISA slots. This arrangement leaves the active controllers in hot plug slots, preserving the ability to replace a failed controller in a controller pair without shutting down the system.

PCI Hot Plug Slot	PCI/EISA Slot	Comments and Recommendations
		Allows hot replacement of failed non-redundant controller.
		Cannot replace failed controller without downtime.
		Redundancy and Hot Plug functionality. Recommended configuration.
		Maximizes availability of Hot Plug slots. Recommended only when PCI bus is full.
		Cannot replace failed controller without downtime. Not recommended.
		Provides redundancy for non-hot plug systems. Not recommended for PCI Hot Plug systems.

Table 2 : PCI Hot Plug Slot Usage Examples

Table 2 shows the possible arrangements of controller pairs in the PCI bus slots, providing useful information for planning PCI slot usage in your system.

THINGS TO CONSIDER DURING WINDOWS NT INSTALLATION

The significant points to consider when installing Windows NT on a PCI Hot Plug system are:

- Automatic device detection may not yield results consistent with actual hardware configuration.
- The presence of multiple network adapters may complicate the network setup phase.
- PCI Hot Plug technology for Windows NT relies on the presence of the Windows NT RPC service.
- PCI Hot Plug technology for Windows NT 4.0 requires installation of the Compaq SSD for Windows NT to provide updated drivers, utilities, and operating system support code.

These points are covered in more detail in this section, including some tips and tricks for simplifying the installation process.

Automatic Device Detection and Driver Overrides

Installation Tip #1: *It is much easier to use the Windows NT default drivers during Windows NT installation, then upgrade the drivers to hot plug aware drivers after Windows NT is installed.*

During the preliminary setup phase, Windows NT setup scans the system to discern which devices are attached and load the appropriate device drivers. The device drivers that ship with Windows NT 4.0 pre-date PCI Hot Plug technology, and are not hot plug aware. Devices that will benefit from installation of hot plug aware device drivers, such as the NetFlex-3/Netelligent Controllers, 32-Bit Fast SCSI-2 Controllers, and SMART-2 Controllers, are completely reliable when used with the default device drivers. Therefore, it is recommended that you install all of Windows NT 4.0 using the default drivers and apply the hot plug aware drivers after the fact.

The Windows NT 4.0 default device drivers for some Compaq products do not reflect the current product names. This discrepancy might lead to some confusion during the setup of Windows NT. To avoid this confusion, Table 3 lists current Compaq device names and the default Windows NT drivers that support them.

TABLE 3: COMPAQ DEVICE NAME AND WINDOWS NT 4.0 DEFAULT DRIVERS

Compaq Device Name	Windows NT 4.0 Default Device Driver Description
Compaq SMART-2 Disk Array Controller	Compaq Drive Array
Compaq 32-Bit Fast SCSI-2 Controller	Symbios Logic C810 PCI SCSI Host Adapter
Embedded Compaq 32-Bit SCSI-2 Controller	Symbios Logic C810 PCI SCSI Host Adapter
Compaq Netelligent Network Interface	Compaq NetFlex-3

Setting Up Multiple Network Adapters

Installation Tip #2: *To simplify network setup, only one network adapter should be attached to the network during Windows NT installation.*

Windows NT treats each network interface or controller pair as an autonomous network entity. Using TCP/IP as the example, each network interface requires either a unique IP address or a unique DHCP supplied address. This rule applies to individual adapters even if they will form controller pairs later. Be aware that this behavior may cause a problem during the network setup phase if two adapters attempt to claim the same node name on the same network using two different addresses.

Operating System Components Required

Note*: The RPC service can be installed on a stand-alone server with no other network components loaded through the Network applet of Control Panel.*

Compaq PCI Hot Plug technology uses RPC as the primary interface between the PCI Hot Plug Utility and the Hot Plug service. Installation of the RPC service is required. Likewise, since the RPC service depends on having a routable protocol through which it can send messages to a remote system, installation of a routable network protocol such as TCP/IP is essential if access to remote machines is desired.

Installing Compaq SSD for Windows NT

The initial release of Compaq Hot Plug technology for Windows NT requires installation of the Compaq SSD for Windows NT (version 2.00 or greater). Included on the SSD are the hot plug aware device drivers for the Compaq NetFlex-3 and Netelligent Controllers as well as the SMART-2 Array Controllers and the 32-bit Fast SCSI-2 Controller. The SSD also provides the updated CPQRCMC service and System Management driver, both required for hot plug functionality.

This section briefly covers the installation of the Compaq SSD for Windows NT. It is not intended as an exhaustive description of the installation procedure, but it does cover the basic requirements for setting up hot plug functionality. For more information on Compaq SSD for Windows NT, refer to the README file included with the software.

Installation Tip #4: *Remember that hot plug functionality requires both the Compaq Remote Monitor Service and the Compaq System Management Driver. Do not deselect those options.*

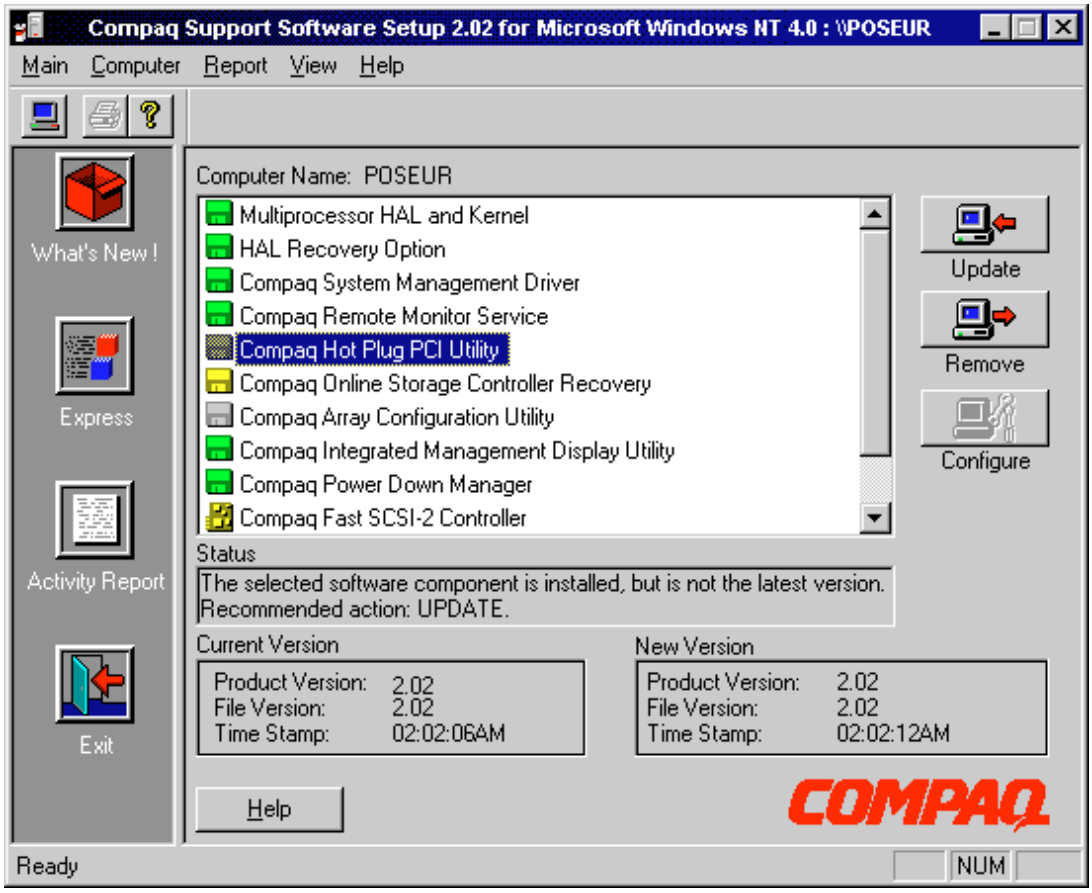


Figure 6 : Compaq SSD for Windows NT Setup Screen

When the Setup Utility for the SSD is run, you are presented with the screen shown in *Figure 6*. This screen lists the options available from the SSD. You have the option of selecting the components you wish to install or upgrade individually, or you may use the *Express* button to allow Setup to select the options you need.

Table 4 lists the components provided by Compaq SSD for Windows NT and details that are required for implementing Online Storage Controller Recovery Option.

TABLE 4 : 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 Hot Plug PCI	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.

Installation Tip #5: *Using the Express option of Compaq SSD for Windows NT setup provides everything you need to enable Hot Plug functionality, and is simpler and faster than selecting the individual components manually..*

Compaq SSD Express Setup

Express setup detects the Compaq devices on the system and builds the list of drivers and support code required by those devices. The setup program displays the options it is about to install and allows the system installer to review and alter the list, as shown in Figure 7.

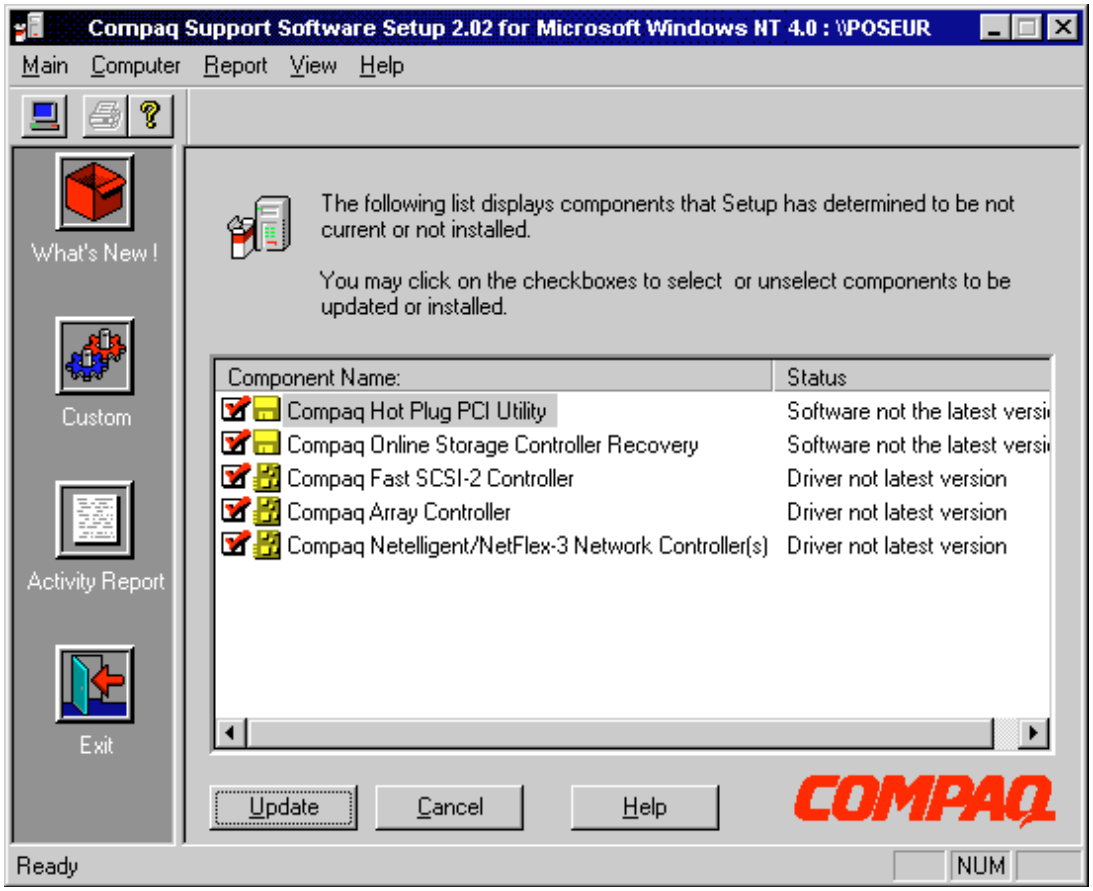


Figure 7 : Compaq SSD for Windows NT 2.02 Express Screen

Using the *Express* option directs Setup to detect the devices and software options installed, and allows you to install or update the components required to support whatever is detected. After clicking the Express button, you will be presented with a screen showing the options Setup will install. From this screen you may select or deselect any of the options shown. The components required to support Online Storage Controller Recovery Option are installed by default when using the Express Setup option.

HAL Recovery Option

Installation of the HAL Recovery option requires the original media for Windows NT 4.0. The HAL Recovery option creates a new boot option called *Windows NT Server 4.0 [HAL Recovery]*. This boot option performs a 'minimal' boot and allows recovery from HAL inconsistencies. Installation of this option prevents future occurrences of this message.

MANAGING THE PCI HOT PLUG SYSTEM

This section discusses the use of the PCI Hot Plug hardware and the hot plug management software. Also covered are related issues of managing the Windows NT environment in which the PCI Hot Plug technology runs.

Using the PCI Hot Plug Utility

The PCI Hot Plug Utility is the primary user interface that permits the system manager to observe and control the PCI Hot Plug slots on the local system and on remote hot plug systems. The Compaq PCI Hot Plug Utility is part of the Compaq SSD for Windows NT. Once installed, the utility appears as the *Compaq PCI Hot Plug* applet under Control Panel, as well as appearing in the special *Compaq System Tools* folder. When invoked, the PCI Hot Plug Utility displays the primary screen, as shown in Figure 8.

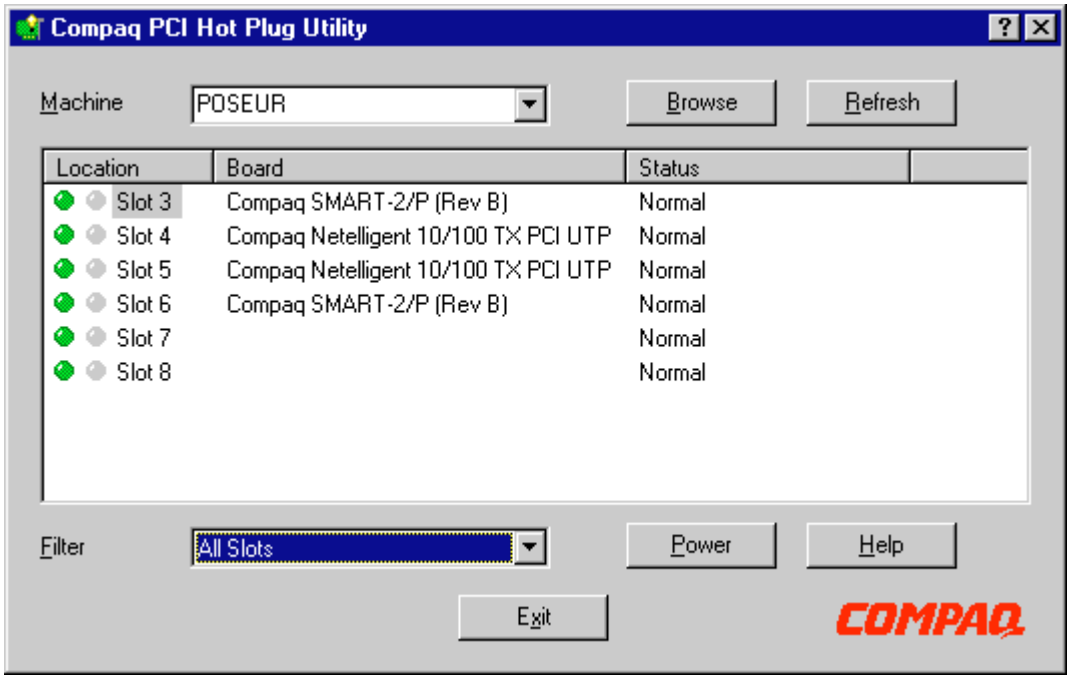


Figure 8: Compaq PCI Hot Plug User Interface for Windows NT

The PCI Hot Plug Utility provides a means for managing the PCI Hot Plug slots and the hot plug aware devices plugged into them. The filter allows you to view a subset of the available PCI slots, including limiting the view to only the failed slots. Table 5 lists the primary controls available from the PCI Hot Plug Utility and describes their use.

TABLE 5 : PCI HOT PLUG UTILITY PRIMARY FUNCTIONS

Function	Description
Browse	Selects the system being viewed and managed by the utility (as described in a later section).
Refresh	Manually triggers a screen update.
Power	Switches the power off and on for the individual hot plug slots.
Help	Invokes the PCI Hot Plug specific help page.

Filter	Used to select the criteria that determines which PCI Hot Plug slots are shown by the utility.

Along with these primary controls, the utility provides a secondary set of controls, shown in Figure 9, accessed by clicking the right mouse button when one of the hot plug slots is highlighted. Table 6 lists the functions available through right-click menus and describes their use.

Figure 9: PCI Hot Plug Utility Right Click Menu

TABLE 6 : PCI HOT PLUG UTILITY RIGHT CLICK FUNCTIONS

Function	Description
Power	Switches the power on and off for the specified slot.
Fail	Forces a device failure at the driver level.
Unfail	Attempts to clear a failure of a device at the driver level.
Properties	Displays the properties page(s) for the selected device.

The Properties Pages for Hot Plug Aware Devices

The General Properties page, shown in Figure 10, provides the information required by system administrators to locate the device, identify it, and discern which device driver is controlling it. The General Properties page provides detailed information about the physical and logical location of the device.

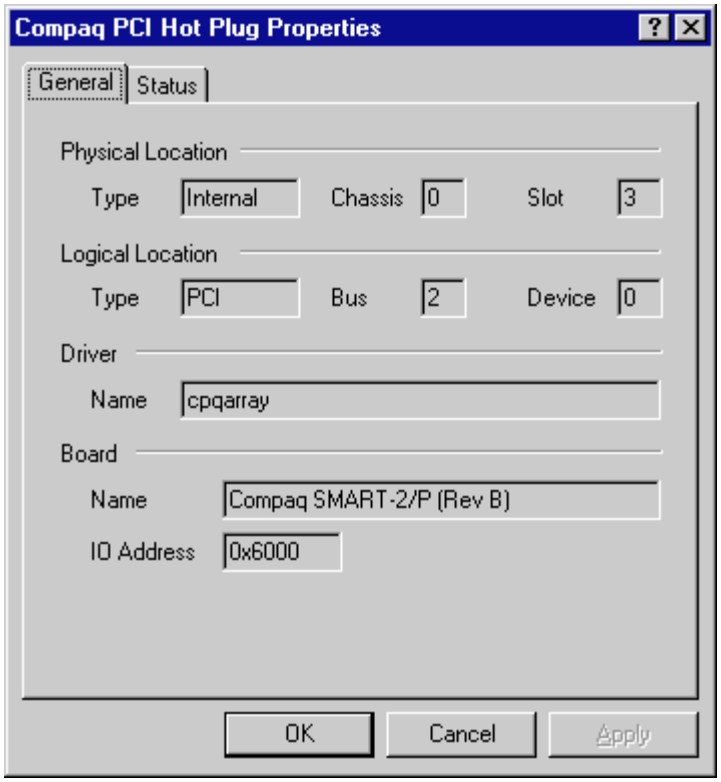


Figure 10 : PCI Hot Plug Utility General Properties Page

The physical location information allows the system manager to view which physical PCI slot the device occupies. Logical location information provides the means for finding the device in a device listing for the system. In addition to location information, the General Properties page indicates the unique name of the device driver that serves the device. The PCI Hot Plug Utility polls the device for any vendor-supplied name information. Any information returned will be displayed in the Board Name box. The IO Address of the device is also provided to assist in resolving device

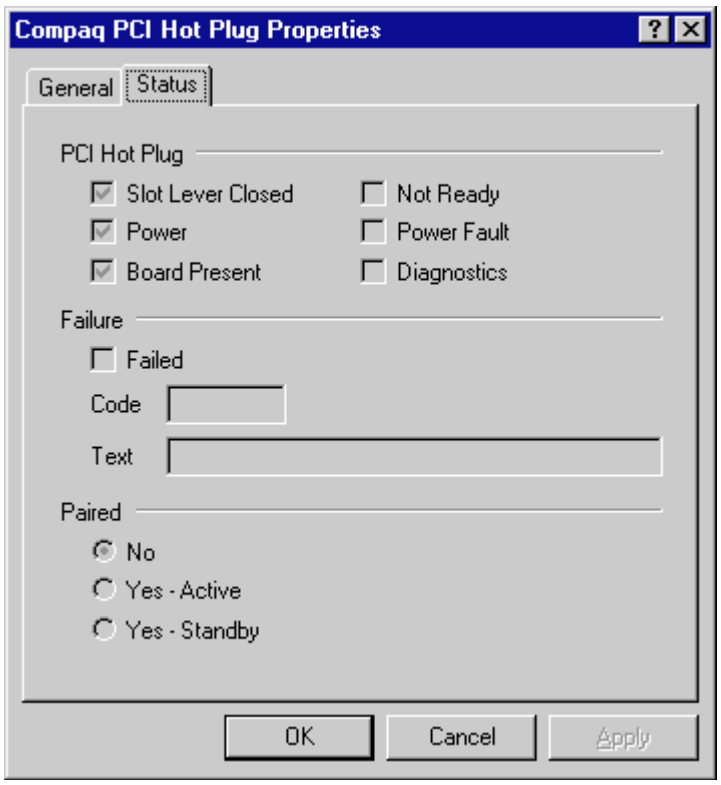


Figure 11 : PCI Hot Plug Utility Status Properties Page

conflicts.

The Status Properties page, shown in Figure 11, provides detailed information about the status of the hot plug slot and the device that it contains. The status information includes the indicators described in Table 7. In addition, any failure of the associated device within the slot is reported, along with the failure code and any associated text. This display provides system administrators with the information necessary to quickly isolate and resolve problems with PCI Hot Plug slots and the devices they connect.

TABLE 7 : PCI HOT PLUG STATUS PROPERTIES

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	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 controller pair.
Paired: Yes - Standby	The PCI adapter is the standby member of a controller pair.	Not the standby member of a controller pair.

The Devices Properties page, shown in Figure 12, appears only when a single PCI adapter contains multiple devices. The Compaq Netelligent Dual Network Interface is an example of a single PCI adapter that contains multiple devices. The Devices Properties page provides information about the individual devices on the PCI adapter connected to the PCI Hot Plug slots. Table 8 lists the fields displayed on the Device Properties page and describes the information presented.

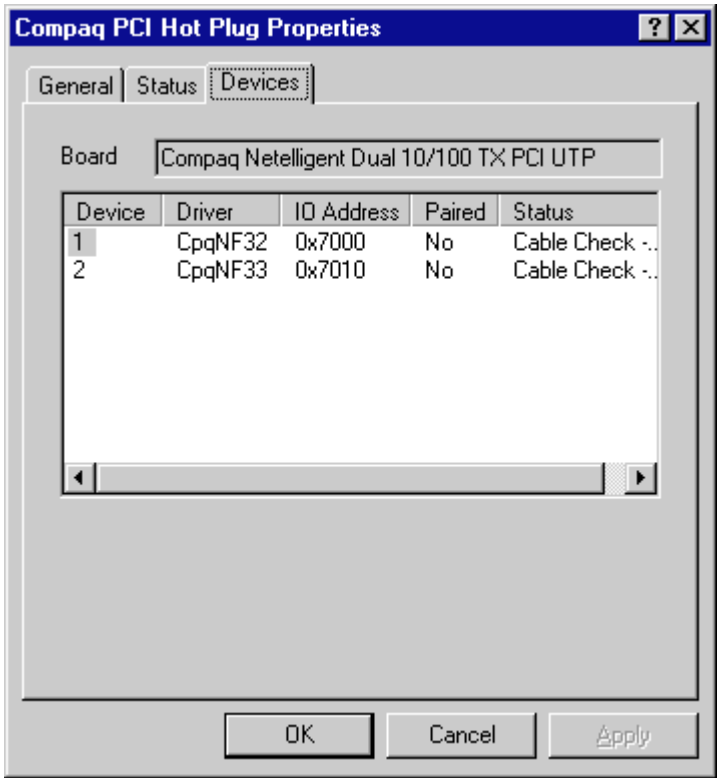


Figure 12 : PCI Hot Plug Utility Devices Properties Page

TABLE 8 : PCI HOT PLUG DEVICES PROPERTIES

Field	Description
Board	Manufacturer supplied information about the adapter, returned after polling the device.
Device	Ordinal number of the device.
Driver	Driver name, including instance number, of the device driver controlling the device.
IO Address	Physical IO Base address of the device.
Paired	Indicates whether the device is part of a controller duplex pair.
Status	Current status of the device.

Remote Management of PCI Hot Plug

The PCI Hot Plug Utility has the ability to manage the PCI Hot Plug slots of remote systems as well as the local system. The *Browse* facility works in much the same ways as the Network Neighborhood browser, presenting the user with a graphical view of the network, as shown in Figure 13. Though the browser displays all the systems it finds on the network, there are specific criteria for systems managed by the PCI Hot Plug Utility. These criteria are the same whether referring to the local system or a remote system:

- The system must have hot plug system hardware.
- The system must have the CPQRCMC service running.
- The system must have the System Management driver loaded.
- The user must have an account with appropriate privileges on the selected system.

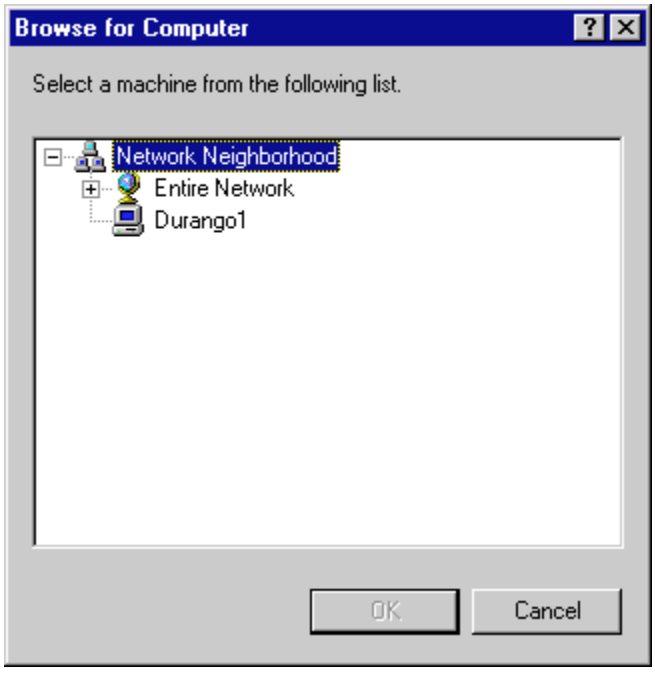


Figure 13: Compaq PCI Hot Plug Utility Browser Screen

If the local system is not a hot plug system, the PCI Hot Plug Utility needs only the RPC service and the underlying network protocol to manage remote hot plug systems. The PCI Hot Plug Utility does not require that the local system have a copy of the hot plug aware device drivers for devices located on remote systems. Each system only needs device drivers for the controllers on that system.

Hot Plug Slot LEDs

Each PCI Hot Plug slot has two LED indicators located above the release clamp on the back of the system. These LEDs indicate the status of the associated PCI Hot Plug slot. The green LED (top) indicates the PCI slot has power applied. The PCI Hot Plug Utility can power down the slot, thereby turning off the green LED as well.

The amber LED (bottom) indicates a condition has been detected that requires corrective action, such as the failure of the PCI controller in that slot.

Procedure for Replacing a Hot Plug Device

The correct procedure for replacing a hot plug device in a Windows NT System includes the following steps:

***Warning**: Always use the PCI Hot Plug Utility to turn off slots before operating slot release levers and removing adapters. Never operate the slot release lever for a slot while the green LED is lit.*

1. Invoke the PCI Hot Plug Utility.
2. Locate the controller you wish to remove and highlight the slot it occupies.
3. Click the *Power* button in the PCI Hot Plug Utility to remove power from the PCI Hot Plug slot.
4. Wait for the green LED to turn off, indicating the power is off for that slot.
5. Open the slot release lever.
6. Remove the adapter, being careful not to touch adjacent adapters.

***Caution**: Be sure to connect all cables before closing a slot release lever. Some devices may not recover from having power applied without a cable connected.*

7. Insert the replacement adapter of the same device type and revision as the adapter being replaced, being careful not to touch adjacent adapters.
8. Attach any cables to the adapter before closing the slot release lever.
9. Close the slot release lever.
10. Click the *Power* button in the PCI Hot Plug Utility to restore power to the slot.

Slot Release Levers and the Power Function

Hot plug systems use electronic switches that disable power to the hot plug slots. These switches are attached to slot release levers that protect the hot plug hardware from damage resulting from accidental removal of active controllers. The switches do not serve the same function as the Power function of the PCI Hot Plug Utility. When the PCI Hot Plug Utility powers off a PCI slot, it notifies the system and the device driver that the device is unavailable. This notification occurs only when the PCI Hot Plug Utility powers off the slot. If the slot release lever is used while the PCI slot is still powered on, the device drivers are not given advance notice of the power loss. This action may cause data loss or system instability.

TROUBLESHOOTING

The PCI Hot Plug service logs three types of events:

- Errors internal to the service (labeled CPQRCMC)
- Hot plug events (labeled Hot Plug)
- Driver errors, such as failures logged by drivers to the service

Internal errors are only logged to the NT Event log, whereas driver errors and hot plug events are logged to the Compaq Integrated Management log in addition to the NT event log. Table 9 describes Windows NT event log entries for the PCI Hot Plug service.

TABLE 9: EVENT LOG ENTRIES FOR CPQRCMC

Category	Severity	Event Description Text	Comments and Recommendations
Device Driver	Error	The device driver, Cpqarray, reported a critical condition: Drive Array Controller Failure (Bus X, Slot Y)	A SMART-2 Array Controller has failed or was manually failed. Check the cables and look for event log entries with CPQARRAY as the source.
Device Driver	Informational	The device driver, Cpqarray, reported a repair to: Drive Array Controller Failure (Bus X, Slot Y)	Indicates that the previously reported failure of the SMART-2 Array Controller has been repaired. No action is required.
Device Driver	Warning	The device driver, CpqNF32, reported a warning: Network Adapters No Longer Redundant (Slot X, Port Y)	A NetFlex-3/Netelligent controller that is part of a controller pair has failed or was manually failed. Check cables and look for event log entries with CPQNF32 as the source.
Device Driver	Informational	The device driver, CpqNF32, reported a repair to: Network Adapters No Longer Redundant (Slot X, Port Y)	Indicates that the previously reported failure of the NetFlex-3/Netelligent controller has been repaired. No action is required.
Hot plug	Informational	The Compaq Hot Plug Service, Cpqrcmc.exe, reported: Slot Lever Closed (Slot X)	The slot release lever for the slot specified was closed. No action required.
Hot plug	Informational	The Compaq Hot Plug Service, Cpqrcmc.exe, reported: Slot Lever Opened (Slot X)	The slot release lever for the specified slot was opened AFTER the slot was powered off by the PCI Hot Plug Utility. No action required.
Hot plug	Informational	The Compaq Hot Plug Service, Cpqrcmc.exe, reported: Slot Power Off (Slot X)	The PCI Hot Plug Utility turned off the power to the specified slot. No action required.
Hot plug	Informational	The Compaq Hot Plug Service, Cpqrcmc.exe, reported: Slot Power On (Slot X)	The PCI Hot Plug Utility turned power on for the specified slot. No action required.
Hot Plug	Warning	The Compaq Hot Plug Service, Cpqrcmc.exe, reported a warning: Unexpected Power Loss (Slot X)	The slot release lever was opened BEFORE the slot power was removed using the PCI Hot Plug Utility. Always turn off power to the PCI slot using the PCI Hot Plug Utility BEFORE operating the slot release lever.

Warning: *Attempting to perform PCI Hot Plug operations on an adapter that is not hot plug aware can cause unpredictable results, including system failure or data loss. Before performing a PCI Hot Plug operation, make certain that the slot does not contain an unsupported PCI device. Do not attempt to utilize unsupported adapters as replacement adapters in PCI Hot Plug operations.*

Table 10 provides a listing of pop-up error messages with descriptions of the problems that cause them and recommended corrective actions.

TABLE 10 : POP-UP ERROR MESSAGES AND RECOMMENDED ACTIONS

Pop-Up Error Message	Description of Problem	Recommended Actions
Critical Error on slot N: The adapter inserted is the wrong revision. Try a different adapter.	With hot replacement, only adapters of the same revision can be used to replace a failed adapter.	Insert an adapter of the same revision as the failed adapter, or cycle the system power to reset the adapter revision.
Critical Error on slot N: An incorrect adapter was inserted. Try a different adapter.	With hot replacement, only adapters of the same type can be used as replacements for failed adapters.	Insert an adapter of the same type as the failed adapter being replaced, or cycle the system power and reconfigure the system to use the new adapter type.
Critical Error on slot N: The space allocated for resources on this controller is too small. Try a different adapter.	Some memory or I/O space requirement of the replacement adapter is larger than the requirements of the original adapter.	Insert an adapter with the same memory and I/O size requirements as the original board, or cycle system power and reconfigure the system to accept the new adapter requirements.
Critical Error on slot N: Can't configure the adapter.	Most likely cause is that an incorrect replacement adapter was inserted	Insert an adapter with the same options or modules installed, or cycle system power and reconfigure the system to use the new adapter.
Critical Error on slot N: Unexpected power loss. The slot lever was opened, before power to the slot was off.	Unexpected power loss to the PCI slot; the slot release lever was operated on a supported adapter before the PCI Hot Plug Utility was used to turn off power to the slot.	Always use the PCI Hot Plug Utility to turn off power on a slot before operating the slot release lever.

If, after following all of the recommended actions, a replacement adapter continues to cause one of the problems listed above, try moving the adapter to a different PCI slot. Moving the adapter to a different slot will require cycling the system power and performing a system configuration to reconfigure the PCI bus.

Hot Plug Related Windows NT Registry Entries

Table 11 lists the Windows NT registry entries that pertain to Compaq PCI Hot Plug components. These registry entries should not be modified with the Registry Editor. Modification of these registry entries could lead to unpredictable system behavior or loss of hot plug functionality.

TABLE 11: HOT PLUG RELATED WINDOWS NT REGISTRY ENTRIES

Registry Entry Name	Description/Comments
HKEY_LOCAL_MACHINE\SOFTWARE\Compaq\CPL Launcher\CPQPCI	PCI Hot Plug Utility applet
HKEY_LOCAL_MACHINE\HARDWARE\Other_Drivers\SysMgmt	System Management Driver
HKEY_LOCAL_MACHINE\SOFTWARE\CpqRcmc\ClassDLLs\NicMiniport\CPQNF3	Pointer to hot plug support driver.
HKEY_LOCAL_MACHINE\SOFTWARE\CpqRcmc\ClassDLLs\SCSIMiniport\CPQ32FS2	Pointer to hot plug support driver.
HKEY_LOCAL_MACHINE\SOFTWARE\CpqRcmc\ClassDLLs\SCSIMiniport\CPQARRAY	Pointer to hot plug support driver.

PCI Hot Plug Related Files for Windows NT 4.0

Table 12 lists files associated with implementing hot plug functionality under Windows NT Server 4.0. It includes files associated with specific devices and files updated to support hot plug functionality.

TABLE 12: FILES RELATED TO PCI HOT PLUG FOR WINDOWS NT 4.0

Path and File Name	Description
\%SystemRoot%\system32\CPQHPL.CPL	Compaq PCI Hot Plug Utility control panel applet (points to CPQPCI.EXE)
\%SystemRoot%\system32\CPQPCI.EXE)	Compaq PCI Hot Plug Utility
\%SystemRoot\\system32\CPQRCMC.EXE	Compaq Remote Monitoring service
\%SystemRoot\\system32\CPQRPCL.DLL	Compaq Remote Procedure Call DLL to CPQRCMC
\%SystemRoot%\system32\cqrnicmn.dll	Class DLL for Network Interface
\%SystemRoot%\system32\cqrscsmn.dll	Class DLL for SCSI Interfaces
\%SystemRoot%\system32\NETFLX3.CPL	Advanced Network Control Utility control panel applet (points to NETFLX3.EXE)
\%SystemRoot%\system32\NETFLX3.DLL	Device-class DLL for NetFlex-3/Netelligent
\%SystemRoot%\system32\NETFLX3.EXE	Advanced Network Control Utility
\%SystemRoot%\system32\CPQACU*.*	Compaq Array Configuration Utility and supporting files
\%SystemRoot%\system32\drivers\NETFLX3.SYS	Device driver for NetFlex-3/Netelligent
\%SystemRoot%\system32\drivers\SYSDOWN.EXE	System shutdown utility
\%SystemRoot%\system32\drivers\SYSMGMT.SYS	Compaq System Management driver
\%SystemRoot%\system32\drivers\CPQARRAY.SYS	Compaq Smart-2 Disk Array Controller device driver
\%SystemRoot%\system32\drivers\CPQ32FS2.SYS	Compaq 32-Bit Fast SCSI-2 device driver

FUTURE RELEASES

Compaq is working directly with Microsoft to ensure that PCI Hot Plug functionality is included in future releases of the Windows NT operating system. When Windows NT offers built-in hot plug support, Compaq drivers and services will take full advantage of the standard interfaces.

The first release of PCI Hot Plug technology for Windows NT provides the ability to hot replace PCI options. Future releases of PCI Hot Plug technology for Windows NT will provide the ability to perform hot upgrades and hot expansions. With hot upgrade capability, PCI option upgrades and driver code upgrades will occur without shutting down the system. Hot expansion capability provides a means for expanding the number of PCI options without shutting down the system. These future extensions of PCI Hot Plug technology will provide extremely flexible and reliable solutions that adapt to customer needs.

SUMMARY

Compaq is committed to making PCI Hot Plug an open industry standard, which translates into increased diversity of hot pluggable devices and decreased dependence on any single vendor. Compaq offers additional options that enhance the fault tolerance and system availability of Compaq servers, such as network controller redundancy and mass storage controller redundancy. Compaq PCI Hot Plug technology for Windows NT will soon advance fault tolerance from current hot replacement technology to the next generations: hot upgrade and hot expansion. These advances will provide system administrators with the tools they need to provide unsurpassed system availability, even during times of growth and change.