

# TECHNOLOGY BRIEF

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## Compaq PCI Hot-Plug in a Microsoft® Windows NT® Server Environment

*The need for high-availability solutions to reduce or eliminate unscheduled downtime is affecting an increasingly broad base of business. As companies begin to take advantage of industry standard platforms to deploy distributed, business-critical computing infrastructures, the emphasis on high availability and fault tolerance will continue to increase.*

*With the introduction of PCI hot-plug technology, Compaq has taken an important step toward answering this need. This technology reduces the cost of problem resolution by allowing system administrators to identify and replace suspect or failed PCI boards without bringing down the system.*

*This paper outlines the interactions between the PCI hot-plug technology and the Windows NT® operating environment. This technology is being developed for the next generation of Compaq servers.*

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A fundamental key to hot-plug development as an open standard is the PCI SIG. Compaq initiated and currently chairs the workgroup aimed at establishing a recognized industry standard for PCI hot-plug technology. As one of the five founding members of the overall PCI standards body, Compaq previously led similar efforts such as the development of the PCI Specification version 2.1. The PCI hot-plug workgroup includes other industry leaders such as Adaptec, Cirrus Logic, Hewlett-Packard, IBM, Intel, and Texas Instruments. The workgroup has made significant strides since its inception in June 1996, including:

- Established the objectives of the PCI hot-plug specification and drafted a set of goals to meet those objectives.
- Identified and agreed upon the component concepts (systems, OS, and adapters).
- Completed first draft of the specification, and in review by workgroup.

Compaq is working with major OS vendors to accelerate the delivery of the technology and to ensure the incorporation of PCI hot-plug capabilities into planned releases of the operating systems. Compaq is also assisting independent hardware vendors in their development of hot-plug aware device drivers. In addition, Compaq will develop hot-plug capable drivers for leading server adapters such as the NetFlex-3 controllers, Netelligent controllers, the SMART-2/P Disk Array Controller and the Fast Wide SCSI-2 controller.

The three pieces of the standardization effort (PCI SIG, OS, and IHV) encompass a broad range of companies and expertise areas. Because of the breadth of expertise needed, Compaq is in a unique position to lead the industry in developing such a global open standard. Compaq has both the hardware expertise to identify appropriate standard requirements and the software expertise to provide enabling technologies to the OS and independent hardware suppliers. Because of this unique position, Compaq is able to gather the support of major OS suppliers, IHVs, and systems companies that will allow PCI hot-plug to become an open industry standard.

### **Hardware Supported**

PCI hot-plug is initially being deployed on the next generation family of high-end Compaq server platforms based on the Intel Pentium Pro processor. As a superset of the PCI standard, the PCI hot-plug bus will accept any standard PCI controller. However, only controllers which have hot-plug aware drivers can take full advantage of the hot-plug capability. Several independent hardware vendors are committed to providing hot-plug capable devices at or near the time these systems become available. Compaq will make hot-plug aware versions of the NetFlex-3 and Netelligent network interfaces, the Smart-2/P Disk Array Controller and the Fast-Wide SCSI-2 controllers available at the time hot-plug systems ship in the first half of 1997.

### **Software Supported**

Compaq will provide a utility for monitoring and controlling the hot-plug PCI slots on the local system or on network connected nodes, as illustrated in Figure 1. This utility will use Remote Procedure Calls (RPC) to communicate with the Compaq systems management driver (SYSMGMT.SYS). The systems management driver, included with the Compaq SSD for Windows NT, acts as the intermediary between the hot-plug aware device drivers and the hot-plug bus. Using this intermediary precludes the need for imbedded changes of the operating system, allowing device driver development to be independent of hot-plug aware operating system releases. Compaq will provide PCI hot-plug device drivers that run under Microsoft Windows NT 4.0 for NetFlex-3 and Netelligent network interfaces as well as the Smart-2/P Disk Array Controllers. Future releases of Windows NT will include hot-plug capable device drivers.

## SUMMARY OF PCI HOT-PLUG TECHNOLOGY

Compaq is developing hot-plug solutions that consist of the hot-plug system hardware, hot-plug aware device drivers, system software and operating system support, and a user interface (see Figure 1). The Compaq PCI hot-plug hardware isolates each PCI hot-plug slot from all other devices on the PCI bus. This level of isolation is vastly superior to other possible implementations that would isolate only groups of PCI slots, or even entire PCI buses. By offering slot-level controls, Compaq provides the greatest flexibility in fault isolation and recovery. This level of isolation eliminates interruption to other components and applications using those components, enabling the system to continue performing useful work throughout the hot replacement.

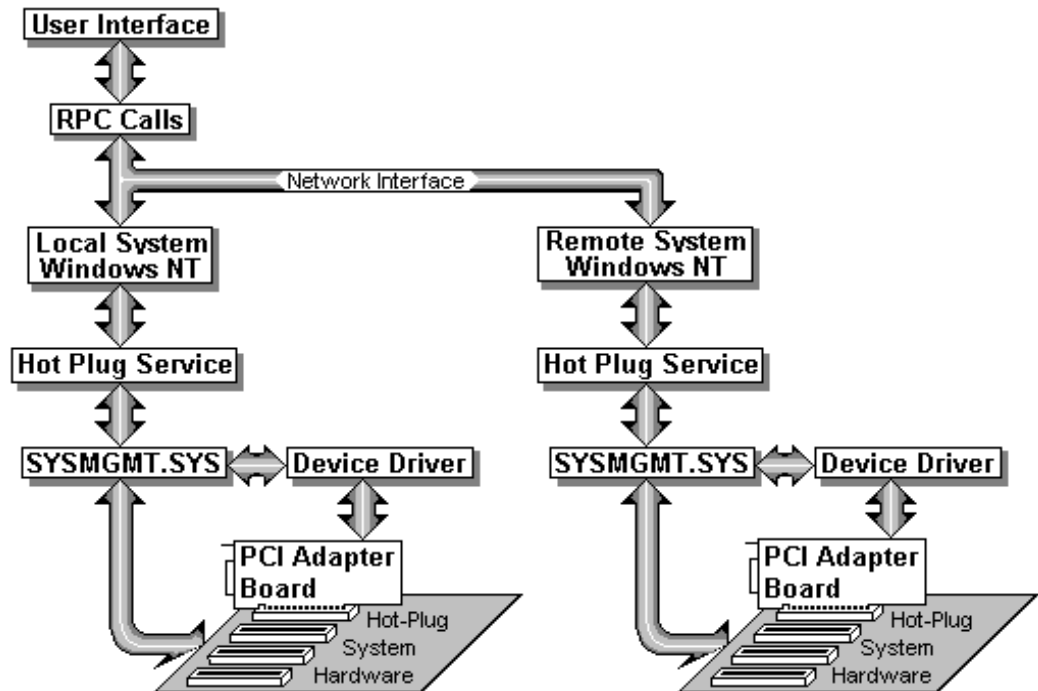


Figure 1: Overview of PCI hot-plug

Compaq intentionally designed hot-plug technology such that no hardware changes are required for industry-standard PCI adapter boards. New features need only be added to the device driver to fully utilize hot-plug capabilities. This design criteria is one reason that independent hardware vendor support for PCI hot plug is so strong.

## OPERATIONAL ELEMENTS

Installation of the hot-plug user interface creates a new icon in the Control Panel called Compaq Hot-Plug. This utility can also be accessed through a shortcut in the Administrative Tools folder. The utility provides a means for managing the hot-plug PCI slots on the local server and on remote nodes. A built-in filter permits the user to select the chassis and slots being viewed. The Compaq hot-plug utility provides information about the controllers plugged into the hot-plug slots, such as card location, board specific information, driver name, duplex status, and board status.

The administrator can use the Compaq hot-plug utility to perform the following maintenance tasks:

- Turn the power to individual slots off and on to permit controller replacement
- View the properties page(s) for the controllers
- Mark devices "Failed" when they are suspect and remove that status once repaired
- Run diagnostics on the controllers to determine their current status

Along with the Compaq hot-plug utility, the Compaq SSD for Windows NT provides several other utilities that enhance the fault protection of Compaq servers. These include the Compaq Mass Storage Controller Duplexing utility and the Advanced Network Control utility. While not directly involved in the management of the hot-plug PCI bus, these utilities work in cooperation with the hot-plug aware drivers to provide increased management capability for hot-pluggable devices.

The Compaq Mass Storage Controller Duplexing utility sets up controller redundancy for Compaq SMART-2 and SCSI-2 controllers. This arrangement provides protection against the failure of a single controller as described in the next section titled *Mass Storage Controller Duplexing*.

The Advanced Network Control utility configures and manages NetFlex-3 and Netelligent network interface controllers (NICs). In addition, the system management interface allows the utility to manage NetFlex-3 and Netelligent NICs on other systems connected to the network.

This utility also provides the administrator the ability to form and dissolve redundant controller pairs, install, uninstall or update device drivers, or view and manage the properties of the individual controllers. For more information about the Advanced Network Control utility, see the Compaq White Paper, *Compaq Advanced Network Error Correction Support in a Microsoft Windows NT Environment* document number 114A/1196.

### Mass Storage Controller Duplexing

Controller duplexing creates a high level of redundancy in the mass storage subsystem by effectively linking two similar controllers into a cooperative pair. The Compaq Mass Storage Controller Duplexing 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.

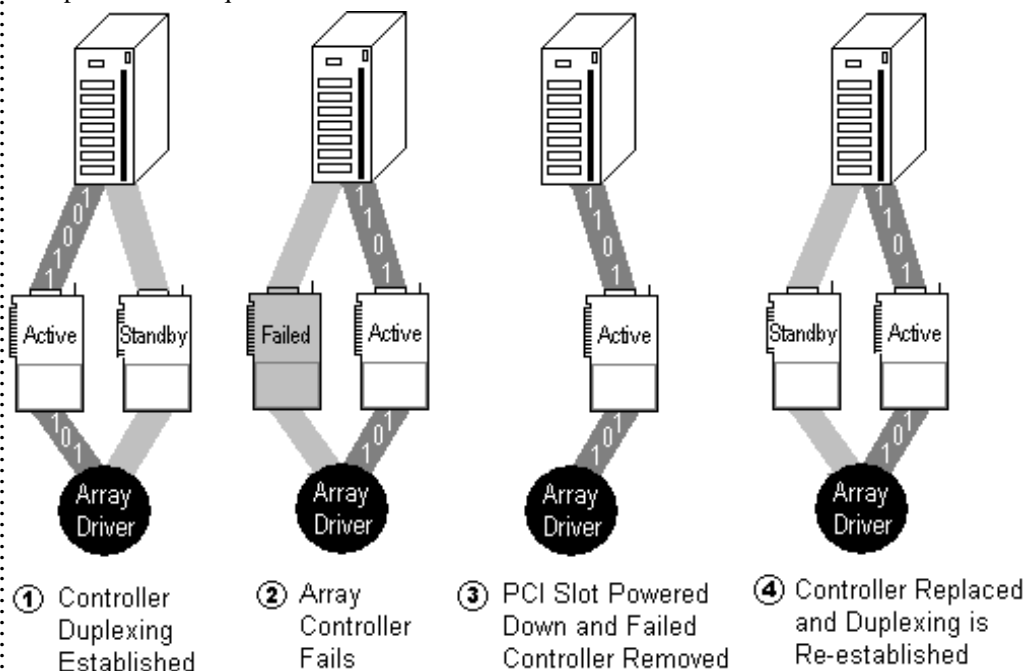


Figure 2: Recovering from a mass storage controller failure using controller duplexing and PCI hot-plug

Hot-pluggable disks provide a means of preserving data availability when a disk fails. However, if a PCI controller failed, the system previously required a shutdown to replace the failed device. PCI hot-plug provides a means for replacing a mass storage controller without shutting down the system. The administrator powers off the PCI slot with the Compaq Hot-Plug utility while the rest of the system remains unaffected. After replacing the failed controller, the administrator powers on the PCI slot again through the Compaq Hot-Plug utility. The device driver automatically detects the restored controller. 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 2.

### Redundant Network Interface Controller Technology

A controller pair is formed when two network interface controllers 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. This change occurs regardless of the cause of the problem, including a break in the physical network wiring or even a failure of the hub.

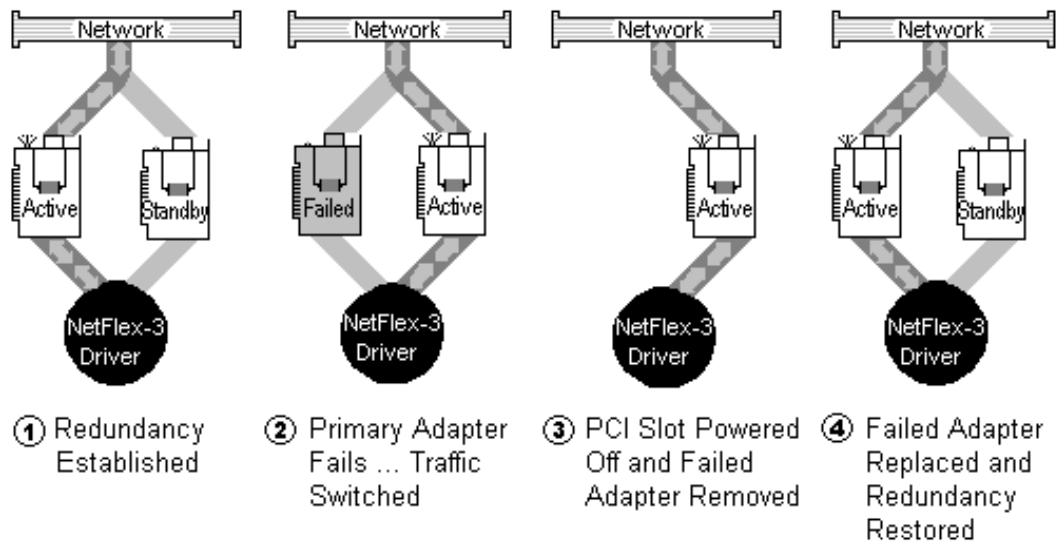
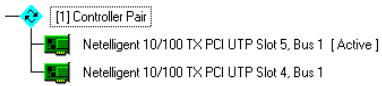


Figure 3: Recovering from network controller failure using network controller redundancy and PCI hot-plug

When the network interface module must be replaced, PCI hot-plug functionality permits the system administrator to do so without shutting down the system, as shown in Figure 3. Using the Compaq Hot-Plug utility the administrator powers off the affected PCI slot. The administrator then replaces the failed module and activates the slot again through the Compaq Hot-Plug utility.

The device driver automatically detects the presence of the replacement module. The driver provides three options for switching the controllers into active service; Manual, Switch on Fail, and Smart Switch. The Switch Now button invokes an immediate manual switch. Switch on Fail performs a switch automatically whenever the active adapter fails. Smart Switch activates the redundant adapter only when the primary adapter fails and reactivates the primary adapter when it becomes operational again.

Using PCI hot-plug technology the administrator maintains the fault tolerance of the network interface without incurring downtime or loss of connectivity to the server.

**FUTURE APPLICATIONS OF HOT-PLUG TECHNOLOGY**

Compaq is striving to making PCI hot-plug an industry standard to simplify the process of extending the number and variety of hot-plug capable devices available. Compaq is also working directly with several independent hardware vendors to assist them in producing hot-plug aware device drivers for their PCI controllers.

Future releases of Compaq hot-plug technology will permit hot upgrades of hardware, and hot expansions as well. Hot upgrades will allow PCI option upgrades to next generation hardware without interruption of service. Hot expansion will provide the opportunity to add PCI options to a server while the system remains operational. These future enhancements of hot-plug technology extend beyond fault tolerance into the realm of change tolerance.

**SUMMARY OF TECHNOLOGY**

The introduction of Compaq PCI hot-plug technology greatly enhances the fault tolerance and the general reliability of midrange systems. By designing hot-plug technology around the Intel Pentium Pro processor and enhancing the industry standard PCI bus, customers benefit from the significant advantages of this architecture, including increased option availability and excellent price/performance. Because the PCI hot-plug bus can accept any industry standard PCI controller, no special controllers are required to build Compaq hot-plug systems. Systems configured with traditional PCI devices today can be made hot-plug capable through the installation of hot-plug aware device drivers as they become available.

Future releases of the PCI hot-plug technology will extend the capabilities of Compaq servers even further, permitting the hot upgrade of existing modules and the hot expansion of the system options. Coupled with existing and enhanced fault tolerance technologies, these extensions of the hot-plug technology will set new standards for high availability systems. Compaq is a leader in delivering innovative, new technologies that provide increased system availability and serviceability for critical application environments.