TECHNOLOGY BRIEF

September 1998

Compaq Computer Corporation

ECG Technology Communications

CONTENTS

Compaq Fibre Channel Storage System Technology

EXECUTIVE OVERVIEW

The Compaq Fibre Channel Storage System is the first Compaq primary storage solution incorporating Fibre Channel interconnect technology. This solution overcomes inherent limitations of small computer systems interface (SCSI) interconnect technology. It is designed to satisfy the requirement of such enterprise applications as databases, data marts, email, groupware, web servers, and file and print for ever greater storage capacity and scalable input/output (I/O) performance. The architecture of this initial Fibre Channel storage solution enables administrators to achieve multiple goals simultaneously:

- To scale the storage capacity supported by a single, six-PCI-slot server easily and cost effectively from gigabytes to more than 9.6 terabytes
- To scale the storage capacity supported by a single I/O slot easily and cost effectively to more than 1.6 terabytes
- To scale cache and processing power for increased I/O performance
- To conserve I/O slots for connecting other types of I/O devices

This technology brief explains the hardware components, hardware architecture, firmware functionality, software support, and performance expectations for the Fibre Channel Storage System. It discusses anticipated future enhancements. It also identifies by title and number other Compaq documents about related topics. To view those documents, visit the Compaq website: www.compaq.com

Please direct comments regarding this communication to the ECG Technology Communications Group at this Internet address: TechCom@compaq.com

NOTICE

Compaq Fibre Channel Storage System Technology

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INTRODUCTION

SCSI: small computer system interface

Applications central to enterprise operations demand remarkable storage capacity and scalable performance. Data marts, for example, may grow by as much as 400 percent per year. Email data and Lotus Notes data typically double each year. Databases and consolidated print and file applications also demand ever increasing storage capacity. With its inherent I/O and physical limitations, SCSI technology cannot support the scalability of storage capacity and I/O performance required by such applications.

The expanding needs for enterprise storage capacity and performance demand new storage solutions. Through extensive study of possible alternatives, Compaq determined that Fibre Channel is the best interconnect technology to propel future growth of enterprise storage. As a result, Compaq actively participates in industry standardization efforts for Fibre Channel interconnect technology and is developing products incorporating that technology.

***NOTE**: This paper includes the terms "fibre" and "fiber." Fibre is the international spelling used in Fibre Channel standards to include both optical and copper media. Fiber refers to the optical media used to implement Fibre Channel.*

The Compaq Fibre Channel Storage System is the first Compaq primary storage solution incorporating Fibre Channel technology. The Fibre Channel architecture of this solution enables administrators to scale the storage capacity supported by a single, six-PCI-slot server from gigabytes to more than 9.6 terabytes, while simultaneously scaling cache, processing power, and throughput of their storage subsystem. This leap in capacity and scalability results from hardware and software innovations to proven Compaq products and from total integration of the storage system. The Fibre Channel Storage System is targeted for computing environments with requirements for large and rapidly growing storage capacity and for scalable I/O performance.

This technology brief will explain the hardware components, hardware architecture, firmware functionality, software support, and performance expectations for the Fibre Channel Storage System. It will also discuss anticipated future enhancements. A companion technology brief explains the Compaq strategy for developing high-performance and high-capacity external storage based on Fibre Channel technology. On the Compaq website, see *Strategic Direction for Compaq Fibre Channel-Attached Storage*, document number ECG009.1097.

HARDWARE TECHNOLOGY

The Fibre Channel Storage System comprises nine hardware components that can be interconnected to form a Fibre Channel Arbitrated Loop (FC-AL) topology:

- Compaq Fibre Channel Array
- Compaq Fibre Channel Array Controller
- Compaq Fibre Channel Host Adapter
- Compaq Fibre Channel Storage Hub 7
- Compaq Fibre Channel Storage Hub 12
- Short wave gigabit interface converters (GBICs-SW)
- Long wave gigabit interface converters (GBICs-LW)
- Multimode fiber optic cables
- Single-mode fiber optic cables

This section will describe the function of each hardware component and then explain the hardware architecture and Fibre Channel topology used in the Fibre Channel Storage System.

Fibre Channel Array

A Fibre Channel Array is an external drive enclosure containing a high-performance Fibre Channel Array Controller, disk drive housings, fan assembly, and power supplies. A single Fibre Channel Array accommodates up to eight 1.6-inch or twelve 1-inch Wide-Ultra SCSI-3 drives. As Table 1 shows, a single, fully populated Fibre Channel Array can provide a total capacity of up to 145.6 gigabytes using eight spindles. For installations in which improved performance is more important than maximum capacity, 12 spindles placed in a Fibre Channel Array can provide up to 109.2 gigabytes of capacity.

Spindle: a hard disk drive

The Fibre Channel Array is available in tower or 4U rack form factor. It supports hot-pluggable drives plus a hot-pluggable, redundant fan assembly and power supplies. In the future it will also support hot-pluggable, redundant Fibre Channel Array Controllers.

Table 1: Storage Capacity of a Single Compaq Fibre Channel Array

Maximum Number of Drives	Drive Size (inches)	Native Capacity per Drive (gigabytes)	Maximum Total Capacity (gigabytes)		
			RAID 0	RAID 1	RAID 4 or 5
8	1.6	18.2	145.6	72.8	127.4
8	1.6	9.1	72.8	36.4	63.7
12	1.0	9.1	109.2	54.6	100.1
12	1.0	4.3	51.6	25.8	47.3

Fibre Channel Array Controller

The Fibre Channel Array Controller is an intelligent Fibre Channel-to-SCSI array controller integrated into the Fibre Channel Array. The controller is based on the Compaq SMART-2 architecture and has two Wide-Ultra SCSI-3 channels. Each channel can transfer data at 40 megabytes per second for a total of 80 megabytes per second possible internal bandwidth. The array controller-to-host interface is Fibre Channel for high-speed connection to the server. The Fibre Channel interface can transfer data to the server at burst rates of 100 megabytes per second.

RAID: redundant array of independent disks

The Fibre Channel Array Controller supports RAID 0, 1, 4, and 5. It also supports multiple logical drives and on-line capacity expansion within the array. It features sixth-generation Compaq RAID technology and components and a total of 64 megabytes of usable cache (16 megabytes read and 48 megabytes user-selectable read/write).

The Fibre Channel Array Controller supports Wide-Ultra SCSI-3, Fast-Wide SCSI-2, or Fast SCSI-2 drives. Use of SCSI technology inside the Fibre Channel Array allows customers to use existing SCSI disk drives. Since hard disk drives are the most costly part of a storage system, this compatibility can reduce the cost of implementing a Fibre Channel Storage System.

Hot-Swapping Disk Drives

The Fibre Channel Array Controller supports removing individual failed disk drives from a Fibre Channel Array and replacing them while the array is active on the Fibre Channel loop. Once the new drives are installed, the Compaq Automatic Data Recovery software rebuilds data to the new drives automatically, without administrator intervention.

On-Line Capacity Expansion

The Fibre Channel Array Controller supports adding disk drives to a Fibre Channel Array and redistributing the data across the drives in the array while the array is active on the Fibre Channel loop. Note, however, that an entire Fibre Channel Array cannot be added to the storage system while the loop is active.

Array Accelerator

Each Fibre Channel Array Controller integrated in a Fibre Channel Array includes an enhanced Array Accelerator with a total of 64 megabytes of cache. Of that total, 16 megabytes is dedicated read cache that is integrated on the base controller board. The remaining 48 megabytes is user-selectable (using the Compaq Array Configuration Utility described later), battery-backed read/write cache located on a small, removable board that plugs into the base controller. For owners of the original Fibre Channel Array Controller with 32 megabytes of cache, Compaq also offers a memory upgrade that expands the total memory available to 64 megabytes. This memory upgrade is also battery-backed and easy to install. The default allocation of this memory cache is 50 percent read cache and 50 percent write cache. Through firmware, the user can change this allocation from 0 to 100 percent for read cache and from 0 to 75 percent for write cache.

The Fibre Channel Array Controller uses a write caching scheme that allows applications to continue without waiting for write operations to complete. This technique is also referred to as a posted-write caching scheme. Without this type of caching, the controller would be forced to wait until write data is actually written to disk before returning completion status to the operating system. With write-back caching, the controller can post write data to high-speed cache memory and immediately return completion status to the operating system. The write operation is completed in microseconds rather than milliseconds. Data in the write cache is written to disk later, at an optimal time for the controller.

DRAM: dynamic random access memory

While data is in the write cache, it is protected against memory chip failure by Error Checking and Correcting (ECC) technology and against system power loss by integrated battery backup. The removable DRAM and batteries keep posted-write data secure in the unlikely event that power should be lost or the base controller board should fail. Should a system power outage occur while write data is stored in the cache, the data will be protected for at least four days by power from the battery backup system. Once system power is returned, the posted-write data will automatically be written to disk. Should the base controller board fail, the small write cache board can be removed and installed on a replacement base controller board, and the posted-write data will automatically be written to disk.

The 16-megabyte read-ahead cache integrated on the Fibre Channel Array Controller uses an intelligent read-ahead algorithm that can anticipate data needs and reduce latency. It can detect sequential read activity on single or multiple I/O threads and predict that sequential read requests will follow. It then reads data from the disk drives before the data is actually requested. When the read request does occur, it can then be serviced out of the high-speed cache memory at microsecond speeds rather than from the disk drive at millisecond speeds. This adaptive read-ahead scheme provides excellent performance for sequential small block read requests. At the same time it avoids degradation of random read performance because firmware automatically disables read-ahead when nonsequential read activity is detected.

The ECC technology used on the Array Accelerator provides greater data protection than mirroring and is much more cost effective. The ECC scheme generates 16 bits of check data for every 64 bits of user data. This check data can be used not only to detect errors but also to correct them. ECC can be used to detect and correct DRAM bit errors, DRAM chip failures, and memory bus errors on the Array Accelerator connector.

Fibre Channel Host Adapter

The Compaq Fibre Channel Host Adapter is a high-speed host interface that provides connectivity from the server to one or multiple Fibre Channel Arrays. The host adapter can be connected directly to a single Fibre Channel Array (Figure 1). Using a Fibre Channel Storage Hub, a single host adapter can be connected to multiple Fibre Channel Arrays (Figure 2).

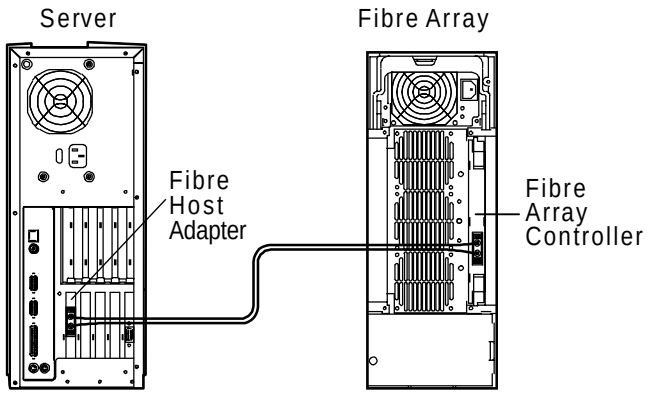


Figure 1. The Compaq Fibre Channel Host Adapter can be connected directly to a single Fibre Channel Array by means of fiber optic cable.

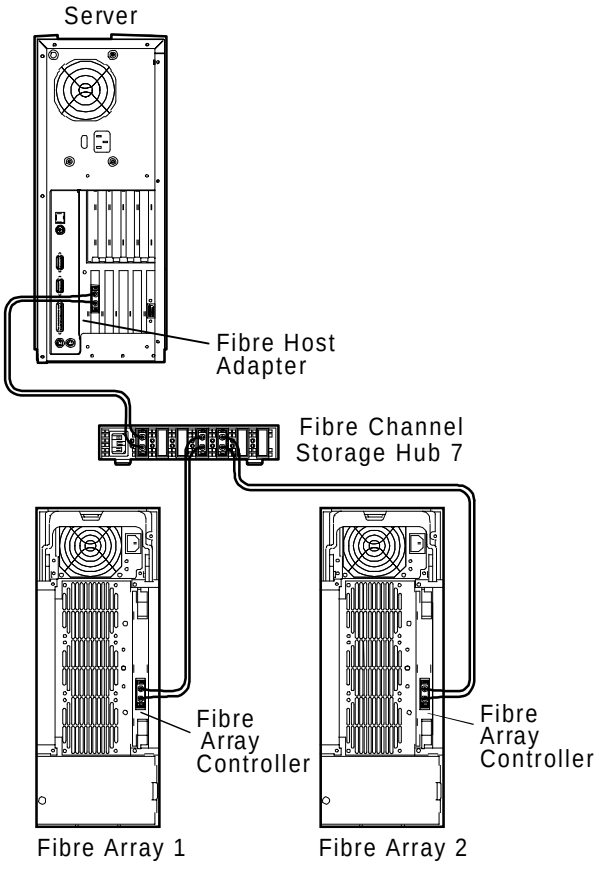


Figure 2. A Fibre Channel Storage Hub is used to connect the Fibre Channel Host Adapter to multiple Fibre Channel Arrays.

The Fibre Channel Host Adapter is available in either a PCI version or an EISA version. The Fibre Channel Host Adapter/P is a PCI bus master device. The Fibre Channel Host Adapter/E is for use in a server equipped only with an EISA expansion bus or with a server that has a majority of EISA bus slots. It takes advantage of the EISA architecture by performing 32-bit bus master burst transfers. Both the PCI and EISA versions of the Fibre Channel Host Adapter require installation of a gigabit interface converter into the I/O port before the multimode fiber cable is connected.

The Fibre Channel Host Adapter supports the Compaq ProLiant and Rack-Mountable ProLiant family of servers. For up-to-date information about specific server models supported, consult the Compaq website.

Fibre Channel Storage Hub 7

The Compaq Fibre Channel Storage Hub 7 is a seven-port hub that creates a 100-megabytes-per-second Fibre Channel Arbitrated Loop through its internal wiring and logic. In a standard Fibre Channel Storage System configuration, it connects one Fibre Channel Host Adapter and up to six Fibre Channel Arrays. A 1U rackmount kit is available for the Storage Hub 7.

With the use of a Storage Hub 7, a Fibre Channel Host Adapter occupying a single I/O slot can support up to six Fibre Channel Arrays for a total storage capacity of either 873.6 gigabytes (using 48 x 18.2-gigabyte, 1.6-inch drives) or 655.2 gigabytes (using 72 x 9.1-gigabyte, 1.0-inch drives). If, for example, sufficient slots were available in a server, eight Fibre Channel Host Adapters plugged into that server could support 48 Fibre Channel Arrays for a total capacity of 7.0 terabytes. By contrast, Compaq SMART Array Controllers can support only two ProLiant Storage Systems per I/O slot.

Fibre Channel Arrays can be added to the Storage Hub 7 as requirements for storage capacity grow. However, adding a Fibre Channel Array to the hub requires that the system administrator shut down and restart the server(s) and then run the Compaq Array Configuration Utility, which will be described later.

Compaq recommends use of the Fibre Channel Storage Hub 7 for most Fibre Channel Storage System configurations because it provides the best value for customers.

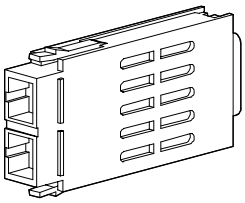
Fibre Channel Storage Hub 12

The Compaq Fibre Channel Storage Hub 12 is an intelligent, unmanaged, 12-port hub similar to the Fibre Channel Storage Hub 7. Every Storage Hub 12 includes both a rackmount kit and rubber feet for desktop use.

With the use of a Storage Hub 12, a Fibre Channel Host Adapter occupying a single I/O slot can support up to eleven Fibre Channel Arrays for a total storage capacity of either 1.6 terabytes (using 88 x 18.2-gigabyte, 1.6-inch drives) or 1.2 terabytes (using 132 x 9.1-gigabyte, 1.0-inch drives). In a server with six PCI slots, Compaq Fibre Channel Storage Hubs 12 allow a maximum storage capacity of more than 9.6 terabytes. By contrast, Compaq SMART Array Controllers can support only two ProLiant Storage Systems per I/O slot.

The Storage Hub 12 will be manageable in the future through a management module upgrade. This hub is therefore the ideal solution for Fibre Channel Storage System configurations requiring either the highest level of slot utilization or storage capacity exceeding 5.2 terabytes for a six-PCI-slot server.

Gigabit Interface Converter

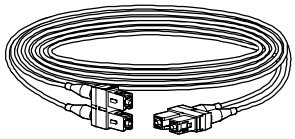


short wave gigabit interface converter (GBIC-SW)

Gigabit interface converters (GBICs) are available in two varieties: short wave (GBIC-SW) for connections up to 500 meters and long wave (GBIC-LW) for connections between 500 meters and 10 kilometers. These industry-standard connection devices hot plug into Fibre Channel storage hubs and controllers. A GBIC converts serial electrical signals to and from serial optical signals for transmission of data across the Fibre Channel media. A GBIC-SW provides a transmission rate of 100 megabytes per second in each direction over 500 meters of 50-micron, multimode fiber optic cable. A GBIC-LW provides a transmission rate of 100 megabytes per second in each direction over 10 kilometers of 9-micron, single-mode fiber optic cable. Taking into account arbitration and transmission overhead, however, the sustainable transmission rate likely to be achieved by a GBIC-SW or a GBIC-LW is 75 to 80 megabytes per second.

A GBIC is required for each connection in a Fibre Channel Storage System. GBICs-SW are provided with Fibre Channel Arrays and Fibre Channel Host Adapters. GBICs-LW and single-mode fiber optic cables, as well as additional GBICs-SW and cables, can be purchased separately.

For trouble-free operation, Fibre Channel connectors and GBICs must be kept clean. To protect them from contamination, GBICs and fiber cables are shipped with dust caps installed. A dust cap should be removed only to make an optical connection; it should be reinstalled if the GBIC or cable is subsequently disconnected. Compaq products ship with instructions for making clean connections. Cleaning should be performed anytime that an open connection might have been exposed to dust or that there is doubt about its cleanliness. A cleaning kit is available from Compaq for this purpose.



50-micron, multimode fiber optic cable

Cables

The Fibre Channel Storage System uses 50-micron, multimode fiber optic cable, and 9-micron, single-mode fiber optic cable. The Fibre Channel Array ships with a 2-meter multimode cable. The Fibre Channel Host Adapter ships with a 5-meter multimode cable. Standard lengths for multimode cable option kits are 2, 5, and 15 meters. For installations requiring longer cable lengths, single-mode cables, or additional cables, customers may contact a Compaq reseller or special cable supplier. The Compaq white paper *Fibre Channel Technology: Understanding Fiber Cabling and Connecting to Building Infrastructure*, document number ECG003/0298, describes Fibre Channel transmission, types of cable, and connection components.

Hardware Architecture

Compaq determined that Fibre Channel is the best interconnect technology to overcome inherent I/O and physical limitations of SCSI technology and to propel future growth of enterprise storage. For its first scalable Fibre Channel storage solution for x86-based servers, Compaq selected Fibre Channel Arbitrated Loop (FC-AL) topology. Document number ECG009.1097, *Strategic Direction for Compaq Fibre Channel-Attached Storage*, explains Compaq strategy for primary storage.

FC-AL is a serial interface that creates logical point-to-point connections between ports. Because it uses the minimum number of transceivers and no centralized switching function, FC-AL provides a low-cost, yet highly flexible solution.

Fibre Channel nodes each have one or more ports that enable external communication. Each port uses two fibres to communicate with its neighboring ports on the loop, one for incoming information and the other for outgoing information. All the components that connect ports comprise the interconnect topology.

The Storage Hub 7 contains seven serially connected ports (Figure 3). The Storage Hub 12, on the other hand, contains 12 serially connected ports. Internal signaling within the hubs is

electrical. The internal connections and logic of the hubs create a Fibre Channel Arbitrated Loop. The bandwidth of the loop is shared by all ports on the loop. A single pair of ports on the loop communicates at any one time, while the other ports on the loop act as repeaters. Each port is fitted with a port bypass switch to maintain the continuity of the loop should a controller or device attached to that port malfunction or be powered off. This port bypass capability improves fault tolerance.

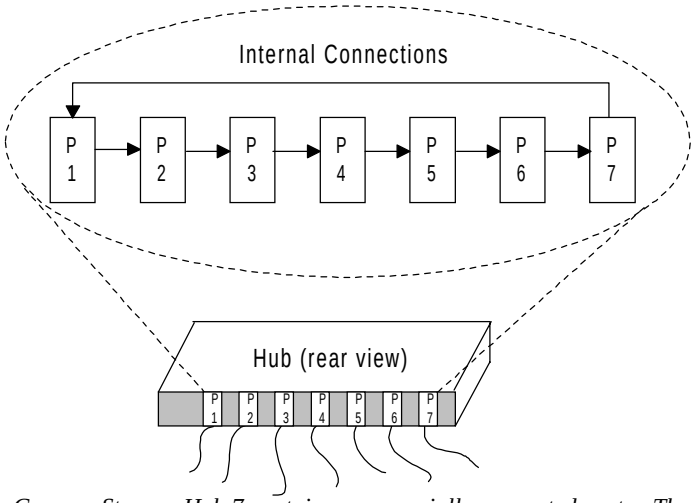


Figure 3. The Compaq Storage Hub 7 contains seven serially connected ports. The internal connections and logic of the hub create a Fibre Channel Arbitrated Loop.

The short wave laser technology used in the Fibre Channel Storage System supports transmission distances between ports of up to 500 meters on 50-micron, multimode fiber optic cable with no electromagnetic interference (Figure 4). Consequently, the Fibre Channel Host Adapter can be located as much as 500 meters from the Fibre Channel Storage Hub, which in turn can be located as much as 500 meters from the Fibre Channel Arrays. GBIC-LW and single-mode fiber optic cables can replace GBIC-SW with mutilmode cables to increase the point-to-point connection distance to 10 kilometers.

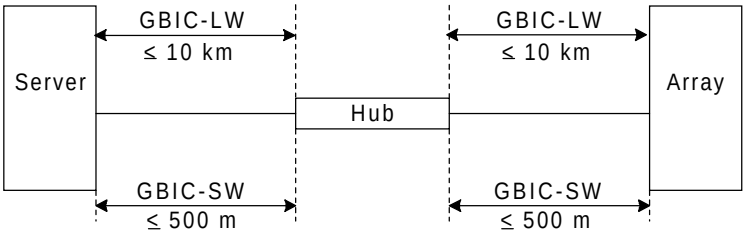


Figure 4. Short wave laser technology and 50-micron fiber optic cable used in the Compaq Fibre Channel Storage System support reliable transfers between system components located up to 500 meters apart. For longer connections, 9-micron fiber cables and GBICs-LW should be used.

In deploying the Fibre Channel Storage System, key goals included expanding the storage capacity accessible by a server, supporting shared storage configurations, and enabling customers to scale storage capacity economically to meet their needs. Compaq achieved these goals by moving disk array controllers outside the server and into external drive array housings and by

connecting them through a Fibre Channel Storage Hub to a host-based adapter occupying a single server slot. With this architecture, a single server can access up to six Fibre Channel Arrays with a potential storage capacity of 1.6 terabytes using only one I/O slot and the Compaq Fibre Channel Storage Hub 12.

The Fibre Channel Storage System supports optional on-line spare drives. Data availability and reliability are enhanced by RAID functionality provided in the Fibre Channel Array Controller and by the data integrity features and low error rates of Fibre Channel. A redundant, hot-pluggable fan assembly and an optional, redundant hot-pluggable power supply add to the subsystem availability.

FIRMWARE

ROM: read only memory

The firmware stored in ROM on the Fibre Channel Host Array Adapter and on Fibre Channel Array Controllers defines the features of the Fibre Channel Storage System. The firmware controls RAID operation, error handling, and management information as reported to Compaq Insight Manager. The Fibre Channel Storage System ships with the appropriate firmware loaded. If a customer chooses to install previously used disk drives in a Fibre Channel Array, however, the administrator may need to flash the disk ROM to upgrade the firmware on the used disk drives.

For easy maintenance, firmware upgrades for the Fibre Channel Storage System can be flashed onto the Fibre Channel Array Controller using Compaq Options ROMPaq. It is provided on the Compaq SmartStart and Support Software CD 3.60 or later that is provided with the Compaq Fibre Channel Host Adapter.

The Compaq SmartStart and Support Software CD contains software, drivers, and utilities that automate installation of a reliable, well integrated, proven server configuration. This easy-to-follow program streamlines server setup, tunes the Compaq server to take full advantage of the hardware and software, and provides consistent server performance.

The Fibre Channel Storage System has enhanced drive array capabilities. Therefore, Compaq recommends that customers use the latest Systems ROMPaq to flash the ROM on existing servers before installing a Fibre Channel Host Adapter. Systems ROMPaq is a special Compaq utility for updating the firmware in Compaq servers. It is also provided on the Compaq SmartStart and Support Software CD 3.60 or later.

OPERATING SYSTEMS SUPPORTED

The Fibre Channel Storage System supports the following operating systems:

- Microsoft Windows NT 4.0
- NetWare 3.12, NetWare 3.20, and intranetWare
- SCO OpenServer 5, UnixWare 2.1, and UnixWare 7
- Banyan VINES 6.x and 7.x
- OS/2 SMP 2.11 and OS/2 Warp Server family of products
- Sun Solaris 2.5, 2.5.1, and 2.6

Installing operating system software from the Compaq SmartStart and Support Software CD 3.6 or later ensures that required device drivers for the operating system will automatically be installed and configured.

With the exception of the new Compaq Fibre Channel Storage Hub 12, components of the Compaq Fibre Channel Storage System support Microsoft Cluster Server. Once the necessary

testing and integration work is complete, the Storage Hub 12 will also support Microsoft Cluster Server. For the most up-to-date information about software support, consult the Compaq website.

COMPAQ UTILITIES

Compaq has developed several utilities to simplify configuration and maintenance of the Compaq Fibre Channel Storage System.

Array Configuration Utility

The Compaq Array Configuration Utility (ACU) uses a graphical interface to streamline configuration of Fibre Channel Arrays. It contains intuitive on-line configuration wizards that provide guided paths for complete array configuration. It also contains customized paths for administrators needing complete control over configuration options. Version 1.20 and later of the ACU provides an interface to intelligent features of the Fibre Channel Array Controller that make it easy for administrators to configure, modify, expand, manage, and monitor their storage. This utility is provided on the Compaq SmartStart and Support Software CD V3.60 or later. It can be used to configure the Fibre Array Controller initially, to add disk drives to an existing configuration, or to reconfigure the controller.

The Array Configuration Utility provides the following assistance:

- Illustrates the controller configuration in an easy-to-understand graphical format
- Contains configuration wizards that walk the administrator through the configuration process
- Suggests optimal configuration and fault tolerance for unconfigured controllers
- Identifies various configuration errors
- Indicates physical location of drives being configured

The concept of an array has a special meaning in the Compaq Array Configuration Utility. An *array* is defined as a set of physical disk drives that are grouped together and can be subdivided into logical drives striped across all disks in the set. Using the Compaq Array Configuration Utility, an administrator can quickly assign physical drives to an array. Up to four drives can be assigned as on-line spares, and from one to 32 logical drives can be created per controller. The ACU steps through each logical drive configuration until all space is allocated. Fault tolerance levels can be selected on a logical drive basis.

Custom configuration paths allow the administrator to examine the details of both logical and physical views and make specific configuration changes if necessary. Graphical views of the array and the logical drives make it easy to visualize how the storage is configured.

Capacity expansion is done at the array level, not at the logical drive level. In most cases, all disk drives attached to a controller should be grouped together into a single array. This provides the most efficient use of RAID redundancy.

In designing the ACU for the Fibre Channel Storage System, Compaq added some new features to assist administrators. For example, if many Fibre Channel Arrays are installed in one location (such as a data center), it may be difficult for an administrator to remember the physical location of the drive being configured at any given time. To eliminate that problem, the ACU now flashes all three LEDs on the physical drive tray for the controller being configured. The user interface has also been changed in this ACU to display more information such as the ID assigned to each Fibre Channel Array on the Fibre Channel Arbitrated Loop. The administrator may change these ID assignments in the Controller Settings window.

LED: light-emitting diode

The Compaq ACU was originally designed to configure a maximum of eight controllers. Currently Windows NT 4.0 supports a maximum of eight logical drives in a Fibre Channel Array. In maximum configuration environments, the ACU may operate a bit slower than expected. As a visual aid at such times, the ACU displays an hourglass cursor to indicate that it is processing.

Fibre Fault Isolation Utility

Since the Fibre Channel Storage System is the first Compaq product to use an FC-AL topology and the loop includes many components, Compaq developed two new support tools: the *Fibre Channel Troubleshooting Guide* and the Fibre Fault Isolation Utility (provided on the Compaq SmartStart and Software Support CD 3.60 and later). The troubleshooting guide describes components of the Fibre Channel Storage System and the Fibre Fault Isolation Utility. It contains flowcharts and other information for troubleshooting.

The purpose of the Fibre Fault Isolation Utility is to verify the installation and operation of a new or existing Fibre Channel Storage System. When used with the troubleshooting flow charts, this utility provides fault detection and help in isolating problems on the Fibre Channel Arbitrated Loop.

Off-line server: a server on which the operating system is not running

Compaq recommends running the Fibre Fault Isolation Utility as soon as all hardware components of the Fibre Channel Storage System have been connected and before configuring the system. This utility is run off-line on the server. It displays a Windows 95 window showing each Fibre Channel Host Adapter and each Fibre Channel Array that is properly connected on the loop. If one of these components is not displayed on the screen, the *Fibre Channel Troubleshooting Guide* should be consulted to determine why.

The Fibre Fault Isolation Utility displays all devices that are properly logged on to the Fibre Channel Arbitrated Loop and tests for link errors within the loop. A link is that portion of the loop between the Fibre Channel Host Adapter and the Fibre Channel Storage Hub or between the Fibre Channel Storage Hub and the Fibre Channel Array.

User Diagnostics

If the Fibre Fault Isolation Utility indicates that a fault exists, the administrator can run the User Diagnostics Utility that Compaq developed for enterprise systems. The User Diagnostics Utility is a group of hardware diagnostic tests designed to test the Compaq Fibre Channel Array and attached SCSI drives. This utility can isolate a fault to a specific drive within a Fibre Channel Array or to a specific link in the loop. Together with the *Fibre Channel Troubleshooting Guide*, the User Diagnostics Utility can be used to find the cause of potential faults in a Fibre Channel Storage System.

NOTE: *With Compaq SmartStart and Support Software CD 3.60, the first test mode of the User Diagnostics Utility is operational only when the utility is run on a notebook computer or a handheld PC. The second test mode will become operational on a server with release of the SmartStart and Support Software CD 4.0. Check the Compaq website at www.compaq.com for future availability.*

The hardware diagnostic tests within the User Diagnostics Utility are grouped into two test modes. The first test mode, which runs on a notebook computer or a handheld PC, takes advantage of the built-in self-test on the Fibre Channel Array Controller to determine which subsystem is failing. Tested components include cache, RAM, PCI bus, SCSI bus, LEDs, Fibre Channel Array Controller, power supply, system fans, GBICs, and fiber cable. This first test mode also displays information about the Fibre Channel Array Controller such as firmware revision, worldwide name, and board serial number. The second test mode, which will run on a server through the Fiber Channel interconnect, displays the array controllers and logical volumes found, configuration revisions, and firmware revisions. These tests allow multiple logical volumes to be exercised simultaneously and trap any error conditions.

The User Diagnostics Utility is available on the Compaq SmartStart and Support Software CD 3.60 or later that is provided with Compaq servers and that ships with the Fibre Host Adapter kit. On the CD, Compaq provides two versions of User Diagnostics: a Windows 95 version (to run on a server or notebook computer) and a Windows CE version (to run on a handheld PC). The two

versions are separate executables. Both versions will provide the same functionality to perform the first test mode. Only the Windows 95 version will provide the functionality to perform the second test mode.

Running User Diagnostics is simple, but it requires slightly different steps, depending on whether the administrator runs the utility on a server, notebook, or handheld PC. Table A in the appendix indicates how to access and run User Diagnostics from the three types of machines.

Array Diagnostics Utility

Because array controllers are complex devices, Compaq provides an Array Diagnostics Utility (ADU) to help administrators quickly identify such problems as an incorrect version of firmware, drives installed in the wrong order, inappropriate error rates, or a failed battery on the Array Accelerator board. The ADU displays an even more detailed analysis of the system configuration than the Array Configuration Utility does. If the cause of a problem is still not apparent, the ADU can generate a full report that administrators can fax or email to Compaq customer service for phone support.

An off-line version of the ADU is provided on the Compaq Support Software CD V3.60 or later. The ADU is designed for use not only with Fibre Channel Array Controllers, but also with Compaq SMART-2 and SMART Array Controllers.

Compaq Insight Manager

SNMP: simple network management protocol

Compaq Insight Manager is a client-server SNMP-based tool for integrated management of the server environment. It provides the capability for monitoring performance and other operating characteristics of SMART-2 or Fibre Channel Array Controller-based storage. It displays configuration information, OS device driver version numbers, controller firmware version numbers, pre-failure warranty information, and operating statistics. The Fibre Channel Storage System is supported by Compaq Insight Manager 3.60 and later.

Insight Manager warns administrators of potential drive problems before they occur. A background task monitors several key drive parameters and notifies Insight Manager if a drive fails to meet certain factory-preset criteria. Insight Manager, in turn, alerts the administrator to the potential problem.

PERFORMANCE

The Fibre Channel Storage System is designed to scale capacity and performance simultaneously. Each Fibre Channel Array adds processing power and cache to the overall system. The more spindles a Fibre Channel Storage System contains, the higher the I/O performance scales. This fact is best illustrated by comparing the maximum number of I/O transactions per second per PCI slot provided by a Fibre Channel Storage System to the maximum number provided by a ProLiant Storage System controlled by a SMART-2DH Array Controller or by a SMART-SL Array Controller (see Figure 5 and Table 2).

In comparative tests performed in Compaq laboratories, test engineers used 2-kilobyte random accesses to simulate an online transaction processing (OLTP) application. The accesses were 67 percent reads and 33 percent writes. The test results shown in Figure 5 indicate that a Compaq SMART-2DH Array Controller occupying a single PCI slot can support approximately 440 simulated OLTP I/Os per second. The Fibre Channel Storage System, on the other hand, can support approximately 2,540 OLTP I/Os per second using a single PCI slot. The high degree of capacity and performance scalability makes the Fibre Channel Storage System an ideal storage solution for large, power-hungry databases.

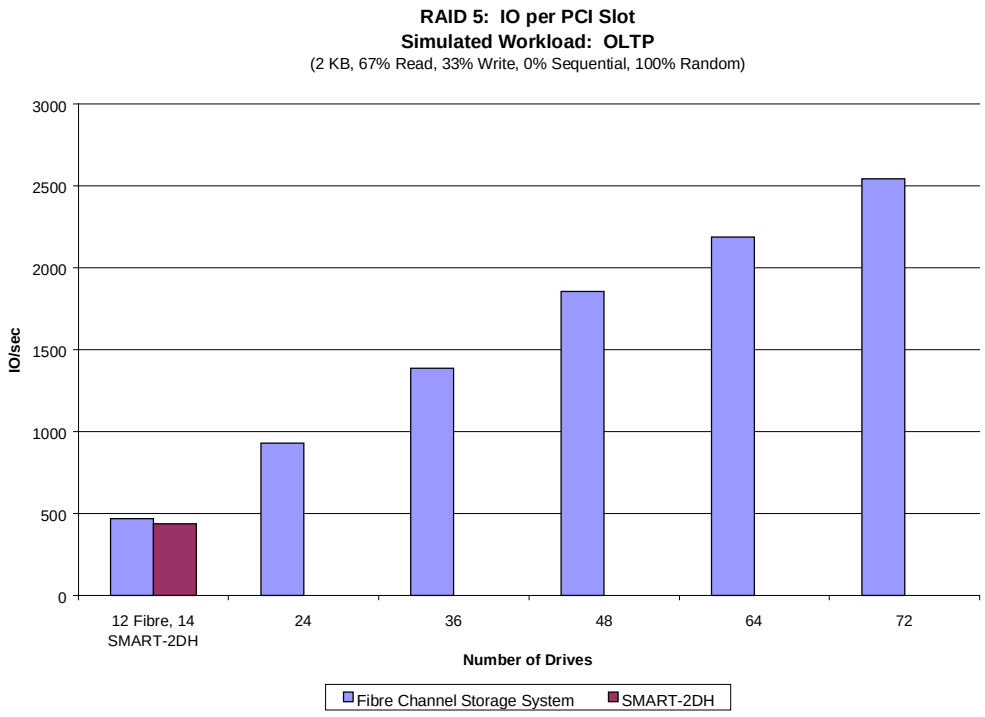


Figure 5. Performance scalability of Compaq SMART-2DH Array Controller-based storage systems and of the Compaq Fibre Channel Storage System

Table 2. Comparison of Three Compaq Storage Systems

	SMART-2SL Array Controller & ProLiant Storage System	SMART-2DH Array Controller & ProLiant Storage System/F	Fibre Channel Storage System	
Type of Drives	1.6-inch, 18.2 GB	1.6-inch, 18.2 GB	1-inch, 9.1 GB	1.6-inch, 18.2 GB
Maximum Drives per Slot	7	14	132	88
Capacity/Slot TOTAL RAID 5 RAID1 RAID 5 + Spare	 < 127 GB < 109 GB < 55 GB < 91 GB	 < 255 GB < 237 GB < 127 GB < 218 GB	 < 1.2 TB < 1.1 TB < 601 GB < 1.01 TB	 < 1.6 TB < 1.4 TB < 801 GB < 1.2 TB
Transfer Distance	3.75 m (12 ft)	3.65 m (12 ft)	GBIC-SW: 500 m (1,640 ft) GBIC-LW : 10 km (32,808 ft)	GBIC-SW: 500 m (1,640 ft) GBIC-LW: 10 km (32,808 ft)
Capacity Growth Rate	Moderate	Moderate	Fast	Fast
Fault Tolerance	Hard Drive	Hard Drive Write cache backup	Hard Drive Write cache backup	Hard Drive Write cache backup
Applications	branch office and departmental file and print groupware communications	departmental and centralized file and print groupware/web centralized communi-cations database	centralized, high-capacity file and print groupware/web high-capacity and high-performance database data marts	centralized, high-capacity file and print groupware/web high-capacity and high-performance database data marts

Migration to Fibre Channel from SCSI Technology

Incompatibilities in bus and drive mapping exist between Compaq ProLiant Storage Systems and the Compaq Fibre Channel Storage System. For this reason, data stored on hard drives in a ProLiant Storage System connected to a SMART-2 Array Controller cannot be migrated directly to a Fibre Channel Storage System. Instead, migrating stored data from an existing storage system to a Fibre Channel Storage System requires a full backup and restore operation. See the Compaq website for details about migrating to a Fibre Channel Storage System from a Compaq ProLiant Storage system using the Compaq SMART-2DH Array.

Future Product Enhancements

Planned enhancements to Compaq Fibre Channel-attached primary storage include support for a redundant system with no active, single point of failure. Such a system would include redundant host adapters, redundant storage hubs, redundant Fibre Channel Arbitrated Loops, and redundant array controllers.

FOR MORE INFORMATION

Other Compaq white papers provide additional information about Fibre Channel technology and the Compaq Fibre Channel Storage System. Look for them on the Compaq website.

APPENDIX

Table A summarizes the steps required to run the Compaq User Diagnostics Utility on a Compaq server, notebook computer, or handheld PC.

Table A: Running the User Diagnostics Utility on a Server, Notebook, or Handheld PC

Step	Server	Notebook	Handheld PC
1.	Take the server offline.	Use the Diskette Builder on the Compaq SmartStart Support Software CD 3.60 or later to create a diskette containing the Windows 95 version of the User Diagnostics Utility.	Use the Diskette Builder on the Compaq SmartStart Support Software CD 3.60 or later to create a diskette containing the Windows CE version of the User Diagnostics Utility.
2.	Boot the server from the Compaq SmartStart CD 4.0 or later.	Use the diskette to install the User Diagnostics Utility on the notebook computer.	Use the diskette to install the User Diagnostics Utility on a desktop computer.
3.	Run the Windows 95 version of the User Diagnostics Utility.	Using a serial cable, connect the notebook computer to the serial port on the Fibre Channel Array.	Using a serial cable, connect the handheld PC to the desktop computer.
4.		Run User Diagnostics on the notebook computer.	Download User Diagnostics from the desktop computer to the handheld PC.
5.			Disconnect the handheld PC from the desktop computer.
6.			Using a serial cable, connect the handheld PC to the serial port on the Fibre Channel Array.
7.			Run User Diagnostics on the handheld PC.