COMPAQ

# StorageWorks Enterprise Backup Solution

**Tech Note**

**First Edition (November 1998)**
**Part Number ECG1050398**
**Compaq Computer Corporation**

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Compaq StorageWorks Enterprise Backup Solution Tech Note

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# Contents

**Troubleshooting and Diagnostics** *continued*

# About This Guide

This guide is designed to be used as step-by-step instructions for installation, and as a reference for operation, troubleshooting, and future upgrades.

**WARNING:** To reduce the risk of personal injury from electrical shock and hazardous energy levels, only authorized service technicians should attempt to repair this equipment. Improper repairs could create conditions that are hazardous.

**IMPORTANT:** The installation of options and servicing of this product shall be performed by individuals that are knowledgeable of the procedures, precautions, and hazards associated with equipment containing hazardous energy circuits.

## Symbols in Text

These symbols may be found in the text of this guide. They have the following meanings.

**WARNING:** Indicates that failure to follow directions in the warning could result in bodily harm or loss of life.

**CAUTION:** Indicates that failure to follow directions could result in damage to equipment or loss of information.

**IMPORTANT:** Presents clarifying information or specific instructions.

**NOTE**: Presents commentary, sidelights, or interesting points of information.

## Compaq Technician Notes

**WARNING:** Only authorized technicians trained by Compaq should attempt to repair this equipment. All troubleshooting and repair procedures are detailed to allow only subassembly/module level repair. Because of the complexity of the individual boards and subassemblies, no one should attempt to make repairs at the component level or to make modifications to any printed wiring board. Improper repairs can create a safety hazard. Any indications of component replacement or printed wiring board modifications may void any warranty

**CAUTION:** To properly ventilate your system, you must provide at least 12 inches (30.5 cm) of clearance at the front and back of the computer.

**CAUTION:** The computer is designed to be electrically grounded. To ensure proper operation, plug the AC power cord into a properly grounded AC outlet only.

**WARNING:** To reduce the risk of personal injury from electrical shock and hazardous energy levels, do not exceed the level of repair specified in these procedures. Because of the complexity of the individual boards and subassemblies, do not attempt to make repairs at the component level or to make modifications to any printed wiring board. Improper repairs could create conditions that are hazardous

**WARNING:** To reduce the risk of electric shock or damage to the equipment:

- If the system has multiple power supplies, disconnect power from the system by unplugging all power cords from the power supplies.
- Do not disable the power cord grounding plug. The grounding plug is an important safety feature.
- Plug the power cord into a grounded (earthed) electrical outlet that is easily accessible at all times

**CAUTION:** To properly ventilate your system, you must provide at least 12 inches (30.5 cm) of clearance at the front and back of the computer

**IMPORTANT:** Any indication of repair at the component level or modification of a printed wiring board may void any warranty.

## Getting Help

If you have a problem and have exhausted the information in this guide, you can get further information and other help in the following location.

### Compaq Web Site

The Compaq Web Site has information on this product as well as the latest drivers and Flash ROM images. You can access the Compaq Web Site by logging on to the Internet at:

http://www.compaq.com.

## Telephone Numbers

For the name of your nearest Compaq Authorized Reseller:

In the United States, call 1-800-345-1518
In Canada, call 1-800-263-5868

For Compaq technical support:
In the United States and Canada, call 1-800-386-2172
For Compaq technical support phone numbers outside the United States and Canada, visit the Compaq Web Site at:

http://www.compaq.com.

# *Chapter 1*
# Introduction

Compaq developed the Enterprise Storage Network (ESN) architecture to give customers comprehensive storage management and control over expanding information resources. ESN is the foundation of all comprehensive storage solutions that Compaq will deliver in late 1998, starting with the **Compaq StorageWorks Enterprise Backup Solution** (EBS). This is an enterprise-designed backup/restore solution that will provide consolidated backup for the distributed enterprise over a Fibre Channel-based network.

The Compaq StorageWorks EBS is the first Fibre Channel-based tape storage system that effectively manages the Enterprise Storage Network's demanding data storage needs. Though the EBS performs well as a stand-alone network for consolidated tape storage, it is designed to work with the Compaq Fibre Channel Storage System, a Fibre Channel-based solution for disk storage. Compaq offers these independent yet complementary approaches as a complete solution for disk and tape storage, developing these solutions to deliver storage as a service to the enterprise.

The Compaq StorageWorks EBS improves overall enterprise performance with the following features:

- **An independent Fibre Channel network** solves the immediate problem of user productivity caused by limited network bandwidth for storage. Fibre Channel connectivity and feature-enhanced storage software removes the flood of backup data from the corporate communications network and places it on an independent, fast and reliable Fibre Channel storage network. The result is improved backup performance, larger backup windows and augmented user access over the network without SCSI cable restrictions, all in a Compaq integrated solution.
- **Central protection and storage** of Terabytes (TB) of corporate data lowers the enterprise's total cost of ownership. Multiple servers sharing tape storage throughout the enterprise delivers automation, management and security at a fraction of traditional attached storage system cost.
- **Powerful, Compaq-enhanced software** manages and automates the backup-and-restore process using Compaq servers, libraries and Fibre Channel-interconnect hardware.
- **Scalability** is achieved two ways:
  - Through Fibre Channel-enhanced design flexibility featuring connectivity up to 500 meters
  - The ease of adding tape libraries to fill even the most difficult enterprise's performance demands

The EBS accommodates today's network storage issues, yet extends beyond the limits of traditional networks. This Compaq solution empowers customers to build a powerful, flexible enterprise architecture to fulfill individual business requirements, particularly in the key industries of banking, finance, insurance, and large retail establishments. Supporting the Windows NT 4.0 operating system and NetWare on most Compaq servers, the Compaq StorageWorks Enterprise Backup Solution is the tape storage solution for today and enterprise environments of the future.

# *Chapter 2*
# The Fibre Channel Solution

## Fibre Channel Technology

Fibre Channel is a media-independent, industry-standard interconnect and high-performance serial I/O protocol that supports simultaneous transfers of multiple protocols. Its Gigabit speed throws open the door to storage networks of the future. Compaq has partnered with Hewlett Packard to develop the Fibre Channel Host Bus Adapter (HBA), based on the HP Tachyon chip that allows high-performance SCSI protocol transmission through a Fibre Channel medium. Multi-mode fibre optic cable allows greater transmission distance–500 meters presently and 10 kilometers in the near future–perfect where disaster recovery or centralized storage is a priority.

An integrated set of standards for Fibre Channel is being developed by committees accredited by the American National Standards Institute (ANSI), defining new protocols for flexible information transfer. For additional information on the Fibre Channel protocol, see the Technology Brief "**Strategic Direction for Compaq Fibre Channel-Attached Storage"** (ECG009/1097) at www.compaq.com/support/techpubs.

## Why Fibre Channel?

The Fibre Channel-based Enterprise Storage Network (ESN) has many advantages over current technology.

- **Storage Independence—**Storage resides on a dedicated, high-performance ESN independent of the corporate network, maximizing overall network bandwidth and performance. This creates an alternate path for high-volume data transfer between servers and tape drives. The storage devices are shared by multiple servers and communicate directly to eliminate bottlenecks inherent in traditional networks.
- **Speed**—Fibre Channel offers an unprecedented 100 Megabytes per second (MB/s) bandwidth, providing room to grow and fast access to data.
- **Volume**—Fibre Channel's larger packet size--2 KB versus 1.5 KB--and its arbitration and data-multiplexing schemes move larger volumes of data between two points than the corresponding Ethernet facilities that exhibit larger overheads.
- **Scalability**—A Fibre Channel fabric can address 16 million devices connecting arbitrated loops that can contain 126 devices each. The ability to interconnect numerous devices is a major concern in large servers and clusters, where backup problems are common. Clusters with hundreds of Gigabytes of on-line data often require automated tape libraries with four to eight drives operating concurrently.
- **Low Overhead**—Fibre Channel's low overhead--36 bytes out of every 2,112 bytes and chip level encoding and decoding are ideally suited for large file transfers. The OC-12 asynchronous transfer mode (ATM) overhead is much higher--5 bytes out of every 53-byte frame. Even Gigabit Ethernet must be encoded and decoded through traditional software IP stacks with added operating system overhead.

- **Versatility**—Fibre Channel has direct storage interfaces and can guarantee the in-order delivery of frames at a network protocol level that SANs require. Gigabit Ethernet and ATM do not.
- **Greater Transmission Distances**—The present distance of 500 meters will expand easily to 10 kilometers.
- **Cables**—Smaller, more flexible cabling improves cable deployment and management.

Clearly, current Ultra SCSI, ATM, and Ethernet environments do not have the performance or the fault resilience necessary to administer the functional characteristics of an Enterprise Storage Network.

# *Chapter 3*
# System Integration

Integrating the Compaq StorageWorks EBS into the enterprise environment requires analysis of all enterprise components and their effect on overall performance. Fibre Channel components add speed and design flexibility to the enterprise backup plan. Tape storage consolidation enables tape libraries and management consoles to manage data and consolidate resources that traditionally have been distributed throughout the enterprise. Analysis of each storage system within the enterprise will determine if minimum requirements of security, data availability, disaster recovery, vital record retention, and business-specific needs are met. Tape storage vaults can now contain the tape libraries and management consoles that can manage data and consolidate resources that have traditionally been spread throughout the enterprise.

## Backup Topologies

Traditional systems are backed up with independent local backup or centralized network-based servers. Tape libraries bring automation to the enterprise but do not solve the problems of LAN bandwidth and resource sharing. The EBS is the first step in applying Fibre Channel solutions to enterprise zones that demand more than existing systems can provide. We must analyze each backup system to determine the effectiveness and practicality for each zone in the enterprise.

# Local Backup Environments

Figure 3-1 shows an independent, local backup environment in which each server connects to its own backup device via a SCSI bus. The operator loads a dedicated instance of the backup software for each server that has a backup requirement. The backup software reads the data from primary storage and writes the data to the backup device. The operator controls the application, either locally at each server or remotely, depending upon the application's remote management capabilities. The operator manages the media for each server locally and manually. In installations where large quantities of servers exist, the management of backup media becomes a formidable task.

**NOTE**: In this arrangement the LAN is not part of the data path and the backup device's speed usually determines backup efficiency. Management is difficult, and equipment and maintenance costs are high.

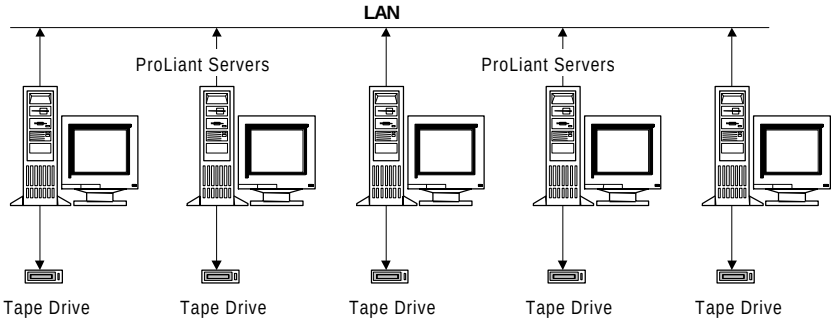


Figure 3-1. Independent local backup environment

## Centralized Network Backup

Media management difficulties forced network backup applications to evolve, leading to the implementation of backup over the centralized corporate network. Unfortunately, centralized backup causes additional traffic that consumes precious bandwidth needed for business productivity. As a result, backups must be carefully scheduled to allow smooth operation on the network. Again, in installations where there are multiple servers, the network is the normal bottleneck.

A tape library adds capacity and automation, further reducing media management problems. The Compaq DLT 3570 library holds 15 cartridges that collectively store over a Terabyte (TB) of data at 2:1 compressibility. The library also has up to 2 DLT drives, each drawing data at a rate of 10 Megabytes per second. However, with more consolidation and faster backup devices such as the DLT 35/70 drive, the LAN becomes more of a bottleneck, even when using a 100 Megabit per second dedicated backup LAN.

**NOTE**: In this arrangement, the data path is across the LAN

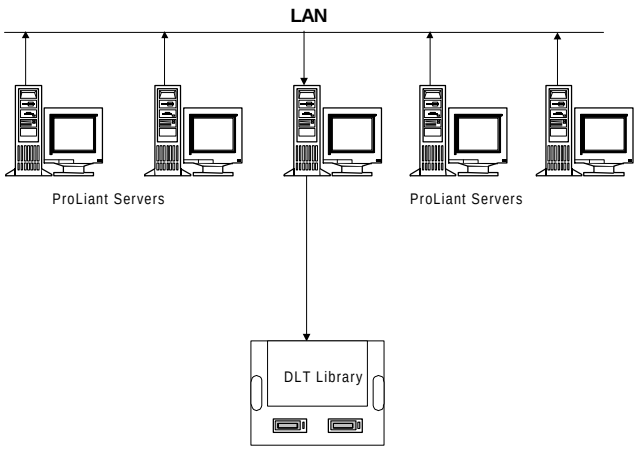


Figure 3-2. Centralized network backup

For further information on DLT library performance, see DLT Library Performance Brief "**High Performance Backup of Enterprise Servers,"** (ECG002/1297) at www.compaq.com/support/techpubs/

# Compaq StorageWorks EBS

With the Compaq StorageWorks EBS, Compaq has created a separate Enterprise Storage Network. The use of Fibre Channel frees the corporate network for business productivity. Figure 3-3 shows the basic topology of the Compaq Enterprise Backup Solution.

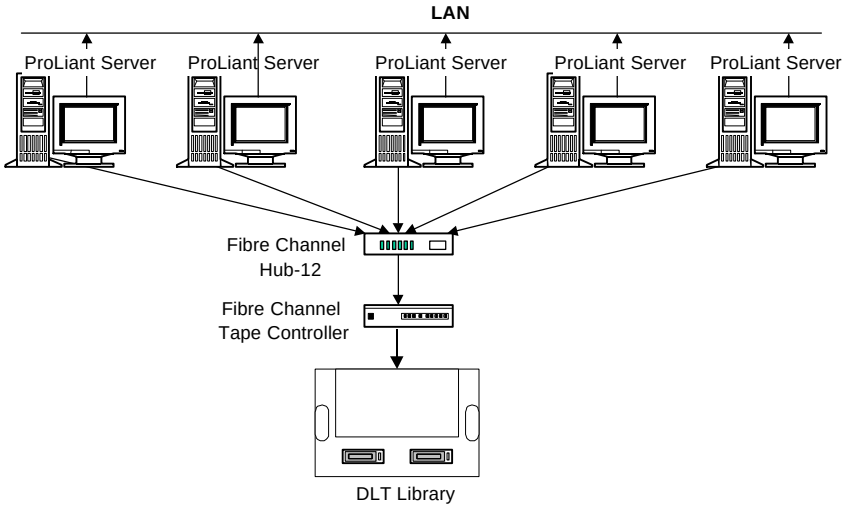


Figure 3-3. Compaq StorageWorks Enterprise Backup Solution (EBS)

**NOTE**: Chapters 4 through 9 describe the Fibre Channel-based EBS in detail.

## Scalability of EBS

Compaq has partnered with two leaders in the industry: Seagate Software Inc. and Computer Associates Inc., to develop EBS software applications. Seagate Software Inc. created the Shared Storage Option for Backup Exec and Computer Associates Inc. created the Enterprise Library Option for ARCserveIT.

Both applications' device-sharing options allow multiple servers to arbitrate and share backup devices over a storage network. This solution does not route backup-and-restore traffic through a single server, as seen with the centralized network-based backup model, although the backup devices appear to be locally connected to each server. Since the Enterprise Storage Network is based on high throughput Fibre Channel technology, the centralized corporate network **will not form a bottleneck**. This allows the high performance of the DLT drives to be utilized.

Figure 3-4 illustrates the basic scalability of the EBS.

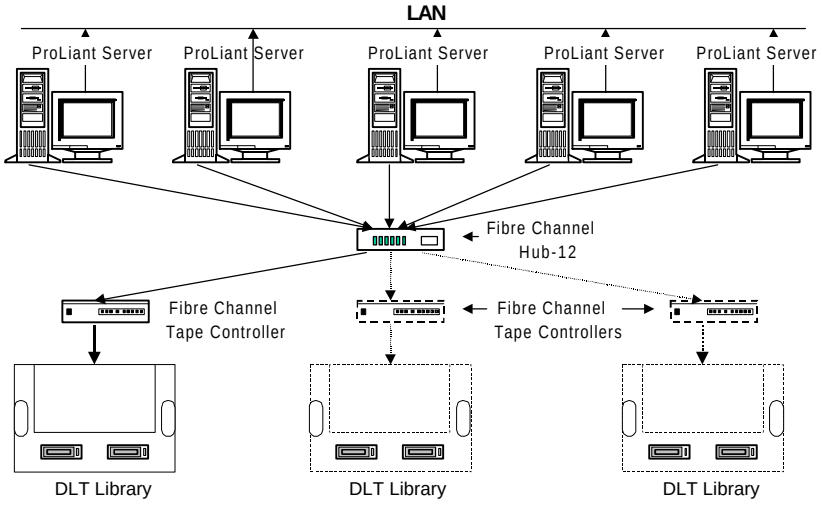


Figure 3-4. Basic scalability of the Compaq StorageWorks Enterprise Backup Solution

## Steps to Successful Integration

To integrate the Compaq StorageWorks EBS into your enterprise environment, thoroughly analyze your existing network following these described steps. This way, you can determine how the speed and design flexibility of Fibre Channel components can best serve your enterprise system.

1. **Outline** your existing enterprise network in detail. Begin by creating your own network-based map that typically includes:
   - ❑ network connections
   - ❑ hubs
   - ❑ routers
   - ❑ bridges
2. **Detail** the plan, showing:
   - ❑ operating systems
   - ❑ existing tape backup devices
   - ❑ quantities of storage for each component
   - ❑ total capacity as well as space in use for each component
   - ❑ links between components, with data link rates, ex: 10/100 Ethernet, FDDI
3. **Evaluate** each component, keeping in mind that servers and workstations are separated by functionality according to:
   - ❑ work load
   - ❑ growth
   - ❑ impact on overall vital records
   - ❑ need for levels of protection
4. **Analyze** each department and type of data to determine if backup and restore needs are being met with existing systems. Slower network links will function with traditional attached tape storage for small data sets or workstations that contain slow-growing static data. High-volume mission-critical data types will require the EBS in order to meet the ever decreasing backup windows.
5. **Apply EBS solutions to demanding enterprise zones.** In-depth details of the EBS will be presented in Chapters 4-9.

# *Chapter 4*
# Performance

When analyzing speed and performance, it is helpful to look at the entire backup process as a system of components or pieces. Each of these components needs to be thoroughly understood in order to locate possible performance bottlenecks. The following discussion presents test results from years of software and hardware testing to obtain the best backup-and-restore performance solutions available.

Compaq's engineering team is dedicated to the study of these performance issues. Through a detailed understanding of the backup process, Compaq has developed the Compaq StorageWorks Enterprise Backup Solution (EBS) that performs backup-and-restore tasks at levels that have proven themselves to be the best of the industry.

## Five Easy Pieces

Compaq Engineering has divided the backup process into a set of five components or pieces. Each piece needs to be factored into the backup equation to determine the maximal performance in any specific situation.

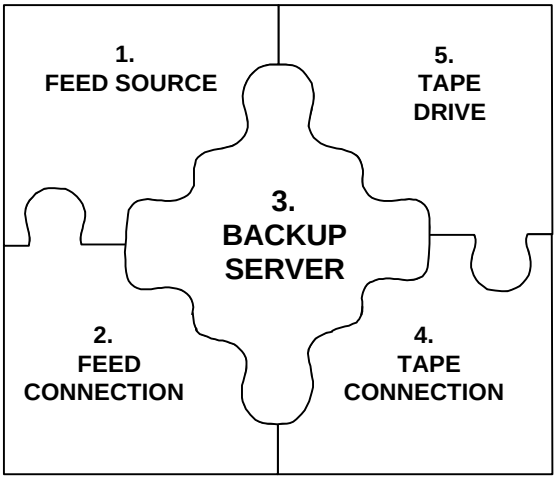


Figure 4-1. Five Easy Pieces of the EBS

The five pieces of the EBS are:

1. **The Feed Source**—Usually the hard disk Primary Storage system, but it can be network-connected storage or even a remote system.
2. **The Feed Connection**—Usually a SCSI or Fibre Channel connection, but in the case of network storage, it could be the network link itself.
3. **The Backup Server**—The system actually doing the data backup work.
4. **The Tape Connection**—For the EBS, this is Fibre Channel.
5. **The Tape Drive (Secondary Storage) System**—For the EBS, these are Compaq DLT 3570 Library systems.

# The Feed Source—Primary Storage Piece 1

The performance of Primary Storage is often the most overlooked factor in obtaining a high performance backup. Compaq's testing demonstrates that it is necessary to read from the primary storage device at a speed at least three times faster than the tape-backup write speed. A single spindle SCSI drive that can only be read at 10 Gigabytes (GB) per hour cannot be backed up to tape at 10 GB per hour.

Compaq, therefore, suggests SMART-2 Array Controllers or the Fibre Channel Primary Storage systems as a way to obtain the performance today's high-power servers need, and to provide the read-speed necessary to utilize the EBS effectively. Figure 4-2 illustrates some of these solutions.

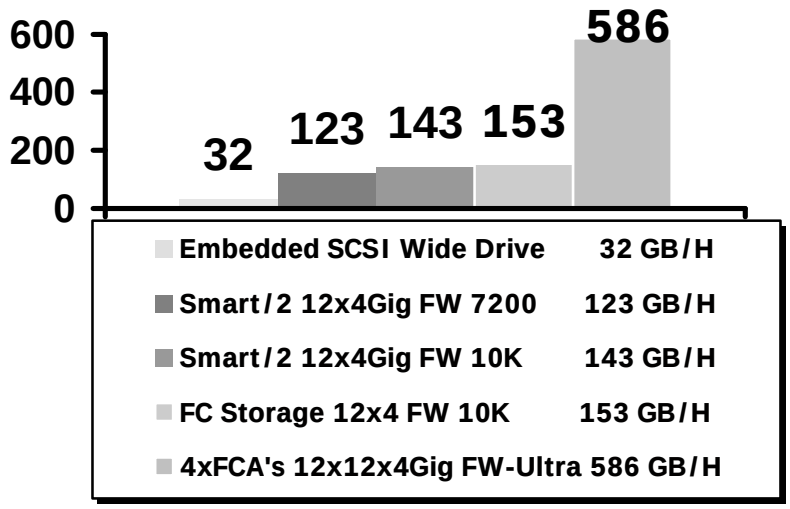


Figure 4-2. Primary Storage "Read Speeds" as rated in Gigabytes per hour

Notice that the performance of the single channel embedded SCSI drives is far slower than any SMART-2 or Fibre Channel Host Bus Adapter (FCHBA). The far right column that presents the grouping of 4 FCHBA cards connected to 12 Fibre Channel Storage systems shows how using multiple adapters can improve storage performance. The SMART-2 controllers may also be used in multiples to augment backup performance.

Raw performance is the primary factor in Piece 1, but it is not the only determining factor. The inclusive list of possible bottlenecks in Primary Storage follows.

## Additional Bottlenecks in Primary Storage

### Volume Structure

If you are using multiple storage adapters and multiple drives within a single drive volume, consider striping the volume across the drives versus using a simple volume set. The striped set will pull data from all the drives concurrently, versus the sequential structure of the standard volume set. Use of multiple volumes helps overall backup performance by permitting additional simultaneous backup jobs. High backup rates can be achieved using this valuable technique.

### Block Size

Use of the largest block size available will provide the fastest data transfers. Most operating systems permit formatting of the primary storage to a maximum of 64 Kilobytes (KB).

### File Size

Another important consideration you may not be able to control is the actual size of the data files in each zone of the enterprise. There is a performance consideration based on the number of files to be backed up when using "file-by-file" backup software. In other words, it is much faster to backup 100 files that are 10 Megabytes (MB) each (1 Gigabyte) than it is to backup 100,000 files that are 10 Kilobytes (KB) each. Although this is not usually a problem with image-based backup software, it will apply when that image software is also creating an index that will be used later for a file-by-file restore.

**Bottom line:** if you have numerous small files, get the fastest primary storage system available to offset the impact of small files on backup performance.

### File Content

File content also impacts performance, depending on the file's data compressibility. Separately or in tandem, backup software and tape drive hardware both compress data using mathematical algorithms that speed up the backup process.

To illustrate this point, assume that you want to backup your company phone directory, called PHONE.TXT, and it is a 100-Kilobyte (KB) text file. Without compression, just for example, assume that it takes one minute to backup that file to tape. If you turn on software and hardware data compression, you might be able to compress that file at a 2:1 ratio so that when backing up the file, it is in a compressed format of only 50 Kilobytes (KB) and it takes half as long.

Some files are highly compressible, such as many text documents and spreadsheets. But other data, like image files, graphics and pre-compressed databases may not compress at all. Backup speed can vary greatly based on this factor, and can be the cause of slow performance. Using the highest performance hardware available will minimize the compressibility issue.

Chapter 8, "Sizing the Enterprise Backup Solution," details the effect of compression on backup and restore performance.

### Application-Based Restrictions

There are a number of different databases available on the market, each with its own specific set of limitations and problems in the backup area. In general, if you are using a database of any type, try to find an "agent" for that database that assists the backup program in backing up that database. These "agents" can greatly improve performance, as well as permit live (hot) backups of the database. The importance of this aspect cannot be overstressed.

## The Feed Connection—SCSI or Fibre Channel Piece 2

The connection of Primary Storage to the backup server is usually by means of either SCSI or Fibre Channel. For various reasons, the Fibre Channel has many advantages over SCSI. The SMART-2 choice is not as fast or scalable as the Fibre-Channel solution but can normally provide high enough performance to fully drive the EBS.

Figure 4-3 below shows the performance of SMART-2 (SCSI) versus the Fibre Channel solution. Although the Fibre Channel Solution appears only slightly faster, the real advantage to Fibre is its ability for further growth. These larger systems also have a linear expansion of disk cache that keeps the performance at very high levels for any size system configuration.

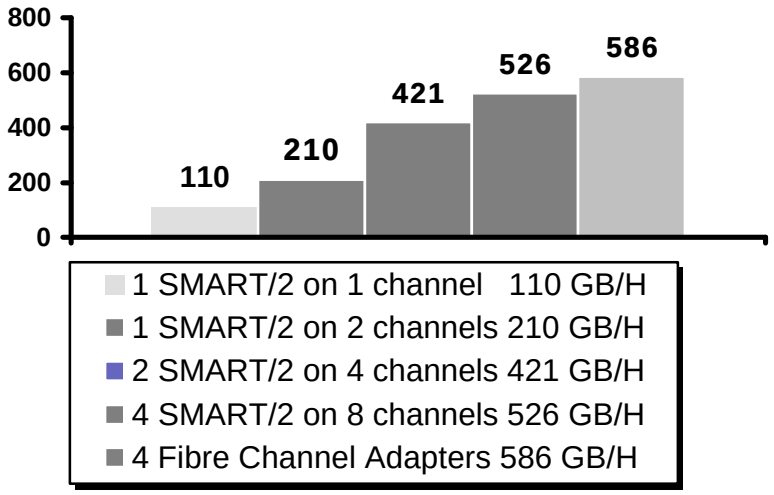


Figure 4-3. Performance of SMART-2 (SCSI) versus the Fibre Channel Solution

## The Backup Server—Piece 3

In the Compaq StorageWorks EBS, the backup server holds equal importance to the other devices and is one of the most complex. Not surprisingly, a high-performance server is needed to execute high performing backups. Assuming you have engineered fast primary storage and that it is connected in a fashion that provides adequate “read-speed,” you now need to consider the parts of the backup server that can cause backup performance “bottlenecks.”

### Processors

The CPU’s performance affects backup speed, so the installation of multiple high-speed CPUs will increase performance. Compaq defines a high performance server as having four 200 Mhz Pentium Pro processors with 512K cache in each. Although many backup programs only need 5 to 20% of a CPU for each backup job running, sometimes software tape array generation requires 80% of a 4 CPU complex.

### Memory

Main memory (RAM or SRAM or DRAM or DIMMs) requirements vary, based on which applications are running concurrently with the backup software. Backup software requires 64 to 1024 Megabytes (MB) of RAM. For the EBS, 256 Megabytes (MB) of main memory is a good starting point.

### Bus Architecture

For the best performance from a Compaq Server, use Compaq's Dual Peer-to-Peer bus systems--the 5000, 6500 or 7000 servers. These servers have dual PCI busses that allow balancing of multiple primary storage adapters to feed the EBS Fibre Channel Host Bus Adapter (FCHBA) at a high rate of speed.

## Tape Drive Connection—Piece 4

The fourth piece is a high-performance Fibre Channel PCI Host Bus Adapter card. It simply supplies a 100 Megabyte (MB) per second link to the Fibre Channel Tape controller, far better in every way than the old method of SCSI cabling. Future versions of Fibre Channel will replace the existing optical interface with versions that will double and even quadruple the performance of the Fibre Channel loop.

## The Tape Drive Solution—Piece 5

The tape drive solution is the fifth piece in determining backup-and-restore performance. Use of the Compaq Fibre Channel Tape Controller and its connection to the DLT 35/70 tape drive is a simple way to scale backup-performance. One 35/70 tape drive can back up data up to 43 GB per hour when data is highly compressible. By adding drives and Fibre Channel Tape Controllers, as shown in Figure 4-4 below, you can increase the ability to perform high speed backups, if all other factors have been optimized.

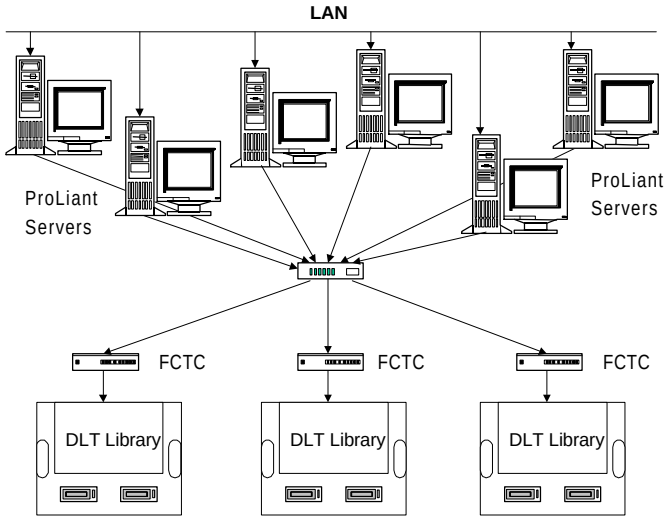


Figure 4-4. The tape drive solution

# *Chapter 5*
# Application Integration

Developing the Compaq StorageWorks EBS requires coordination of backup strategies for each enterprise component. Lightning fast Fibre Channel solutions permit consolidation and ease of automation, but may be overkill for small data sets or workstation environments. Intermixing high-speed Fibre Channel with LAN-based backups is effective when well defined and tuned to serve the needs of each enterprise zone.

Compaq's new solution can be mixed with existing backup solutions to allow customer flexibility and enhance rather than obsolete customer's earlier backup investments at three basic levels:

- Intermixing or augmenting to segregate high and low performance backup needs
- Centralizing backup using existing and Fibre Channel technologies
- Consolidating management and security

## Mixed Operating System Environments

The EBS is currently available for Microsoft Windows NT 4.0 and Novell IntraNetWare 4.11 operating systems. Each group of servers on a single Fibre Channel Loop must be all Windows NT 4.0 or all NetWare. When other operating systems need to be backed up, the use of agents must be incorporated into the solution. A variety of agents can backup UNIX or a mixture of Windows NT 4.0 and NetWare, but these systems use traditional LAN transport for their data and are susceptible to bottlenecks inherent in the LAN.

## The Software Solution

The EBS provides end-to-end connectivity of tasks, applications, and hardware. Compaq partnered with Seagate Software Inc. and Computer Associates Inc., who developed multi-initiator software to work with EBS Fibre Channel components. Drivers for Windows NT and NetWare, intelligent firmware in the new components, and application integrations that present the Tape Storage Devices to the application in a shared environment were developed.

## Software Server Components

Each server on the Fibre Channel loop must have the following components installed to access the shared tape devices.

1. **WINDOWS NT 4.0** with **SP3** or **NOVELL INTRANETWARE 4.11**
2. **CPQFCALM,** the Compaq Fibre Channel Arbitrated Loop (FC-AL) miniport driver. This is the driver for the Fibre Channel Host Controller, the component nearest the physical layer.
3. **CPQFCTR**, the Compaq Fibre Channel Filter driver. Some SCSI tape-device commands do not fit into the Fibre Channel protocol, and this driver allows those commands to be executed transparently over Fibre Channel. This filter driver is automatically installed with the host controller driver.

4. The main backup application**,** either Seagate Software Inc.'s **Backup Exec** or Computer Associates Inc.'s **ARCserveIT**.

   a. **Backup Exec**, version 7.2 or later

      - **Autoloader Option**—This changer option permits Compaq DLT 3570 Library use.
      - **Shared Storage Option (SSO)—**This option allows the EBS to device-share. SSO runs with all of the options that are available for Backup Exec, including Open File Manager, Intelligent Disaster Recovery, and all Agent Accelerators.

   b. **ARCserveIT**, Enterprise version 6.6 or later

      - **Tape Library Option**—This changer option permits Compaq DLT 3570 Library use.
      - **Enterprise Library Option (ELO)—**This option allows the EBS to device-share.

## The Backup Exec Environment

Figure 5-1 shows an environment running Seagate Software Inc. Backup Exec (version 7.2 or later) with the Shared Storage Option. The topology has one database server and multiple distributed Backup Exec servers running WINDOWS NT 4.0 or Novell IntraNetWare 4.11. The Backup Exec servers communicate with the database server over the LAN to coordinate the rights to access each of the backup devices.The database is a shared-disk resource that each server accesses. One additional agent-based server is shown for other operating systems.

**NOTE**: Each server on the Fibre Channel loop must have these components installed to access the shared tape devices.

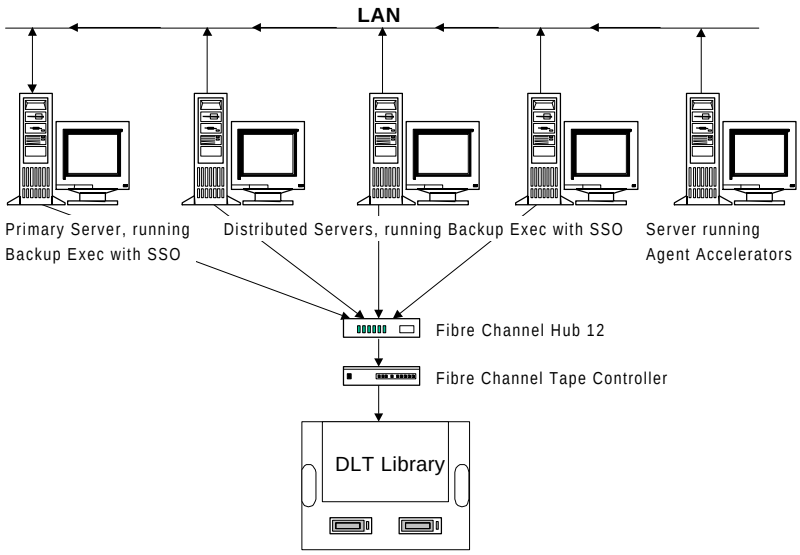


Figure 5-1. Backup Exec Environment with Shared Storage Option (SSO)

## The ARCserveIT Environment

Figure 5-2 shows an ARCserveIT environment with the Enterprise Library Option (ELO).The topology has one databaseserver and multiple distributed servers.The distributed servers communicate with the database server over the LAN to arbitrate for the rights to access the shared backup devices.ELO runs with all of the options that are available for ARCserveIT, including on-line database options, RAID-tape, disaster recovery, and image. One additional agent-based server is shown for other operating systems.

**NOTE**: Each server on the Fibre Channel loop must have these components installed to access the shared tape devices.

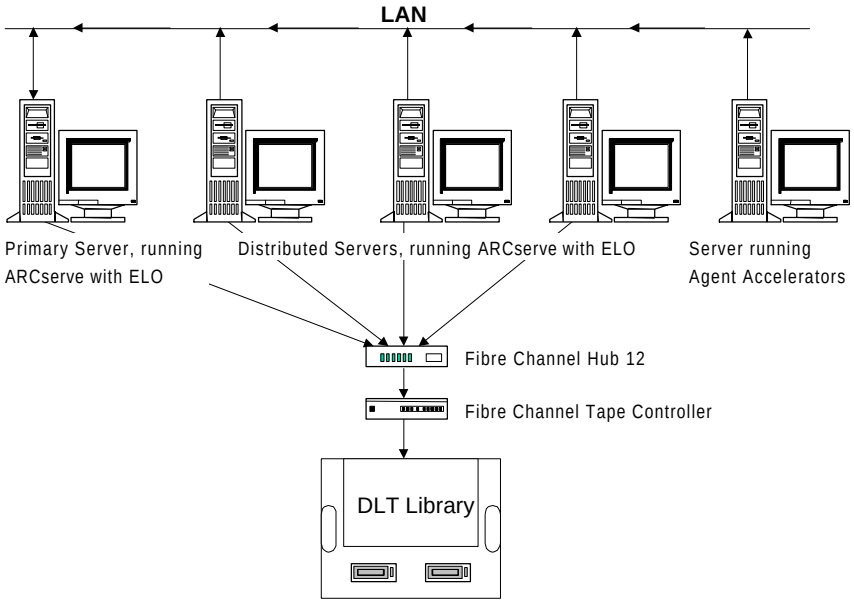


Figure 5-2. ARCserveIT environment with Enterprise Library Option (ELO)

## Today's Maximum Configuration

The solution in Figure 5-3 supports a maximum of three Fibre Channel Tape Controllers, each connected to a DLT 3570 library. This configuration has enough ports remaining to connect to nine servers. A configuration with three DLT 3570 libraries should be targeted when high performance and/or high capacity is a requirement. Assuming 2:1 compression, three DLT 3570 libraries provide a maximum of 3 Terabytes (TB) of storage shared across nine servers. This is an average of 333 GB of tape storage per server connected to the Enterprise Storage Network.

To consolidate more servers with less storage requirements per server, replace two of the libraries with servers to connect eleven servers to one DLT library. Again, assuming 2:1 compression, this 1TB solution yields an average of 95 GB of tape storage per server in the Enterprise Storage Network (ESN).

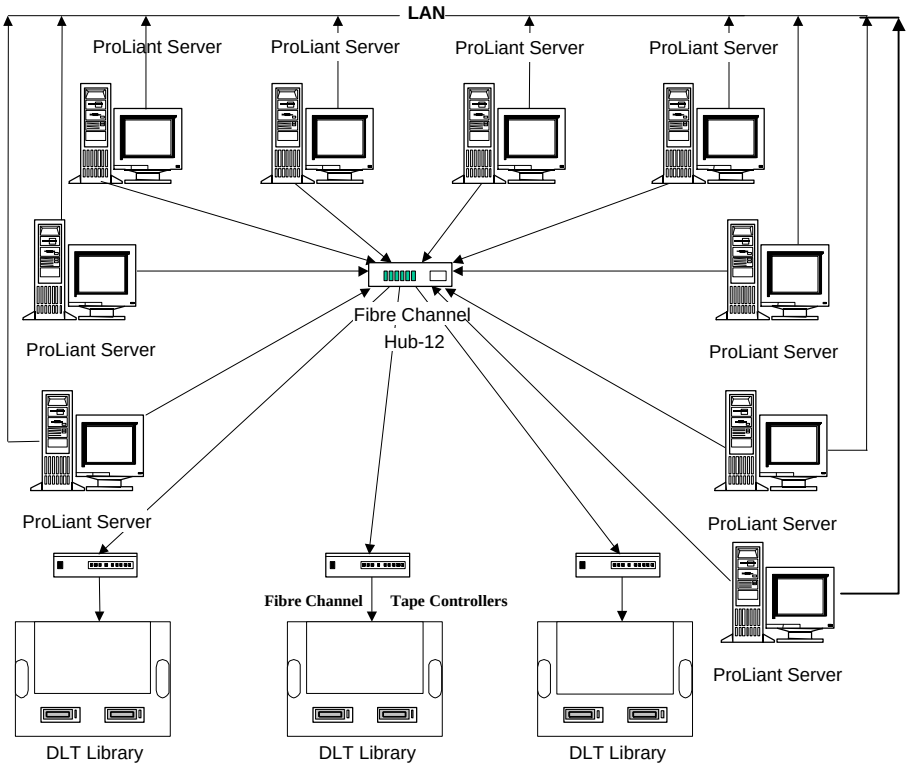


Figure 5-3. Maximum Configuration

# *Chapter 6*
# Enterprise Management

Management of distributed enterprise environments is a prominent benchmark in today's competitive business world. To address this need, Compaq developed a plan that integrates systems and storage-management software. The Compaq StorageWorks EBS improves present-day enterprise management architectures while pioneering tomorrow's technology.

For today's user, Compaq provides Insight Manager as a server management tool, controlling storage as an extension of the server. Compaq Insight Manager provides "element management," and other utilities to manage configurations of subsystems. The Array Configuration Utility (ACU) configures hard disk storage, and configuration of the DLT 3570 Library is shared by the backup application and the library's front panel.

The impending introduction of Compaq Insight Manager XE, a Web-based Enterprise Management (WBEM) application, will build an infrastructure for the integration of all storage management software components. The StorageWorks Command Console management utility will be included to manage and configure StorageWorks subsystems. Partnering with Seagate Software Inc. and Computer Associates Inc., Compaq is developing key software to integrate their management consoles into this architecture. Although EBS components are transparent to the server and the tape library, additional management features will be implemented at the Storage Hub 12 and the Fibre Channel Tape Controller (FCTC) in a future product release.

Tape management is progressing through continuous industry-standard efforts to address the new virtual enterprise storage networks. Tape Alert is a major effort to put advanced device management and reporting functions in the hands of Network Administrators. Using the software created by Seagate Software Inc. and Computer Associates Inc., both who support Tape Alert**,** Compaq has enabled firmware in the DLT drives to pass information from drive to servers. For more information on Tape Alert, consult: http://www.hp.com/tape/tapealert/tawg.html.

While aggressively developing standards-based storage management solutions, Compaq consistently researches new ways to improve storage management. Cooperation with industry leaders has allowed Compaq to deliver on its promise to manage and control accelerating information needs by providing innovative and comprehensive solutions for enterprise storage.

# *Chapter 7*
# Component Summary

After examining a broad range of technologies, Compaq developed the Enterprise Storage Network to take customers well into the 21st century. Working closely with industry-leading independent software vendors (ISVs), Compaq created a fully integrated and seamless solution--the Compaq StorageWorks Enterprise Backup Solution (EBS). This solution consists of the following:

- **An independent Fibre Channel loop** capable of transferring data at 100 Megabytes per second (MB/s).
- **Fibre Channel Host Controllers** and **Fibre Channel Storage Hub 12**, linking the server to the Fibre Channel loop.
- **Fibre Channel Tape Controllers (FCTC)** that convert Fibre Channel to Differential SCSI protocols for the tape libraries. The FCTC also allows autonomous control of the tape unit.
- **The DLT 3570 Tape Library** with two DLT drives for up to 1 TB of storage.
- **Storage management software** that takes advantage of the added bandwidth of Fibre Channel and allows multiple servers to access multiple tape libraries simultaneously.

These components are engineered to provide the EBS with efficient backup of massive amounts of data without adversely affecting network utilization. Each component offers the best way to protect large volumes of data and component integration fills consumer needs for reduced administrative costs, greater manageability, and minimization of network traffic.

Figure 7-1 represents a typical Fibre Channel setup showing how the Compaq StorageWorks EBS overlays a traditional network.

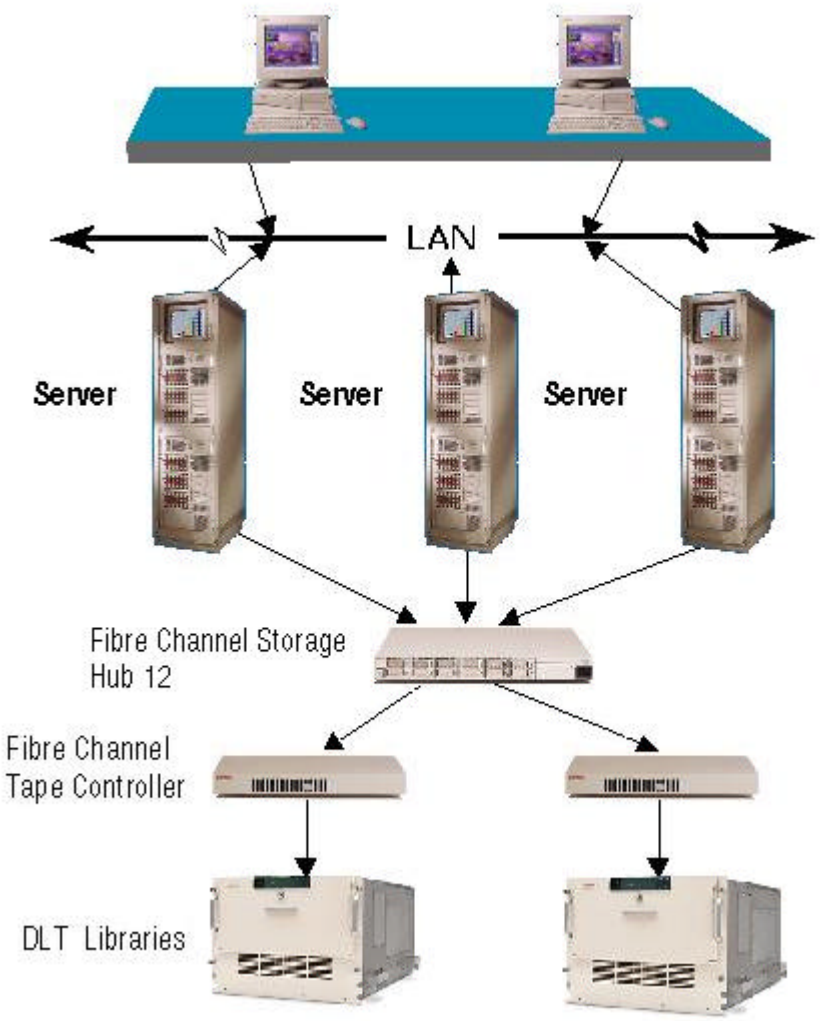


Figure 7-1. Compaq StorageWorks Enterprise Backup Solution

Fibre Channel technology radically alters the relationship between storage management and the capabilities provided by SCSI architecture. Key features and benefits of Compaq's EBS include:

- Up to twelve connections on a single Fibre Channel Storage Hub 12.
- Nine servers that centrally share the storage capacity of three tape libraries or up to 11 servers that share one library.
- Higher capacity per server slot, to enable a more scaleable solution
- Scalability storage units can be added to the Fibre Channel loop to expand the environment according to business needs.

As Compaq's Enterprise Backup Solution evolves, the following additional features will be implemented to allow more complex enterprise environments. This and more of the solution's features are essential to users who continuously undergo data and system growth.

- **Improved distance—**Currently supported distances of 500 meters will expand to 10 kilometers, improving cable management and configuration flexibility.
- **Availability—**Using special features of the backup solution, users can implement complete fault tolerance, including data mirroring, RAID 0,1,4 and 5, and proactive backups that automatically recover backup jobs at any sign of failure. This unique engineering development ensures reliable data availability.
- **Performance—**The short wave Gigabit Interface Converters (GBIC) coupled with Fibre Channel will transmit up to 100 Megabytes per second (MB/s) over 500 meters of 50 micron multi-mode fiber optic cable for greater connectivity and throughput compared to the typical SCSI's 40 MB/s throughput and 5 meter distances. Compaq servers, tape storage subsystems, partner software, storage arrays, and hard drives are tuned to work together to increase application performance.
- **Integration—**The EBS has been developed with Compaq's key partners: Seagate Software Inc. and Computer Associates Inc.. Compaq's strong partner relationships allow the engineering groups to work closely in ensuring unsurpassed product reliability and functionality. These cooperative relationships provide Compaq's customers with the high-quality solutions required by an enterprise environment.

## Fibre Channel Network

Fibre Channel is the next generation in storage technology, combining the reliability and low latency of a serial channel with a network's flexibility and connectivity. The result is a 100 Megabytes per second (MB/s) storage network that supports simultaneous transfer of many different data protocols, including SCSI, IP, and others. This data transfer rate will be supported on fiber-optic links up to 10 kilometers. Now, Compaq's implementation of the Fibre Channel standard will support 50 micron multi-mode fiber optic cable in lengths up to 500 meters. Truly, Fibre Channel offers superior connectivity, performance, and capacity.

For more information on Fibre Channel technology, please refer to the technology brief, "**Strategic Direction for Compaq Fibre Channel-Attached Storage**", document number ECG009.1097, available at: www.compaq.com/support/techpubs/whitepapers

## Fibre Channel Host Controller

A Fibre Channel Host Controller resides in the servers and provides the PCI to Fibre Channel interface for connecting the Fibre Channel Storage Hub 12 to the servers.

Figure 7-2. Fibre Channel Host Controller

## Fibre Channel Gigabit Interface Converter (GBIC)

Fibre Channel GBICs are optical to electrical converters that enable Fibre Channel cables to easily connect the Host Bus Adapter and Storage Hub 12. These hot-pluggable devices add flexibility and reliability to the EBS.

Figure 7-3. Fibre Channel Gigabit Interface Converter

## Fiber Optic Cables

Compaq fiber optic cables are available in 2, 5, and 15 meter lengths. Fibre Channel cables are thin, flexible and easy to install. Industry Standard SC connectors can be installed by contractors to meet enterprise design requirements. The EBS has been tested to support 500 meter lengths of 50 micron multimode fiber and 300 meter lengths of 62.5 micron multimedia fibre.

Figure 7-4. Fiber Optic Cables

## Fibre Channel Tape Controller

A Fibre Channel Tape Controller (FCTC) translates the Fibre Channel protocol to a SCSI protocol between the Fibre Channel Network and the Differential SCSI devices. This allows sharing of the tape libraries. The controller handles single-channel in/single-channel out SCSI. The FCTC is a rack-mountable unit in a 1U form factor. To maximize throughput, Compaq recommends attaching up to two DLT drives per FCTC.

Figure 7-5. Fibre Channel Tape Controller

# Fibre Channel Storage Hub 12

A Fibre Channel Storage Hub 12 enables multiple servers and tape devices to connect to a Fibre Channel loop. A single storage hub allows up to 12 GBIC direct Fibre Channel connections for a centralized backup solution. For example, nine servers can be connected to the storage hub, leaving three available ports for connections to Fibre Channel Tape Controllers. The storage hub is a rack-mountable unit with a 1U form factor.

Figure 7-6. Fibre Channel Storage Hub 12

# Automated Tape Libraries

## DLT 3570 Library

One of the most important elements of the Enterprise Backup Solution is tape library automation. Compaq identified the DLT Library as the first step in the tape storage solution. The DLT 3570 Library is a tape library with two DLT 35/70 tape drives capable of storing up to 1 TB of compressed data on 15 tapes. (Assumes 2:1 compression--See Chapter 8 entitled “Sizing” for more information on data compressibility.)

The DLT Library automates the tape handling process, freeing valuable administrative resources.

Figure 7-7. Compaq DLT 15 Cartridge Library

For more information about the DLT Library, see Technology Brief “**Compaq DLT Library Technology”**, (ECG024/0897) at: www.compaq.com/support/techpubs/white papers.

# Integrated Software Solutions

The backup management software is a crucial component of the EBS that allows the hardware components to work together. Compaq has partnered with Seagate Software Inc. and Computer Associates Inc. to deliver an integrated, centralized, Fibre Channel storage solution. The EBS enables multiple servers to share libraries.

## Seagate Backup Exec


Figure 7-8. Seagate Backup Exec

Seagate Software Inc.'s solution combines the benefits of centralized data storage with a distributed fault-tolerant architecture. Multiple backup servers share common tape storage devices, yet all backup servers operate independently and can initiate backups and restores, regardless of the state of other servers. Each server can maintain its own backup database and/or use a centralized database to further ensure data protection. Seagate Software Inc. added many additional features to increase fault tolerance and data reliability.

Essentially, the Seagate Software Inc. packages manage the backup-and-restore process and add functionality to the hardware. The software:

- Directs and orders Enterprise Storage Network traffic.
- Allows multiple servers to share one tape storage device or one server to share multiple tape storage devices.
- Manages the sharing of tape storage devices according to user specifications.
- All options and features of Seagate Backup Exec are supported by the EBS.

### Computer Associates Inc. ARCserveIT


Figure 7-9. Computer Associates Inc.'s ARCserveIT

- Computer Associates Inc.'s ARCserveIT products were designed around a centralized database server. The primary ARCserveIT server controls device access and coordinates task distribution. This primary server will automatically distribute jobs to the available backup devices.
- All options and features of Computer Associates Inc.'s ARCserveIT are supported by the EBS.

## Service and Support

As more companies move business-critical data into distributed storage networks, the need for comprehensive, mission-critical service and support increases. Compaq recognizes this necessity and, along with its partners, Seagate Software Inc. and Computer Associates Inc., assists customers in deploying and supporting their more sophisticated systems.

See Appendix "A" for more Compaq support contacts.

# Chapter 8

To analyze performance of the Compaq Storage Works Enterprise Backup Solution (EBS), Compaq carefully designed a test suite to emulate real-world applications. The principals of "Five Easy Pieces" (as detailed in Chapter 4) were applied to all components to minimize bottlenecks. By carefully analyzing the effects of compression and automation, Compaq generated formulas to accurately define backup windows and design systems for Lights-out Operations.

To run successful hands-off Lights-out Operations, systems must be sized to fit backup windows and ensure sufficient tape retention. This guarantees safe, unattended backups with minimal human intervention. Full, Incremental and Differential backup jobs were analyzed and the effects of tape changes and application overhead were applied to clarify the overall operations.

These exhaustive tests have resulted in a new tool, **Compaq StorageWorks Backup Sizing Tool**. This one-of-a-kind Compaq application will quickly analyze complex environments while predicting requirements and performance expectations. **Compaq StorageWorks Backup Sizing Tool** can be downloaded from www.Compaq.com/StorageWorks/. An in-depth white paper, *Sizing the Compaq StorageWorks Enterprise Backup Solution*, is available from: www.compaq.com/support/techpubs/whitepapers/.

# The Compaq Enterprise Backup Solution Test-bed Description

## Server Hardware

Figure 8-1. The Compaq ProLiant 6500 Rack-Mount Server

Depending on the task being examined, Compaq included from one to eight Compaq ProLiant servers in the test. Each server was configured to produce optimum performance:

- Each Compaq ProLiant server was equipped with a Compaq Netelligent 10/100Mbit/s TX PCI Ethernet.
- The servers were LAN connected at 10 Megabits per second with one primary domain controller and additional stand-alone servers.
- ProLiant servers included Models 3000, 5000, and 6500 with 2 to 4 processors and 64K to 384K of memory.
- Two Fibre Channel Host Bus Adapters were installed in each ProLiant server, providing separate 1.0625-gigabit connections to hard drive arrays and Enterprise Backup Devices.

## Hard Drive Array

Figure 8-2. Compaq Fibre Channel Storage Array

All servers were equipped with Compaq Fibre Channel Storage arrays.

- Hot-swappable Gigabit Interface Converters (GBICs) and 50 micron multi-mode fiber optic cables connected the servers to Fibre Channel Storage Array Controllers.
- Each controller fed two channels of four Compaq 4.3 GB Wide-Ultra SCSI-3 hard drives, providing a total of 32 GB per server.

## Enterprise Backup Devices

- All servers were connected with GBICs and cables to a Compaq Fibre Channel Storage Hub 12.
- Four Compaq Fibre Channel Tape Controllers were connected to the remaining ports in this single hub configuration.
- Differential SCSI cabling connected each tape controller to four Compaq 3570 DLT Tape Libraries.
- Each Library contained 14 DLT Type IV cartridges and one cleaning tape for a total capacity of 490/980 GB per Tape Library (Assumes 1:1 and 2:1 compression respectively).

## Operating System

- Windows NT Server, version 4.0 was installed on each server in the network.
- Service Pack 3 was installed on each server in the network.

## Backup Software

Seagate Software Inc. and Computer Associates Inc. developed the device-sharing options to meet Compaq's Fibre Channel Enterprise Backup Solution needs. These options are named Shared Storage Option (SSO) and Enterprise Library Option (ELO).

## Speed Tests

Determining the speed of Backup and Restore processes in a real-world environment is the most important factor in designing and implementing the Compaq StorageWorks EBS. Fibre Channel is designed to produce a theoretical maximum of 1.0625 Gigabits per hour. This equates to 100 Megabytes per second or 360 Gigabytes per hour. (Test results are expressed in GB/H for clarity).

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**IMPORTANT:** A single DLT 7000 drive is rated at a theoretical maximum of **18 GB/H**.

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To determine the approximate speed of backup and restore jobs in an EBS environment, Compaq began testing non-compressible (1:1) data.

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**IMPORTANT:** Compaq tested both the Seagate Backup Exec and Computer Associates (CA) ARCserveIT in an EBS environment to benchmark the DLT performance**.** Both Seagate and CA generated consistent throughput of approximately **15 GB/H**.

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Tests were performed with each job configured to write to a single DLT drive. Tests show near-linear scalability. Three DLT 3570 tape libraries are supported by the initial release of the EBS, providing 6 DLT 7000 drives as backup targets.

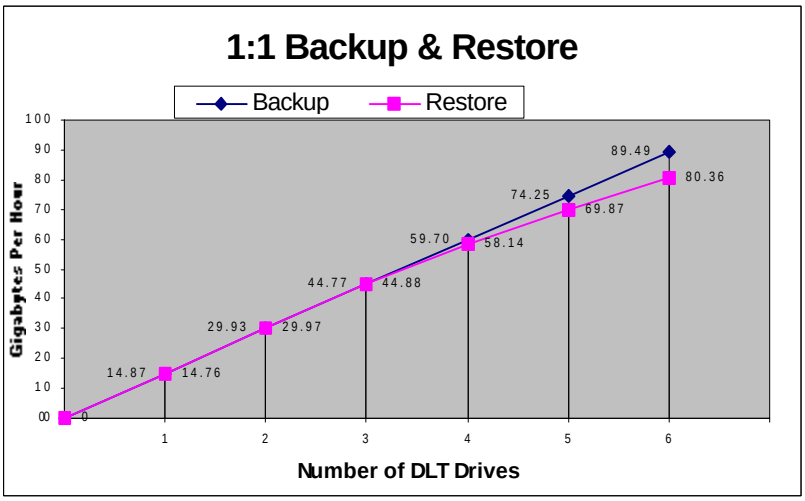


Figure 8-3. Test Results of Backup and Restore Jobs.

## Compression Tests

**IMPORTANT:** The amount of compression has a direct impact on the rate that a DLT 7000 tape drive can write data.

Tests showed the number of DLT drives and compression scaled near 1:1, but the total rate of combined throughput declined slightly as compression increased. It was also determined that the maximum throughput on a single DLT drive was 43 GB/H.

Restore rates also scaled near 1:1 with the same effect of compression and one additional factor.The maximum combined restore rate topped out at 90 GB/H for various numbers of drives and compression rates.

**NOTE**: The test results were based on a controlled set of variables, but real-world data compression varies from file to file.

To find a realistic average backup rate, the data sets were generated in One Megabyte (1M) files. The principals presented in Chapter 4, "Performance," explain how small file sizes slow down backup rates and extremely large files improve backup rates. Compression algorithms also vary and compress data at different rates.

Compaq developed a data-generation program based on the industry standards PKZIP© algorithm and created Four Gigabyte (4 GB) volumes at compression rates of 1:1, 2:1, 3:1, and 4:1. The DLT 7000 drive uses the LHA compression algorithm that created actual compression rates of 1.7:1 for the 2:1 generated file. The 3:1 data compressed 2.5:1 and the 4:1 data compressed 3.3:1.

Industry standard expresses backup and restore rates at a typical 2:1 compression ratio. Compaq tried many interpolations from actual jobs compressed to estimate 2:1 compression tables. To validate tests in a real-world environment, the test team searched thousands of user files for 1-M files and compressed them with the DLT drive until a file was found that compressed 2.013:1. A 4-GB data set was created by replicating this file and is referred to as 2:1 TRUE in the test results.

A formula was derived that closely approximates the 2:1 TRUE data set. The formula was compared to actual backup and restore jobs at all tested compression rates.

**IMPORTANT:** The formula can approximate backup and restore rates for the EBS, but every backup or restore job in the real-world is subject to performance variables. The formula and Sizer Tool are only estimates that are designed to be as close as possible to real world conditions.

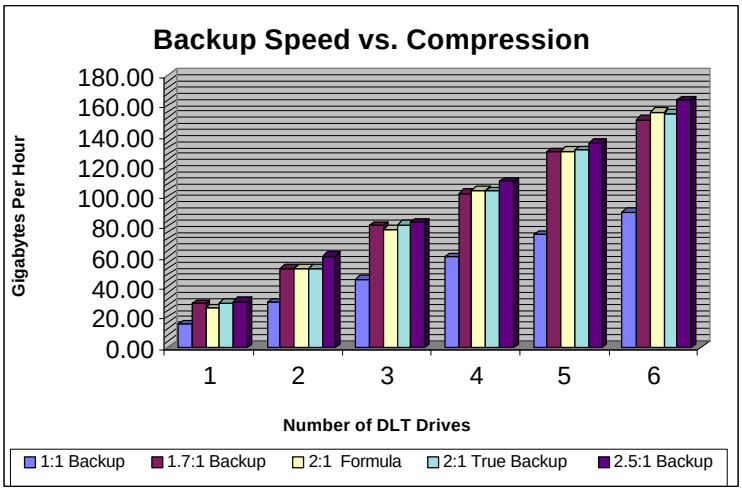


Figure 8-4. Comparisons of actual compressed jobs and the formula

# Backup Formula

***If* ((Base Rate * Compression) – (Compression$^2$)) < 43**

***Then* ((Base Rate*Compression)–(Compression$^2$)) * Drives) = Backup Rate**

***Else* (43 * Drives) = Backup Rate**

- The Base Rate for 1:1 Backups is 15 GB/H
- The Drives equal the number of DLT Drives backing up data
- The Compression Loss (CL) is equal to Compression Squared

## Backup Examples

### 2:1 Compression Examples

***If*** **((BR * COM) – (COM$^2$)) <43** ***Then*** **((BR*COM) - CL) * DRV) = MaxBU**

***Else*** **(43 * DRV) = MaxBU**

**Table 8-1**
**2:1 Compression Examples**

| Number of Drives | Base Rate = 15, COMpression = 2, CL = COM$^2$ | GB/H |
|---|---|---|
| **1** | if((15*2)-(4))=26 <43 (true) then(((15*2)-(4)) * 1) = | 26 |
| **2** | if((15*2)-(4))=26 <43 (true) then(((15*2)-(4)) * 2) = | 52 |
| **3** | if((15*2)-(4))=26 <43 (true) then(((15*2)-(4)) * 3) = | 78 |
| **4** | if((15*2)-(4))=26 <43 (true) then(((15*2)-(4)) * 4) = | 104 |
| **5** | if((15*2)-(4))=26 <43 (true) then(((15*2)-(4)) * 5) = | 130 |
| **6** | if((15*2)-(4))=26 <43 (true) then(((15*2)-(4)) * 6) = | 156 |

### Examples With Varying Compressibility

**Table 8-2**
**Examples With Varying Compressibility**

| COMpression | Number of Drives=6, Base Rate = 15, CL = COM$^2$ | | GB/H |
|---|---|---|---|
| **1.7:1** | *if*((15*1.7)-(2.9))=22.6 <43 (true) *then*(((15*1.7)-(2.9)) * 6) | = | 136 |
| **2:1** | *if*((15*2)-(4))=26 <43 (true) *then*(((15*2)-(4)) * 6) | = | 156 |
| **2.5:1** | *if*((15*2.5)-(6.3))=31.2 <43 (true) *then*(((15*2.5)-(6.3)) * 6) | = | 188 |
| **3.3:1** | *if*((15*3.3)-(10.9))=38.6 <43 (true) *then*(((15*3.3)-(10.9)) * 6) | = | 232 |
| **4:1** | *if*((15*4)-(16))=44 <43 (false) *then*(43* 6) | = | 258 |

# Restore Formula

***If*****(((Base Rate * Compression)–(Compression$^2$))*Drives)<90**

***Then*** **(((Base Rate*Compression)–(Compression$^2$)*Drives)=Restore Rate**

***Else*** **90=Restore Rate**

- The Base Rate for 1:1 Restores is 15 GB/H
- The Drives equal the number of DLT Drives backing up data
- The Compression loss is equal to Compression Squared

## Restore Examples

### 2:1 Compression Examples

***If*(((BR*COM)-($C^2$))*DRV)<90 *Then* (((BR*COM)–($C^2$))*DRV)=MaxRestore**

***Else* 90=MaxRestore**

### 2:1 Compression (BR=15, COM=2, CL=($COM^2$), DRV 1-6

**Table 8-3**
**2:1 Compression Examples**

| Number of Drives | Base Rate = 15, COMpression = 2, CL = COM2 | GB/H |
|---|---|---|
| **1** | if (((15 * 2) - (4)) * 1) =(26) < 90 (true) then (((15 * 2)-(4))*1) = | 26 |
| **2** | if (((15 * 2) - (4)) * 2) =(52) < 90 (true) then (((15 * 2)-(4))*2) = | 52 |
| **3** | if (((15 * 2) - (4)) * 3) =(78) < 90 (true) then (((15 * 2)-(4))*3) = | 78 |
| **4** | if (((15 * 2) - (4)) * 4) =(104) < 90 (false) then (90) = | 90 |
| **5** | if (((15 * 2) - (4)) * 5) =(130) < 90 (false) then (90) = | 90 |
| **6** | if (((15 * 2) - (4)) * 6) =(156) < 90 (false) then (90) = | 90 |

### Examples With Varying Compressibility

**Table 8-4**
**Examples With Varying Compressibility**

| COMpression | Number of Drives=2, Base Rate = 15, CL = COM2 | GB/H |
|---|---|---|
| **1.7:1** | if (((15*1.7)-(2.9))* 2)=(45)<90 (true) then (((15*1.7)-(2.9))*2) = | 45 |
| **2:1** | if (((15*2) -(4))*2) =(52)<90 (true) then (((15*2)-(4))*2) = | 52 |
| **2.5:1** | if (((15*2.5)-(6.3))*2) =(62)<90 (true) then (((15*2.5)-(6.3))*2) = | 62 |
| **3.3:1** | if (((15*3.3)-(11))*2) =(77)<90 (true) then (((15*3.3)-(11))*2) = | 77 |
| **4:1** | if (((15*4) -(16))*2) =(88)<90 (true) then (((15*4) – (16))*2) = | 88 |
| **5:1** | If (((15*5) – (25)*2 =(100)<90 (false) then (90) = | 90 |

# Lights Out Tests

Lights out tests were designed to consider factors that would affect backup rates when automated tape libraries are connected to the EBS. Tape retention policies determined the number of tapes needed to maintain several sets of backups that can be overwritten after the retention period has expired. Full, Incremental, and Differential backups were analyzed to find factors that would affect performance when large quantities of data were processed.

## Calculating Tape Retention

How you are storing the backup data on tape, and how long you keep the tapes before they are erased greatly impacts the total number of tapes needed to maintain the desired backup schedule. Follow the procedure below to determine the amount of storage you will need.

See the whitepaper entitled Sizing the Compaq StorageWorks Enterprise Backup Solution at: www.compaq.com/support/techpubs/whitepapers for more information on calculating tape retention.

### Backup Descriptions

There are three basic types of tape rotation within each backup cycle. Each method offers advantages and disadvantages in cartridge use and restore time.

- **(F) Full Backups Only—**All data is backed up every time a backup is conducted (regardless of the frequency of the backups). This method uses the highest amount of tape cartridges and tape bandwidth but offers the highest level of disaster recovery and restore speed.
- **(I) Full/Incremental Backups—**Each backup cycle will include one full backup and multiple incremental backups. Incremental backups back up all data that has changed since the last backup of any type. This method minimizes cartridges over the other two methods but will also offer the slowest restore times of the three methods.
- **(D) Full/Differential Backups—**Each backup cycle will include one full backup and multiple differential backups. Differential backups back up all the data that has changed since the last full backup. This method minimizes cartridges over the full-only method but will normally increase the restore time for large restores. Single file restore performance should not be affected.

### Procedure

1. **Calculate data sets.** Determine the number of full, incremental, and/or differential data sets to be retained.
2. **Assign percentages** to each backup set for a given number of days. For example:
   - Full (F) = 100%
   - Incremental (I) = 20%*
   - Differential (D) = 20%*

   ***NOTE**: Actual Incremental and Differential percentages vary for every backup set, based on the actual amount of data changed.
3. **Total** the percentages.
4. **Calculate total storage** needed:
   - Total Percentage*Data Set (in GB) = Total Storage Needed (in GB)
5. **Calculate storage capacity** of each tape:
   - 35 GB*Compression Rate = Tape Capacity
6. **Calculate number of tapes** needed:
   - (Total Data*Retained Percentage)/Tape Capacity = Number of Tapes Required

### Examples

The following examples use the procedures described above to calculate tape retention.

- Retaining 3 full backups at all times.

7. **Calculate data sets**: This example requires four full sets to ensure that the 4th backup completes successfully before erasing the first full backup.
8. **Assign percentages**: F=100%
9. **Total the percentages**: F+F+F+F=400%
10. **Calculate total storage needed**: Assuming a 100 GB data, 400 GB of tape are needed to retain 3 full backups at all times. 400%*100 GB = 400 GB
11. **Calculate tape storage capacity**: Assuming 2:1 compression, each tape will hold 70 GB of data. (35 GB*2)=70 GB
12. **Calculate number of tapes needed**: You will need 6 tapes for this example:

**Answer:** (100 GB*400%)/70GB = 5.7 or 6 tapes

- **Retaining 3 Full Backups and 4 Incremental Backup Sets**

1. **Calculate data sets**: This example requires each data to set include 3 Full and 4 Incremental backups. A 4th Full backup is required to ensure that the 4th backup completes successfully before erasing the first Full backup.
2. **Assign percentages**: F=100%, I=20%

**Total** the percentages:

- (F+I+I+I+I)+(F+I+I+I+I)+(F+I+I+I+I)+(F)=640%

(100+20+20+20+20)+(100+20+20+20+20)+(100+20+20+20+20)+(100)=640%

1. **Calculate total storage needed**: Assuming a 100 GB data, 640 GB of tape are needed to retain 3 full backups at all times. 640%*100 GB = 640 GB
2. **Calculate tape storage capacity**: Assuming 2:1 compression, each tape will hold 70 GB of data. (35 GB*2)=70 GB
3. **Calculate number of tapes needed**: You will need 10 tapes for this example:

**Answer:** (100 GB*640%)/70GB = 9.1 or 10 tapes

- **Retaining 3 Full and 4 Differential Backups**

1. **Calculate data sets**: This example requires each data set to include 3 Full and 4 Differential backups. A 4th Full backup is required to ensure that the 4th backup completes successfully before erasing the first Full backup.
2. **Assign percentages**: F=100%, D=20%, increasing 20% per day.

Total the percentages:

- (F+D+D+D+D)+(F+D+D+D+D)+(F+D+D+D+D)+(F)=1000%
- (100+20+40+60+80)+(100+20+40+60+80)+(100+20+40+60+80)+(100)=1000%

1. **Calculate total storage needed**: Assuming a 100 GB data, 1000 GB of tape are needed to retain 3 full backups at all times. 1000%*100 GB = 1000 GB.
2. **Calculate tape storage capacity**: Assuming 2:1 compression, each tape will hold 70 GB of data. (35 GB*2)=70 GB.
3. **Calculate number of tapes needed**: You will need 15 tapes for this example:

**Answer:** (100 GB*1000%)/70GB = 14.2 or 15 tapes

### Calculating Backup Windows

#### Volume Calculations

Backup windows can be virtually 24 hours per day with the EBS due to the use of a separate Storage Area Network for data movement. However, many administrators prefer to schedule backups at off hours for management reasons. To calculate the time needed to perform various backup jobs, the backup rate as defined in the Backup Formula section must be compared to the data sets being backed up. Using the examples in the tape retention section, calculation examples are as follows:

- Example 1: Full Backup
  - Compression rate = 2:1
  - Formula Backup Rate = (15*2)-(4) = 26 GB/hr
  - Data Set = 100 GB
  - Full Backup 100% 100 GB
  - Backup Window = (Data Set / Formula Backup Rate = Hours)
  - 100 GB /26 GB/H = 3.85 Hrs = **3:51 Hrs**
- Example 2: Incremental Backup
  - Compression rate = 2:1
  - Formula Backup Rate = (15*2)-(4) = 26 GB/hr
  - Data Set = 100 GB
  - Incremental Backup 20% 20 GB
  - Backup Window = (Data Set / Formula Backup Rate = Hours)
  - 20 GB /26 GB/hr=.77 hrs=**46 Minutes**
- Example 3: Differential Backup
  - Compression rate = 2:1
  - Formula Backup Rate = (15*2)-(4) = 26 GP/hr
  - Data Set = 100 GB
  - Incremental Backup 20 % Day 1, 40 % Day 2, 60 % Day 3, 80% Day 4.

**Table 8-5**
**Backup Window = (Data Set / Formula Backup Rate = Hours)**

| | | | |
|---|---|---|---|
| Day 1 | 20 GB/26 GB/H= | .77 Hrs | 46 Minutes |
| Day 2 | 40 GB/26 GB/H= | 1.54 Hrs | 1:33 Hrs |
| Day 3 | 60 GB/26 GB/H= | 2.31 Hrs | 2:19 Hrs |
| Day 4 | 80 GB/26 GB/H= | 3.08 Hrs | 3:05 Hrs |

**NOTE:** These calculations assume that one drive is being used per backup. If 2 or more drives are used by dividing volume sets the total backup window can be divided by the number of drives used for the backup.

### Tape Change Adjustment

Backup windows are determined by the total elapsed time required to backup sets of data. The number of DLT Drives can be increased by adding Tape Libraries to the EBS to meet the most demanding needs. The effects of unloading and loading new tapes when the tape capacity is exceeded were measured to more accurately calculate backup windows. Data sets were increased to 180 GB and were generated using the 2:1 TRUE file described in the "Compression Tests" section. The results were compared to the 4 GB data sets previously tested. The result showed a total loss in backup performance of approximately 3%. This 3% reduction in performance should be applied to all backups that exceed the volume of one tape.

### Incremental or Differential Adjustment

Incremental and differential backups must compare archive bits of all files in the 180 GB data set and only back up the files that have changed since the last differential or full backup. To simulate real-world conditions, Compaq developed a program that would randomly change 20% of the archive bits of the files after each backup.The rates for the 36 GB backed up were compared to the backup formula generated for 2:1 compressible data. The result showed a total loss in backup performance of approximately 14%.This 14% reduction in performance should be applied to all Incremental and Differential backups.

**IMPORTANT:** Real world effects on Incremental and Differential backups will vary depending on the percentage of changed files in each data set.

## Compaq StorageWorks Enterprise Backup Solution Sizing Tool.

Compaq developed a sizing tool to:

- Allow easy input of the many variables that affect backup performance.
- Calculate the number of tapes and libraries necessary to allow Lights Out operations.
- Speed calculations to ensure that backup windows are not exceeded.

The tool allows selection of server configurations that can be replicated or modified to represent enterprise zones. Detailed calculations and equipment required are presented, showing quantities and part numbers necessary to deploy the Compaq StorageWorks Enterprise Backup Solution. The Compaq StorageWorks EBS Sizer Tool is available from **www.Compaq.com/StorageWorks/.**

## Parameter Screen

The Parameters view collects information about the tape management implementation. You must choose the operating system your solution will support, then add a server to be supported in the solution. Once you have completed the interview session for that server, the Parameters view displays again. At this time, you can choose to copy, edit, or delete that server. You can also add another server.

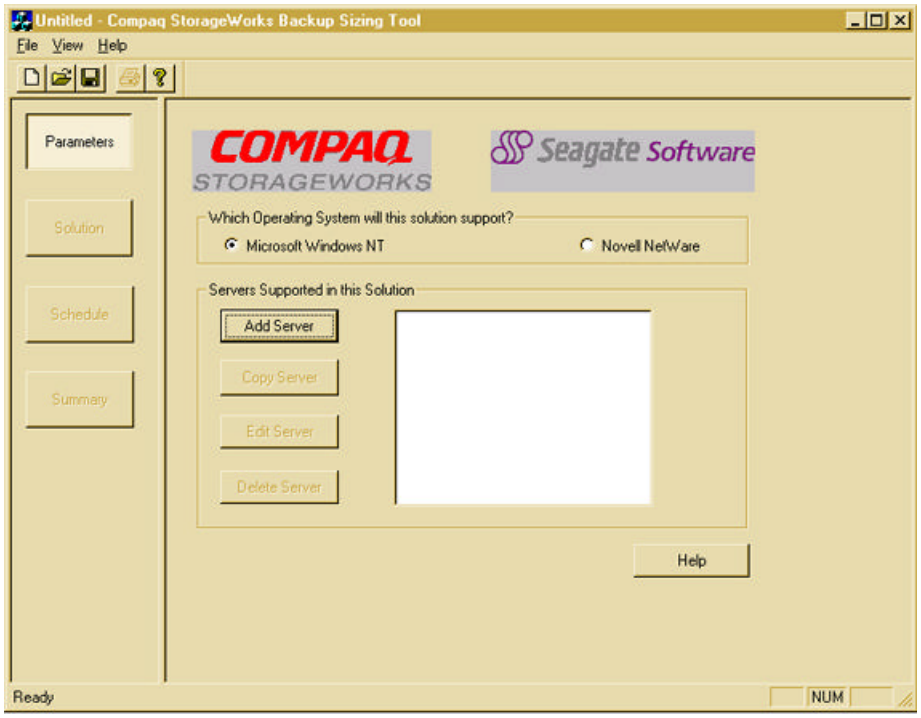


Figure 8-5. The Parameter Selection Screen

### Server Information

Enter a server name and the estimated total Gigabytes of data to be backed up.

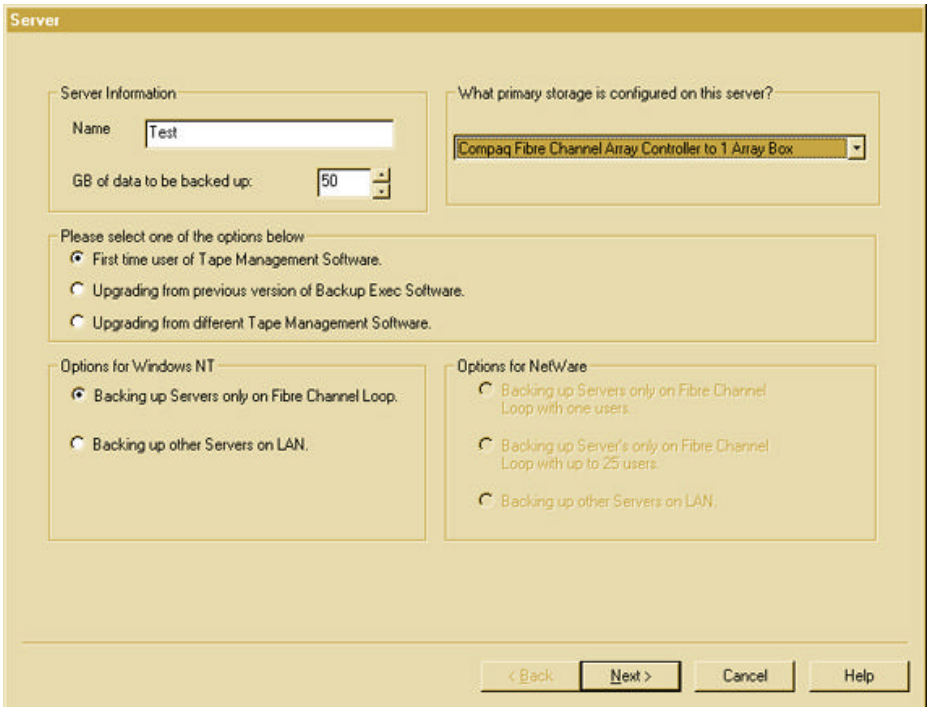


Figure 8-6. The Server Information Screen

### What Primary Storage system is configured on this server?

The Primary Storage configuration is an important link in the backup performance calculation. It has a direct effect on the speed at which the server can send data to the tape device. Select the type and configuration that most closely matches your server's primary storage system. Pull down the menu selections for various hard disk controllers to select the approximate feed speed of the primary storage system.

Ideal primary storage feed speed would be above three times the backup rate (3:1) of each DLT drive. This will allow the data to stream to the DLT drive and achieve near 100% performance. If the feed speed is 2:1 but less than 3:1, the backup performance is reduced by approximately 20%. If the feed speed is less than 2:1, the backup performance is reduced by approximately 50%. The sizer tool uses the reduction ratios to better estimate the actual performance for various primary storage controller systems.

**IMPORTANT:** These percentages are only estimates and individual performance may vary.

### Select Software Options

Choose the appropriate options for the server being configured. This information is used to select the software modules that are detailed in the solution. These options do not affect the performance calculations.

### Data on Server Screen

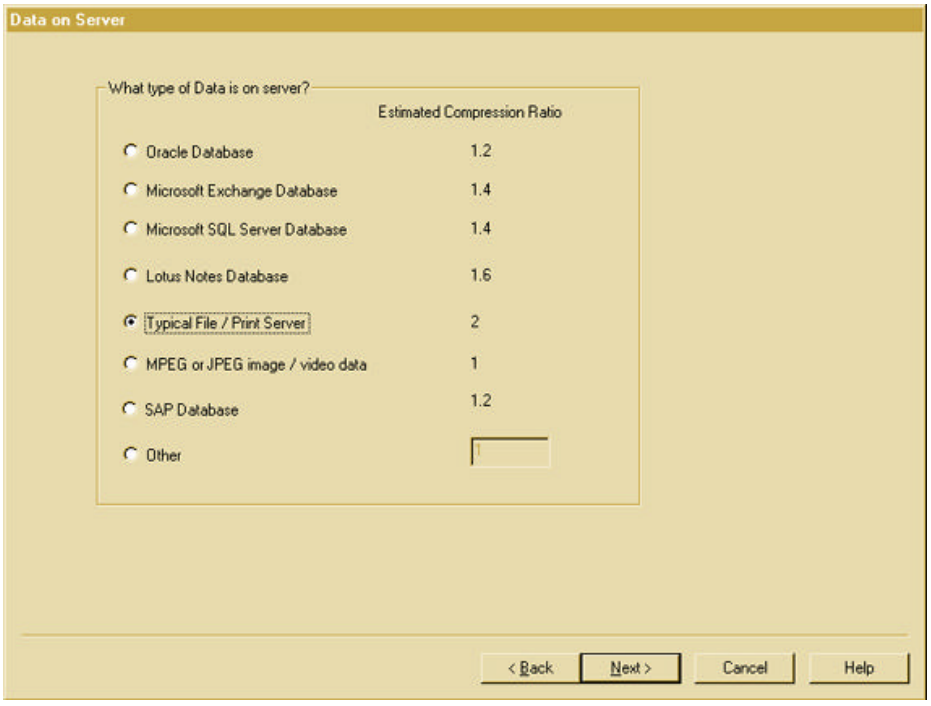


Figure 8-7. The Data Compressibility Information screen.

### Compressibility

You can specify the type of data you need to back up.

Tests have shown that not all data can be compressed equally. The compression ratio will affect the amount of data that can be stored on each tape cartridge, as well as the speed at which the tape drives can read/write the data.

If you have been performing tape backups on your servers with DLT tape drives, you should already have a good idea of the expected compression ratio for your data. Select the type of data that most closely matches your environment, or enter this information in the Other field.

If your server has multiple types of data, select the composite average compression ratio you expect to achieve.

### Agent Option Selection

When selecting Oracle, Exchange, SQL, or SAP, the appropriate agent software and part numbers will be included in the Solution and Summary Screens.

## Partial Backup Screen

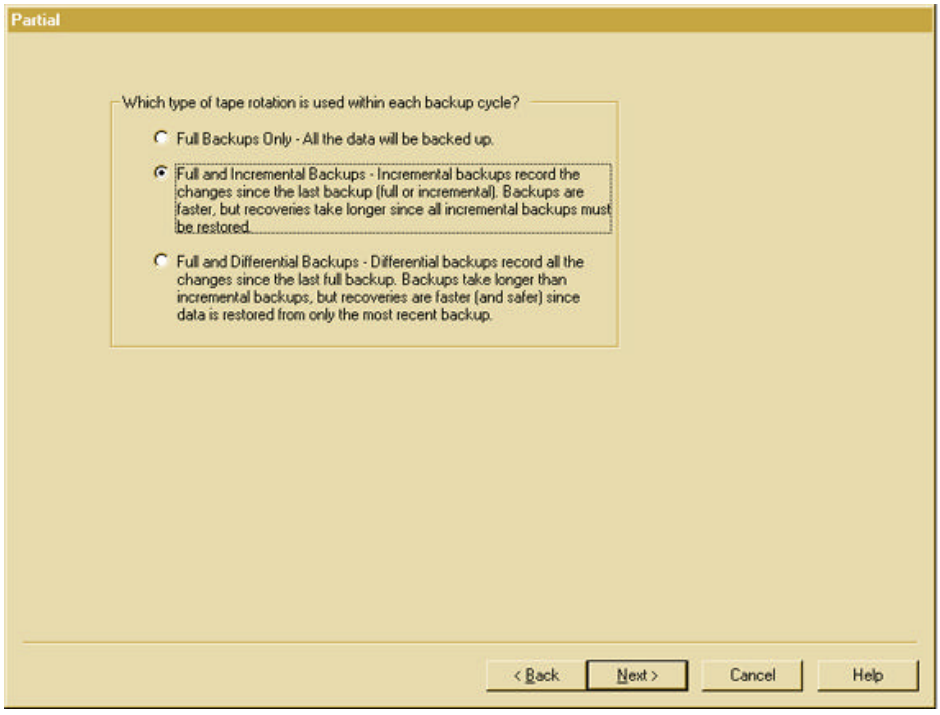


Figure 8-8. The Partial Backup Information Screen

The Partial Screen allows you to enter the type of tape rotation to be used within each backup cycle. There are three basic types of tape rotation within each backup cycle. Each method offers advantages and disadvantages in cartridge use and restore time.

## Schedule Screen

The Schedule Screen allows you to enter your backup schedule.

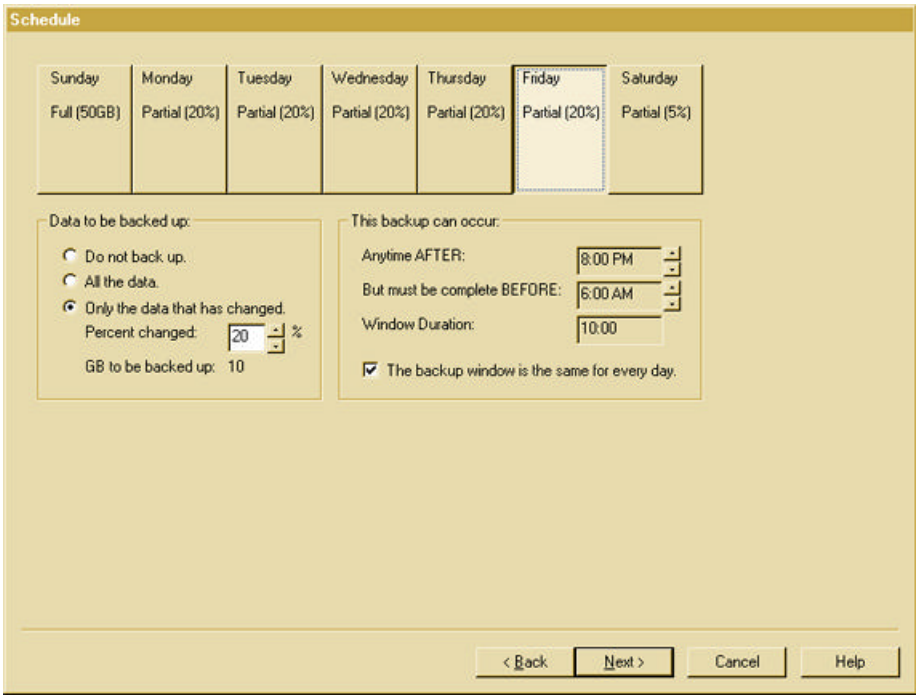


Figure 8-9. The Schedule Information Screen.

### Data to be Backed Up

For each day of the week, specify the type of backup that will be performed. Selecting the only data that has changed option will refer to either differential or incremental backups as defined on the previous screen. Differential backups back up all data that has been changed since the last full backup, while incremental backups back up all data that has been changed since the last backup of any type.

### Percentage Changed

Estimate the percentage of data that will have changed for this backup. This will help estimate the amount of data being backed up during this operation.

### Backup can Occur

Specify the beginning and ending time for the backup window for this server. You can specify a different backup window for each day of the week, or you can specify one single backup window that will apply to all days.

## Retention Screen

### Full Backup Retention

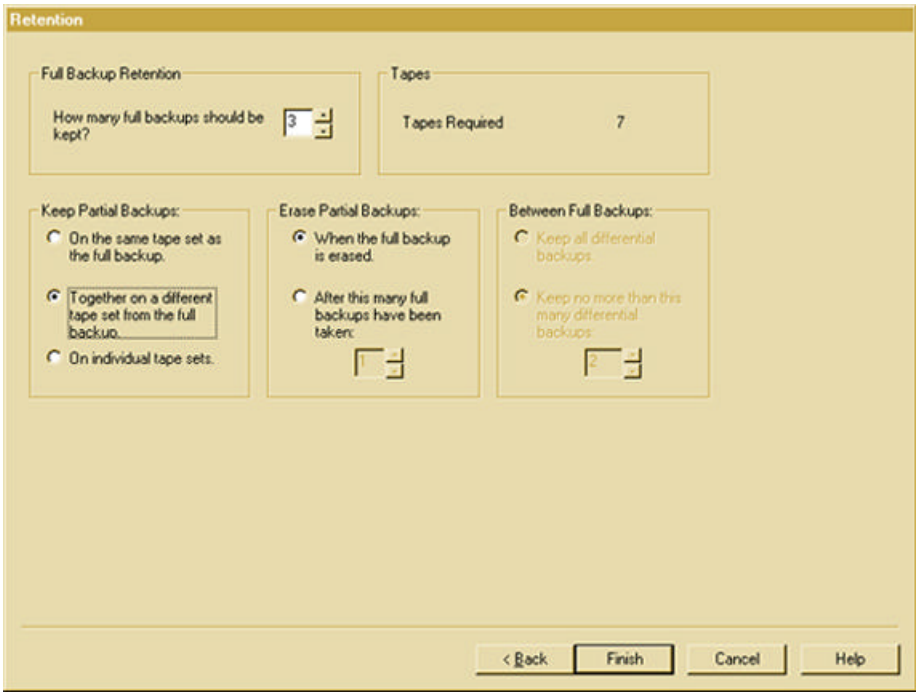


Figure 8-10. The Tape Retention Information screen.

Specify how many cycles of full backups you will want stored within the tape library. This is called "nearline storage." Backup data stored within the library can be restored more quickly than data stored outside the library. If this number is too large you may encounter a capacity problem with your library.

### Keeping Partial Backups

This allows you to define the way tape sets are managed between the full and partial backups. There are three options:

1. **On the same tape set as the full backup:** Full and partial backups for one cycle (usually one week) are all part of a single tape set. The retention schedules for these cartridges must be equal. With this option, all partial backups are retained as long as the preceding full backup is retained.
2. **Together on a different tape set from the full backup:** Partial backup data is written to a dedicated tape set that is separate from the full backup tape set. Each day's partial backup is "appended" to the end of the last partial backup. One retention period is defined for the entire partial backup tape set. This is the most common option since most users choose to define a longer retention period for full backup tape sets than the partial backup tape sets.
3. **On individual tape sets:** Each day's partial backup is written on a separate tape set. Any excess capacity remaining on the last tape of the day's partial backup is wasted since the next day's backup is written to a new tape set.

### Erase Partial Backups

This allows you to define the retention period for your partial backups. This option does not appear if you selected "On the same tape set as the full backup" on the previous question.

### Between Full Backups

This only appears if you choose to perform differential backups and also choose to keep each partial backup on a separate tape set. There are two options:

1. **Keep all differential backups:** Each differential backup within a cycle is retained until the time stated within the "Erase partial backups."
2. **Keep no more than this many differential backups:** Differential backup tape sets will be recycled after there are the specified number of differential backups or when the time stated within the "erase partial backups" is reached. For example, if you are performing differential backups on M-F and specify "2" for this question, you will perform differential backups on Monday and Tuesday. On Wednesday, Monday's tape set will be deleted. On Thursday, Tuesday's tape set will be deleted.

### Tape Sets

This shows the number of tapes required for this server.

## Solution Screen

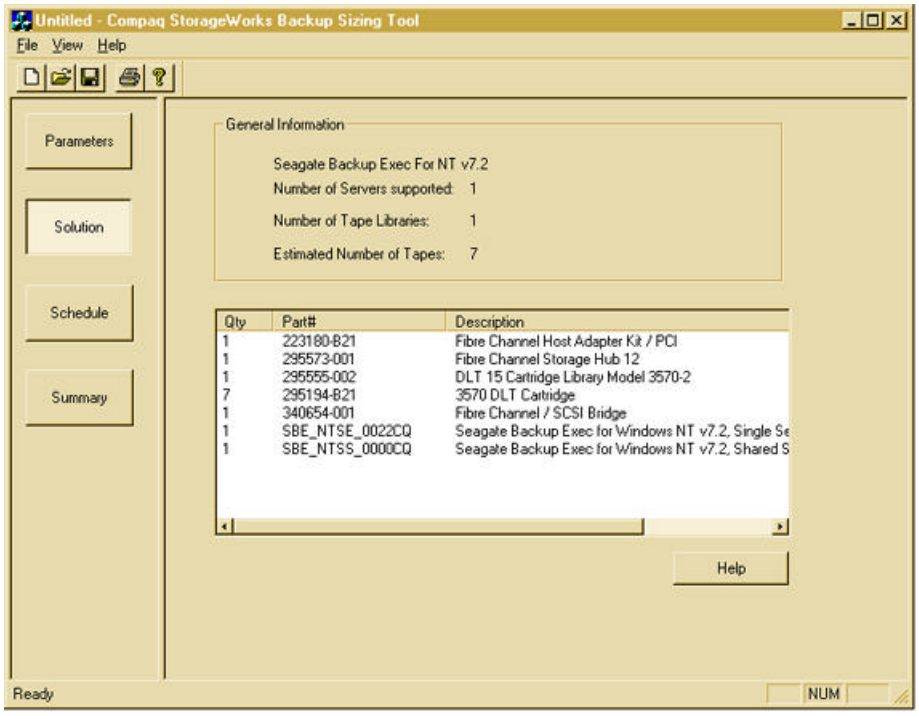


Figure 8-11. The Solution Information Screen.

The Solutions view displays the list of solutions that support the performance and business requirements specified for the tape management implementation.

GeneraI information displays, including the necessary software type and version and the number of servers, tape libraries, and tapes you will need for the solution.

All of the suggested components are listed to create the solution recommendations, including quantity needed, part number, and description.

Part numbers shown are based on US Domestic product descriptions. Consult your Compaq Authorized Dealer or reseller for specific configurations.

## Schedule Screen

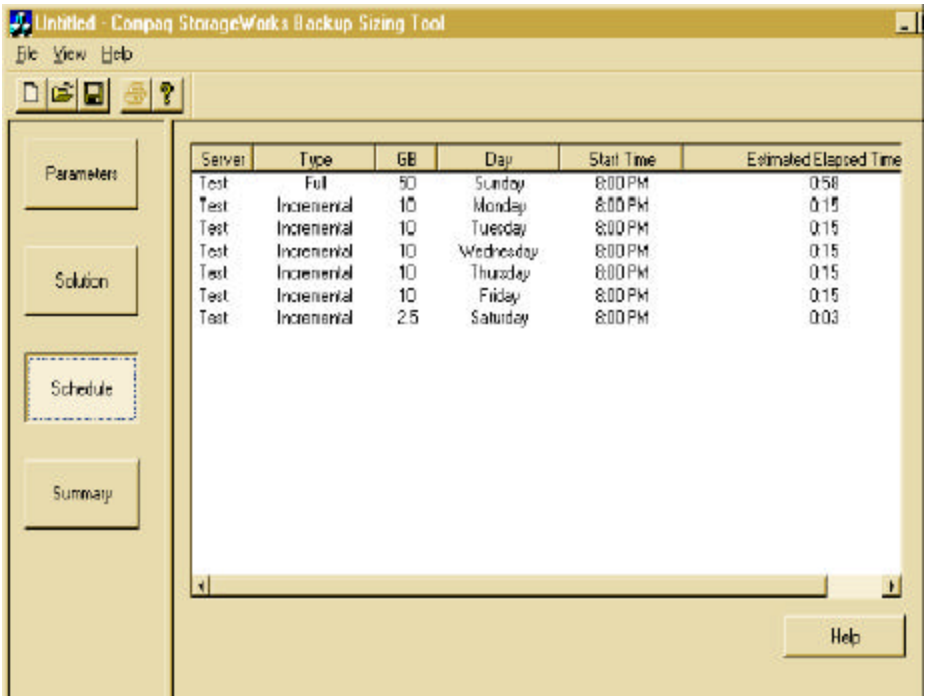


Figure 8-12. The Schedule Information Screen.

The **Schedule Screen** allows you to view your backup schedule.

The Schedule view displays the complete backup schedule you have selected through the interview session dialog.

Elapsed times are based on the formulas described in the Summary View Help Screen. For detailed information, refer to the Compaq StorageWorks Enterprise Backup Solution Tech Note at: www.compaq.com/StorageWorks/

## Summary Screen

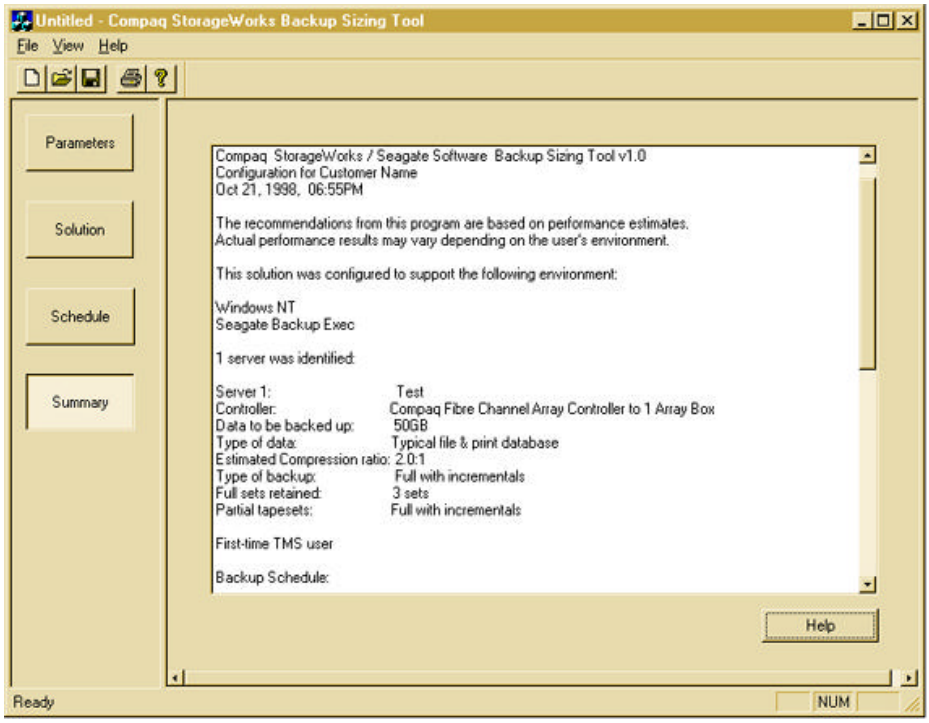


Figure 8-13. The Summary Information Screen.

The Summary Information Screen recaps all data collected and the solution developed by the Sizer tool, based on the calculation information presented in the beginning of this chapter.

### Adding Additional Servers

By returning to the parameters screen, you can add, copy, or delete additional servers to develop the Enterprise Backup Solution that represents your environment.You can navigate forward and backward through the Parameters screen to vary tape rotation schemes and view the results.

Warning messages pop up when the configured solution exceeds the capacity of the maximum configuration currently supported.

## Information and Tools

### Whitepaper

For more information on sizing your system, see the whitepaper entitled "**Sizing the Compaq StorageWorks Enterprise Backup Solution**" at:
**www.Compaq.com/support/techpubs/whitepapers**

### Software

**Compaq StorageWorks Backup Sizing Tool** can be downloaded from: **www.Compaq.com/StorageWorks/.**

# *Chapter 9*
# Troubleshooting and Diagnostics

As Compaq developed the Enterprise Backup Solution, troubleshooting and diagnostics were very carefully considered. Since the newest component was the Fibre Channel Arbitrated Loop (FC-AL), Compaq developed the **Compaq Fault Isolation Utility** to analyze the stability and integrity of the loop components. In addition, Compaq developed diagnostics for the SCSI devices connected to the FC-AL. The **Compaq User Diagnostics 2.02H** is currently limited to storage devices only but will be incorporated into the next generation of user diagnostics, that in turn will be incorporated into the next generation of servers.

## Fibre Channel Fault Isolation Utility

The Fibre Channel Fault Isolation Utility verifies the integrity of a new or existing FC-AL installation. When used with troubleshooting flow charts, this utility provides fault detection and help in locating a failing device on the FC-AL.

Each device on the FC-AL has an arbitrated loop physical address (ALPA). The ALPA is allocated dynamically--it can change from power-up to power-up, or as new devices are added to the loop. The login is an important concept in Fibre Channel. The fault isolation utility indicates all devices that are logged-in to the FC-AL. The utility dynamically updates the screens to show the current ALPA of each component. Additionally, a Loop Error Histogram is displayed when specific servers or components are highlighted to further analyze the health of individual components. The utility analyzes Fibre Channel components including the Host Bus Adapter and the Fibre Channel Tape Controller. The Fibre Channel Storage Hub is logically transparent to the operations of the FC-AL but even a failed Storage Hub can be detected when the Fault Isolation Utility is used in combination with the Troubleshooting Flow Charts.

Details and Flow Charts are available in the *Fibre Channel Troubleshooting Guide* (Fourth Edition Part Number 297877-004).

## Installing the Utility

Use the instructions in this section to install the Fibre Channel Fault Isolation Utility.

The latest files for the Fibre Channel Fault Isolation Utility, as well as information about installing the utility, are located on the Compaq SmartStart and Support Software CD. To access these files, create a set of Compaq diskettes from the Compaq SmartStart and Support Software CD.

## Materials Needed

Use the following items to create a set of diskettes:

- Compaq SmartStart and Support Software CD
- Blank diskettes
- A server or workstation with a bootable CD-ROM drive. (This may be the system in which you have installed the Fibre Channel Host Controller.)

## Creating the Diskettes

To create the diskettes:

1. **Boot** the server from the Compaq SmartStart and Support Software CD.
2. **Select** *Create Support Software* from the Compaq System Utilities screen.
3. **Select** *Create Support Software Diskettes* from the Diskette Builder screen.
4. **Scroll** down the list and select *Fibre Channel Fault Isolation Utility.*
5. **Follow** the instructions on the screen to create and label diskettes.

## Running the Utility

To run the Fibre Channel Fault Isolation Utility:

### Diskette Operations

1. **Place** the diskette in the diskette drive of the server that is connected to the Fibre Channel Arbitrated Loop.
2. **Reboot** the system. The Windows-based utility will load automatically.

### CD Operations

1. **Insert** the Smart Start CD in the CD ROM Drive.
2. **Select** Run Fibre Channel Diagnostics.
3. **Select Next** – The Windows-based utility will load automatically.

### Program Displays

The utility's main display is shown below. It displays each FC-AL from the perspective of the server. All Fibre Host Controllers in the server are shown with a slot number and indicate a PCI (/P) or EISA (/E)

**NOTE**: The Enterprise Backup Solution only supports PCI Host Bus Adapters to ensure adequate performance.

Each Fibre Channel Array and Fibre Channel Tape Controller is shown as a branch of the Fibre Host Controller that it is connected to. The Arbitrated Loop Physical Address (ALPA) is shown for each Fibre Channel Controller.

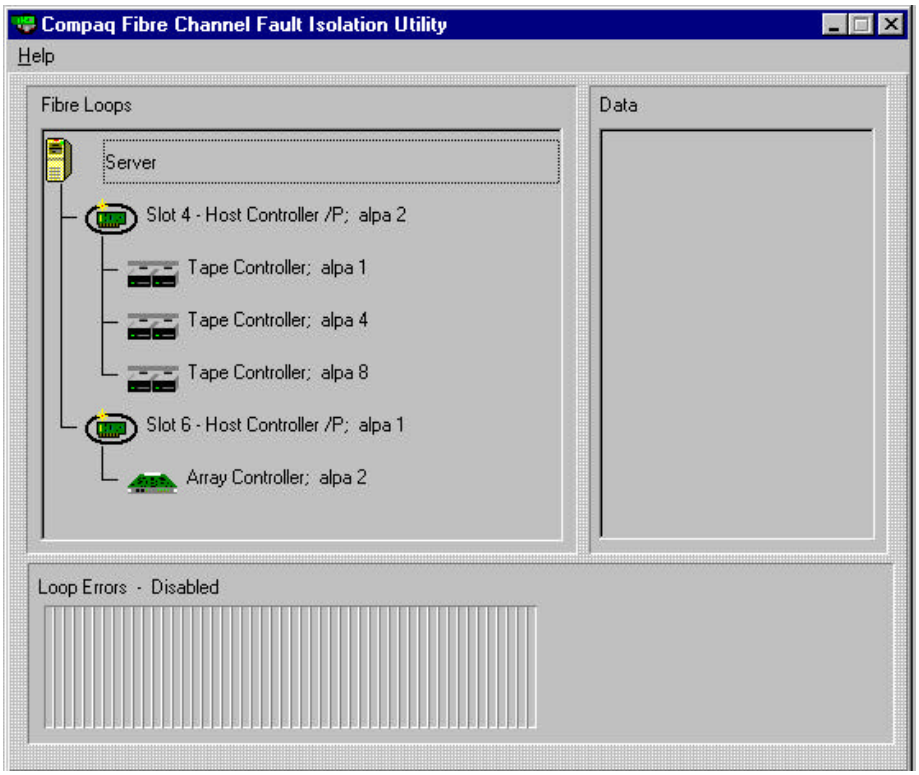


Figure 9-1. The Fibre Channel Fault Isolation Utility's Main Display

## Display of a Fibre Channel Tape Controller

The Fibre Channel Fault Isolation Utility displays detailed information about any Fibre Channel Tape Controller connected to the FC-AL. Figure 9-2 shows a Fibre Channel Tape Controller selected, with detailed information about this tape controller displayed to the right. A Fibre Channel Disk Array Controller is also shown on a separate FC-AL.

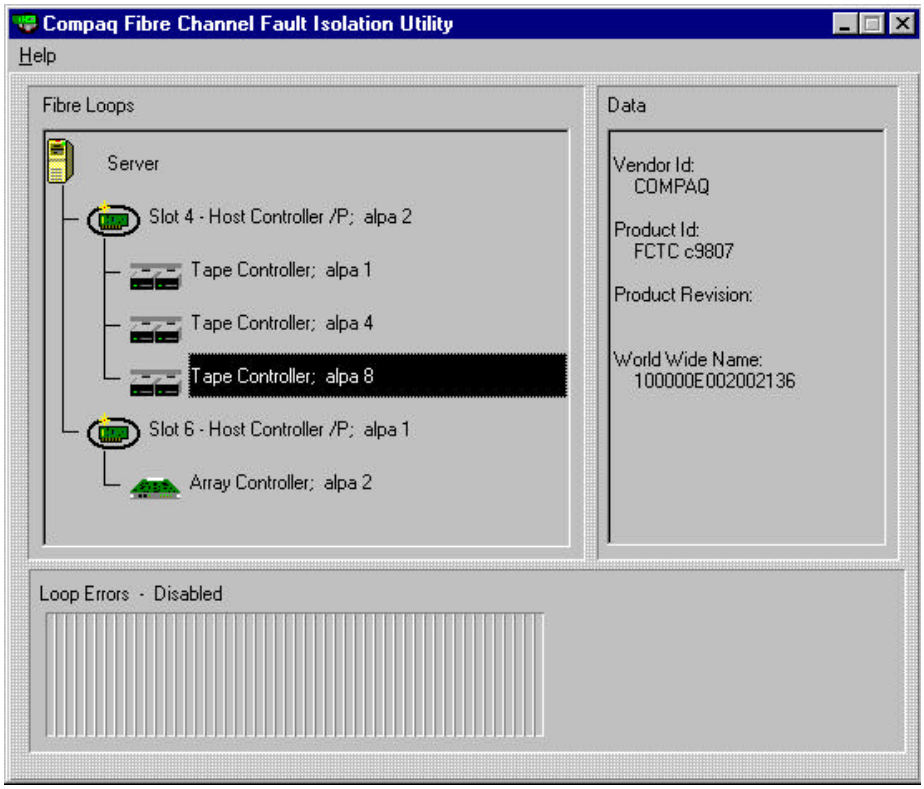


Figure 9-2. Detailed information Displayed about a Tape Controller

The information displayed in the data field includes:

- **Vendor ID**: Identifies the vendor of the target controller
- **Product ID**: Identifies the product
- **Product Revision**: Revision level of the product
- **World Wide Name**: A unique identifier in a Fibre Channel system, different for each Fibre Channel Component.

There is no correspondence between the order in which Fibre Channel target controllers appear on this screen and how they are physically connected on the FC-AL. The display shows the Fibre Channel target controllers are connected to the same FC-AL as the Fibre Channel Controller indicates.

## Loop Error Histogram Display

The Loop Error Histogram indicates errors detected on the FC-AL when a Fibre Channel Host Controller is highlighted. Each bar represents 3 seconds. The histogram scrolls from right to left; the most recent errors on the right, and the least recent errors on the left. Figure 9-3 shows a single error period. Notice that FC-AL errors do not update the histogram unless a Fibre Channel Host Controller is highlighted. This occurs because the server's only view of the FC-AL is through the Fibre Channel Host Controller, yielding no real indication of where the source of errors may be. When errors are displayed, individual components may be disconnected from the FC-AL to determine the failing cable, GBIC, or component. The flow charts in the Troubleshooting Guide help you through this process.

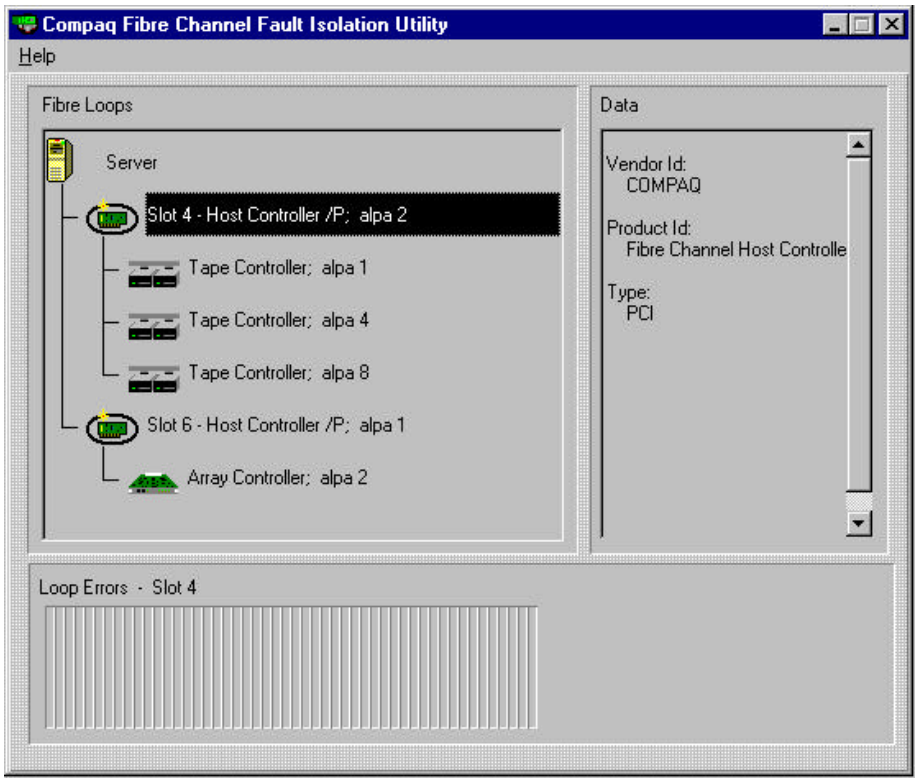


Figure 9-3. The Loop Error Histogram showing a single error period

Selecting the server causes the sum of all errors on all FC-ALs to be displayed. Selecting a different Fibre Channel Host Controller will display the errors associated with that FC-AL.

# Display of an FC-AL with a Missing Fibre Channel Tape Controller

The figure below shows a Fibre Channel Host Controller highlighted with a Fibre Channel Tape Controller missing. This indicates that while the Tape Controller has logged-on since this utility was started, it is not currently logged-on. This could mean that it has been physically disconnected or that errors are occurring on the FC-AL at a great enough frequency to prevent the device from logging in again.

If there are a large number of errors occurring in the FC-AL, the Fibre Channel Host Controller may not be able to communicate with the Fibre Channel Tape Controllers on the FC-AL. In this case, the Fibre Channel Controllers may appear to be offline in the program, although in reality they are physically connected to the FC-AL. When an FC-AL shows errors, the Fibre Channel Array and Tape Controllers may alternate between being logged-on the FC-AL or missing.

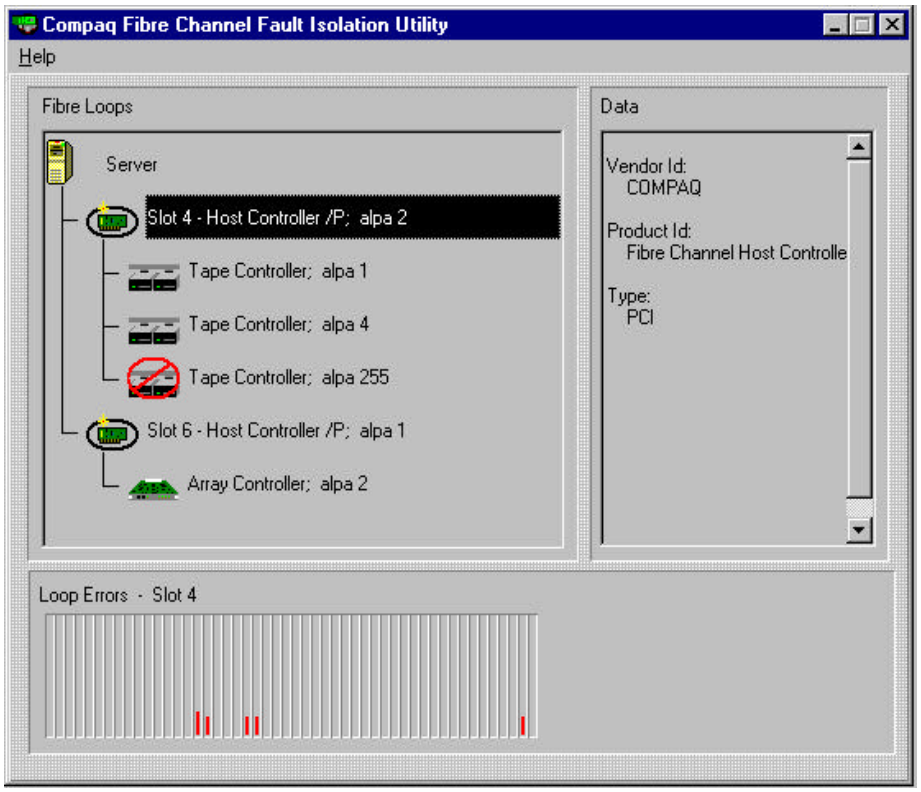


Figure 9-4. Display of a FC-AL with a Fibre Channel Tape Controller shown as missing

## Uninitialized Fibre Channel Arbitrated Loop Display

In Figure 9-5 the FC-AL connected to the Fibre Channel Host Controller in Slot 6 has not initialized. This can be derived from the Fibre Host Controller having the default ALPA of 255. If this controller was already initialized as part of an FC-AL, it would have a valid ALPA.

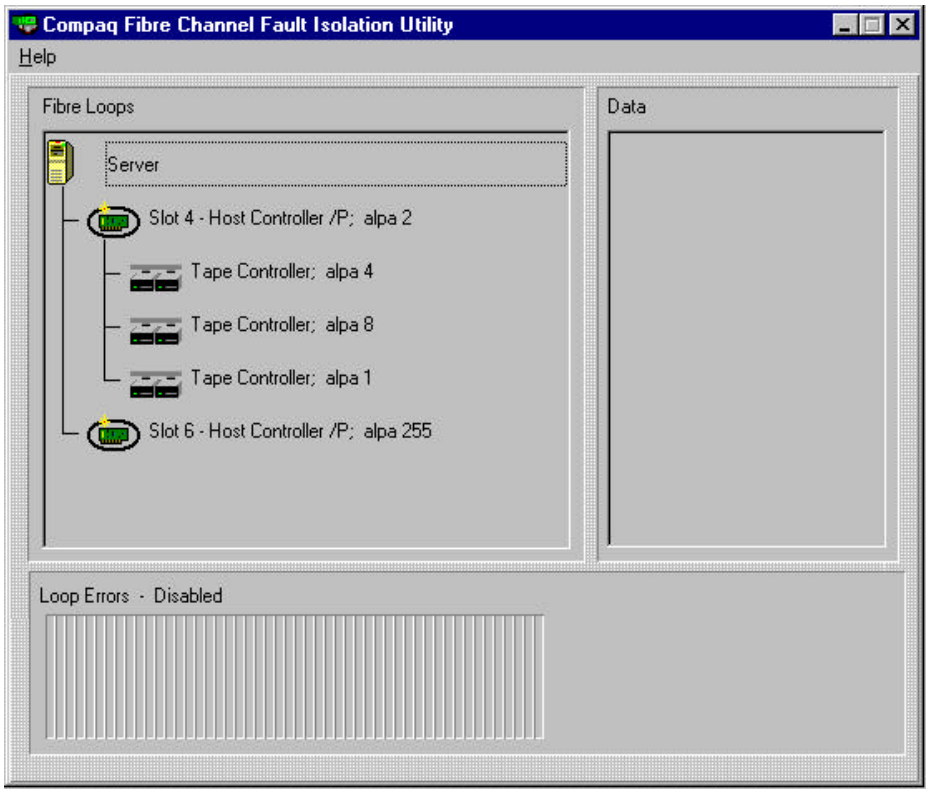


Figure 9-5. Display showing uninitialized FCTC in Slot 6

## Information and Updates

For more information on Fibre Channel Arbitrated Loop, see additional whitepapers at:

www.compaq.com/support/techpubs/whitepapers

## Compaq User Diagnostics

To further diagnose the components connected to the Fibre Channel Arbitrated Loop, Compaq developed an advanced set of "Compaq User Diagnostics". The support for Fibre Channel components was coupled with the SCSI device support section since the SCSI hard disk and DLT Tape Libraries appear logically as SCSI devices to the servers operating systems.

An advance version (2.02h) of the diagnostic utility is available from: www.compaq.com/StorageWorks/.

Future versions will be available on Compaq SmartStart CDs and the full features of Fibre Channel Diagnostics will be incorporated into Compaq's full line of diagnostic software.

## Introduction Screen

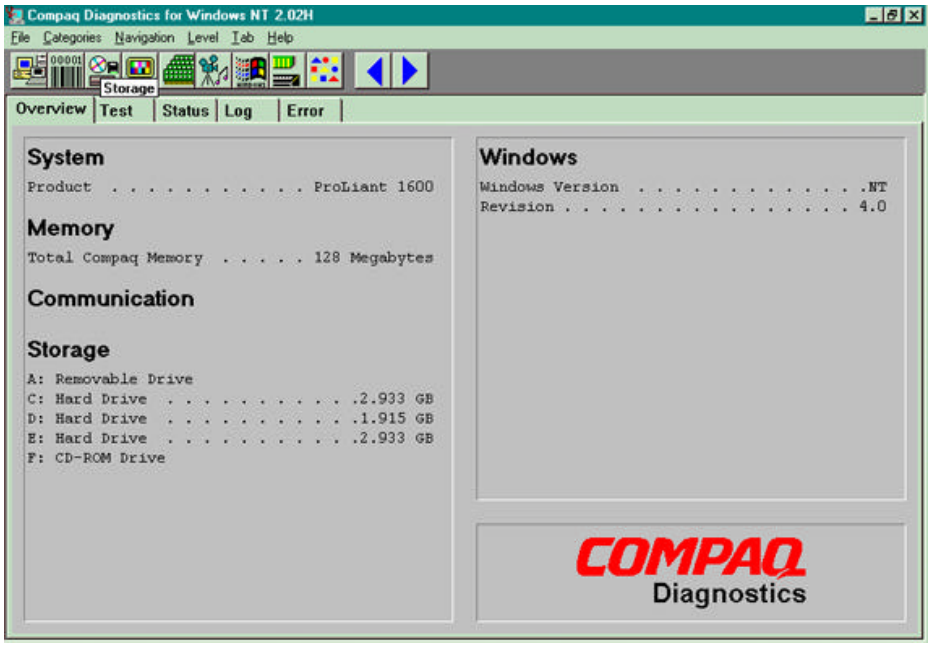


Figure 9-6. Display of Compaq Diagnostics for Windows NT

## Storage Screen

The Storage Screen displays all SCSI devices that appear to the server whether they are Fibre Channel attached or directly attached with conventional SCSI controllers and cables.Figure 9-7 shows the expanded view of a Fibre Channel Tape controller (FCTC).

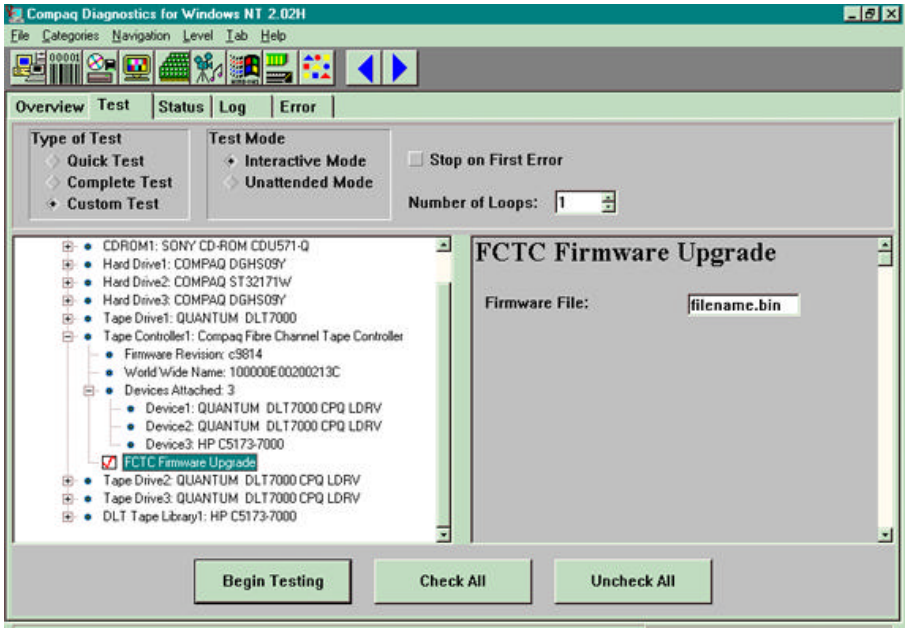


Figure 9-7. Expanded view of the FCTC

The Firmware revision and World Wide Name are displayed to easily identify each device. The devices attached to each FCTC are also displayed. A unique feature of Compaq User Diagnostics is the ability to upgrade Firmware in the FCTC. By selecting the Firmware Upgrade check box, the Firmware File dialog box appears with the ability to enter the path and file name of the appropriate firmware revision. By selecting Begin Testing, the firmware upgrade procedure will proceed. For the most recent version of FCTC firmware check: www.compaq.com/StorageWorks/**.**

**NOTE**: Firmware Upgrades should be performed by qualified technicians and abnormal interruption of the process can render the FCTC unusable**.**

## Tape Drive Diagnostics

By expanding the DLT Tape Drive section, the Firmware revision is available, including descriptions of SCSI Bus, Target and LUN information. This information is very important when troubleshooting or identifying devices in complex enterprise environments. Physical tests can also be performed by selecting Test Unit Ready and Buffer Tests. These tests are non-destructive, do not require moving media to the DLT Tape drives, and can quickly determine the health of drives. For in-depth diagnostics of a suspect drive in DLT Tape Libraries, the front panel diagnostics routines should be performed. Consult the DLT 3570 User's guide for additional details.Firmware upgrades can also be performed with the same cautions as mentioned for the Fibre Channel Tape Controller.

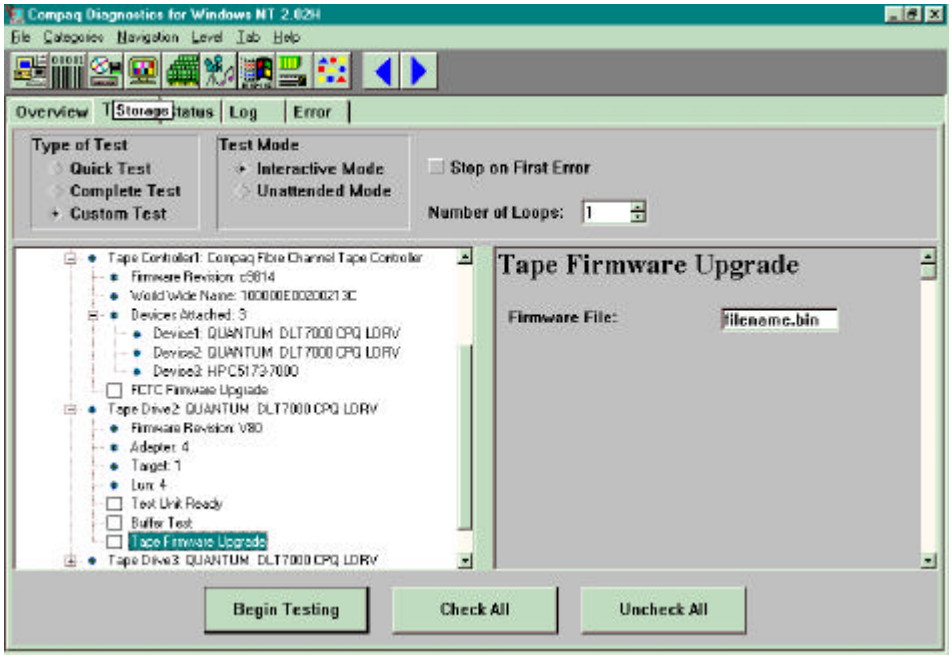


Figure 9-8. Expanded view of a DLT Tape Drive

## DLT Tape Library Diagnostic Screen

By expanding the DLT Tape Library section, Firmware versions, SCSI Identification information, and Library Element Status are displayed. In addition to Test Unit Ready commands, a Force Inventory and Move Media Command are available. These Diagnostic routines will verify existence of tapes and allow the testing of the Robotic Controller and mechanical mechanisms within the library. Firmware upgrades are available for the Robotic Controller, but should be used with extreme caution.

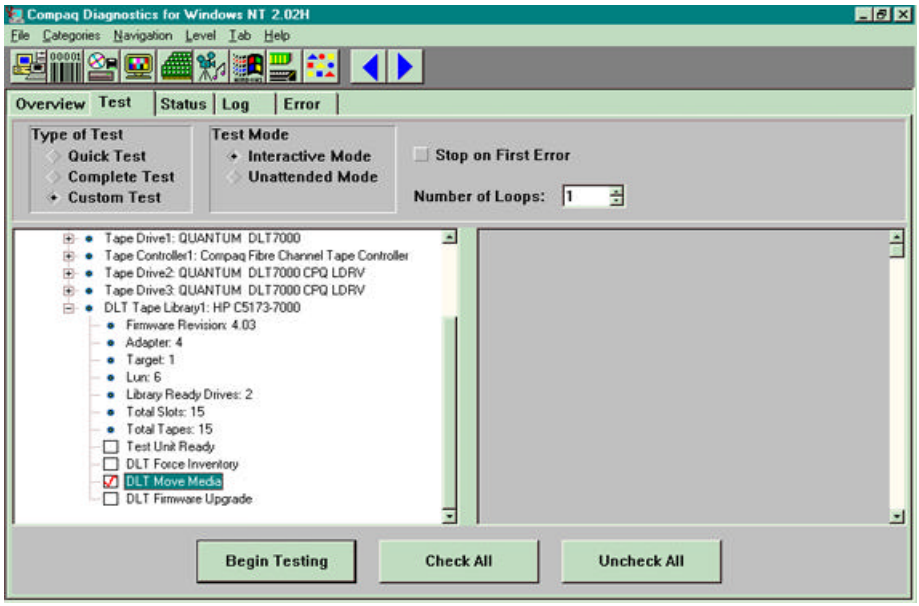


Figure 9-9. Expanded view of the DLT Tape Library Diagnostics

## Move Media Screen

The Move Media command is a good way to access the DLT Tape Library from remote locations to determine the health of the Robotic Controller, mechanical mechanisms and the Load & Unload ability of the DLT Drives. Caution should be taken to ensure that scratch media is used in testing the Move Media commands. Any time a tape is loaded and unloaded in a DLT drive, there is the possibility of destroying stored data or the actual media itself. Selections can be made to return the media to it's original position or leave it in the drives. Care should be taken to return media to it's original position to ensure the integrity of Bar Code element status and application software inventory requirements.

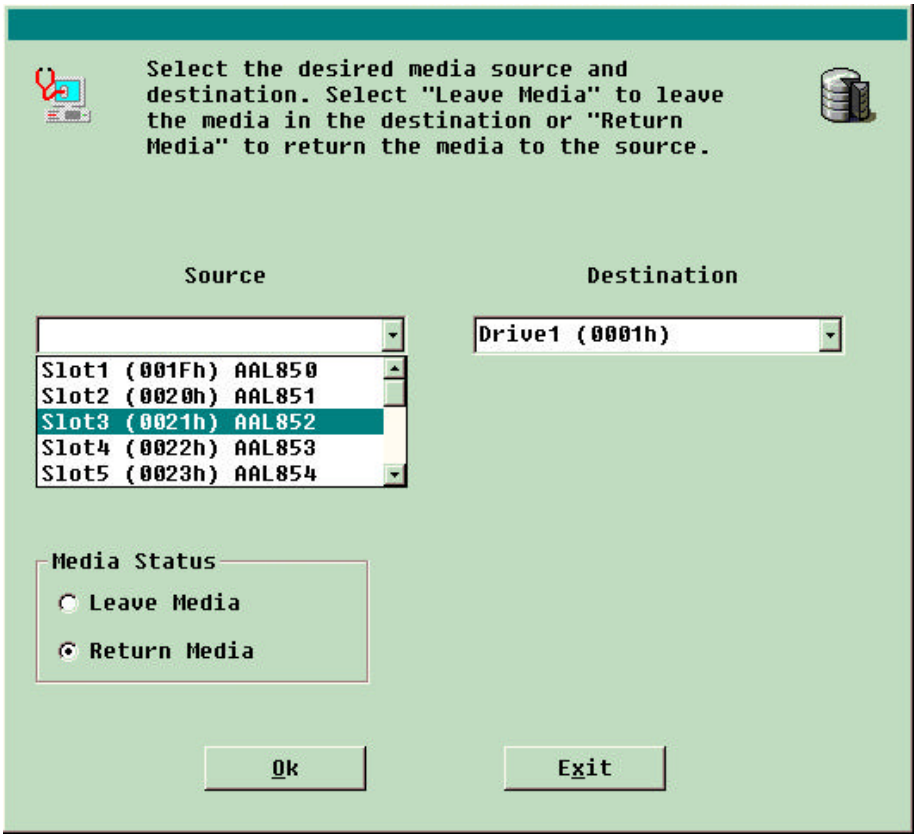


Figure 9-10. Move Media command screen

## Information Screens

Additional Status, Log, and Error screens are available for review of test results. Information Icons display general system information, however, in-depth diagnostics of components other than Storage Products is not available in version 2.02H.Full versions of Compaq User Diagnostics and additional information is available at http://saturn.wins.compaq.com/Revolution/Default.htm.

# *Appendix A*
# Compaq Technical Support

## Telephone Numbers

In the United States, call 1-800-345-1518

In Canada, call 1-800-263-5868

**Table A-1**
**Compaq Worldwide Telephone Numbers**

| Location | Voice | Fax |
|---|---|---|
| APD | 65-7503030 | 65-7504909 |
| Argentina | 54-1 313 3100 | 54-1 313 3100 Ext. 21 |
| Australia | 61-2-9911-1955 | 61-2-9911-1900 |
| Austria | 0222-87816-16 | 0222-87816-82 |
| Bahrain | 973-210-214 | |
| Belgium | (02) 716-96-96 | (02) 725-22-13 |
| Brazil | 55 11 5505-3600 | 55 11 5505-3922 Ext. 4336 |
| Canada | 1-800-386-2172 | |
| Caribbean | 1-800-345-1518 | |
| Central America | 281-378-2206 | |
| Chile | 562-274-3007 | |
| China | 86-10-834-6721 | 86-10-834-6713 |
| Colombia | 571-345-0266 | 571-312-0157 |
| Czech Republic | 42-2-232-8772 | 42-2-232-8778 |
| Denmark | 45-90-4545 | 45-90-4595 |
| Equador | 593-2504540 | |
| Europe/Middle East/Africa | (49) 089-9933-2891 | |
| Finland | 9800-206-720 (+358-800-1-206720) | 90-6155-9899 (+358-0-61559899) |
| France | (33 1) 41-33-4455 | (33 1) 41-33-4263 |
| Germany | 0180-5-212111 | 089-9933-3399 |

*Continued*

**Compaq Worldwide Telephone Numbers** *Continued*

| Location | Voice | Fax |
|---|---|---|
| Hong Kong | 852-90116633 | 852-28671734 |
| Hungary | 36-1-201-8776 | 36-1-201-9696 |
| India | (91-80) 559-6023 | |
| Italy | 392-57-90300 | 392-575-00686 |
| Japan | 0120-101589 | +81 3-5402-5959 |
| Korea | 82-2-523-3575 | 82-2-3471-0321 |
| Malaysia | (603) 718-1636 | |
| Mexico | (525) 229-7910 | (525) 229-7988 |
| Netherlands | 06-91681616 | 06-8991116 |
| New Zealand | 649-307-3969 | |
| Norway | 22-072-020 | 22-072-021 |
| Poland | 48-2-630-3535 | 48-2-630-3553 |
| Portugal | 351-1-4120132 | 351-1-4120654 |
| Singapore | 65-7503030 | 65-7504909 |
| South Africa | +27-11-728-6999 | +27-11-728-3335 |
| Spain | 341-640-1302 | 341-640-0124 |
| Sweden | (46) 8 703 5240 | (46) 8 703 5222 |
| Switzerland | 411 838 410/2222 | 01-837-0969 |
| Taiwan | (886) 2-3761170 | (886) 2-7322660 |
| Thailand | 62-2-679-6222 | 62-2-679-6220 |
| United Kingdom | 44-81-332-3888 | 44-81-332-3409 |
| United States | 1-800-386-2172 | 1-800-345-1518 |
| Venezuela | (582) 953.69.44 | (582) 952.86.70 |

## Compaq Website

Visit the Compaq website at www.compaq.com.

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