COMPAQ
White Paper

June 1998
ECG063/0498

Prepared by ECG Technology Communications Group

Compaq Computer Corporation

Contents

Fibre Channel Storage System: A Comparison to SMART-2DH

Abstract: The volume of data that businesses must store and manage continues to grow. This growth is driving new requirements for storage with superior capacity, scalability, performance, and uptime. With the introduction of the Compaq Fibre Channel Storage System and Compaq's existing SMART-2/DH-based storage solutions, Compaq now offers two state of the art storage solutions to meet these business-computing requirements.

The two solutions address different storage needs. The system architect must consider several factors to determine the appropriate solution for each application and computing environment.

This paper compares the Compaq Fibre Channel Storage System to SMART-2/DH-based technology and discusses how to choose between the systems based on:

- Business objectives (costs, efficiencies, etc.)
- Application requirements (capacity, performance, availability, etc.)
- Server platform (compatibility, integration, etc.)

Fibre Channel Storage Systems offers very high capacity and easy scalability for high storage growth applications. It is an ideal solution for large capacity file/print, centralized email, GroupWare, database and data mart applications. It also supports Microsoft Windows NT Clustering, making it ideal for higher-availability business applications.

The SMART-2/DH is an ideal solution for average capacity applications with slower data volume growth rates, or where the ease of adding storage capacity is not as important. It offers a similar performance and the same RAID data protection as the Fibre Channel Storage System but at a lower cost per megabyte. Unlike the Fibre Channel Storage System, it does not support server clusters.

Notice

Fibre Channel Storage System: A Comparison to SMART-2DH
White Paper prepared by ECG Technology Communications Group

First Edition (June 1998)
Document Number ECG063/0498

Introduction

With the explosive growth rate in data storage and the emergence of new paradigms in storage solutions, selecting the appropriate storage solution for an enterprise computing application is more complex than ever. Clear goals and objectives will help to ensure that a choice between alternative storage solutions will meet your enterprise storage requirements today and will support stable growth in the future.

When selecting the best storage solution for a particular environment, it is important that you consider the impact it will have on the following:

- Business objectives (efficiencies, cost, management, etc.)
- Application requirements (capacity, performance, availability, etc.)
- Server platform (compatibility, integration, etc.)
- Storage configuration

The objective is to create a balanced system in terms of performance, availability, scalability, ease of management, cost, etc. In the following paragraphs, we will consider each of these items using an example application and will arrive at an optimal storage solution. Following this discussion, you will learn more about the features of the Fibre Channel Storage System and the SMART-2/DH-based SCSI storage system, and how to apply the strongest points of each system to your own storage requirements.

Decision Steps

Business Objective

The first step in choosing any storage solution is to clearly state the objective management wishes to achieve. Clearly, this statement will vary from business to business in its specifics, but some generalizations apply across most businesses. For the purpose of this discussion, our objective will be to apply automated business applications to increase productivity and improve our decision processes. This is a common goal of OLTP database applications such as SAP or BaaN. Because these applications are critical to any business, system availability is a key requirement.

Application Requirements

Selection of the software application to meet the goals stated in the first decision step becomes a matter of matching the features offered in the software to the requirements established in the business objective statement. Ideally, more than one application will fit the requirements. Once selected, the application requirements for performance, availability, capacity, and growth must be fully understood. This step identifies the hardware resources required to run the selected application at the performance level necessary to achieve the business objective. Considerations include the number of clients expected, response latency, initial storage requirements, data growth estimates, and down time restrictions. When these parameters are clearly defined, platform selection may be made. The following chart can help in this process.

	File & Print	Centralized Email	Web Server	DSS Database	OLTP Database
Capacity	<50 GB	<50 GB	50 to 100 GB	100 GB	100 GB
Growth Rate	<50% / yr.	<50% / yr.	50% to 100% / yr.	50% to 100% / yr.	50% - 100% / yr.
Availability / Fault Tolerance	Low to Medium	Medium	Medium to High	Medium	High
SMART-2/DH Advantage	Price / Performance	Price / Performance	Price / Performance CPU Utilization	Price / Performance CPU Utilization	Price / Performance CPU Utilization
Fibre Channel Storage System Advantage	High Capacity Slot Utilization	High Capacity Slot Utilization Scalable Performance High Availability	High Capacity Slot Utilization Scalable Performance High Availability	High Capacity Slot Utilization Scalable Performance	High Capacity Slot Utilization Scalable Performance High Availability

Table 1. Application Requirements

Availability

In the enterprise environment today, network downtime is virtually unacceptable. Both solutions offer high availability features such as N+1 fans, redundant power supplies, intelligent RAID controllers, hot spare disk drives, and pre-failure warnings. However, the Compaq Fibre Channel solution offers the enterprise client the additional availability of server clustering and redundancy needed to meet the demanding requirements of business critical applications. Figure 1 highlights the relative availability of the Compaq StorageWorks Product line.

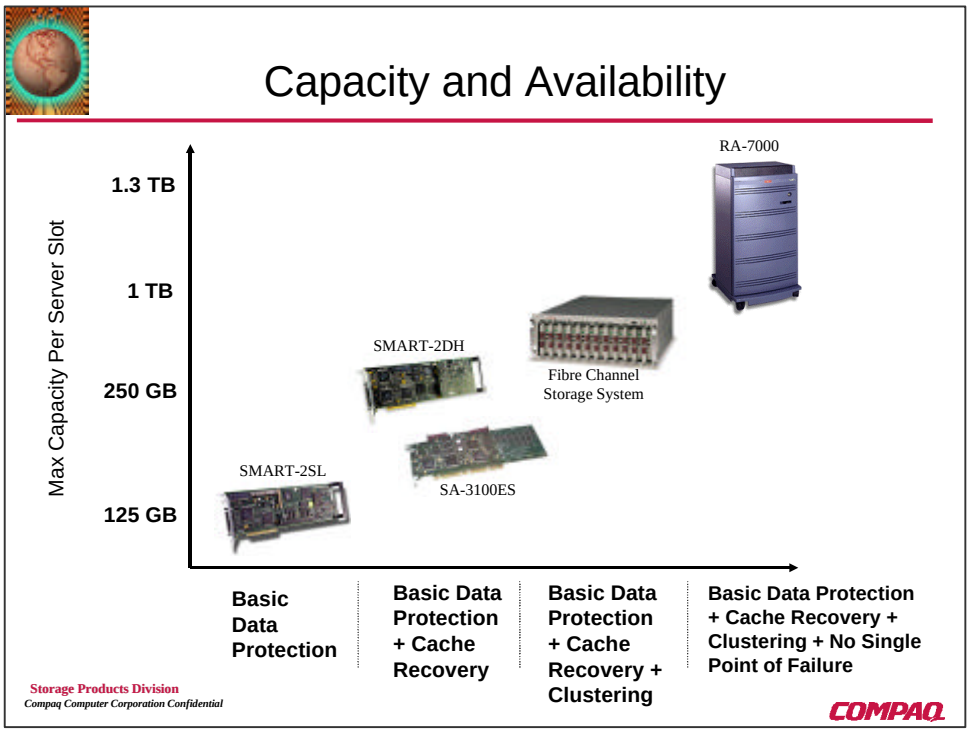

Figure 1. Capacity and Availability

Performance

The system architect must next determine the application performance, the CPU-utilization requirements, and the optimum storage configuration for the application. OLTP applications, as in our example, typically place heavy demands on the CPU. Because the SMART-2/DH and Fibre Channel Storage System are high performance architectures, performance is likely to exceed requirements and competitive offerings. In general, the performance of these two storage solutions is similar for most applications. However there are some important differences which are worth examining. Figure 2 depicts the relative performance of the Compaq StorageWorks Product line.

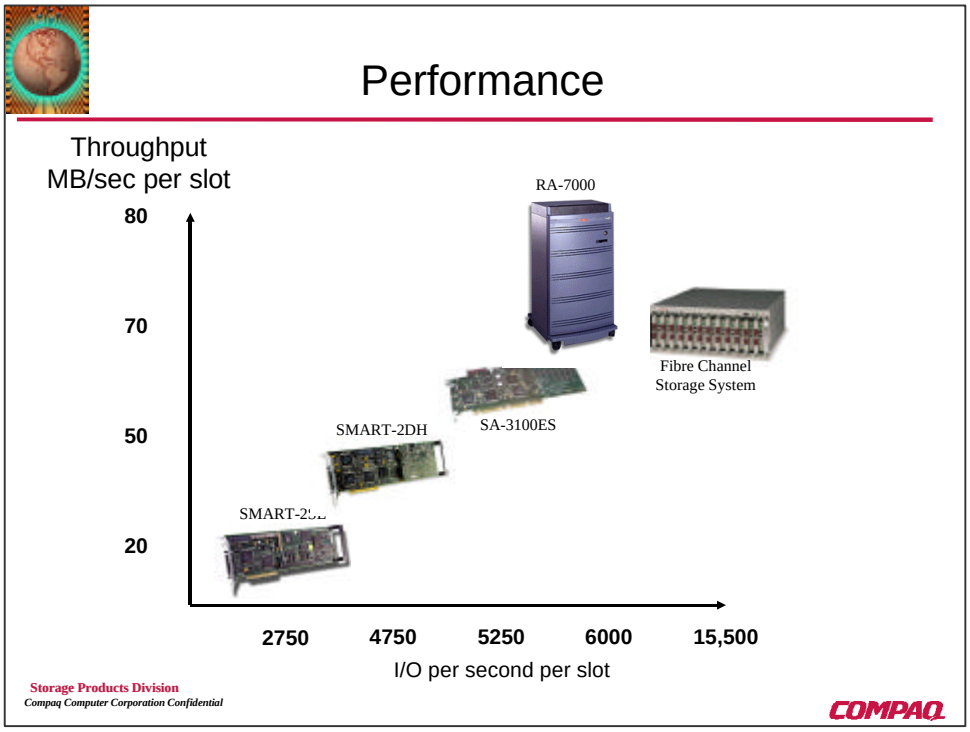

Figure 2. Performance

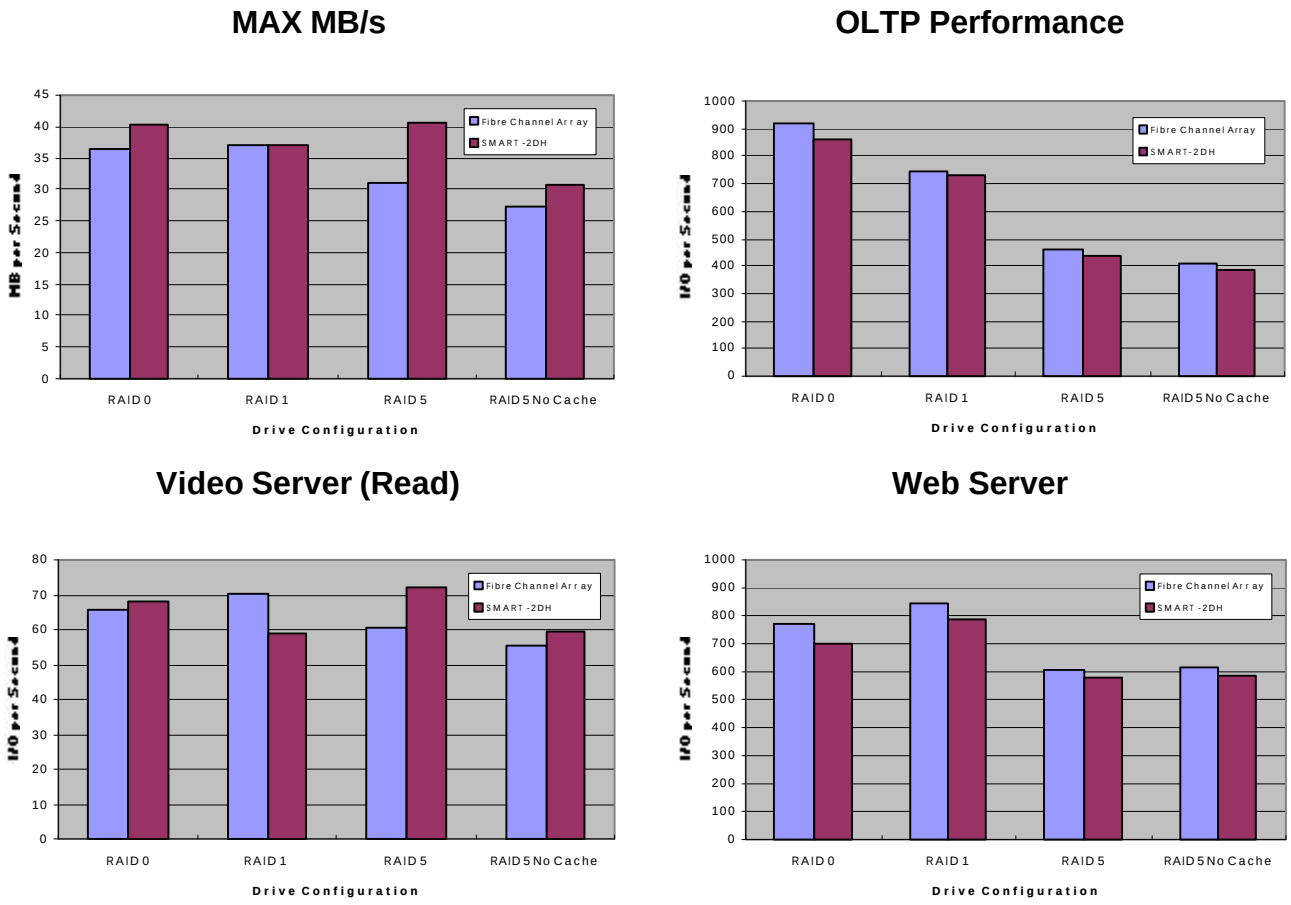

Figure 3. Fibre Channel Storage System and SMART-2/DH Performance

The four charts in Figure 3 illustrate the performance of the Fibre Channel Storage System and SMART-2/DH ProLiant Storage System under several simulated workloads. The tool used for this performance benchmarking is called Iometer[1]. Iometer, developed by Intel, can be used to generate random and sequential IO access of varying sizes. Using Iometer, it is possible to simulate the IO access patterns of many complex applications, like those shown in the charts. These charts show how many IOs per second the SMART-2/DH and Fibre Channel Storage System can perform given IO access patterns typical of OLTP, Video Server (Read) and Web Server applications. Actual application performance may vary due to application and environment specific issues. Such issues include data relationships (i.e., locality of reference) and application CPU utilization.

[1] These results were obtained using Iometer version 1998.01.05, Copyright 1996-98 by Intel Corporation. Intel does not endorse any Iometer results.

The tests were run using a high end ProLiant 6000 server with 2 Pentium Pro, 200 MHz processors, 512 KB L2 Cache, 1 GB RAM and NT 4.0, SP3. The storage systems were configured with a similar number of drives. The Fibre Channel Storage System was tested with 12 hard drives while the SMART-2/DH ProLiant Storage System was tested with 14 hard drives. For each RAID level, the performance difference between SMART-2/DH-based storage and the Fibre Channel Storage System is relatively small. For OLTP application workloads, Fibre Channel actually has a slight advantage. However, this chart does not characterize the differences in CPU utilization, which is lower with the SMART-2/DH solution because it uses an intelligent controller residing on the system's PCI bus. The bottom line though is that performance alone is not enough reason to select one storage system over the other. Other characteristics must be examined.

Scalability

The system architect must consider the data volume today, and anticipate the growth rate to arrive at the best storage solution. Maximum slot utilization and scalability of both storage and performance make the Compaq Fibre Channel solution especially suitable for volume growth that exceeds 50% per year.

A typical critical business application in enterprise computing today is SAP/R3. This application has payroll, accounting, product database, inventory control, and business performance tracking and reporting modules that work together to support the complex requirements in modern enterprises. This application places severe demand on the storage subsystem, both in storage capacity, and in the volume of data moved between the storage system and the network. Scalability is important; redesigning the corporate network when adding storage capacity is not an option. In addition, low latency and high throughput are required to keep critical business information flowing.

In the following graph, a Fibre Channel Storage System was compared with a SMART-2/DH ProLiant Storage System using the same Iometer tool from Intel. In this test, we compared performance under an OLTP workload as the number of external storage enclosures was scaled to their maximum configuration. Since the SMART-2/DH Storage System has two external channels, that meant that we could attach a maximum number of 14 hard drives to the storage subsystem. The Fibre Channel Storage System can scale up to 6 external storage arrays with 12 drives each for a total of 72 hard drives in one PCI slot. It might be expected that the Fibre Channel Storage System would suffer a latency penalty since the array controllers are located external to the server on the Fibre Channel Loop. However, once the transaction requests begin to be executed (i.e. the loop is filled), the throughput becomes very similar for like numbers of drives in both solutions.

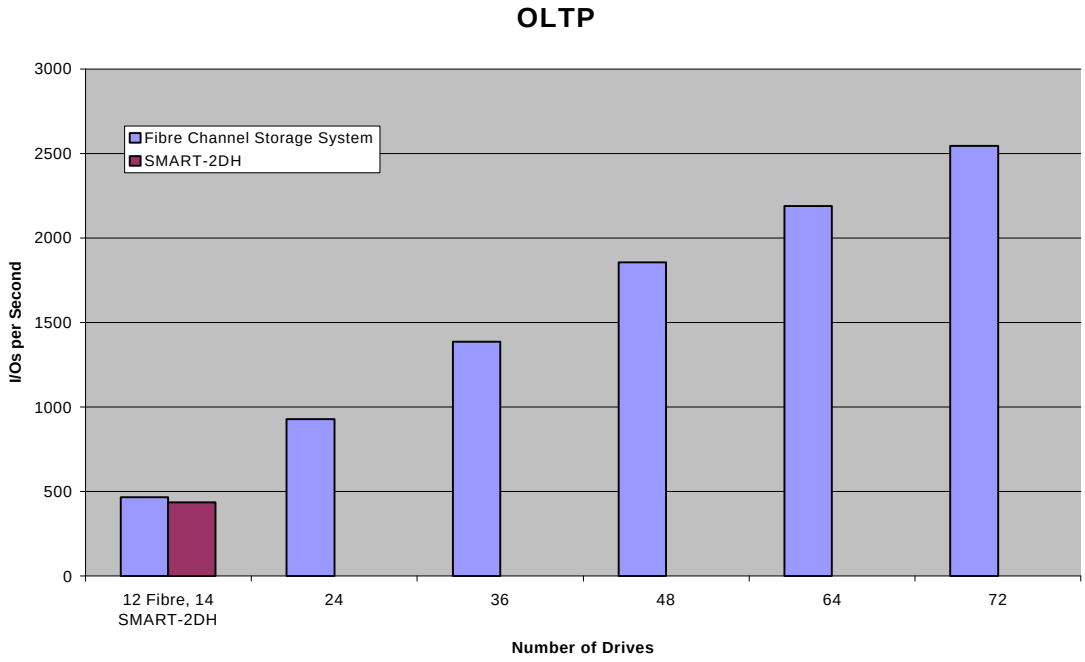

Figure 4. Fibre Channel Scalability

The real advantage of the Fibre Channel Storage System is that it can be scaled to very large numbers of drives, and therefore, high levels of performance. In our example, as the SAP/R3 application is deployed in the enterprise, the number of clients and data storage requirements can be expected to increase. This places even greater demands on the storage system – demands that the Compaq Fibre Channel solution can meet.

Server Platform

Selecting an appropriate platform to meet immediate and growth requirements is now relatively simple. The data and application performance requirements are clearly identified, and the computing power necessary to drive the application at anticipated workloads is known. For the purposes of our SAP/R3 example, the platform utilizes a high-end ProLiant Server as the database server.

Both the SMART-2/DH and Fibre Channel Storage System offer tight integration with Compaq Servers. In fact, choosing either solution for Compaq Server Platforms will ensure consistent disk drive architectures, management systems, and configuration tools across the entire environment. This is something that can not be done with third party storage systems. The following chart can further assist system architects in determining which storage solution to choose based on the chosen server platform.

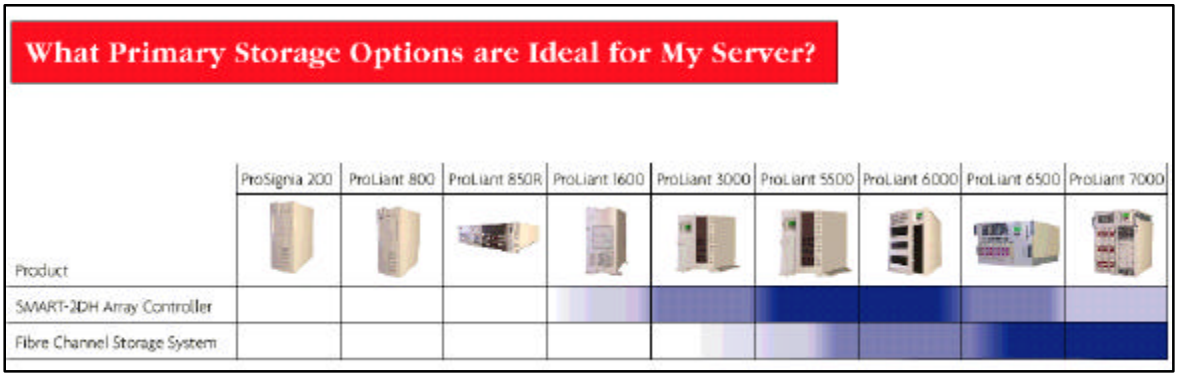

Figure 5. Fibre Channel Scalability

The choice of storage system is critical to meeting the business objective spelled out in step 1, "Business Objective." Both the Fibre Channel Storage System and the SMART-2/DH ProLiant Storage Systems have strong points that may be exploited to yield a system of very high overall performance – much higher than is achievable using one technology to the exclusion of the other. For instance, Fibre Channel technology does not provide boot support at this time. Therefore, configuring a system with an internal SMART-2/DH controller for the system boot drives and an external Fibre Channel Storage System for the application and data drives can provide a very scalable, high performance system.

Storage System Configuration

The final decision step is crucial in determining system fault tolerance as well as overall performance. RAID configurations that support fault tolerance and hot swapping of drives are available. For our example deployment, a RAID 5 configuration is chosen because it provides a very affordable yet robust data protection for critical business data.

The Fibre Channel Storage System can provide even greater levels of data safety through Microsoft Cluster Server support and by geographically separating servers and storage by as much as 10 km. This allows remote cluster configurations to be created to further reduce the risk of system downtime.

After determining your data growth and data fault tolerance requirements, determining the amount of available storage is rather straightforward. In our example, we will require 100 GB of storage for our OLTP database that will grow at 50% per year. Since we would like to plan for one year of growth, we will need 150 GB of RAID 5 storage. That amounts to two external storage boxes. Now let us examine how that can be configured in both a Fibre Channel and SMART-2/DH environment.

SMART-2/DH Storage System

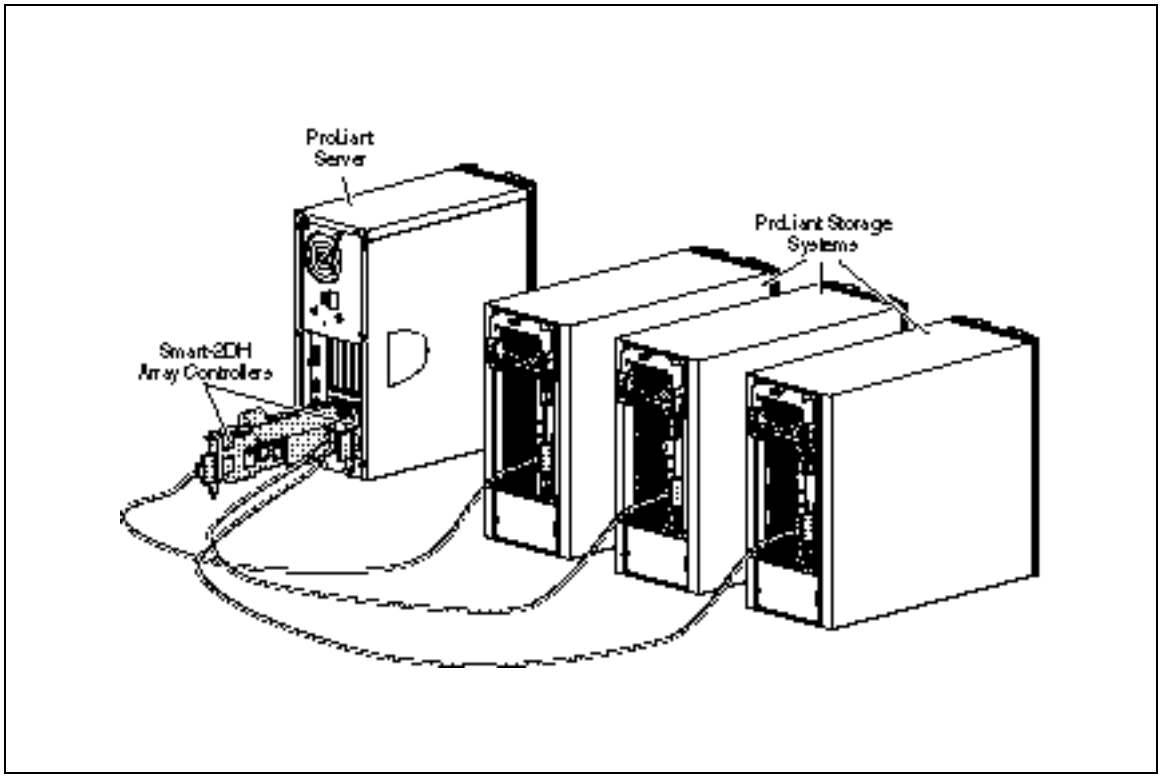

Figure 6. SMART-2/DH ProLiant Storage System

One configuration that is capable of supporting our example SAP application consists of a ProLiant server attached to two ProLiant storage systems through one SMART-2/DH Array controller. This configuration satisfies the immediate storage capacity requirements. As the data volume grows, however, we would have to add an additional SMART-2/DH Array controller to the server to attach a third ProLiant Storage System.

Fibre Channel Storage System

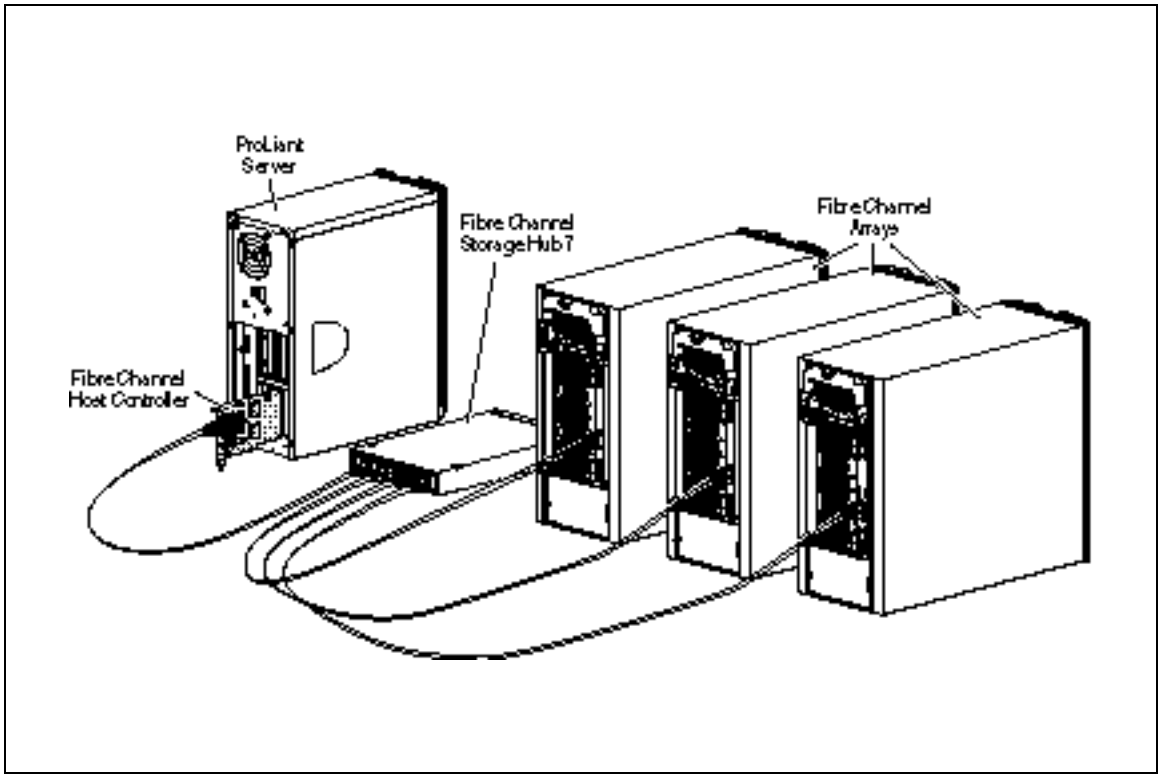

Figure 7. Fibre Channel Storage

A second configuration that is capable of supporting our example SAP application is a ProLiant server attached to a Compaq Fibre Channel Storage Hub 7, which in turn is connected to two Fibre Channel Storage Arrays. As additional storage is required, a third Fibre Channel Array can easily be added without adding an additional controller card to the ProLiant Server.

With the Compaq Fibre Channel System, a business can start with just enough storage capacity to meet the immediate needs, and easily add additional storage as the data volume requirements increase. In addition to the outstanding growth capability, the capacity can be increased 'on the fly' – drives can be removed and added to the storage array while the system is on-line!

For some Operating Systems, storage capacity can be increased without disrupting operation. Consequently, system availability is improved, both during maintenance and during growth.

In addition to disk drives, backup devices such as high capacity tape backup systems or other secondary storage devices can be attached to the enterprise network to support data migration and high-speed data backup.

Choosing the Storage Solution

After analyzing all of the business, application, and configuration requirements, we determined that the Fibre Channel Storage System was ideal for this application. This solution provides high capacity and a high degree of scalability and availability. The system can be implemented with a single Fibre Channel Storage Hub attached to a single PCI slot in the server through the Compaq Fibre Channel Host Controller. Initially, one or two Fibre Channel Arrays provide the needed storage. As database storage requirements grow, increasing the storage capacity is much easier than with SCSI storage systems, thereby providing simple scalability for future growth.

Feature Comparisons

	Fibre Channel Storage System	SMART-2/DH ProLiant Storage System
Array Intelligence *	External to server	Internal to server
Cache Memory Total Cache Battery Backed (max write)	 64 MB 48 MB	 16 MB 16 MB
Cache Management Automated Cache Tuning	Yes	
Host-to-Storage Enclosure Connectivity *	Fiber Channel Arbitrated Loop (FC-AL)	SCSI
Bandwidth *	100-Mb/s	40-Mb/s (Wide Ultra SCSI-3)
Multi-Platform OS Support	Windows NT 4.0; NetWare 3.12 & 3.20; intraNetWare; SCO OpenServer 5, UnixWare 2.1, UnixWare 7; Banyan VINES 6.x & 7x; OS/2 SMP 2.11 and Warp Server Family of Products; Solaris for Intel Platforms 2.5/2.5.1 & 2.6	
Drives per Server Slot *	48 1.6-inch, 72 1-inch	14 1.6-inch, 14 1-inch
Maximum Capacity per Server Slot (using 18.2 GB hard drives) *	874 GB	255 GB
Boot Support *	No	Yes
Fault Prevention Auto Reliability Monitoring Dynamic Sector Repair Drive Parameter Tracking	 Yes Yes Yes	
Fault Tolerance RAID Support Online Spare Support Online Capacity Expansion	 0, 1, 4, 5 Yes, up to 4 for each array controller Yes	
Logical Drive Movement Physical Drive Displacement	No Yes	Yes Yes
Fault Recovery Automatic Data Recovery	Standard	
Manageability and Serviceability Array Configuration Hot Swap Drives	 Array Configuration Utility Yes	
Upgradability Array Storage Firmware	Yes, through ROMPaq	
Maximum cable distances*	500 meters (1600 feet)	3.75 meters (12 feet)
Physical media	Fiber optic	Copper

* Key difference

Fibre Channel Performance Tuning

The exceptional connectivity and scalability of the Fibre Channel Storage System provide users with many ways to optimize their storage configurations. For example, with a single Storage Hub 7, users can configure up to 72 drives on a single server I/O slot. They may also spread the same number of drives over several server I/O slots. The optimal configuration depends on the application performance characteristics, business objectives, storage environment, etc. Here are some rules of thumb to help guide storage architects when configuring Fibre Channel Storage.

Rules of Thumb

1. Random, small block workloads (e.g., OLTP) will scale very nicely as additional Fibre Channel Arrays are added to a Fibre Channel Arbitrated Loop (FC-AL). Thus, when Short Wave Multi-Mode Fibre cables are used, Fibre Channel Arrays may be attached to all ports of a Fibre Channel Hub without degrading the performance of random, small block workloads. Performance will degrade however when Long Wave Single Mode Fibre runs of 10 Km are added to the loop (see Rule of Thumb #3)
2. Sequential, large block workloads (e.g. Video Server) do not scale linearly as additional Fibre Channel Arrays are added to the FC-AL. Under these workloads, a single Fibre Channel Array can achieve a throughput of 36 MB per second and three Fibre Channel Arrays can saturate the 100 MB per second bandwidth of a single Fibre Channel Loop. Therefore, to maximize sequential large-block workload performance, limit the number of Fibre Channel Arrays per loop.

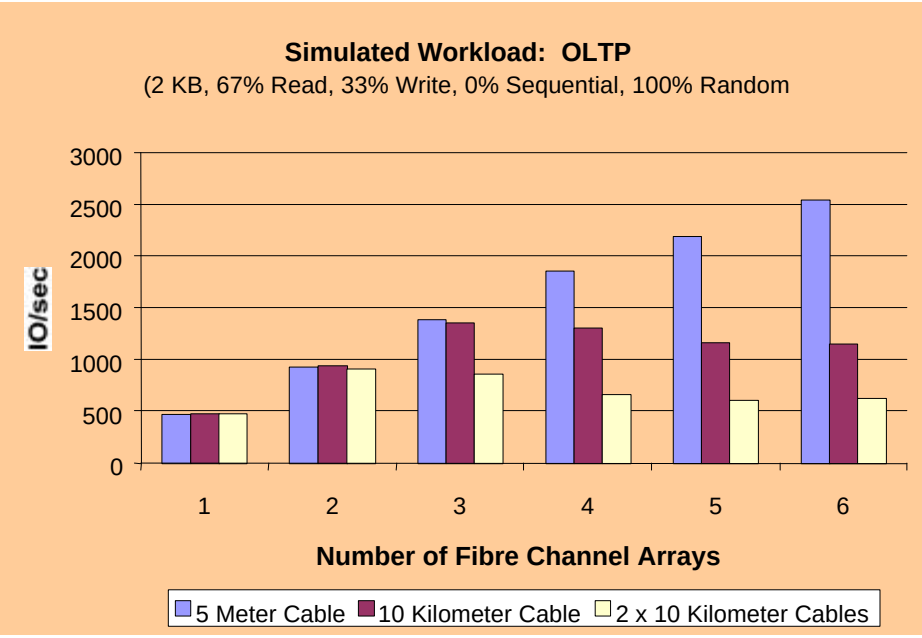

Figure 8. Effect of Cable Length on Throughput

3. Although Long Wave GBICs are not available today, these configurations will be supported in future releases of the Fibre Channel Storage System Firmware and Software. To increase the performance when Long Wave Single Mode cable runs of up to 10 Km are added to the FC-AL configuration, limit the number of Fibre Channel Arrays to 3 per loop (Figure 7).

Migration Issues

Migration issues are a very significant consideration for most customers. No one wishes to lose an investment in existing equipment. This is another feature of fiber channel storage where the Compaq solution has an answer.

Migration of Drives

A least one SMART/SMART-2 Array controller and drive must remain in the system. The Compaq Fibre Channel Array does not have provision to boot the system.

Compaq wide ultra hot-plug SCSI drives are also supported by the Fibre Channel Storage System. This does not mean that all array configurations can be moved directly from a supported ProLiant storage system to the Fibre Channel Storage System. Each Fibre Channel Array can house a maximum of twelve 1-inch or eight 1.6-inch drives.

Compaq recommends the following six-step procedure to migrate most enterprise storage solution from SMART/SMART-2 to Fibre Channel.

1. Back up the existing data.
2. Power down the ProLiant Storage System.
3. Move the drives to the Compaq Fibre Channel Array.
4. Power up the Compaq Fibre Channel Array.
5. Configure the drives with the Array Configuration Utility (ACU).
6. Restore the data to the array.

However, ProLiant Storage model /F2 or /U2 configurations can migrate using the following four-step procedure if the drives are kept in the same relative order provided that FC Array Controller firmware v1.14 or later is used.

1. Back up the existing data.
2. Power down the ProLiant Storage System.
3. Move the drives to the Compaq Fibre Channel Array.
4. Power up the Compaq Fibre Channel Array.

ProLiant Conversion

ProLiant Storage models /F1, /F2, /U1, and /U2 may be converted to Compaq Fibre Channel Arrays with a Compaq conversion kit. Both rack-mount and bench mount models are convertible. A Fibre Channel Host Controller must be installed in the server. If more than one Compaq Fibre Channel Array is installed, a Fibre Channel Storage Hub 7 is also required.

Conclusions

To meet the demanding business computing environment today, a comprehensive approach to storage technology is necessary. No single storage connection technology satisfies all requirements. Compaq offers a broad range of products to meet these requirements. Both the Fibre Channel Storage System and the SMART-2/DH solution offer the high performance demanded by many of today's business critical applications. Therefore, the choice between the two solutions is driven more by availability and scalability

The Fibre Channel storage System provides very high levels of availability with support for Microsoft Windows NT clustered server configurations. In addition to its ability to provide very high capacity, it is also very scalable in terms of both capacity and performance. Configurations can start out small and be easily scaled to larger capacities by simply adding Fibre Channel Arrays to the loop. Up to 72 drives can be attached to a single server slot through a single Fibre Channel host controller and Storage Hub 7.

These features make the Fibre Channel Storage System ideal for large File/Print, Centralized Email, Decision Support Systems (Data marts), and On-line Transaction Processing (OLTP) applications.

Appendix 1 –Tech Notes

Fibre Channel

The Fibre Channel Storage System uses the components described in Table 1. The system transmits data at 100 MB/sec with better reliability than SCSI since optical fiber is immune to electrical interference.

Component	Description
Fibre Channel Array	An external storage cabinet that houses the Fibre Channel Array Controller and up to twelve 1-inch or eight 1.6-inch Wide-Ultra SCSI disk drives
Fibre Channel Array Controller	An intelligent Fibre Channel to SCSI array controller with 32-MB cache (contained within the Fibre Channel Array)
Fibre Channel Storage Hub 7	Supports interconnection of up to seven devices on a Fibre Channel Arbitrated Loop (FC-AL)
Fibre Channel Host Controller	An EISA or a PCI to Fibre Channel host adapter
Gigabit Interface Converter (GBIC)*	Converts short wave optical signals to electrical signals (and vice versa)
Multimode Cable	2m**, 5m*** or 15m 50-micron fiber optic cable. All cables are available as separate options. 62.5-micron fiber optic cable****

* One pair ships with the Fibre Channel Array and the Fibre Channel Host Controller
** Ships with the Fibre Channel Array
*** Ships with the Fibre Channel Host Controller
**** Supported but not supplied by Compaq

Fibre Channel System Architecture

Architecture refers to the location of the intelligence required to operate the array. The Fibre Channel Storage System is an external architecture ideally suited for high capacity systems where scalable I/O and performance are required. Figure 9 shows the Fibre Channel Host Controller located in the server and connected via fiber to the Storage Hub 7.

Fiber cable runs from two ports on the Storage Hub 7 and connects to two Fibre Channel Arrays. Each Fibre Channel Array houses a Fibre Channel Array Controller and disk drives. The Storage Hub 7 supports up to six Fibre Channel Arrays with up to twelve 1-inch or eight 1.6-inch drives.

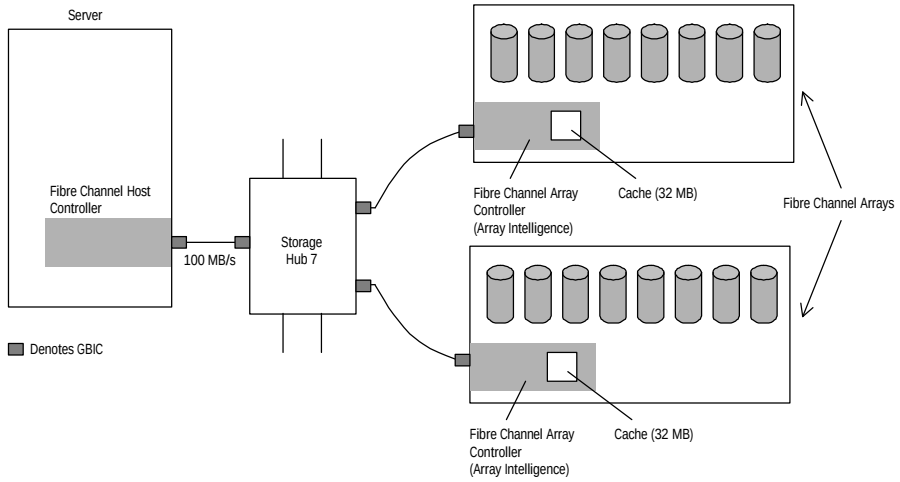

Figure 9. The Fibre Channel Storage System

SCSI

Figure 10 shows the architecture of a storage system using a SMART-2/DH Array Controller. The dual channels on the array controller connect via SCSI to support a maximum of two ProLiant/U1 Storage Systems.

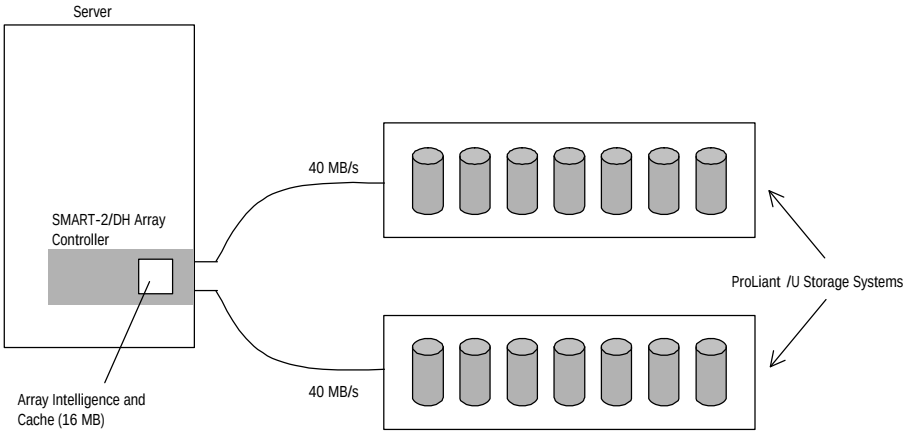

Figure 10. The SMART-2/DH Storage System

SCSI Architecture

Architecture refers to the location of the intelligence required to operate the array. The array intelligence and cache in the SMART-2/DH storage solution are located on the SMART-2/DH Array Controller inside the server. This is an example of *internal* architecture.

Appendix 2 –Test Bed

Table 2 shows the server configuration used to develop the performance figures.

Table 2. Server Configuration

Model	ProLiant 6000
Processor(s)	2 Pentium Pro, 200 MHz, 512 KB L2 Cache
Memory	1 GB
Operating System	NT 4.0, Service Pack 3

Table 3 shows the storage subsystem configuration for the Fibre Channel tests.

Table 3. Fibre Channel Storage Configuration

Host Adapter	Fibre Channel Host Controller
# Host Adapters	1
Controller Type	Fibre Channel Array Controller
Controller Firmware	1.14
Controller Cache	16 MB Read / 16 MB Write
# Controllers	1 - 6
Storage Box	Fibre Channel Array
# Storage Boxes	1 - 6
Drives/Storage Box	12
Logical Drives/Storage Box	1
RAID Level	5
Drive Type	4.3 GB, 7200 rpm

Table 4 shows the storage subsystem used for the SMART-2/DH tests.

Table 4. Fibre Channel Storage Configuration

Controller Type	SMART-2/DH
Controller Firmware	2.08
Controller Cache	8 MB Read / 8 MB Write
# Controllers	1 - 6
Storage Box	Fibre Channel Array
# Storage Boxes	2
Drives/Storage Box	7
Logical Drives/Storage Box	1 for every 2 Storage Boxes
RAID Level	5
Drive Type	4.3 GB, 7200 rpm