Compaq StorageWorks

Heterogeneous Open SAN Design

Reference Guide

First Edition (January 2001)
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Compaq Computer Corporation

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About This Guide

This guide describes rules for designing Compaq StorageWorks heterogeneous open Storage Area Networks (SANs).

Text Conventions

This document will use the following conventions to distinguish elements of text when necessary:

Keys	Keys appear in boldface. A plus sign (+) between two keys indicates that they should be pressed simultaneously.
USER INPUT	User input appears in a different typeface and in uppercase.
FILENAMES	File names appear in uppercase italics.
Menu Options, Command Names, Dialog Box Names	These elements appear in initial capital letters.
COMMANDS, DIRECTORY NAMES, and DRIVE NAMES	These elements appear in uppercase. [NOTE: UNIX commands are case sensitive and will not appear in uppercase]
Type	When you are instructed to *type* information, type the information **without** pressing the **Enter** key.
Enter	When you are instructed to enter information, type the information and then press the **Enter** key.

Symbols in Text

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

WARNING: Text set off in this manner indicates that failure to follow directions in the warning could result in bodily harm or loss of life.

CAUTION: Text set off in this manner indicates that failure to follow directions could result in damage to equipment or loss of information.

IMPORTANT: Text set off in this manner presents clarifying information or specific instructions.

NOTE: Text set off in this manner presents commentary, sidelights, or interesting points of information.

Related Documents

Topic	Document Title
Tru64 UNIX	RA8000/ESA12000 and MA8000/EMA12000 HSG80 Solution Software V8.5B for Tru64 UNIX Installation Reference Guide
Compaq OpenVMS	RA8000/ESA12000 and MA8000/EMA12000 HSG80 Solutions Software V8.5B for OpenVMS, Installation Reference Guide
Windows NT (Intel), Windows 2000	RA8000/ESA12000 and MA8000/EMA12000 HSG80 Solution Software V8.5B for Windows NT, Windows 2000 - Intel, Installation Reference Guide
Windows NT (Intel), Windows 2000	RA8000/ESA12000 FC-Fabric SAN Configurations for Windows NT, Windows 2000–Intel, Application Note
Sun Solaris	RA8000/ESA12000 and MA8000/EMA12000 HSG80 Solution Software V8.5C for Sun Solaris Installation Reference Guide
HP-UX	RA8000/ESA12000 and MA8000/EMA12000 HSG80 Solution Software V8.5C for HP-UX Installation Reference Guide
HP-UX	HP-UX Fibre Channel Hub Application Note
IBM AIX	RA8000/ESA12000 and MA8000/EMA12000 Solution Software V8.5B for IBM AIX Installation Reference Guide

Topic	Document Title
Linux	RA8000/ESA12000 and MA8000/EMA12000 Solution Software V8.5B for Linux Installation Reference Guide
Novell NetWare	RA8000/ESA12000 and MA8000/EMA12000 Solution Software V8.5B for Novell NetWare Installation Reference Guide
SGI IRIX	RA8000/ESA12000 and MA8000/ESA12000 HSG80 Solution Software V8.5B for SGI IRIX Installation Reference Guide
HSG80 Controller	HSG80 Array Controller, ACS Version 8.5 Configuration Guide
HSG80 Controller	HSG80 Array Controller, ACS Version 8.5 CLI Reference Guide
StorageWorks Command Console	Command Console V2.3 User Guide
Enterprise Backup Solution	Enterprise Backup Solution Reference Guide
Fibre Channel SAN Switch	Fibre Channel SAN Switch Management Guide
Fibre Channel Storage Switch, 8 & 16 Port	StorageWorks Fibre Channel SAN Switch Installation and Hardware Guide
StorageWorks Command Console	Command Console for the SAN Switch Installation Guide

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 locations.

Compaq Technical Support

You are entitled to free hardware technical telephone support for your product for as long you own the product. A technical support specialist will help you diagnose the problem or guide you to the next step in the warranty process.

In North America, call the Compaq Technical Phone Support Center at 1-800-OK-COMPAQ. This service is available 24 hours a day, 7 days a week.

NOTE: For continuous quality improvement, calls may be recorded or monitored.

Outside North America, call the nearest Compaq Technical Support Phone Center. Telephone numbers for world wide Technical Support Centers are listed on the Compaq website. Access the Compaq website by logging on to the Internet at http://www.compaq.com.

Be sure to have the following information available before you call Compaq:

- Technical support registration number (if applicable)
- Product serial numbers
- Product model names and numbers
- Applicable error messages
- Add-on boards or hardware
- Third-party hardware or software
- Operating system type and revision level
- Detailed, specific questions

Compaq Website

The Compaq website has the latest information on this product as well as the latest drivers. You can access the Compaq website by logging on to the Internet at http://www.compaq.com/storage.

Compaq Authorized Reseller

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.
- Elsewhere, see the Compaq website for locations and telephone numbers.

Chapter 1

Introduction to SAN Design

Overview

This guide describes Compaq StorageWorks scalable heterogeneous open Storage Area Networks (SANs). A SAN is a network of shared storage resources that can be allocated across a heterogeneous environment. SANs connect multiple heterogeneous servers to single or multiple shared storage systems using Fibre Channel switches.

SANs redefine previous concepts of computer storage. Recent advances in technology make it possible to organize and manage storage as a resource independent of the local system. SANs enable new ways to configure and use storage. The result is that a SAN can keep data preserved in a common pool or multiple pools where it can be easily accessed and managed. This method of storage reduces operational costs, supports business growth, and strengthens the corporate infrastructure.

Compaq StorageWorks heterogeneous Open SANs can be configured to provide:

- Data protection
- High availability
- Long distance accessibility
- High connectivity with high bandwidth
- Common storage access for multi-vendor platforms
- Storage consolidation
- Local, centralized, or distributed storage access
- Centralized backup and restore
- Centralized storage management
- Disaster tolerance

A heterogeneous, scalable SAN is the answer for the increasingly complex and exponentially growing storage needs of today's businesses. SANs provide effective centralized management of primary storage (disks) and secondary storage (tapes) at a lower total cost. The topologies and design rules described in this guide will help you design a SAN that will fill your immediate business needs and enable your SAN to be scaled in incremental steps as your business needs demand expanded capacity.

Heterogeneous Open SAN Concepts

Open SAN Design Philosophy

Compaq StorageWorks heterogeneous Open SANs embody a philosophy about how storage networks should be constructed. Understanding this philosophy enables you to take advantage of the features and functionality provided by StorageWorks products.

Compaq SAN products are constructed as cooperating combinations of moderately sized components. Using varying numbers of smaller subsystem components allows greater flexibility in SAN design and provides for incremental scaling over time. This approach is well suited for designing and implementing a SAN that can accommodate diverse geographic and data locality requirements.

Each component in the Compaq SAN product line is designed to enable this Open SAN philosophy. For example, Compaq Fibre Channel switches have multiple ports and can be interconnected across long distances to achieve large network configurations. This connectivity is also known as a Fibre Channel "fabric." Each fabric has ports into which several computer servers, storage systems, and related components can be integrated.

The controllers used in the Compaq StorageWorks RAID Array products also enable the Open SAN philosophy. Each Compaq controller has multiple ports available for connection to the fabric. Each controller can support a heterogeneous mixture of servers, which means that controllers and servers can be added to the existing infrastructure in an incremental fashion. This maximizes the flexibility of the configuration, and supports a number of scalable growth paths from any given SAN configuration starting point.

SAN Technology

Storage Area Networks can be complex. Compaq simplifies this complexity by providing three approaches to SAN design and implementation. You can design and implement your SAN using a Compaq standard topology design, create a variation of a Compaq design, or create a custom design by following the Compaq SAN design rules. Each of the Compaq

standard topologies is optimized for a particular data locality type and offer different levels of connectivity, allowing you to select the ideal SAN implementation that is best suited to your specific needs.

- Compaq standard topologies specify the arrangement of Fibre Channel switches within a SAN Fabric and are optimized for specific data locality needs and typical workloads.
- The SAN design rules specify the maximum limits and guidelines for custom-designed topologies and also allow SAN designs that can be tailored to meet unique or specific storage and access requirements. See Chapter 3, *SAN Fabric Design Rules* and Chapter 4, *Heterogeneous SAN Platform Rules*.

NOTE: In this document "SAN topology" refers to the arrangement of Fibre Channel switches within a fabric.

Compaq Standard SAN Topologies

The Compaq standard SAN topologies provide four types of multi-switch SAN Fabric implementations, Cascaded, Meshed, Ring, and Backbone SAN Fabrics.

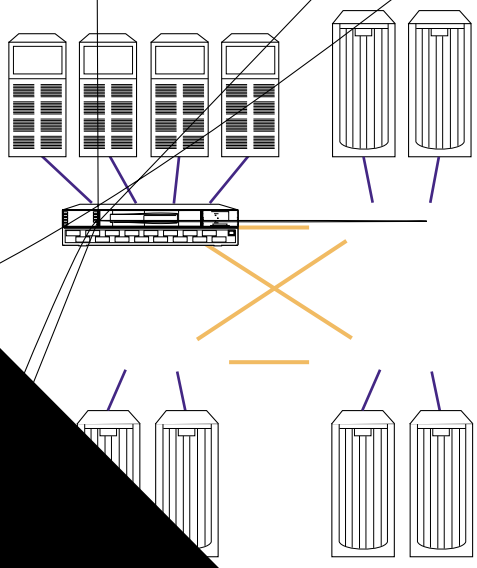
Cascaded, Meshed, and Ring SAN Fabrics

The first three fabric implementations (See Figure 1–1) are SAN implementations where all switches in the fabric are utilized for connecting servers and storage. See in Chapter 2, *SAN Fabric Topologies*. Typically, in these types of fabric arrangements, a lower percentage of the total number of switch ports is used for inter-switch connectivity. See *Connectivity* in this chapter. Trade-offs can be made allowing for an increase in the number of Inter-Switch Links (ISLs), by reducing the total number of ports used for servers and storage.

Backbone SAN Fabric

Backbone SAN Fabrics (See Figure 1–2) are implementations where one or more Fibre Channel switches within the fabric are used primarily for connection to other switches. The server and storage connections in a Backbone SAN Fabric design are concentrated on edge switches. These switches are attached to a central backbone switch or switches. See in Chapter 2, *Tree Backbone Fabrics*.

In addition to these base topology designs, other variations are possible. For example, in a Backbone SAN Fabric design it may be desirable to locate centralized primary storage or centralized secondary storage, such as tape backup, directly on a backbone switch.



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implementation requirements. There may be specific cases where Compaq standard topologies (or variants) do not meet your specific needs or requirements. In these cases, a custom SAN design can be created provided that the SAN design rules described in this document are strictly followed. See Chapter 3, *SAN Fabric Design Rules* and Chapter 4, *Heterogeneous SAN Platform Rules*.

Design Considerations

Whether choosing a Compaq standard SAN topology or creating a custom design, you should thoroughly review all aspects of each of the design considerations described in this guide. Some items may be more or less important to individual designs, but each should be carefully evaluated with regard to expected future needs and growth, in addition to current needs.

Data Locality

A major factor in determining the optimal SAN topology design is the desired or required location or method of storage deployment. Storage deployment should be based on the specific application requirements for data locality or placement of data; local, centralized in a single storage pool or centralized pools, or distributed among storage pools throughout the fabric.

Local or "one to one" is where the primary data access is between servers and storage connected to the same Fibre Channel switch. Centralized or "many to one" is where the primary data access is between many servers and centrally located storage. Distributed or "many to many" is where data access varies between many different servers and many different storage systems. Many to many data access is conducive to applications or deployments where you wish to implement SAN-wide storage pooling and sharing.

Selection of the appropriate SAN topology design should primarily be based on the expected primary data locality need, however consideration should also be given to corporate, departmental, and organizational requirements relative to data grouping and accessibility.

Geographic Layout

The physical layout of campuses, facilities, and the location of servers and storage within individual buildings can be a major factor in determining the appropriate SAN design. Support for long distances throughout the SAN allows for interconnection schemes that can easily accommodate specific and varying geographic needs. Compaq SANs can be implemented with inter-switch segment distances of up to 10 km per segment for multi-segment fabrics or up to 100 km for a single long distance segment fabric.

Connectivity

Connectivity needs directly affect the total number of Fibre Channel switches required. Including data locality and geographic requirements, the total number of ports required for connectivity of servers and storage are a major consideration when evaluating different SAN topology designs. You should include future connectivity requirements and choose a design that can be scaled or migrated to a topology design with more capacity, if required. Your design should also provide adequate fabric performance by implementing the required number of ISLs.

If the total number of ports required exceeds a given topology design, you should consider higher capacity topologies or perhaps deploy multiple independent SANs.

Storage Capacity

The total storage capacity requirements, both present and future should be calculated to ensure that the design implemented is adequate to meet your needs. Storage capacity can be expanded by adding larger capacity disk devices, adding additional disk devices, or by deploying additional storage systems in your SAN.

Heterogeneous Platforms and Operating Systems

Compaq heterogeneous Open SANs support a wide range of multi-vendor hardware platforms and operating systems in a mixed environment. This allows you to tailor your SAN for the specific platforms and operating systems you require. Compaq storage controllers can be shared across many different platforms and operating systems, all managed within the same SAN. Specific support limits of individual platforms and operating systems may vary and need to be understood and considered when evaluating SAN designs. See in Appendix A, *Heterogeneous Open SAN Products*.

Scalability and Migration

One of the major benefits that Compaq standard SAN designs provide is the capability to grow or scale incrementally over time as storage and connectivity needs increase. For all designs, consideration should be given to choosing a design that will accommodate expected future growth and usage requirements.

Compaq-designed SAN topologies can address immediate needs and requirements, and accommodate future changes. There are also migration paths for each of the topologies to provide for configuration flexibility, expansion, and increased capabilities. Refer to Chapter 7, *Best Practices*, for information about scaling and migrating different SAN topology designs as some transitions are easier to perform then others. All aspects of scaling and migration should be understood when choosing a topology design.

See also in Chapter 2, *Scalability and Migration*.

Backup and Restore

SAN-based backup capabilities provide high bandwidth backup capabilities and centralized control of the backup and restore operations. This can provide significant savings in time and management over individual server or network based backup and

restore implementations. SAN designs should provide adequate connectivity and bandwidth for backup, to ensure the full benefit of SAN based backup can be realized. See Appendix A, *Supported Products*.

Data Availability

SAN implementations can provide different levels of data availability. There are varying levels of availability designs ranging from the simplest single component and single path designs up to the highest availability, or No Single Point Of Failure (NSPOF) designs. In many cases the different levels can be implemented within the same SAN allowing mixed data protection levels, depending on the level of protection required for specific applications or data. See Chapter 2, *Data Availability in a SAN*.

Disaster Tolerance

Consideration must be given to the criticality of data in the event of unforeseen catastrophic site failures. Remote data replication requirements should be considered in the SAN design to ensure protection against site failures and full recovery of critical data. Selected data can be copied to remote storage arrays automatically providing recovery capabilities in the case of a primary site interruption or possible loss. Using multiple storage arrays, portions of the SAN can be configured for disaster tolerance, providing a common SAN with mixed data protection levels.

NOTE: Disaster tolerance requires a SAN design that implements two or more separate fabrics, which provides the highest availability no single point of failure protection.

Performance and Application Workloads

Performance requirements need to be considered in any SAN Fabric design. This can be difficult, because data traffic in a SAN is not always predictable. Consider the types of applications that will be utilized on the SAN relative to data locality classification. Applications can usually be classified as high bandwidth or high throughput. What is important is that any design chosen provides an adequate level of performance based on the data locality classification of the major applications being utilized.

Other factors to consider are the locality of data in relation to the servers most likely to access the data and the number and placement of ISLs between switches in the fabric.

Switch and Hop Counts

Data routing through the fabric is described in terms of hops, where a single hop is one or more ISLs between any two switches. The general rule is that you should minimize the number of hops between devices that will communicate in a SAN.

Oversubscription

All Compaq Fibre Channel switches implement a "non-blocking" design. That is, any pair of ports can be active and transfer data without impacting data transfer between another pair of ports. This feature should be carried throughout the design of the fabric itself.

Oversubscription or congestion can occur in a fabric with multiple switches when data from multiple sources must be sent to a single destination port, or when data is required to be sent across an ISL from multiple input ports. In situations where this occurs, the Fibre Channel switches utilize fairness algorithms to ensure that all devices are serviced. The switches will interleave frames from multiple devices, thus giving fractional bandwidth to all devices. If this occurs often, overall performance in the fabric will be reduced. Oversubscription can be minimized by ensuring your fabric design provides for an adequate number of ISLs between all switches, and minimizes scenarios where many devices or ports are attempting to access a single destination device or port.

Manageability

Compaq SANs can be designed for local, centralized or distributed access to data. Regardless of the arrangement or location of the storage components and the preferred data access method, SAN management can be centralized using a dedicated SAN Appliance. The SAN Appliance connects directly to the SAN through a Fibre Channel switch providing full access to all devices in the SAN. The SAN hardware devices can be monitored and managed utilizing SAN Web-based tools either resident or invoked through the SAN Appliance. For implementations not utilizing the SAN Appliance, tools can be run on a local server or client configured for access in the SAN. See Chapter 5, *SAN Management Tools*.

Fabric Zoning

Zoning is a fabric management service used to define logical device subsets within a SAN. Zoning enables resource partitioning for management and access control. The Compaq Fibre Channel switch Zoning feature provides a way to control SAN access at the node device or port level. Zoning can be used to separate one physical fabric into many logical

fabrics consisting of selected server and storage devices or ports. This capability allows you to set up barriers between different operating environments, to deploy logical fabric subsets by creating defined server and/or storage groups, or to define temporary server and storage zones for tape backup. Zones can be configured dynamically and the number of zones and zone membership are effectively unlimited. Nodes can be in multiple zones to allow overlapping, depending on the desired access control.

Selective Storage Presentation

Compaq storage systems employ an exclusive LUN selection or masking feature called Selective Storage Presentation (SSP). This feature allows you to assign or selectively present storagesets (LUNs) from multiple storage systems to multiple servers and host bus adapters of differing types in a SAN.

Utilization of both SSP and Fabric Zoning provides for the most flexible SAN node and device access management. These features should be viewed as complementary in that usage of both provides the greatest range of SAN storage access management capabilities.

Chapter 2

SAN Topologies

Overview

This chapter describes the Compaq standard SAN topologies. You should review each of the SAN design considerations previously described in the first chapter before you select an appropriate topology design. The design considerations enable you to generate an accurate list of prioritized requirements for your SAN design. This list of requirements provides a basis for selecting the optimum fabric topology.

There are three approaches that you can choose when designing your SAN. You can choose to implement a Compaq standard SAN topology design, a subset or variation of a Compaq design, or you can design a custom SAN topology. With all methods, the final SAN design must adhere to the SAN design rules described in Chapter 3, *SAN Fabric Design Rules* and Chapter 4, *Heterogeneous SAN Platform Rules*.

Regardless of the approach taken, you should review the Compaq standard SAN topologies section in this chapter. This provides a greater understanding of the different aspects of SAN implementation. Compaq recommends that you first consider implementing one of the Compaq standard topologies or a variation of one of these designs. If your requirements cannot be met by one of these topology designs, then you can implement a customized SAN topology design, provided you follow the design rules.

Compaq Standard SAN Topologies

The Compaq SAN topology designs reflect the proper application of the SAN design rules. Each of the topology designs is tailored for particular data access and connectivity needs. Collectively these designs provide a wide range of options for selecting the appropriate SAN design for your specific requirements. Variations of these designs can be validated by adhering to the appropriate rule set for each topology type.

The different types of Compaq standard SAN topologies are described in detail in the following sections. Consider the advantages of each design category before choosing a specific topology design.

SAN Fabric Topologies

SAN Fabric topology designs include:

- Cascaded Fabrics: See *Cascaded Fabrics*.
- Meshed Fabrics: See *Modified Meshed Fabrics*.
- Ring Fabrics: See *Ring Fabric*.
- Tree Backbone Fabrics: See *Tree Backbone Fabrics*.

The smallest SAN consists of a single Fibre Channel switch, server, and storage system. You can scale a SAN Fabric up to the support limits listed for each of the fabric topology designs to increase the number of connections for servers and storage.

You can also view the topologies as a way to connect existing smaller SANs or SAN islands. If you have already deployed multiple small SANs, you can connect them into larger fabrics up to the maximum fabric size shown for each of the topology types. For example, if you have deployed two four-switch meshed SANs as separate SANs, you can merge these into a larger single eight-switch meshed SAN as shown in Figure 2–2, *Modified Meshed SAN Fabric*.

If you have multiple single switch SAN Fabrics, you can connect these into a single larger SAN Fabric by connecting them in a ring or to a central backbone as in the Tree Backbone fabric topology.

If more capacity is required, you can deploy multiple independent SANs. As larger fabric configurations are supported over time, the independent SANs may be interconnected to form even larger SANs, provided the maximum fabric support limit rules are followed.

Advantages of Using Cascaded, Meshed, or Ring SAN Fabric Designs

Each of the design types can be:

- implemented as a separate SAN for specific departments or applications within a large company to accommodate different data access needs.
- implemented with centralized backup capabilities, reducing the cost of backup and restore operations.
- deployed in one or more co-located groups of enclosures.
- deployed across a wide area with inter-switch distances up to 10 km, or even 100 km.
- used to provide a good way to begin deploying SANs and Fibre Channel technology in a modular, controlled approach. Storage consolidation can be implemented on a departmental or independent SAN basis. Future capabilities will allow for more switches within a single SAN, interconnection of multiple SANs to build larger fabrics, and provide for additional consolidation, if desired, or broader server-to-storage access.
- centrally managed.
- implemented with all Availability levels. See *Levels of Availability*.
- upgraded to higher capacity topologies or topologies optimized for different data access types if needs change.

Cascaded Fabrics

A cascaded fabric SAN (See Figure 2–1) is a string of switches or levels of switches connected together by one or more ISLs. The switches are arranged in a linear array, each one connected to the switch that is next in line, or arranged in a vertical cascade with multiple levels off a single top switch.

Cascaded fabric designs are well suited to applications where data access is local. That is, access requirements for a server (or groups of servers) is typically to the same storage system or storagesets. Groups of servers and the storage being accessed can be connected to the same switches providing the highest level of performance. Cascading provides a means to scale the SAN for additional connectivity of servers and storage, and allows for centralized management and backup.

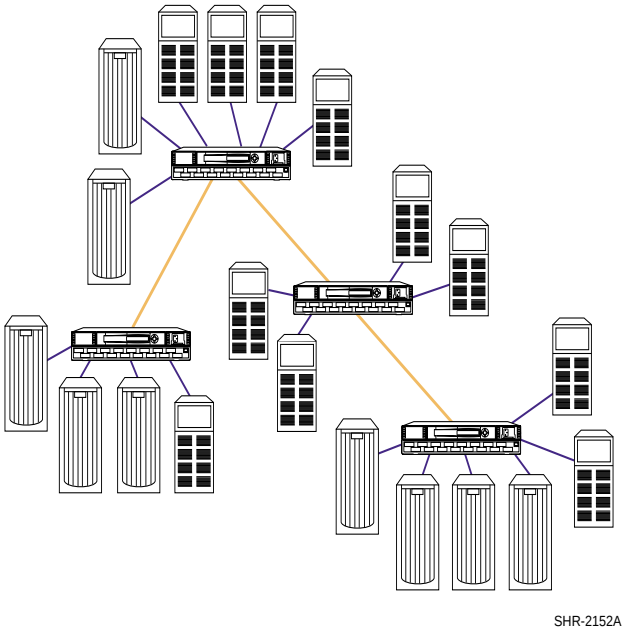


Figure 2–1. Cascaded Fabric SAN

Cascading designs can also be used for centralized or distributed access; however, traffic patterns should be well understood and should be factored into the design to ensure that there are an adequate number of ISLs to meet performance requirements. Using more than one ISL between switches in a cascade also provides redundant paths between a given pair of switches in the fabric.

Advantages of a Cascaded Fabric

- Accommodates diverse geographic conditions
- Scales easily for additional connectivity
- Shared backup is supported
- Shared management is supported
- Optimal local access is inherent in the fabric design

Modified Meshed Fabrics

A meshed fabric is similar to a cascaded fabric, however in a meshed fabric design, all switches are interconnected so there are at least two paths or routes from any one switch to any other switch in the fabric. This is true even if it is implemented with single ISLs between switches. This type of connectivity provides a level of fabric resiliency, so if a single ISL or ISL switch port interface fails, the fabric can automatically re-route data through an alternate path, even if this means through other switches in the fabric.

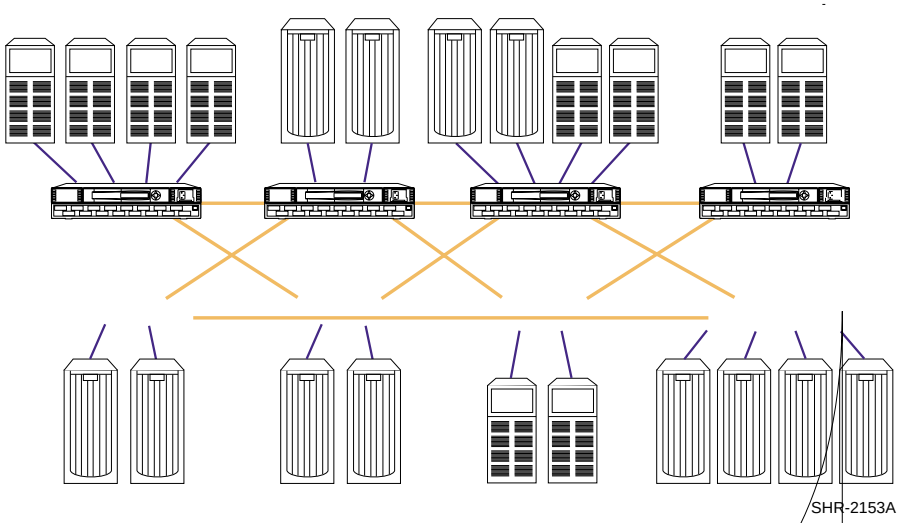


Figure 2–2. Modified Meshed SAN Fabric

In a full mesh design with all switches connected to all other switches, the efficiency of fabric relative to available ports can decrease as more switches are added. The efficiency of this fabric design can be improved by implementing a slightly modified mesh design, (See Figure 2–2).

In this example diagram, as switches are added, they are only connected to adjacent switches, not all other switches in the fabric. This still provides the benefits of full many to many connectivity without a decrease in efficiency.

Meshed fabrics are well suited to applications where data access is a mix of local and distributed. The full connectivity ensures many to many access, while at the same time allowing localized access to individual switches, servers and storage.

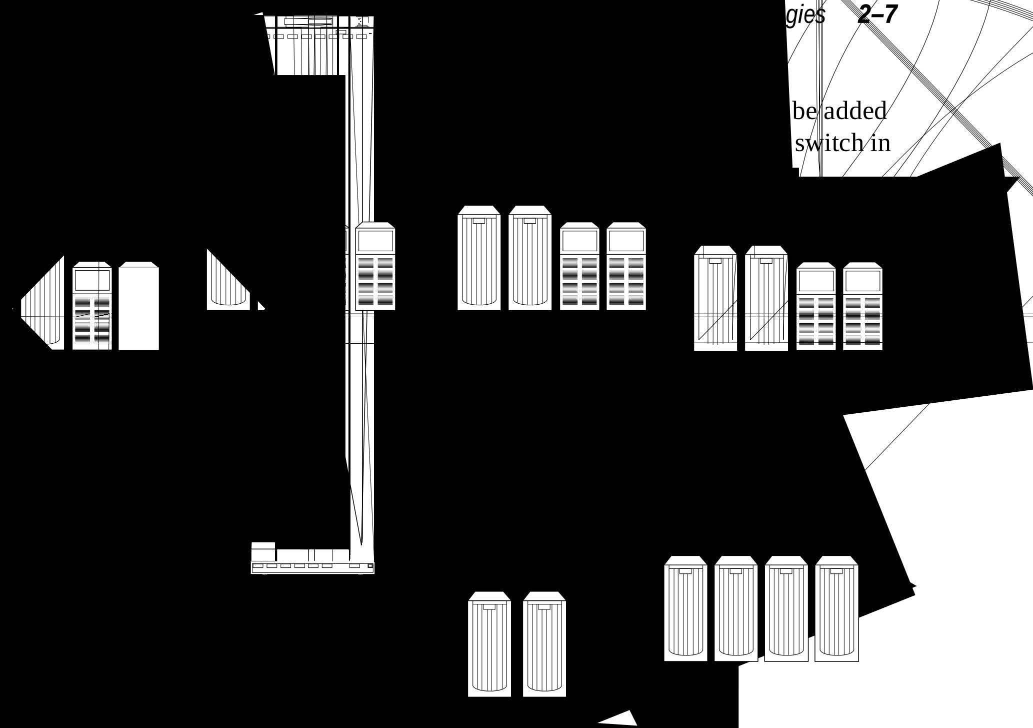
Advantages of a Meshed Fabric

- Can be configured for any to any or local data access, or a mix
  Reduces staff effort by minimizing reconfiguration and re-cabling of existing Fibre Channel switches. Adapts easily to new or different storage needs.
- Provides protection against link and switch port failures
  Fabric design allows Fiber Channel switches to automatically re-route under failure conditions, saving time and effort to manually trace the problem and re-route.
- Scales easily
  The mesh design can be extended from a four switch fabric to six or eight or more switches easily, and without disruption to the existing SAN.
- Shared backup is supported
  One or more Automated Tape Libraries can be added to the mesh fabric at various points without impacting performance or management.
- Shared management is supported
  All SANworks tools can navigate and manage the Storage Area Network in the mesh fabric, saving time and effort.
- Optimal distributed access is inherent in the fabric design
  The mesh design affords ease of adding servers to the SAN without impacting existing connections or equipment. This is especially useful for companies where there is rapid growth, or computing and storage needs are changing frequently.

Ring Fabric

A ring fabric (See Figure 2–3, *Ring Fabric SAN*) is a continuous ring of switches connected together into a single fabric. Each switch is connected to adjacent switches on either side with the last switch in the ring connected back to the first. This arrangement of switches provides almost the same level of fabric resiliency as the mesh design with full fabric connectivity and at least two internal fabric paths or routes. The maximum number of switches supported in the ring of a Ring fabric is 14, which results in a maximum switch hop count of seven under normal circumstances. (Because the ring provides connectivity in two directions, any two devices are never more than seven hops apart in a 14 switch ring). If using less than 14 switches in a ring, additional switches can be added

[redacted] be added [redacted] switch in [redacted]



[redacted] where da[redacted]ays localized. [redacted] the same switch, [redacted]jority of data [redacted] This implementation prov[redacted] way to scale [redacted]g a switch and groups of servers [redacted]d storage as a [redacted] to increase the size of the SAN over time.

[redacted]onfigured and installed before the server requirements are [redacted]ecause the ability to install the fabric infrastructure beforehand can [redacted] installation of each incremental storage system or server.

[redacted]g the switches within the ring provides a way to centrally manage the SAN [redacted] for centralized backup. This design allows data access through the ring, if [redacted], provided an adequate number of ISLs are specified in the design. The ring fabric [redacted] recommended for applications that require many to many connectivity.

Advantages of a Ring Fabric

- Easy to build
  Each Fiber Channel switch can support servers and storage, thus saving time and effort on SAN design and implementation.
- Scaling is simple and non-disruptive
  Fiber Channel switches can be added one at a time, as storage and connection needs dictate. Each Fiber Channel switch can support identical servers and storage for controlled growth, or can support a variety of heterogeneous systems for new demands of the business.
- Shared backup is supported
  One or more Automated Tape Libraries can be added to the ring fabric at various points without impacting performance or management.
- Shared management is supported
  All SANworks tools can navigate and manage the Storage Area Network in the ring fabric, saving time and effort.
- Optimal local access is inherent in the fabric design
  The majority of the data traffic is within each switch in the ring, minimizing any allocation, fabric and performance issues.
- Modular design
  Saves time and effort on design and implementation by complementing the basic modularity of all StorageWorks products, including the raid array controllers, universal packaging, and secondary storage (Automated Tape Libraries).

Backbone SAN Fabrics

A Backbone SAN Fabric design has one or more Fibre Channel switches acting as fabric backbones dedicated to connecting to other switches within the fabric. The backbone switches act as routers with full bandwidth and redundant connectivity to all other switches. This type of implementation offers the best "many to many" connectivity and evenly distributed bandwidth throughout the fabric.

The design is well-suited for implementations where data traffic patterns may vary and even be random at times, but the underlying need is for full network “many to many” connectivity with high performance. This topology is also ideal if you require or plan to implement in the future, SAN-wide storage pooling and sharing.

Tree Backbone Fabrics

See Figure 2–4. A Tree Backbone fabric is a three-level Backbone SAN Fabric implementation where the center level switch or switches are dedicated as backbone or distribution switches. The backbone switches connect to all edge switches on the upper and lower tiers in the fabric. Servers and storage can be connected intermixed to any of the edge switches on either tier for maximum connectivity flexibility.

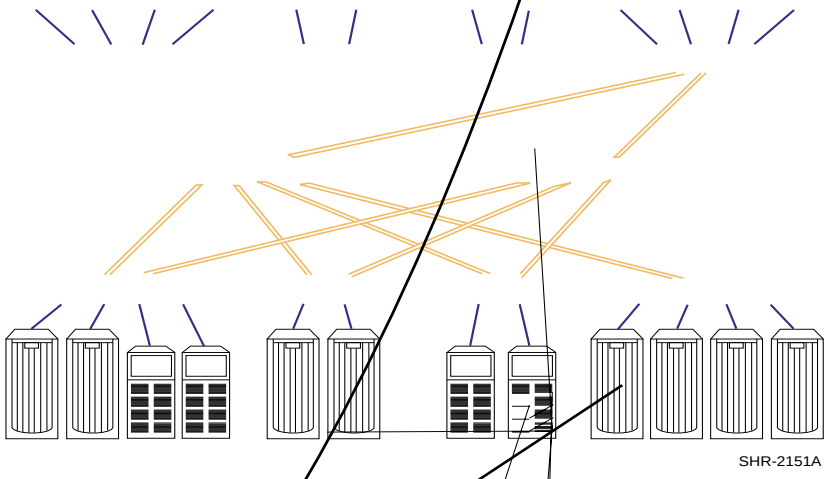


Figure 2–4. Tree Backbone SAN

If required, design trade-offs can be made that allow for connection of centralized primary or secondary storage directly on the backbone switches (this may reduce access or available bandwidth to specific portions of the fabric). Future capabilities will allow interconnecting Backbone SANs using ports on the backbone switches, or additional dedicated backbone switches to build larger fabrics.

Compaq SAN Fabrics currently support a large number of switches in a fabric. See Figure 2–5 for an example diagram of a Tree Backbone SAN with 20 switches

Advantages of Tree Backbone SANs

- Efficient port expansion: new switches need only be connected to backbone switches.
  Saves time and effort during the design and implementation phases by isolating the new switches from the existing SAN backbone.
- All edge switches are only two hops apart.
  Save design effort for adding new servers and storage to any point on the SAN. The uniformity of access supports new usage patterns without requiring redesign and re-cabling.
- When implemented with two or more backbone switches, provides a level of switch redundancy in a single fabric.
  Backbone design allows Fiber Channel switches to automatically re-route under failure conditions, saving time and effort to manually trace the problem and re-route.
- Can be centrally managed.
  All SANworks tools can navigate and manage the Storage Area Network in a tree backbone fabric, saving time and effort.
- Full "many to many" connectivity with evenly distributed bandwidth and redundant connectivity.
  Supports varying connection and performance demands regardless of the location within the SAN. At the same time, provides uniform routing and redundancy from a single SAN design.
- Improved bandwidth with multiple parallel ISLs.
  Additional ISLs ensure that all data traffic within the tree backbone SAN will be managed without any performance degradation, regardless of the location of servers and storage relative to each other.
- Offer maximum flexibility for implementing mixed access types: Local, Distributed, or Centralized
  Saves effort planning data traffic patterns; the tree backbone supports all access patterns.
- Can be deployed or distributed across a wide area with multiple inter-switch distances up to 10 km each or a single long distance switch separation of 100 km.
  Accommodates diverse geographic needs while supporting a wide variety of servers and storage needs and traffic patterns
- Can be implemented with centralized backup capabilities, reducing the cost of backup and restore operations
- Can be implemented with all availability levels
  Saves effort in the design and implementation phases by offering a single design for a variety of usage requirements.

- Can be an upgrade path from other SAN designs. Backbone SAN designs offer evenly distributed bandwidth and full many to many connectivity; they are the best solution for flexible SAN-wide storage pooling and sharing.
- Well-suited to take full advantage of expected future technological developments such as storage virtualization
  Saves the investment made in the SAN by continuing its use as more advanced tools, products, and designs become available.

Topology Data Access Usage

Each of the SAN topologies can be characterized by how well they provide specific data access. See Chapter 1, *Data Locality*. Table 2–1 provides a general characterization of the different topology designs as a means to compare each of the design types by optimal data access capabilities. Use the table as a basis for selecting the best-suited topology for the expected access needs.

Individual topologies can be tailored or modified to better meet specific requirements. For example, choosing a Tree Backbone design provides the best overall “many to many” connectivity, and allows portions of the tree implementation to be configured for local access. This can be accomplished by connecting servers and storage typically accessed on the same switch within portions of the tree.

Table 2–1 Topology Usage Rating

SAN Topology	Data Locality		
	Local “One to One”	**Centralized “Many to One”**	**Distributed “Many to Many”**
Cascaded	Highest	Not Recommended	Not Recommended
Meshed	High	Medium	High
Ring	Highest	Medium	Not Recommended
Tree Backbone	Medium	Highest	Highest

Topology Maximums

Table 2–2 indicates the maximum number of switches and ports supported for each of the Compaq standard SAN topologies.

Table 2–2 Topology Maximums

SAN Topology Min/Max Number of Switches	Total Number of Ports		Maximum Number of Device Ports[1]	
	Single Fabric	Two Fabrics	Single Fabric	Two Fabrics
Cascaded, Meshed, Ring[2] Single Fabric: 2 to 20 Two Fabrics: 4 to 40	320	640	~200	~400
Tree Backbone Single Fabric: 5 to 20 Two Fabrics: 10 to 40			192	384

1. Assumes 16-port switches. Indicates the number of ports available for server and storage connectivity. For Cascaded, Meshed, and Ring fabrics the number of device ports is approximate since this is dependent on the specific switch arrangement and the number of ISLs utilized.

2. The maximum number of switches supported in a ring is fourteen; additional switches can be added if you reduce the number of switches in the ring. A maximum of 20 switches can be implemented in a single fabric if there are no more than ten switches in the ring within the fabric, and no more than seven hops between any two devices in the fabric.

NOTE: The maximums shown presume the minimum number of ISLs. Depending on your specific application, you may need more ISLs. This reduces the overall number of ports available for servers and storage. Attaching the SAN Management Appliance also reduces the total number of ports available for servers and storage. See Chapter 5, *SANworks Management Appliance*.

Data Availability in a SAN

Data availability in a SAN can be influenced by many factors. The fabric architectural design, the number of Fibre Channel switches, and the number of ISLs between switches can all have a direct effect on the fabric availability. The number of connections or paths between a given server or clustered servers and the fabric, and the number of storage controller connections or paths into the fabric affects data availability and accessibility, as well as performance.

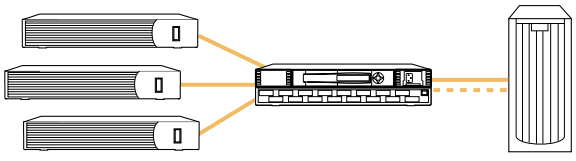
From the perspective of SAN architecture and fabric topology design, fabric availability can be classified into at least four categories or levels. The different categories offer a range of availability levels from the most basic interconnect scheme with no redundancy, up to fully redundant NSPOF designs.

Levels of Availability

1. Single Fabric/Single Server and Storage Paths
2. Single Meshed Fabric/Single Server and Storage Paths
3. Single Meshed Fabric/Multiple Server and Storage Paths
4. Multiple Fabrics/Multiple Server and Storage Paths

Level 1: Single Non-meshed Fabric/Single Server and Storage Path

These designs are implemented with single links between each switch, connected in one fabric. The Fibre Channel switches are arranged so that servers and storage connect into the fabric using single paths. This type of design does not provide any level of fabric or fabric path redundancy, but does offer the highest connectivity level relative to port count.



SHR-2165A

Figure 2–6. Level 1: Maximum Connectivity

Level 2: Single Meshed or Cascaded Fabric/Single Server and Storage Path

These designs have more than one ISL between switches and/or multiple paths or routes to all switches in the fabric. Servers and storage connect into the fabric using single paths. This provides the benefit of fabric resiliency. If a single switch port or a link between two switches fail, the fabric automatically re-routes data to an alternate fabric link or route. The servers see no interruption in their I/O flow.

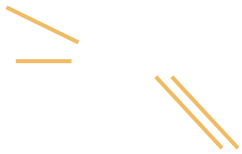


Figure 2–7. Level 2: Fabric Resiliency

Level 3: Single Meshed or Cascaded Fabric/Multiple Server and Storage Paths

These designs are the same as Level 2 with the addition of multiple data paths between servers and storage connecting into one fabric. Level three offers the benefits of both fabric resiliency and multiple server and storage paths. In the unlikely event of a switch, host bus adapter, or path failure, data is automatically re-routed to an alternate path in the servers and storage, and through the fabric. The servers see no interruption in their I/O flow. Level 3 requires the use of fabric zoning to define two separate paths in a single fabric.

Figure 2–8. Level 3: Single Fabric High Availability Multi-Pathing

Level 4: Multiple Fabrics/Multiple Server and Storage Paths

Like Level 3, Level 4 provides for multiple data paths between servers and storage, but in the Level 4 designs these paths are connected to physically separate fabrics. This type of design provides the highest level of availability and offers the highest no single point of failure protection (NSPOF). Any activity that may affect the fabric performance or usability will be overcome by routing data to another alternate fabric. The servers see no interruption in their I/O flow.

The Level 4 design eliminates any vulnerabilities to fabric failures, for example, human error such as improper switch replacement procedure, inadvertent erroneous fabric configuration settings, or a fabric service failure. This type of design also provides the highest level of performance and a higher number of available ports, since all fabrics can be accessed and utilized simultaneously during normal operations.

This level of protection is available for all Compaq standard SAN topologies by replicating the chosen design in two or more separate fabrics. Although this increases the overall cost of the implementation, the added benefit beyond the increase in data availability is an increase in total available ports. For example, choosing to implement a single fabric four switch-meshed design with multiple server and storage paths provides up to 52 ports for server and storage connectivity. Implementing the same topology using two fabrics provides up to 104 ports for server and storage connectivity.

Utilizing two fabrics also allows for a non-disruptive transition from one topology type to another. You can failover all operations to one fabric and transition the other fabrics to a new topology without service outages.

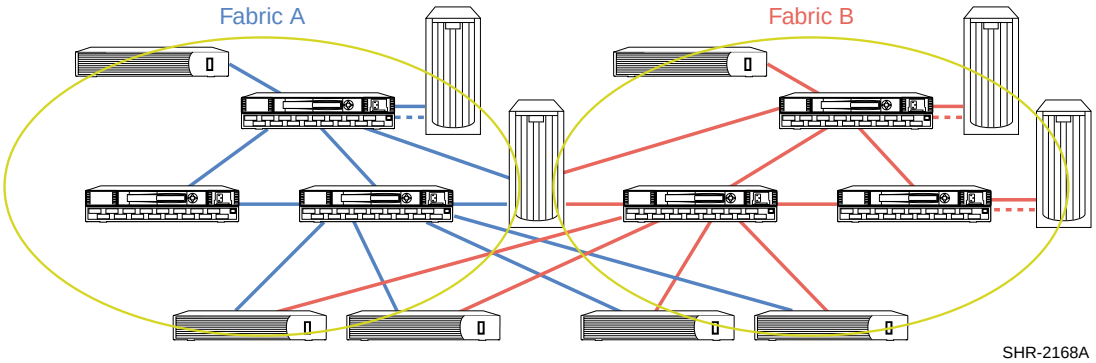


Figure 2–9. Level 4: Dual Fabric High Availability Multi-Pathing Fault Tolerant

Table 2–3 characterizes data availability and indicates the supported topologies for each level.

Table 2–3 Fabric Design Data Availability

Fabric Design	Availability Level		SAN Topologies
Single Fabric (Non-Meshed)	1	No Redundancy	Single Switch or Multiple Switches with Single ISL Cascade
Single Meshed Fabric **Multiple Fabric Paths**	2	Medium	Two ISL Cascade, Meshed, Ring, Tree
Single Meshed Fabric **Multiple Fabric Paths** **Multiple Server and Storage Paths** [1]	3	High	All
Two (or more) Fabrics **Multiple Server and Storage Paths**	4	Highest (NSPOF)	All

1. Requires the use of zoning to define a minimum of two separate data paths within the single fabric.

Availability Design Considerations

Two major considerations in choosing an availability level are the criticality of data access and cost. For mission critical applications, first consider full redundant fabric designs. The additional cost can usually be justified when you consider the cost associated with the loss of access to critical data.

You should also remember that the additional cost of more than one fabric provides more than just redundancy since the number of available ports will typically double. If this increased connectivity can be utilized by adding more servers and storage to the SAN, the cost factor is minimized. Table 2–4 characterizes data availability levels relative to cost and total number of available ports.

Table 2–4 Availability Factors

Fabric Design	Level	Hardware Cost Factor[1]	Available Ports[2]
Single Fabric (Non-Meshed)	1	x	n–#ISLs
Single Meshed Fabric **Multiple Fabric Paths**	2	x + Additional ISLs	n–#ISLs
Single Meshed Fabric **Multiple Fabric Paths** **Multiple Server and Storage Paths [3]**	3	x + Additional ISLs + Additional HBAs	n–#ISLs – Additional HBA Ports
Two (or more) Fabrics **Multiple Server and Storage Paths**	4	x + Additional ISLs + Additional HBAs + Additional Switches	2n–#ISLs – Additional HBA Ports

1. The variable x is the cost of a single nonmeshed fabric. It is used as a reference for comparison.
2. The variable n is the total number of ports available for devices in a SAN fabric.
3. Requires the use of zoning to define a minimum of two separate data paths within the single fabric.

Scalability and Migration

Each of the Compaq standard SAN topologies can be scaled incrementally to increase connectivity and overall capacity. You should always plan for expected future growth when doing your initial SAN design to minimize disruption when expanding capabilities and capacity over time. If you do exceed the capacity of a given topology, or find that data access needs have changed, it is possible to migrate one topology to another. Refer to Chapter 7, *Best Practices* for information about migrating topologies.

Table 2–5 lists the migration paths and the options for scalability for all topologies.

Table 2–5 Topology Migration & Scaling

SAN Topology	Migration	Scalability (For All Topologies)
Cascaded	Convert to Meshed, Ring or Tree	■ Increase the number of switches ■ Use higher port count switches ■ Transition to a different topology ■ Deploy multiple fabrics
Meshed	Convert to Ring, or Tree	
Ring	Convert to Meshed or Tree	
Tree	Add additional backbone switches	

Chapter 3

SAN Fabric Design Rules

Heterogeneous SAN Fabric Design Configuration Rules

The sections in this chapter contain SAN Fabric design configuration rules for Heterogeneous SANs. The exact configuration rules for a SAN begin with the base SAN Fabric rules. These are modified depending on the specific topology implementation rules, platform or operating system and storage system rules described in Chapter 4, *Heterogeneous SAN Platform Rules*, and the requirements of applications being run on the SAN. Read the documentation and release notes for all hardware and software products that are being utilized on the SAN for additional configuration information details. See *Related Documents* in the preface for a list of related documentation.

General SAN Fabric Rules

1. Up to 20 switches total in a SAN fabric using Compaq SAN Switch 8/16 and 8/16-EL model switches.

   NOTE: Tru64 UNIX is currently supported with up to 10 switches in a SAN fabric.

2. Up to four switches total in a SAN fabric using Compaq Fibre Channel Switch 8/16 model switches.
3. All Compaq Fibre Channel 8-port and 16-port switch models are supported inter-mixed[1]. When mixing Compaq SAN Switch 8/16 and 8/16-EL models with Compaq Fibre Channel Switch 8/16 models, compatible mode settings must be set in the SAN switches. Refer to the SAN Switch documentation.
4. Up to seven switch hops (eight switches) maximum between any two devices.

5. Within a single fabric where switches are interconnected, each Fibre Channel switch must have a unique domain number (Domain ID) and a unique World Wide Name (WWN). All switch configuration parameters in each switch must be the same.
6. Up to 16 inter-switch links (ISLs) on a switch, with up to eight active ISLs to the same destination.
7. Any mix of servers and storage systems is allowed in a SAN provided the specific platform, operating system, and storage system rules are followed. Refer to the appropriate sections in this guide and the documentation listed in the section *Related Documents* in the preface.

Specific Fabric Topology Rules

1. Up to 20 Fibre Channel switches in a Cascaded, Meshed, or Backbone SAN Fabric topology
2. Up to 14 Fibre Channel switches configured in a ring with a Ring SAN Fabric topology. Up to 20 switches in a Ring SAN Fabric provided that no more than 10 switches are in a ring and no more then 10 switches are outside of the ring, one switch cascaded from each of the 10 ring switches. .
3. Up to seven switch hops between any two devices in a Cascaded, Meshed, or Ring SAN Fabric topology.

General Fabric Performance Recommendations

- Whenever possible, devices that exchange the highest amount of data should be connected to the same Fibre Channel switch
- When devices exchanging data are on different switches:
  - Minimize the number of hops between devices
  - For high bandwidth applications, configure a maximum of two active storage controller ports per ISL
  - For high throughput applications, configure a maximum of six active storage controller ports per ISL
  - For mixed applications, configure a maximum of four active storage controller ports per ISL

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1. Compaq Fibre Channel Switch 8/16 model switches are not supported in fabrics with greater than 4 switches (General SAN Fabric Rule 2).

SAN Appliance Rules and Recommendations

1. It is recommended that a SAN Appliance be used to manage the SAN when a fabric contains more than four Fibre Channel switches.
2. When using a SAN appliance, one SAN Appliance is required for each fabric in multiple fabric SANs.

SAN Fabric Zoning Rules

The fabric zoning feature is supported with all Compaq Fibre Channel switch models. Zoning can be used to logically separate devices and different hardware platforms and operating systems in the same physical SAN. Use of zoning is optional; however, there are specific conditions when zoning is required:

- When mixing different hardware platforms, operating systems or storage systems that are currently only supported in homogenous SANs, and it is unknown whether or not there are interaction problems
- When there are known interaction problems between different hardware platforms or operating systems and specific storage system types
- When the number of nodes or ports in the SAN is such that you exceed a storage system connection support limit

Refer to Chapter 4, *Heterogeneous SAN Platform Rules*, for rules about mixing specific platforms in a Heterogeneous SAN without the need for fabric zoning.

SAN Component Interconnect Descriptions and Rules

The following sections describe rules for SAN component interconnects–switch port interfaces and physical cabling.

Fibre Channel Switch Interface Usage Descriptions

- E-Port interface for switch to switch connectivity
- F-Port interface for fabric attached device–initiators (host bus adapters) and targets (storage ports)
- FL-Port interface for public loop fabric-aware 24-bit Fibre Channel addressable devices–initiators

- FL-Port interface for private loop 8-bit Fibre Channel addressable devices–private FC-AL initiators and targets. This requires use of the Compaq SAN Switch 8/16 and 16-EL models' QuickLoop Feature. Typically this feature is only required when a specific platform can only be configured with a private FC-AL host bus adapter driver.

  Access with QuickLoop - The QuickLoop switch feature allows private FC-AL initiators and targets configured in a QuickLoop to communicate with each other through the switch. Since all initiators configured *inside* a QuickLoop are private they cannot communicate with targets outside of the QuickLoop. QuickLoop is only supported on Compaq SAN Switch 8/16 and 16-EL models when used with MA6000, MA/RA8000, or EMA/ESA12000 storage systems.

Fiber Optic Interconnects/Distance Rules

1. The minimum[1] allowable bend radius of fiber optic cable specified by cable size is:
   - ❏ 25 mm for 50 and 62.5 micron multi-mode fiber optic cable
   - ❏ 5 mm for 9 micron single-mode fiber optic cable
2. Minimum fiber optic cable segment length is 2 meters between Fibre Channel devices (a transmitter and a receiver). The 2 meter minimum does not apply to patch cords through a passive patch panel if the overall total distance between the transmitter and receiver of the devices being connected through the patch panel is at least 2 meters.
3. Up to 200 meters maximum distance per cable segment between devices and switches or switches and switches using 62.5/125 micron multi-mode fiber optic cable and short wavelength GBICs or GLMs[2].

   NOTE: Information on the use of 62.5 micron fiber optic cable is provided to facilitate use of previously installed cable. Compaq recommends 50 micron fiber optic cable for any new installation requiring multi-mode fiber.
4. Up to 500 meters maximum distance per cable segment between devices and switches or switches and switches using 50/125 micron multi-mode fiber optic cable and short wavelength GBICs or GLMs.
5. Up to 10 km (6 miles) maximum distance between any two Fibre Channel switches using 9/125 micron single-mode fiber optic cable and long-wavelength GBICs.

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1. Specification is based on representative cables. Consult manufacturer for parameters of specific cables.
2. GLMs are used in the HSG60 (MA6000) and HSG80 (MA/RA8000, EMA/ESA12000) storage controllers

6. Maximum of 70 km (42 miles) distance between devices when configured through seven 10 km switch to switch segments. This rule is based on a maximum of 10 km between any two switches and a maximum of seven hops between devices.
7. Up to 100 km (60 miles) distance between any two Fibre Channel switches using 9/125 micron single-mode fiber optic cables and very long distance GBICs. When using a single 100 km link in the SAN, all other segments can be a maximum of 500 meters each. The 100 km distance can be made up of multiple segments as long as the total distance does not exceed 100 km and each segment that is greater then 10 km uses very long distance GBICs. For example, two 50 km segments are supported since the total does not exceed 100 km and the hop count does not exceed seven.

   NOTE: Refer to the Data Replication Manager (DRM) solution documentation for specific interconnect and distance rules related to DRM configurations.

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Table 3–1 Storage Product Interconnect/Transport Support

Interface/Transport	Storage Product		
	Heterogeneous SAN	**DRM**	**Enterprise Backup Solutions (EBS)**
Fibre Channel via 50 micron multi-mode fiber optic cable and short-wave GBICs	Up to 500 meters per cable segment	Up to 500 meters per cable segment	Up to 500 meters per cable segment
Fibre Channel via 62.5 micron multi-mode fiber optic cable and short-wave GBICs	Up to 200 meters per cable segment	Up to 200 meters per cable segment	Up to 200 meters per cable segment
Fibre Channel via 9 micron single-mode fiber optic cable and long-wave GBICs	Up to 10 km per cable segment	Up to 10 km per cable segment	Up to 10 km per cable segment
Fibre Channel via 9 micron single-mode fiber optic cable and very long distance GBICs	Up to 100 km per cable segment	Up to 100 km per cable segment	Up to 100 km per cable segment
Fibre Channel via Wave Division Multiplexing (WDM) and Dense Wave Division Multiplexing (DWDM)	Not Supported	Supported Up to 100 km	Not Supported
ATM over single T1/E1 Wide Area Network (WAN)	Not Supported	Supported No Distance Limit	Not Supported
ATM over single T1/E1 WAN (Inverse Multiplexing)	Not Supported	Supported No Distance Limit	Not Supported
ATM over T3/E3 WAN	Not Supported	Supported No Distance Limit	Not Supported
ATM over fractional and/or shared T3/E3 and OC3 WAN	Not Supported	Supported No Distance Limit	Not Supported

Fiber Optic Cable Loss Budgets

The information in this section is based on the Fibre Channel Physical Interface Specification. Refer to the specification document for more information.

NOTE: Media losses are not specified due to variances between different fiber optical cable manufacturers. In all cases the specification that must be followed is the total channel insertion loss, which includes media losses.

1. For 62.5/125 micron fiber optic cable up to 200 meters:
   Maximum of 3 db total channel insertion loss[1], 0.75 db loss per mated connector pair.

   NOTE: Information on the use of 62.5 micron fiber optic cable is provided to facilitate use of previously installed cable. Compaq recommends 50 micron fiber optic cable for any new installation requiring multi-mode fiber.

2. For 50/125 micron fiber optic cable up to 500 meters:
   Maximum of 4 db total channel insertion loss, 0.75 db loss per mated connector pair.
3. For 9/125 micron fiber optic cable up to 10 km:
   Maximum of 7.8 db total channel insertion loss, 0.75 db loss per mated connector pair.
4. For 9/125 micron fiber optic cable up to 100 km:
   Maximum of 23 dB total channel insertion loss, 0.75 dB loss per mated connector pair.
5. Use of optical fiber patch panels is supported provided the total channel insertion loss between the transmitter and receiver for the cable segment routed through the patch panel does not exceed the maximum listed for the connector and cable type in use.

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1. Channel insertion loss is the combined passive loss from connectors, splices, and media between the transmitter and receiver.

Chapter 4

Heterogeneous SAN Platform Rules

Platform and Operating System Rules

This chapter describes rules related to specific platforms, operating systems and storage products. For additional information refer to the applicable platform specific application notes and individual product documentation. Refer to the preface for a list of related documentation.

General Platform/Operating System Rules

1. Each platform listed is supported in all SAN Fabric topology configurations unless otherwise noted in this guide or the applicable platform application notes.
2. Any mix of servers (clustered and standalone) and storage systems allowed based on the maximums given in Table 4–3 and in the platform specific application notes and documentation.
3. Refer to Table 4–2 for information related to mixing platforms on a single shared storage system. In certain situations multiple storage systems may be required to accommodate the requirements of different platforms or operating systems.
4. All Compaq and multi-vendor hardware platforms and operating systems that are supported in a homogeneous SAN are supported in a Heterogeneous SAN if each platform is configured in a separate fabric zone. Refer to Table 4–2 to determine if zoning is required for specific combinations of supported heterogeneous platforms.
5. When using HSG60 or HSG80 controller-based storage systems (MA6000, RA/MA8000, ESA/EMA12000), use fabric zoning to limit the number of connections visible to each storage system to the maximum number available. The number of connections available is based on the version of Array Controller Software (ACS).

6. Servers and storage systems can attach to multiple fabrics. The number of separate fabrics per server is based on the specific server model capabilities and the maximum number of Fibre Channel host bus adapters supported.

Specific Platform/Operating System Rules

Table 4–1 summarizes the rules for configuring each hardware platform or operating system with the supported storage system types. The table lists the platforms, storage system types, and the preferred method of storage attachment for each platform type. The sections following the table describe the rules in more detail.

For the most current information on HBAs, firmware, and drivers see this table.

Refer to Table 4–2 for information about configuring storage systems for shared access to multiple heterogeneous platforms in a SAN.

NOTE: Tru64 UNIX is currently supported with up to 10 switches in a SAN fabric

Table 4–1 Platform/Storage System SAN Attachment Summary

Platform or Operating System	Platform HBA SAN Attachment	MA6000, MA8000, RA8000, EMA12000, ESA12000 Storage Controller SAN Attachment
Compaq OpenVMS 7.2-1, 7.2-1H1 Multi-Path	DS-KGPSA-BC 380574-001 D-KGPSA-CA 168794-B21 F-Port	F-Port using FABRIC topology Multiple-Bus Failover Mode SCSI-3 Mode Command Console LUN enabled Connection name OS parameter type: VMS
Tru64 UNIX 4.0F/G TruCluster Software Products Version 1.6	DS-KGPSA-BC 380574-001 DS-KGPSA-CA 168794-B21 F-Port	F-Port using FABRIC topology Transparent Failover Mode SCSI-2 Mode Command Console LUN enabled/disabled Connection name OS parameter type: TRU64_UNIX
Tru64 UNIX 5.0A, 5.1 Multi-Path TruCluster Server Version 5.0A/5.1	DS-KGPSA-BC 380574-001 DS-KGPSA-CA 168794-B21 F-Port	F-Port using FABRIC topology Transparent or Multiple-Bus Failover Mode SCSI-2 Mode Command Console LUN enabled or disabled or SCSI-3 Mode Command Console LUN enabled Connection name OS parameter type: TRU64_UNIX

Table 4–1 Platform/Storage System SAN Attachment Summary (Continued)

Platform or Operating System	Platform HBA SAN Attachment	MA6000, MA8000, RA8000, EMA12000, ESA12000 Storage Controller SAN Attachment
HP-UX 10.20, 11.0 Multi-Path MC/SericeGuard Clusters	HP A3404A, A3591A/B, A3636A, A3740A A5158A (loop only) L-Port 11.0 only: 218409-B21 F-Port	FL-Port using LOOP_HARD topology (10.20) F-Port using FABRIC topology (11.0) Transparent (Multiple-Bus 10.20 only) Failover Mode SCSI-2 Mode Command Console LUN enabled/disabled Connection name OS parameter type: HP
IBM AIX 4.2.1, 4.3.0, 4.3.1, 4.3.2, 4.3.3	197819-B21 DS-SW1A4-PD F-Port	F-Port using FABRIC topology Transparent Failover Mode SCSI-2 Mode Command Console LUN enabled/disabled Connection name OS parameter type: WINNT
Microsoft Windows NT 4.0 SP5, SP6a, Windows 2000 SP1 MSCS Multi-Path	MA6/8/RA8000, EMA/ESA12000 DS-KGPSA-BC DS-KGPSA-CB F-Port	F-Port using FABRIC topology Transparent or Multiple-Bus Failover Mode SCSI-2 Mode Command Console LUN disabled or SCSI-3 Mode Command Console LUN enabled Connection name OS parameter type: WINNT
Novell NetWare 4.2, 5.x Multi-Path Clusters	MA6/8/RA8000, EMA/ESA12000 120186-B21/291 223180-B21/291	F-Port using FABRIC topology Transparent or Multiple-Bus Failover Mode SCSI-2 Mode Command Console LUN enabled/disabled Connection name OS parameter type: NETWARE
Redhat Linux 6.1 and 6.2 Alpha/Intel	167433-B21 F-Port	F-Port using FABRIC topology Transparent Failover Mode SCSI-3 Mode Command Console LUN enabled Connection name OS parameter type: SUN
SUSE Linux 6.3 Alpha /Intel	167433-B21 F-Port	F-Port using FABRIC topology Transparent Failover Mode SCSI-3 Mode Command Console LUN enabled Connection name OS parameter type: SUN
SGI IRIX 6.5.7, 6.5.8	SGI PCI-FC-1POPT SGI XT-FC-1POPT F-Port	F-Port using FABRIC topology Transparent Failover Mode SCSI-2 Mode Command Console LUN disabled Connection name OS parameter type: SGI

Table 4–1 Platform/Storage System SAN Attachment Summary (Continued)

Platform or Operating System	Platform HBA SAN Attachment	MA6000, MA8000, RA8000, EMA12000, ESA12000 Storage Controller SAN Attachment
Sun Solaris 2.6 (32-bit), 7, 8 (32/64-bit), SUN Clusters Multi-Path	380575-001 32-bit Sbus, 123503-001 64-bit Sbus, 380576-001 32-bit PCI F-Port	F-Port using FABRIC topology Transparent or Multiple-Bus Failover Mode SCSI-2 Mode Command Console LUN disabled Connection name OS parameter type: SUN

Compaq OpenVMS (7.2, 7.2-1, 7.2-1H1)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the KGPSA-BC/CA host bus adapter configured for FABRIC topology
- Controller Settings are SCSI-3, Command Console LUN enabled, FABRIC topology
- The connection name operating system parameter must be set to "VMS"
- Supports Multiple-Bus failover mode only. Multi-path driver is embedded in the operating system
- Supports multi-path high availability configurations implemented in separate fabrics or a single fabric zoned into two logical fabrics
- Servers and storage systems configured for DRM must be zoned. One DRM zone per fabric for each DRM configuration

Tru64 UNIX (4.0F/G, 5.0A, 5.1)

Tru64 UNIX is currently supported with up to 10 switches maximum in a SAN fabric.

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the KGPSA-BC/CA host bus adapter configured for FABRIC topology
- For version 4.0F/G controller settings are SCSI-2, CCL enabled or disabled, FABRIC topology
- For version 5.0A, 5.1 controller settings are SCSI-2, CCL enabled or disabled, or SCSI-3, FABRIC topology
- The connection name operating system parameter must be set to "TRU64_UNIX"

- Tru64 UNIX version 4.0F/G supports Transparent failover, Tru64 UNIX version 5.0A and 5.1 supports Transparent and Multiple-Bus failover mode. Multi-path code is embedded in the V5.0A/V5.1 operating systems
- Supports multi-path high availability configurations implemented in separate fabrics or a single fabric zoned into two logical fabrics
- Tru64 UNIX versions 4.0F/G support TruCluster Software Products Version 1.6
- Tru64 UNIX versions 5.0A and 5.1 support TruCluster Server Version 5.0A/5.1
- QuickLoop is not supported with Tru64 UNIX running TruCluster products
- Zoning required when you configure a SAN for multiple TruCluster products
- You must use zoning when Tru64 UNIX is used in a Heterogeneous SAN with HP-UX, Linux, Microsoft Windows NT, or Windows 2000
- Servers and storage systems configured for DRM must be zoned. One DRM zone per fabric for each DRM configuration

HP-UX (10.20, 11.0)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- Version 10.20 uses the HP FC-AL host bus adapter configured for LOOP topology in a QuickLoop
- Controller settings are SCSI-2, CCL enabled or disabled, configured for LOOP_HARD topology in a QuickLoop
- Supports Transparent failover mode and Multiple-Bus failover mode

  NOTE: Multiple-Bus failover mode is supported for HP-UX version 10.20 only, using the HP PV Links multi-path driver.

- For HP-UX 10.20 only, supports multi-path high availability configurations implemented in separate fabrics or a single fabric zoned into two logical fabrics
- Version 11.0 uses the 218409-B21 PCI host bus adapter configured for FABRIC topology or uses the HP FC-AL host bus adapter configured for LOOP topology in a QuickLoop
- Controller settings are SCSI-2, CCL enabled or disabled, configured for FABRIC topology or LOOP_HARD topology in a QuickLoop
- The connection name operating system parameter must be set to "HP"
- You must use zoning when HP-UX used in a Heterogeneous SAN with other operating systems.

IBM AIX (4.2.1, 4.3.0, 4.3.1, 4.3.2, 4.3.3)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the 197819-B21 host bus adapter
- Controller settings are SCSI-2, CCL enabled or disabled, FABRIC topology
- The connection name operating system parameter must be set to "WINNT"
- Supports Transparent failover mode
- Zoning required when used in a Heterogeneous SAN

Microsoft Windows NT (4.0 SP5, SP6a), Windows 2000 (SP1)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the KGPSA-BC/CB host bus adapter configured for FABRIC topology.
- Controller settings can be SCSI-2, CCL disabled or SCSI-3, CCL enabled, FABRIC topology
- The connection name operating system parameter must be set to "WINNT"
- Supports Transparent failover mode and Multiple-Bus failover mode. SANworks Secure Path multi-path driver is required for Multiple-Bus failover
- Supports multi-path high availability configurations implemented in separate fabrics or a single fabric zoned into two logical fabrics
- Zoning required when used in a Heterogeneous SAN with Linux or HP-UX
- Servers and storage systems configured for DRM must be zoned. One DRM zone per fabric for each DRM configuration

Novell NetWare (4.2, 5.x)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the 120186-B21/291 (64-bit) or 223180-B21/291 (32-bit) host bus adapter
- Controller settings are SCSI-2, CCL enabled or disabled, FABRIC topology
- The connection name operating system parameter must be set to "NETWARE"
- Supports Transparent failover mode and Multiple-Bus failover mode. SANworks Secure Path multi-path driver is required for Multiple-Bus failover
- Supports multi-path high availability configurations implemented in separate fabrics or a single fabric zoned into two logical fabrics

Redhat Linux Alpha/Intel (6.1, 6.2), SUSE Linux Alpha/Intel (6.3)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the 167433-B21 host bus adapter
- Controller settings are SCSI-3, CCL enabled, FABRIC topology
- The connection name operating system parameter must be set to "SUN"
- Supports Transparent failover mode only
- Zoning required when used in a Heterogeneous SAN

SGI IRIX (6.5.7, 6.5.8)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the QLogic 2200F/66 PCI or 2200F/66 XIO host bus adapter
- Controller settings are SCSI-2, CCL disabled, FABRIC topology
- The connection name operating system parameter must be set to "SGI"
- Supports Transparent failover mode

Sun Solaris (2.6, 7, 8, with 7, 8 either 32-bit or 64-bit)

For MA6000, MA/RA8000, EMA/ESA12000 storage systems:

- All servers use the 380575-001 Sbus, 123503-001 Sbus, or 380576-001 PCI host bus adapter configured for FABRIC topology
- Controller settings are SCSI-2, CCL disabled, FABRIC topology
- The connection name operating system parameter must be set to "SUN"
- Supports Transparent failover mode and Multiple-Bus failover mode. SANworks Secure Path multi-path driver is required for Multiple-Bus failover
- Supports multi-path high availability configurations implemented in separate fabrics or a single fabric zoned into two logical fabrics
- Servers and storage systems configured for DRM must be zoned. One DRM zone per fabric for each DRM configuration

Storage System Rules

This section describes rules for configuring storage connected to multiple different platforms and operating systems in a Heterogeneous SAN. For additional information refer to the applicable platform specific application notes and individual product documentation. Refer to the Related Documents section in the preface.

General MA6000, MA/RA8000, EMA/ESA12000 Rules

These storage systems can be configured in a SAN using any Compaq Fibre Channel fabric switch model. (Refer to Chapter 3, *SAN Fabric Design Rules* for rules related to specific switch models.) Table 4–1 lists the platforms and operating systems that are supported using these storage systems. Refer to Table 4–2 for the specific shared access rules when different platforms or operating systems need to access the same MA6000, MA/RA8000, or EMA/ESA12000 storage system.

1. The supported platforms and operating systems are listed in Table 4–1.
2. F-Port fabric attachment to the SAN is available through all Compaq Fibre Channel 8/16, SAN Switch 8/16, and 8/16-EL models. Controller setting is FABRIC topology.
3. FL-Port fabric loop attachment to the SAN with QuickLoop is available through Compaq SAN switch 8/16 and 16-EL model switches. Controller port topology set to "LOOP_HARD".
4. All controller ports must be set to the same topology type.
5. Single or dual redundant controller configurations are supported. For dual redundant controllers, the available failover modes are Transparent and Multiple-Bus. Multiple-Bus failover requires operating system or separate multi-path driver functionality.
6. The heterogeneous platform and operating system mix in the SAN determines the appropriate controller topology attachment, SCSI mode, and Command Console LUN settings for shared storage systems. Refer to Table 4–2.
7. Zoning - Fabric level masking: Use fabric switch Zoning to enable/disable access or communication between devices in the SAN, initiators (host bus adapters) and targets (controller ports). Refer to Table 4–2 for information about when zoning is required.

   NOTE: Each active controller host port presents one SCSI Target ID to every initiator that has a connected path to the port through the fabric. Each path detected by the controller will result in a separate connection name table entry in the controller. (Refer to ACS documentation for information about the maximum number of connection name entries provided in the controller.) Configurations with a greater number of connections than provided must be zoned to limit the number of connections visible to the controller.

8. SSP - LUN level masking:

   Use storage system Selective Storage Presentation to enable/disable LUN access to specific connections. Use the unit offset feature to provide needed LUN numbering for host connections.

   NOTE: Shared access between different servers to the same storage unit (LUN) requires specific application software (i.e., MSCS) to ensure proper data preservation.

9. All host connection name table entries must have the proper operating system type parameter set based on platform type accessing the assigned LUNs. Refer to Table 4–1.

Heterogeneous Platform MA6000, MA/RA8000, EMA/ESA12000 Storage Rules

Table 4–2 specifies the storage system settings that allow for interoperability between combinations of different platforms and operating systems when sharing a single MA6000, MA/RA8000, or EMA/ESA12000 storage system. Use this table to determine if two or more heterogeneous platforms or operating systems can share a single storage system.

The categories in each table entry list whether or not any two platforms are supported sharing a storage system, and if zoning is required. The additional information specifies the supported failover modes, required controller port topology, SCSI mode, and Command Console LUN settings.

Table 4–2 Platform Interoperability for Shared MA6000, MA/RA8000, and EMA/ESA12000

Platform or Operating System	Compaq Open VMS 7.2, 7.2-1 7.2-1H1	Tru64 UNIX 4.0F/G May use Trucluster Software Products V. 1.6	Tru64 UNIX 5.0A, 5.1 May use TruCluster Server Version 5.0A/5.1	HP-UX 10.20, 11.0 MC/ServiceGuard Clusters	IBM AIX 4.2.1, 4.3.0, 4.3.1, 4.3.2, 4.3.3	Redhat Linux 6.1, 6.2 SUSE Linux 6.3 Alpha/Intel	MicrosoftWindows NT 4.0 SP5, SP6a Windows 2000 SP1, MSCS	Novell NetWare 4.2, 5.x Clusters	SGI IRIX 6.5.7, 6.5.8	Sun Solaris 2.6, 7, 8 (32/64-bit) Clusters
Compaq OpenVMS 7.2, 7.2-1 7.2-1H1	Multiple-Bus FABRIC SCSI-3 CCL	Not Supported	Multiple-Bus FABRIC SCSI-3 CCL	Not Supported	Not Supported	Not Supported	Multiple-Bus FABRIC SCSI-3 CCL	Not Supported	Not Supported	Not Supported
Tru64 UNIX 4.0F/G	Not Supported	Transparent FABRIC SCSI-2	Transparent FABRIC SCSI-2	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	With Zoning Transparent FABRIC SCSI-2	Not Supported	With Zoning Transparent FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2	Transparent FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2 No CCL
Tru64 UNIX 5.0A, 5.1	Multiple-Bus FABRIC SCSI-3 CCL	Transparent FABRIC SCSI-2	Transparent or Multiple-Bus FABRIC SCSI-2 or SCSI-3 CCL	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	With Zoning Transparent FABRIC SCSI-2	With Zoning Transparent FABRIC SCSI-3 CCL	With Zoning Transparent or Multiple-Bus FABRIC SCSI-3 CCL	Transparent or Multiple-Bus FABRIC SCSI-2	Transparent FABRIC SCSI-2 No CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL
HP-UX 10.20, 11.0 MC/Service-Guard Clusters	Not Supported	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	10.20 Transparent or Multiple-Bus LOOP_HARD SCSI-2 11.0 Transparent LOOP_HARD or FABRIC	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	Not Supported	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2 No CCL	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2 No CCL	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2 No CCL
IBM AIX 4.2.1, 4.3.0, 4.3.1, 4.3.2, 4.3.3	Not Supported	With Zoning Transparent FABRIC SCSI-2	With Zoning Transparent FABRIC SCSI-2	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	With Zoning Transparent FABRIC SCSI-2	Not Supported	With Zoning Transparent FABRIC SCSI-2 No CCL	With Zoning Transparent FABRIC SCSI-2	With Zoning Transparent FABRIC SCSI-2 No CCL	With Zoning Transparent FABRIC SCSI-2 No CCL
Redhat Linux 6.1, 6.2 SUSE Linux 6.3 Alpha/Intel	Not Supported	Not Supported	With Zoning Transparent FABRIC SCSI-3 CCL	Not Supported	Not Supported	Transparent FABRIC SCSI-3 CCL	With Zoning Transparent FABRIC SCSI-3 CCL	Not Supported	Not Supported	Not Supported

Table 4–2 Platform Interoperability for Shared MA6000, MA/RA8000, and EMA/ESA12000 (Continued)

Platform or Operating System	Compaq Open VMS 7.2, 7.2-1 7.2-1H1	Tru64 UNIX 4.0F/G May use Trucluster Software Products V. 1.6	Tru64 UNIX 5.0A, 5.1 May use TruCluster Server Version 5.0A/5.1	HP-UX 10.20, 11.0 MC/ServiceGuard Clusters	IBM AIX 4.2.1, 4.3.0, 4.3.1, 4.3.2, 4.3.3	Redhat Linux 6.1, 6.2 SUSE Linux 6.3 Alpha/Intel	Microsoft Windows NT 4.0 SP5, SP6a Windows 2000 SP1, MSCS	Novell NetWare 4.2, 5.x Clusters	SGI IRIX 6.5.7, 6.5.8	Sun Solaris 2.6, 7, 8 (32/64-bit) Clusters
Microsoft Windows NT 4.0 SP5, SP6a Windows 2000 SP1 MSCS	Multiple-Bus FABRIC SCSI-3 CCL	With Zoning Transparent FABRIC SCSI-2 No CCL	With Zoning Transparent or Multiple-Bus FABRIC SCSI-3 CCL	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2 No CCL	With Zoning Transparent FABRIC SCSI-2 No CCL	With Zoning Transparent FABRIC SCSI-3 CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL or SCSI-3 CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2 No CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL
Novell NetWare 4.2, 5.x Clusters	Not Supported	Transparent FABRIC SCSI-2	Transparent or Multiple-Bus FABRIC SCSI-2	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2	With Zoning Transparent FABRIC SCSI-2	Not Supported	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL	Transparent or Multiple-Bus FABRIC SCSI-2	Transparent FABRIC SCSI-2 No CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL
SGI IRIX 6.5.7, 6.5.8	Not Supported	Transparent FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2 No CCL	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2 No CCL	With Zoning Transparent FABRIC SCSI-2 No CCL	Not Supported	Transparent FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2 No CCL
Sun Solaris 2.6, 7, 8 (32/64-bit) Clusters	Not Supported	Transparent FABRIC SCSI-2 No CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL	10.20 Not Supported 11.0 With Zoning Transparent FABRIC SCSI-2 No CCL	With Zoning Transparent FABRIC SCSI-2 No CCL	Not Supported	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL	Transparent FABRIC SCSI-2 No CCL	Transparent or Multiple-Bus FABRIC SCSI-2 No CCL

Heterogeneous Platform Storage System Maximums

Table 4–3 lists the maximum supported storage limits for each hardware platform or operating system. The maximums shown are for access to MA6000 storage systems with dual redundant HSG60 controllers or MA/RA8000 or EMA/ESA12000 storage systems with dual redundant HSG80 controllers. If the maximums listed are below the requirements for the number for servers required, deploy multiple storage systems within the SAN.

Table 4–3 Platform Storage Maximums - MA6000, MA/RA8000, EMA/ESA12000

Platform or Operating System	Host Bus Adapters per Server[1]	Active Controller Ports per HBA	LUNs per HBA Target[2]	Servers per Active Controller Port[3]	Servers per Storage System[4]
Compaq OpenVMS 7.2-1, 7.2-1H1	4	16	128	16	32
Tru64 UNIX 4.0F	32	4	8	4	8
Tru64 UNIX 5.0A, 5.1	64	128	128	32[5]	64[5]
HP-UX 10.20, 11.0	16	4	8	8	16
IBM AIX 4.2.1, 4.3.0, 4.3.1, 4.3.2, 4.3.3	4	4	16	4	8
Microsoft Windows NT 4.0 SP5, SP6a Windows 2000 SP1	4	4	8	8	16
Novell Netware 4.2, 5.x,	4	4	32	8	16
Redhat Linux Alpha/Intel 6.1 & 6.2	2	4	64	2	4
SUSE Linux Alpha /Intel 6.3	2	4	64	2	4
SGI IRIX 6.5.7, 6.5.8	4	4	64	2	4
SUN Solaris 2.6, 7 & 8 (32/64 bit)	16	4	64	8	16
Heterogeneous SAN				See Note[6]	

1. The maximum number of host bus adapters supported per server is dependent on the specific server model.
2. The number shown in this column is reduced by one if the command console LUN is enabled.
3. The maximum number of host bus adapters that can be configured for access to an active controller port. Assumes one host bus adapter per server for single path using controller transparent failover or two host bus adapters per server for multi-path using controller multiple-bus failover. For transparent failover, the limit is specified by controller port pair - one active and one standby controller port. For multiple-bus failover, the limit is specified per single active port.
   For example, under Windows NT up to sixteen servers can be configured for access to a controller pair whether configured for transparent or multiple-bus failover mode. In transparent failover mode up to eight servers with one HBA in each can be configured for access to the port 1 active/standby port pair, and up to another eight servers with one HBA in each can be configured for access to the port 2 active/standby port pair.
   In multiple-bus failover mode up to sixteen servers with two HBAs in each can be configured for access. Up to eight servers are configured for access with eight HBAs on port 1 of the first controller and eight HBAs on port 1 of the second controller. Up to another eight servers are configured with eight HBAs on port 2 of the first controller and eight HBAs on port 2 of the second controller. In this example, for both failover modes the limit of eight HBAs/active controller port is never exceeded, and both support up to sixteen servers per controller pair.
4. Assumes one host bus adapter per server for single path using controller transparent failover or two host bus adapters per server for multi-path using controller multiple-bus failover.
5. Requires the use of zoning to limit the number of connections to 32 per port pair.
6. In a heterogeneous SAN, the maximum number of servers per controller pair, per controller port-pair (transparent failover) or per controller port (multiple-bus failover) is equal to the lowest maximum listed in these columns for the operating systems that are sharing the storage system.

SAN/DRM Integration

DRM configured servers and storage systems can coexist in the same SAN (two fabrics) provided zoning is utilized to isolate the DRM configurations. Integration of multiple DRM solutions is supported in the larger heterogeneous SAN provided the following rules are followed.

1. All DRM implementations require Level 4 NSPOF SANs using two separate fabrics. Refer to Chapter 2, *Availability Design Considerations* section.
2. DRM configured servers and storage systems must be in separate zones in the SAN.
3. Shared usage of the DRM configured storage systems by non-DRM configured servers is not supported.
4. All servers and storage systems within a pair of DRM zones (one zone per fabric) are of a single operating system family (homogeneous).
5. Each DRM zone may contain up to four storage systems per site, for a total of eight storage systems.
6. Each DRM zone may contain up to 12 servers per storage system per site. At one remote copy set per server and a maximum of four storage systems per site per instance, a single instance can support up to 48 servers per site.
7. DRM over ATM is not supported in the heterogeneous SAN as the ATM link only supports two storage systems with the same operating system family and does not support cascaded switches.
8. ATM configurations are limited to two Fiber Channel switches.

SAN/OpenVMS Host Based Shadowing Integration

Compaq OpenVMS servers implementing Host Based Shadowing are supported integrated in a heterogeneous SAN with remote shadowset distances of up to 100 km. The long distance link supports mixed heterogeneous SAN and Host Based Shadowing traffic.

Chapter 5

SAN Management Tools

Overview

With the advent of Storage Area Networks (SANs) and fibre channel technology, Compaq is rapidly transitioning from the traditional server, storage and component level-based management tools to a SAN level tool architecture and implementation using Compaq's SAN Management Appliance. This chapter describes the currently available Compaq SAN management tools.

Whether or not you are using a SAN Management Appliance to manage your SAN, virtually all Compaq SAN Management tools have easy to use web-based graphical user interfaces (GUIs).

After determining the hardware design of your SAN, consider the software applications that may be used for SAN management. Whether using a Compaq standard topology or a custom design using the Compaq SAN design rules, it is the Compaq SANworks applications that will provide the day-to-day interface such as management and monitoring of the SAN.

The Compaq Open SAN management strategy is to:

- Simplify storage management using standardized web-based graphical user interfaces (GUIs) residing on easy-to-use, easy-to-implement management appliances.
- Centralize the management of multi-vendor Heterogeneous Open SANs in distributed and consolidated environments.
- Automate policy-based management.
- Optimize functionality by exploiting all currently available management levels such as appliances, SAN fabrics, and servers/storage.

SAN Management Tool Applications

The Compaq SAN management applications can be classified into four major categories:

- Fabric management
- Storage management
- Data management
- SAN usage and monitoring

SAN Fabric Management

SAN Fabric management can be thought of as the control of the SAN infrastructure or "traffic flow" within the SAN. This pertains to control and management of device communication or access within the SAN, such as switch zoning, or LUN level Selective Storage Presentation (SSP). This also includes managing SAN interconnect components, individually and collectively, throughout the fabric.

SAN Storage Management

Storage management allows control of the specific storage system configuration such as redundant paths, creation and management of storagesets (LUNS), setting of RAID levels, and the setting of platform specific SAN interface characteristics and parameters.

SAN Data Management

SAN data management applications help ensure that data is available and accessible when required. The data being stored on the SAN is part of a company's assets. It is imperative to keep this data available to system applications with minimal downtime. Techniques such as cloning, snapshots, data replication, and backups protect the data from disasters.

SAN/Storage Usage & Monitoring

SAN and storage usage and monitoring applications are necessary to provide SAN event notification and fault/failure information for service before SAN anomalies can adversely impact the enterprise. They may also provide reporting and billing information for determining the amount of storage and quality of service delivered.

SANworks Management Appliance

Key to the Compaq SAN management strategy is the use of the Compaq Open SAN Management Appliance. The appliance is a separate SAN-based hardware platform that allows management functions to be performed at the SAN level, independent of servers and storage in the SAN.

The SANworks Management Appliance provides a centralized point for managing and monitoring SAN elements to simplify management tasks and reduce management costs. The unit is an appliance connected directly to the SAN Fabric that performs management functions without involving host computers. This approach preserves valuable application processing cycles, while accommodating mixed computing platforms. Strategically located out of the SAN data path, the appliance allows data transfers to proceed independently between computers and storage devices whether or not the appliance is operating. This appliance optimizes SAN availability and performance while streamlining manageability.

Appliance Features / Functionality

- Simple, unintrusive management of SAN elements
- High SAN performance since the appliance is located out of the data path
- High SAN availability, since data transfers occur independent of the appliance
- Support for multiple management and monitoring applications
- A web-based, centralized user interface
- No console operations for increased SAN management security
- Support for heterogeneous platforms attached to the SAN
- More cycles for processing applications on host servers
- Rack mountable, ease of installation and administration

SAN Management Tool Deployment

Within the different categories of management tools, individual tools are implemented on the SAN appliance, within fabric interconnect components, or within servers/storage systems. Table 5–1 lists the management tools by category, and identifies where the specific tools reside.

Table 5–1 SAN Management Tools & Location

SAN Management Application	SAN Appliance Based	Fabric Based	Server Based	Storage Based
SAN Fabric Management				
SAN/Fibre Channel Switch Management	No	Yes	No	No
SAN Storage Management				
StorageWorks Command Console (SWCC)	No	No	Yes	No
Storage System Array Controller Software (ACS) Command Line Interface (CLI)	No	No	No	Yes
SANworks Secure Path	No	No	Yes	No
SAN Data Management				
SANworks Enterprise Volume Manager (EVM)	No	No	Yes	No[1]
SANworks Virtual Replicator (VR)	No	No	Yes	No
SANworks Data Replication Manager (DRM)	No	No	No	Yes[2]
SANworks Command Scripter	No	No	Yes	No[1]
SAN/Storage Usage & Monitoring				
SANworks Open SAN Manager (OSM)	Yes	No	No	No
SANworks Storage Resource Manager (SRM)	No	Yes	Yes	No
SANworks Storage Resource Manager for Exchange	No	Yes	Yes	No
SANworks Resource Monitor	Yes	No	No	No
SANworks Storage Allocation Reporter	Yes	No	No	No

1. This product is a front-end to the Storage System's CLI.
2. DRM requires Peer-to-Peer ACS Software.

Interfacing with the SAN Management Tools will depend upon whether the SAN Management Appliance is included in the SAN design.

SAN designs that include the SAN Management Appliance can take advantage of the tools that reside on the appliance, such as SANworks Resource Monitor, SANworks Storage Allocation Reporter and SANworks HSG60/80 Element Manager. The appliance provides access to the web-based GUIs for the SAN Management applications.

If the SAN Management Appliance is not included in the SAN design then SANworks Resource Monitor, SANworks Storage Allocation Reporter and SANworks HSG60/80 Element Manager will not be available, as they are appliance-based tools. Interfacing with any of the SAN Management applications web-based GUIs can be accomplished from any server or client supporting a web browser.

SAN Fabric Management Tools

The Compaq Fibre Channel SAN Switches are high performance, scalable switch fabrics designed for creating large SANs. The management functions let you control and monitor fabric topology, frame throughput, error statistics, fans, cooling, media type, port status, and a variety of other information to aid in system debugging and performance analysis.

The administrative and diagnostic functions of the SAN switch are accessible from IP over the RJ-45 10/100BaseT Ethernet port or any Fibre Channel port. You can use any Simple Network Management Protocol (SNMP)-based management product to access the SNMP agent. You can also use any supported web browser to use the Java Web Management Tools.

Supported management methods include:

- SNMP
- Telnet
- Web-based Management Tools launched via StorageWorks Command Console
- Telnet command subset via switch front panel display (Fibre Channel SAN Switch/16 only)

Fabric Zoning

Compaq Fibre Channel switches provide two types of zoning enforcement: software and hardware. A software implementation is based on the Simple Name Server (SNS) enforcement of a zone when you use World Wide Names (WWN) for zoning devices. If a

zone configuration is in effect, responses to SNS queries contain information about only those devices that are in the requestor's zone. Because software zoning is based on the end node WWNs, strict device to specific switch port number cabling is not required. This provides the flexibility to change device-to-switch port cabling without the need to redefine zoning definitions, provided a valid connection into the fabric is maintained.

With hardware enforcement, zones are enforced at the physical switch port level across all fabric switches by hardware blocking of frames. You specify a zoned switch by using the physical fabric port number. Changes in device-to-switch port cabling require that fabric zone definitions be updated. This implementation provides a higher level of security than software zoning since the hardware blocks all access at the switch port level.

SAN Storage Management Tools

StorageWorks Command Console (SWCC)

Command Console is a feature-rich, graphical user interface providing local and remote management of StorageWorks HSG60 and HSG80 array controllers. It is a user-friendly tool for monitoring, configuring, and troubleshooting Compaq storage arrays and controllers.

Command Console can be connected to your StorageWorks controller in several ways. Once connected, the program issues commands and interprets the responses sent by the controller. The user interface displays the logical and physical layout and status of a selected subsystem in graphical form. Command Console consists of two major components: the Client and the Agent. The Client, which includes the user interface and some additional services, provides a window into your storage subsystems. The Agent is a host-resident program that is an interface between the Client and the host's storage controller to interpret and transfer information.

The Agent acts as the Client's assistant in controlling your storage subsystem. The Agent continuously monitors the subsystem and notifies the Client of changes. Commands sent from the Client are received by the Agent and are routed to the storage subsystem via the subsystem's Fibre Channel bus. Subsystem status is transmitted back to the Client from the Agent via the network connection.

Software Features / Functionality

- Easy, graphical configuration of the storage subsystem using an interface similar to Windows Explorer.
- Graphical view of the controller and its physical and logical storage elements.
- Status monitoring of the storage subsystem using intuitive icons.
- Fault notification by pager, electronic mail, and event log entries.
- Management of multiple host systems through a TCP/IP network connection.
- Direct serial port connection.
- Direct SCSI port connection (Windows NT and Windows 2000 Only).
- Robust security that prevents unauthorized access to configuration capabilities.
- The Client supports Microsoft Windows NT 4.0 and Windows 2000.
- The Agent supports Tru64 UNIX, Compaq OpenVMS, and multi-vendor platforms.
- This application is at the server level for both the Client and the Agent.

Storage System Array Controller Software (ACS)/Command Line Interpreter (CLI)

HSG Array Controller Software (ACS) for Fibre Channel Arbitrated Loop and Switched Fabrics provides storage controller software capability for the StorageWorks HSG60 and HSG80 Array Controllers in Fibre Channel arbitrated loop and switched fabric environments. HSG Array Controller Software is designed to be common across multiple operating system platforms. However, there may be operational differences between platforms, and there may also be features that are not supported on every platform.

Management of storage systems based on the HSG60 or HSG80 is provided directly through the controller serial port using a terminal or a terminal emulator (such as Microsoft Windows NT HyperTerminal) using the CLI interface. The CLI provides all the commands necessary to configure controller failover modes and parameter settings, controller and host connections to the SAN, storage set creation, SAN LUN access (SSP), RAID levels, and cache settings. The CLI also provides access to the array controller utilities. The utilities are used to monitor controller functions and statistics, and to allow storage system component replacement procedures to be conducted while the storage system is active.

Selective Storage Presentation (SSP)

SSP provides a way to control SAN access at the storageset or LUN level. SSP allows each server or HBA's storagesets (LUNs) to be presented exclusively to those that are allowed access. Additionally, SSP allows the setting of host modes and LUN offsets for each HBA connected to the storage system. The host mode is specially tailored to the storage communication techniques of the operating system type. The LUN offset feature of SSP allows higher numbered LUNs in a storage array to be presented in a range required by specific operating systems. The SSP feature also provides a way to track the numerous Fibre Channel HBAs within servers attached to a SAN by identifying each by name and WWN.

ACS Features / Functionality

- Host Interconnect and Protocol Services
- Microsoft Cluster Server (MSCS) Support
- Dual Redundant Controller Operation
- Testing and diagnosis of the HSG array controller
- SCSI device control
- Transparent Controller Failover Support
- Multiple-Bus Failover Support
- Asynchronous Disk Swap (Hot Swap)
- ACS system management services
- Local program support
- Mirrored Write-Back Cache support
- Read Ahead Cache support
- Disk Mirroring capability (RAID 1)
- Disk Striping capability (RAID 0, 0+1)
- RAID capability (RAID 3/5)
- StorageSet Expansion
- Disk Partitioning capability

Supported management methods include:

- Terminal emulation through the HSG's serial port using the CLI
- SANworks Command Console
- SANworks Command Scripter

ACS works in a heterogeneous environment that includes Tru64 UNIX and Compaq OpenVMS, Microsoft Windows NT, Windows 2000, Novell NetWare, Sun Solaris, HP-UX, SGI IRIX, IBM AIX, Linux x86, and Linux Alpha. This application is at the storage system level.

SANworks Secure Path Multi-Path Software

Depending on the platform or operating system, high availability functionality may or may not be embedded in the operating system I/O drivers. Tru64 UNIX V5.0A/V5.1 and OpenVMS operating systems have the ability to create and maintain multiple paths over the SAN to the same LUN, with support for these functions embedded. For those operating systems that do not support multi-pathing, Compaq provides this capability using Compaq SANworks Secure Path.

The Compaq SANworks Secure Path provides continuous data access for RAID storage systems accessed by operating systems that are not Compaq-based. When combined with the inherent fault-tolerant features of the RAID Array, this configuration effectively eliminates single points of failure in the storage system.

When a host bus adapter, cable, or controller in a path fails, the failure is detected and I/O is automatically re-routed to the functioning, alternate path. This process, called failover, requires no resource downtime and ensures high availability of data. Storage units that have experienced failover may be configured to failback automatically after a path is restored. Failback can also be done manually through the use of the Secure Path GUI.

Software Features / Functionality

- Switched fabric and loop support
- Automatic path failover
- I/O load distribution
- User-selectable failback

SANworks Secure Path works in a heterogeneous environment. See Chapter 4, *Heterogeneous SAN Platform Rules*.

SAN Data Management Tools

SANworks Enterprise Volume Manager (EVM)

Compaq SANworks Enterprise Volume Manager (EVM) is web-based application software that manages controller-based clone and snapshot operations. Cloning is a mirroring copy function that allows you to create an exact copy of a LUN; snapshot provides a point-in-time copy function. Both that can be used to minimize downtime required for system backups and data migration activities. EVM can be used to meet business continuance requirements by minimizing application downtime required for system backups and data migration activities. EVM automates the creation of command files that control the cloning or snapshot operation. EVM also allows you to mount the clone or snapshot on a second host on the same controller.

EVM automates the creation of command files that control the cloning or snapshot operations. EVM also allows users to mount the clone or snapshot to a new host. The new host can then act as a dedicated backup server or data warehouse server. All operations are performed on the clone or snapshot, minimizing performance impact on the production system.

Software Features / Functionality

- Web-based application
- Easy management of complex cloning and snapshot operations
- Supports LAN-less backup
- Simplified, centralized storage management

Enterprise Volume Manager works in a heterogeneous host environment that includes Tru64 UNIX, Microsoft Windows NT, Windows 2000, and Sun Solaris. This application is at the server level.

SANworks Virtual Replicator (VR)

The Compaq SANworks Virtual Replicator combines a rich set of innovative capabilities that enhances and simplifies storage management for Microsoft Windows NT and Windows 2000 environments. Through virtualization, online volume growth, snapshot and management features, the software complements the standard capabilities within the

operating system. SANworks Virtual Replicator utilizes industry-standard server, storage, and network-interconnect components, protecting an organization's current and future storage investments.

SANworks Virtual Replicator 2.0 provides the ability to create instant, virtual snapshots of production data—without having to physically copy it. A snapshot, which looks exactly like the original disk from which it was copied, takes seconds to create and allows customers to backup and restore data with minimal impact to users and applications. Customers can schedule automated snapshot backups using the integrated policy-based scheduling and scripting features.

Software Features / Functionality

- Virtualization:

  Allows companies to respond quickly to rapidly changing storage capacity requirements. With storage virtualization, multiple storage arrays can be grouped into a pool of disk space for individual or clustered systems to use. Multiple virtual disks, up to 1 terabyte in size, can be created from a pool for users and their applications. System administrators can tailor disk space to specific requirements.

- Online volume growth:

  Enables easy, non-disruptive growth for Windows 2000 with zero downtime. Online Volume Growth allows a system administrator to grow an existing volume on a SANworks Virtual Replicator virtual disk and also on a Windows 2000 basic disk. The system will remain online, and the data on the volume will remain intact.

- Snapshots:

  Enable the instant creation of multipurpose virtual replicas of production data without the requirement of a physical copy. Snapshots function identically to ordinary physical disks with both read and write capability. Whenever a quick copy of production data is needed, snapshots can be used with minimal disruption to running applications. For example, the snapshot can be the source for backup using standard backup tools. Snapshots can remain online for restore operations, testing, and data mining.

- Management:

  Simplification through easy-to-use interfaces using Microsoft Management Console or a command line. Interactive wizards are available to guide the administrator through all management tasks and create automatic schedules of operations.

SANworks Virtual Replicator is supported on Microsoft Windows NT, Windows 2000, Professional, Server, and Advanced Server. This application resides at the server level.

SANworks Data Replication Manager (DRM)

The HSG80 Data Replication Manager Software is the software component of the HSG80 array controller when used in switched fabric environments with remote data replication. Data Replication Manager Software provides a storage-based disaster tolerance and workload migration solution that provides the ability to copy data, in real time, to a remote location, up to 100 km away using direct Fibre Channel or further using ATM links. This is done without any host involvement. The HSG80's dual host port design, when used in DRM configurations, allows for long distance mirroring in a switched Fibre Channel topology.

The software executes in the HSG80 array controller; it processes I/O requests from the hosts, performing the device-level operations required to satisfy the requests. This is done through the use of an initiator and target sharing a Fibre Channel switch connected by a switched Fibre Channel fabric. Data is copied from a local controller directly to another controller at a remote location. This capability provides the ability to maintain the same data at remote locations, providing disaster tolerance protection.

Software Features / Functionality

- Online, real-time data replication to a local or remote site
- Data replication over a Fibre Channel SAN
- Cloning at Initiator and Target sites
- Snapshot support at Target site
- Cascaded switches support
- Full Fiber Channel-to-ATM connectivity with line speeds of T1 through OC3
- Replicate up to 100 km(~60 miles) with Very Long Distance GBIC
- Asynchronous and synchronous transfer modes
- Write History Logging and “Mini-Merge” reconstruction
- Stretched Clusters capabilities for Microsoft Windows NT and Compaq OpenVMS
- Association sets
- Non-RCS LUN support
- Switch Zoning support
- Dense Wave Divisional Multiplexing

Data Replication Manager works in a heterogeneous host environment that includes Tru64 UNIX, Compaq OpenVMS, Microsoft Windows NT, Windows 2000, and Sun Solaris. The application is at the storage system level.

SANworks Command Scripter

Compaq SANworks Command Scripter is application software that provides command-level control of Compaq StorageWorks systems equipped with HSG60, HSG80, HSZ70, and HSZ80 Array Controllers. With Command Scripter, you can create, edit, and run script files that contain StorageWorks Command Line Interpreter (CLI) commands. This allows automation of frequently performed StorageWorks operations.

Two interfaces are included in Command Scripter: a command line interface for local, direct connection to StorageWorks controllers and a web-based interface, which requires StorageWorks Command Console (SWCC)) for centralized, remote connection via browser.

Software Features / Functionality

- Web-based interface for centralized, remote connection to StorageWorks array controllers
- Command line interface for local, direct connection to array controllers
- Select agent host and StorageWorks subsystem
- Create and edit CLI script files
- Run saved CLI script files
- Execute a single CLI command
- Display CLI command history

Command Scripter works in a heterogeneous host environment that includes Tru64 UNIX and OpenVMS, Microsoft Windows NT, Windows 2000, and Sun Solaris. This application is at the server level.

SAN Storage Usage & Monitoring Tools

SANworks Enterprise Network Storage Manager

The Compaq Enterprise Network Storage Manager is the Web portal entry point for managing all storage within an enterprise. It provides discovery, organization, and navigation of enterprise storage, providing links to other SANworks products as well as other vendors' storage management tools. Enterprise Network Storage Manager enhances the Compaq intelligent manageability strategy and will support integration with enterprise management frameworks such as CA Unicenter TNG, Tivoli Enterprise, and HP OpenView.

SANworks Open SAN Manager

SANworks Open SAN Manager allows users to visualize, configure, and monitor the SAN with unparalleled ease. It is a centralized, appliance-based monitoring and management interface for the Open SAN. It is included with and resides on the SANworks Management Appliance, which also provides a single aggregation point for management of the SAN.

The SANworks Open SAN Manager is the industry’s first centralized, appliance-based monitoring and management interface for the Open SAN. Included with the SANworks Management Appliance, Open SAN Manager provides a web-based aggregation and entry point for centralized storage management. This intuitive interface allows the user to organize, visualize, configure and monitor storage from a single navigation point on the SAN. Open SAN Manager provides a launch site for a variety of value-added SANworks applications, such as SANworks Resource Monitor and SANworks Storage Allocation Reporter, and provides navigation links to directly manage storage components on the SAN.

SANworks Storage Resource Manager (SRM)

SANworks Storage Resource Manager is a reporting and event management solution that provides storage data analysis to detect trends, foresee problems, and balance resources by providing automated reporting on storage capacity, consumption, and availability. It automatically scans the enterprise storage topology and collects capacity, consumption, availability, and configuration statistics. It then correlates the data in a Microsoft SQL Server database, and provides out-of-the-box alerts, reports, historical trends, and policies

that enable easy, efficient problem detection and correction. Out-of-the-box storage graphs and historical trends provide the knowledge needed to accurately plan for growth, avoid down time, and justify storage capacity.

Software Features / Functionality

- Automated storage monitoring–like having a 7x24 administrator watching over every file, directory, share point, partition and disk on your network.
- Threshold-based alerts and events issued via SNMP, e-mail, NT event log, and Alerts page.
- Consolidated, network-wide reports inventory all storage assets and identify trouble spots.
- Historical planning trends automatically created to eliminate guesswork in capacity planning.
- 100% web architecture for use anywhere on Intranet, WAN, or dial-up.
- Free space alerts, thresholds, and reports for every disk partition and directory prevent server and application crashes caused by insufficient free disk space.
- Reports on files not backed up identify backup holes to prevent data recovery failures.
- File access trends identify unbalanced and overloaded file servers.
- Incremental and full backup sizing reports keep backups inside backup windows.
- Wasted space and largest file reports identify storage that can be reclaimed, deleted, or archived. Custom filters let you identify specific file types.
- Network-wide user and directory disk space quotas alert the administrator (and the user) when users consume more disk space than they really need.
- Computer, user, and directory groups enable user or project-based chargeback on disk space, so departments and business units pay for what they use.
- Capacity planning trends show when, where, how much disk space to add.
- Directory and share point reports show where to add new users and how to load balance existing file servers.
- Customizable storage filters make SAN planning and server consolidation easy.

SANworks Storage Resource Manager uses Server/Agent architecture with SRM Server running Microsoft Windows NT. The SRM Agents may run on Microsoft Windows NT, Windows 2000 Server, Windows 2000 Advanced Server, Tru64 UNIX, IBM AIX, Sun Solaris, HP-UX, and Red Hat Linux. The SRM Server and SRM Agents reside at the server level.

SANworks Storage Resource Manager for Exchange

Compaq SANworks Storage Resource Manager for Exchange is web-based software that provides network-wide reports, alerts, planning trends, and policies for managing Exchange storage capacity, consumption, and availability. SANworks Storage Resource Manager for Exchange provides the centralized reports and policies needed to manage critical, fast-growing Exchange information stores.

Software Features / Functionality

- Alerts provide advanced warning of out-of-space conditions, such as spikes and full partitions, to ensure availability of Exchange services.
- Exchange Storage Capacity Planning Trends enable avoidance of Exchange Server downtime caused by capacity shortages.
- With backup alerting and trending capabilities, backups do not run into production time.
- Exchange Storage Resource Inventory Reports provide a complete view of Exchange storage topology and eliminate the need for time-consuming, manual inventories.
- Mailbox Consumption Policies eliminate the need for labor-intensive Exchange mailbox quota overrides.
- Automate manual daily tasks, such as backup and partition space checks, on a server by server basis.
- Exchange Storage Consumption Reports and Policies identify Exchange users who are sources of inappropriate or unnecessary disk space use for reclaiming.
- Locate and delete “orphaned mailboxes” that are no longer in use.
- Exchange Storage Capacity Planning Trends enable the delay of storage purchases, until necessary, to save capital and depreciation expenses.
- Exchange Storage Capacity Planning Trends enable accurate planning for growth of Exchange storage, and justification of new purchases to management.

SANworks Storage Resource Manager for Exchange uses Server/Agent architecture with both the Server and the Agent supported on Microsoft Windows NT. This application resides at the server level.

SANworks Resource Monitor

Residing on the SANworks Management Appliance, SANworks Resource Monitor provides continuous and accurate event notification for StorageWorks switches and arrays to reduce mean time-to-repair and increase overall SAN availability. Customizable remote notification options include e-mail, alphanumeric page and SNMP traps. Authorized users can access event information anywhere, anytime via the intuitive Web-based user interface.

SANworks Resource Monitor allows the user to monitor, identify, and address SAN anomalies and events before they can adversely impact the enterprise. This application delivers reliable, continuous monitoring and event notification for supported devices, reducing overall storage management costs while increasing SAN uptime.

Software Features / Functionality

- Scalable Host-Independent Solution
- Preemptive Broadcast Notification.
- Multiple notification options
- Web-based user interface.
- SAN-scale monitoring of Compaq Storage Arrays and switches.
- SANworks Resource Monitor is a host-independent solution.
- This application is at the SAN Appliance level.

SANworks Storage Allocation Reporter

SANworks Storage Allocation Reporter is the industry's first accounting tool that allows SAN storage to be billed as a utility service. Storage Service Providers and IT organizations can track and assign a cost to the storage allocated to an internal department or external storage customer. The application reports on the amount and RAID protection level of storage reserved, quality of storage services delivered; and a pricing model calculates charges on a per gigabyte per time period basis for billing and cost-recovery purposes. This application provides a powerful tool for reporting allocated storage trends, predicting problems, anticipating increased demand, and recovering costs for storage. Information about storage usage can be accessed anywhere, anytime using the web-based user interface. The Reporter provides the capability for delivering storage as a utility service.

Compaq SANworks Storage Allocation Reporter is a web-based application used for reporting and billing of storage and associated Quality of Service (QOS) reserved by customers in a SAN environment. It provides a leading-edge SAN management tool to report allocated storage trends and costs, foresee problems and provide a cost recovery method for quality of service delivered.

SANworks Storage Allocation Reporter automatically provides reporting and billing of allocated LUN capacity from RAID-level storage subsystems and tracks levels of service to bill against consumers.

Software Features / Functionality

- Configuration of customer IDs, custom LUN attributes (QOS), and price sheets.
- Billing reports capture costs of reserved storage by customer.
- Alerts and notifications issued via SNMP and forwarded to enterprise management frameworks, e-mail, and the Microsoft Windows NT event log.
- Consolidated, LUN-level reports inventory and track all reserved storage assets.
- Historical trends automatically created to eliminate the guesswork in storage planning.
- One hundred percent web architecture for use anywhere on Intranet, WAN, or dial-up.
- Reports on the QOS metrics, such as RAID type, backup, remote mirror, or JBOD, associated with reserved storage capacity.
- Billing reports allow for cost recovery of reserved storage by consumer.
- LUN-level cost recovery independent of storage consumers' platform.
- Dates and costs in billing reports displayed in local format.
- No host agent or software required; supports heterogeneous host operating systems (Microsoft Windows NT, Windows 2000, Tru64 UNIX and OpenVMS, Sun Solaris, HP-UX, IBM AIX, and Linux).
- SupportsMA6000, MA/RA8000 and EMA/ESA12000 storage systems.
- Microsoft SQL Server database provides reliable and industry-standard access.
- Web-based online help documentation.
- SANworks Storage Allocation Reporter is a Host-Independent solution.
- This application is at the SAN Appliance Level.

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Chapter 6

Business Considerations

SAN Business Considerations

Why a SAN?

Storage Area Networks (SANs) provide unprecedented levels of flexibility in system management and configuration. Servers can be added and removed from a SAN while their data remains in the SAN. Multiple servers can access the same storage for more consistent and rapid processing. The storage itself can be increased, changed, or re-assigned more easily.

In a SAN, the servers can access a common storage pool and the backup devices can access the same pool. The SAN offers configuration choices that emphasize connectivity, performance, resilience to outage, or all three.

SANs bring enterprise-level availability to open systems servers. Properly designed SAN storage is always available. This allows many open servers to access a common storage pool with the same degree of availability previously reserved for mainframes.

Value

A Storage Area Network provides value for the corporation in several ways. A SAN improves staff efficiency by supporting a variety of operating systems, servers, and operational needs. A SAN is a robust storage infrastructure that can respond quickly to new business models, unexpected growth surges, and corporate mergers.

Storage Area Networks can reduce application time to market, help facilitate processing needs, such as report writing and rapid restores, and introduce new concepts such as zero backup time. SANs support remote data copies at nearly unlimited distances and can form the basis for improved business continuance scenarios using disaster recovery/disaster tolerance configurations. They support the latest security measures and can be managed by Web-based tools from a single location or different places, regardless of the physical location of the SAN.

In a well-designed SAN, these features are complementary and cumulatiym that is, a SAN can incorporate all of these features, or you can start with a SAN designed for any one of them and add other features later. Because of this flexibility, a SAN can grow and adapt to

Time to Market

Compaq SANs can also create data snapshots and copies (clones) for rapid, parallel development efforts. For example, Enterprise Volume Manager (EVM) is the SANworks tool used for creating copies on Windows NT, Windows 2000, Tru62 UNIX, and Sun Solaris systems. EVM allows copies of production data to be used by development groups in a safe, predictable manner. When the testing is finished, the copies can be discarded. The data in the clones is accessible by other servers.

Backup

Compaq SANs create an environment for centralized backup. Compaq's Enterprise Backup Solution (EBS) relieves the corporate LAN of backup traffic. The SAN uses a central location and common tape drives, reducing training and operational costs. Each server accesses the tape drive(s) where its backup occurs. The Automated Tape Library (ATL) and backup control software coordinate all backups. Backup speed is improved as much as 20x faster than LAN based backup.

Storage Area Networks also introduce the concept of distance for remote backup procedures. On a SAN, the ATL can be physically removed from the application servers, on a campus, or even miles distant from the actual data. If necessary, zero application downtime is also possible. EVM can be used to create a copy of the data; the copy is then accessed by a backup server and written to tape without affecting the application server. This allows near-continuous application processing.

User Satisfaction

In general, system uptime equals user satisfaction. Compaq SANs offer new and proven ways to keep the applications running, regardless of component outages or even failures. The ability to configure Compaq storage for disaster recovery/disaster tolerance means that eCommerce and eBusiness applications can be designed and built for continuous operation. While customers and users do not see any loss of service, SANs, and the underlying Compaq "Best Practices" that make them operational, create new levels of service while reducing costs.

SAN Technology Benefits

Storage Area Networks offer the benefits of saving time, saving money, and offering new features. This "technology leap" is evident when SANs are compared to traditional methods of data storage.

SANs may cost more initially, but offer greater scaling and sheer size in terms of the number of servers that can attach to the Storage Area Network and in terms of the storage capacity. In addition, SANs offer a combination of features such as centralized backup, heterogeneity, and flexible use. The flexibility in design possibilities is referenced elsewhere in this document.

The scaling capabilities of a SAN are ideal for large or growing corporations that require rapid deployment, frequent changes, and mixed server environments. Because of the economies of scale provided by the various SANworks and StorageWorks products, Compaq SANs offer true cost savings in operations and training, which allows the corporation to focus on its core competencies.

In addition to these benefits, Compaq SANs offer investment protection in the form of universal disk drives. The disks are packaged in a form factor that is common to all Compaq servers and StorageWorks storage arrays. This means that Compaq customers can extend the useful life of the disks by moving them from the enterprise class arrays to departmental arrays and even to individual servers. Of course, all Compaq StorageWorks products are designed to be user maintainable.

Scenarios

There is a wide variety of Storage Area Network topologies and designs that are possible. Each design should take into account the customer requirements for growth, scaling, data traffic, and performance. The following examples serve to illustrate some of the ways that Compaq SANs can be designed to address various business needs.

1. A customer has multiple Microsoft Windows NT and Novell NetWare servers each with locally attached storage. The environment is dynamic—perhaps a new application is being introduced, perhaps they are migrating from Novell to NT. They spend a lot of time re-configuring storage. Sometimes they run out of disk space on one server while another server has lots of space. The applications are mission-critical; they need to be available.

   The proposed SAN design supports Microsoft Windows NT and Novell NetWare servers on a single StorageWorks storage system. The design is based on a High Availability topology, and has two Fibre Channel 16 port switches. Backup is achieved through a Fibre Channel Tape Controller and an Automated Tape Library. A SAN Appliance monitors the entire SAN for failures. RAIDsets can be easily reconfigured as needed and presented to the various servers.

2. The customer has a back-up window problem. Multiple open system servers are connected to dedicated tape drives (difficult to manage) and/or corporate LAN and the back-ups are not getting done in a timely manner.

The Compaq SAN supports centralized backup from a number of hosts. The data is backed up in an Automated Tape Library that connects to the SAN.

3. A Service Provider wants to use SANs to deploy and manage a rapidly growing customer base. A SAN topology supports rapid growth and a variety of data traffic patterns. It is modular and extensible. Servers and storage can be added to the SAN as business needs dictate.

Chapter 7

Best Practices

Overview

This chapter describes “best practices” for implementing heterogeneous Storage Area Networks. The information contained in this chapter should be used as a guide for constructing your SAN. Although every attempt has been made to provide a best practice recommendation, some aspects of SAN implementation are a matter of preference. Also, the physical location of servers, storage, computer labs, or specific building layout and location may dictate particular aspects of your SAN implementation. In part, this is an expected reality and is often easily accommodated, given the inherent flexibility in implementing SANs and Fibre Channel technology.

Rather than just present a list of best practices, the information has been organized in four sections:

- Planning a SAN
- Configuring a SAN
- Upgrading a SAN
- Troubleshooting

Much of what is presented here is the result of the actual experiences of building large SANs within the internal Compaq engineering environment and at customer sites.

Although this chapter does describe portions of the design process in the planning phase below, it is not meant to convey the entire SAN design process. Contact a Compaq Enterprise Storage Consultant or Professional Services organizations for assistance and consultation on designing SANs.

Planning a SAN

Proper planning considers both present and future requirements. This can be accomplished by over-planning your initial SAN capacity and connectivity requirements to accommodate expected future needs. Whether using a Compaq standard topology or designing your own topology, select a design that not only offers the best implementation for present usage, but also allows you to expand your SAN over time.

It is important that you allocate an adequate amount of time to plan your SAN. In general, the more detail you can define in the planning phase, the greater the benefit you will realize during the configuration phase.

Consider each of these items during the planning phase:

- Deployment Strategy: You can choose to deploy separate smaller SANs with the idea of increasing capacity by growing the SANs independently or by interconnecting the independent SANs in the future. Smaller SANs are easier to construct, larger SANs offer economies of scale from an operational standpoint, but take longer to build.
- Topology Design: Consider the topology design compared to the ease of migrating to another, higher capacity design. In most cases this can be accommodated; however, it is always preferable to choose an initial design that can grow, without the need to transition to a different topology.
- Experience Level: If you are just beginning deployment of SAN technology, consider starting with a smaller implementation. As you gain experience, deploy larger SANs.
- SAN Management Strategy: Refer to Chapter 5, *SAN Management Tools*, for information about SAN management tools. After reviewing this chapter, define the management strategy and the specific tools that you will utilize to manage your SAN.
- Technology Advances: The ideal design considers expected future technological advances, and can easily accommodate the resultant changes. Plan for flexibility in your initial design. Higher port count Fibre Channel switches and faster interconnect speeds are an inevitable evolution of Fibre Channel technology. Ensure that your initial plan addresses and can accommodate expected changes such as these.
- Document the Design: This is one of the most important aspects of the planning process. This allows you to fully review and evaluate the design beforehand, evaluate trade-offs, make changes, and effectively communicate specific plans to all groups affected. The other important benefit of documenting your design is that during the later phases of implementation, the documentation serves as the roadmap for the actual implementation.

Compaq recommends, at a minimum, that you document the following before beginning the actual implementation:

a. Topology Map–Shows the logical SAN topology and fabric interconnect scheme; conveys the overall design from a strategic standpoint, and can also serve to convey how future growth and technological advances will be accommodated.

b. Configuration Layout–Shows the physical layout of the entire implementation. More detailed then the topology map, the layout is used during implementation to verify the correct connectivity. This is also extremely helpful if troubleshooting is required in later phases.

c. Storage Map–Defines the storage system arrangement and configuration in the SAN, and storageset settings such as SSP and RAID levels. This map effectively defines how all of the storage is configured in the SAN.

d. Zoning Map–Defines the inter-node communication access within the SAN. This map defines which nodes or device ports are allowed to communicate with each other in the SAN.

NOTE: A key decision in the zoning implementation process is determining whether you will implement hardware or software zoning. Hardware zoning offers higher security than software zoning but is less flexible because device-to-switch cabling changes require zoning information to be updated.

Configuring a SAN

Once you have completed the planning phase you can begin to configure your SAN. As described in the planning phase, it is important that you document the configuration. During the configuration phase, you should be recording the details of the actual physical configuration.

- Recording. As you construct the SAN, record the cable connections and mark this information on the configuration layout diagram. Record the WWID of all nodes and devices and identify where they physically reside. It is recommended that you place a label on each Fibre Channel HBA with the WWID clearly identified. Compaq storage systems are pre-labeled with this information; however, you may wish to place an additional label on the front of the unit in plain view.
- Cabling. Define a system for cable labeling. Even a small SAN can include a very high number of fiber optic interconnect cables. Label both ends of each cable with the same unique cable number or color code scheme. This will allow you to quickly identify each cable uniquely. Also consider placing a label at each end of the cables that identifies connection points at both ends, such as “TO” and “FROM”. Use label types that are easy to create and read, and ensure they are attached securely to the cable.

- Cable Dressing. Use care when routing fiber optic cable and ensure that you do not exceed the recommended minimum bend radius. For multi-mode fiber cable the minimum bend radius is 25 mm; for single-mode fiber cable the minimum bend radius is 5 mm. Where cables are bundled or hanging unsupported, use velcro tie wraps to group and support the cables. Never use plastic tie wraps as they can damage the internal fiber core if over-tightened.
- Cable Symmetry. When connecting cables, consider slot/port-numbering symmetry. Be consistent across similar servers with cabling in terms of HBA slot placement and cabling to switches. If configuring with two SAN Fabrics and multi-pathing, connect HBA 1 to SAN Fabric 1, HBA 2 to SAN Fabric 2, etc. Cable symmetry is not a requirement, but serves as an aid to troubleshooting.
- Configure Fibre Channel Switches. Although all Compaq Fibre Channel switches are pre-configured, verify that all Fibre Channel switches in the fabric have the same parameter settings and that each has a unique domain ID.

  Label switches using a relevant naming scheme particular to the topology. For example, if implementing a ring topology, label each switch in the ring as Ring1, Ring2. Although not an absolute requirement in all configurations, it is highly recommended that all switches utilize the same switch firmware revision.
- Configure Servers. For each platform or operating system type, utilize the appropriate Compaq StorageWorks platform kit to ensure that the required server drivers and configuration settings are loaded. Ensure that servers are configured with the proper operating system versions and all required updates.

  Use a numbering type scheme for naming multiple servers of the same type, such as NT01 and NT02 for Windows NT servers.
- Configure Storage. Use the storage map created in the planning phase to configure each of the storage systems. Verify server-to-storage connectivity, and access one server at a time.

  When initially defining storagesets, always disable all access first, and then enable the desired individual access. For MA6000, MA/RA8000, and EMA/ESA12000 storage systems, define connection names to be consistent with zoning alias names. Be consistent with connection names relative to storage port and controller connection. Choose a scheme that is easily understood and quickly conveys the physical connectivity.
- Define Zones. Use the zoning map to configure zones. Consider starting with small zones that allow a smaller logical subset of a larger physical SAN to be tested initially.

  Always save old zoning configurations before and after making any zoning change. If possible, it is recommended that no zoning changes be made when an individual switch normally configured in the fabric is temporarily not available.

You can zone by operating system or by storage system. Zoning by operating systems is useful when the operating systems are accessing storagesets that are localized to specific raid arrays. For example, NT1, NT2 and NT3 have access to storage on ARRAY1, and VMS1, VMS2 and VMS3 have access to storage on ARRAY2.

ZONE NAME	**NT_ZONE**	**VMS_ZONE**
Members	NT1	VMS1
	NT2	VMS2
	NT3	VMS3
	ARRAY1	ARRAY2

ARRAY1 will only have host connections for the NT1, NT2 and NT3 servers and ARRAY2 will only have host connections for the VMS1, VMS2 and VMS3 servers.

Zoning by storage system will limit the connections to the G80 to those systems actually having storagesets on them. This is useful when the storagesets for a specific system are on multiple storage systems.

In the above example, we add 3 more NT serves and another storage system to the NT zone:

ZONE NAME	**NT_ZONE**	**VMS_ZONE**
Members	NT1	VMS1
	NT2	VMS2
	NT3	VMS3
	ARRAY1	ARRAY2
	NT4	
	NT5	
	NT6	
	ARRAY2	

Both Array1 and Array2 will have host connections from all 6 NT systems. This may not be a problem in a small SAN, but as the SAN grows the connections will increase. Also, we do not know which of the NT servers are accessing storage on ARRAY1, and which one are accessing storage on ARRAY2.

If we zone by storage system we get:

ZONE NAME	**ARRAY1_ZONE**	**ARRAY3_ZONE**	**ARRAY2_ZONE**
Members	NT1	NT4	VMS1
	NT2	NT5	VMS2
	NT3	NT6	VMS3
	ARRAY1	ARRAY3	ARRAY2

Zoning this way also makes it much easier to troubleshoot, especially if servers access storage on multiple arrays. We could have a zone that looks like this:

ARRAY1_ZONE	ARRAY3_ZONE	ARRAY2_ZONE
ARRAY1	ARRAY3	ARRAY2
NT1	NT1	NT4
NT2	VMS2	NT5
VMS2	VMS3	VMS1
VMS3	NT5	NT2
SUN2	NT6	SUN1

This way, we know that NT1 is only accessing storage on ARRAY1 and ARRAY3. If there is a problem and we cannot see all our storage we know where to start looking for the problem.

Due to some zoning restrictions, you may need more than one zone for a particular ARRAY. If ARRAY1 also has Tru64 UNIX servers, we must zone that separately.

ARRAY1_ZONE1

ARRAY1

Tru64_1

Tru64_2

Zone and Zone Alias Names

When setting up zoning, use meaningful names for zones and zone aliases and be consistent with the naming convention throughout the fabric.

Servers are identified by the WWID of the host bus adapter. Name these by using the system name and the host bus adapter number. For example, server NT1 with one fibre channel HBA would have an alias of NT1_HBA1. Server NT1 with a second HBA would have an alias of NT1_HBA2

RA8000 storage systems in a transparent failover configuration will have two WWID's on the fabric, one for port 1 and one for port 2. Give each RA8000 a unique number. RA8000 number 1 could have aliases of R1_P1 (port 1) and R1_P2 (port 2)

For a multiple-bus failover configuration the RA8000 will present four WWIDS to the fabric. If you have a multi-path NSPOF configuration, two of the WWID's will be in one fabric, the other two will be in the second fabric. Name the ports using an alias such as R2_A1 (Controller A Port 1), R2_A2 (Controller A Port 2), R2_B1 (Controller B Port1), and R2_B2 (Controller B Port 2).

Ports A1 and B2 will be cabled to the first fabric. Ports A2 and B1 will be cabled to the second fabric. The aliases in fabric 1 will be R1_A1 and R1_B2, the aliases in the second fabric will be R1_A2 and R1_B2. Keep the ports and HBA's the same throughout the setup. For example, always have HBA 1, R1_A1 and R1_B2 in fabric1 and HBA 2, R1_A2 and R1_B1 in the second fabric.

Using this convention conveys the failover mode that the RA8000 is configured for. Any alias with a P1 or P2 is in transparent mode, any alias with A1, A2, B1, or B2 is in multiple-bus mode.

Define RA8000 host connection names for the adapter WWID's in the same manner as you defined the alias name in the fabric. For example, the fabric alias name for NT1, HBA1 will be NT1_HBA1. The host connections on the RA8000 controller should match this as closely as possible.

Example:

Alias NT1_HBA1 in the fabric would have host connection names on the RA8000 of:

```
NT1-P1      WINNT      THIS      1     081200    OL this      30
    HOST_ID=2000-0000-C922-8ADC     ADAPTER_ID=1000-0000-C922-8ADC
NT1-P2      WINNT      OTHER     2     081200    OL other     130
    HOST_ID=2000-0000-C922-8ADC     ADAPTER_ID=1000-0000-C922-8ADC
```

Upgrading a SAN

Upgrading a Fibre Channel Switch

See the Installation and Hardware Guide for your switch.

Scaling a SAN

The information in this section applies to all SAN topologies, whether a custom design or Compaq defined.

- Replace eight-port switches with 16-port switches.
- Add additional switches, up to the limits specified for a single fabric in Chapter 3, *SAN Fabric Design Rules*.
- Add a second fabric as a high availability no single point of failure solution.
- Deploy multiple independent SANs.
- Migrate to a different topology (see below).

Scaling Specific SAN Topologies

The information in this section is specific to the Compaq-defined topologies. Refer to the Fibre Channel switch replacement procedure elsewhere in this chapter for information about preventing fabric segmentation when adding new switches to an existing fabric.

Whenever you are expanding a topology, ensure that the new switch and device connectivity is consistent with the original SAN topology design requirements and goals. Avoid making changes to the topology that may serve to disrupt the original topology design goals. If you need to make topology changes based on a change in data access requirements, consider migrating to a different topology that is better suited to meet these needs. It is important in any expansion that the original data access needs be maintained.

If you have implemented a high availability fabric design (refer to Chapter 2, *SAN Topologies*), it may be possible to expand your SAN in a non-disruptive manner. It is highly recommended, however, as a precaution, that all data be backed up and that I/O activity quiesed when adding new switches to the fabric.

Cascaded Fabric

Expand an existing cascaded fabric by connecting a new switch to an available port on an existing switch. If there are no available ports, remove a device or set of devices from an existing switch, connect the new switch to those ports, and connect the device or devices to the new switch.

Meshed Fabric

Expand an existing meshed fabric by connecting a new switch to available ports on an existing switch. If there are no available ports, remove a device or set of devices from an existing switch, connect the new switch to those ports, and connect the device or devices to the new switch. To maintain the meshed topology, you must ensure that there are multiple paths (ISLs) connecting the new switch to the existing meshed fabric.

Ring Fabric

Expand an existing ring fabric by breaking the ring and inserting another switch into the ring.

Add new switches cascaded off of the ring, up to the maximum number of switches supported in a single fabric. When expanding outside of the ring, ensure that no two devices that need to communicate are more then seven hops apart.

Tree Backbone Fabric

Add edge switches. Expand an existing Tree Backbone SAN Fabric by adding additional edge switches. Connect these edge switches to available ports on the one or two backbone switches.

Add a second backbone switch (if your current design only contains one). Connect all of the edge switches to the new backbone switch.

Migrating SAN Topologies

requires that you carefully calculate the number of additional ports that are needed for the additional ISLs. This may require that devices be moved from one switch to another.

- Cascaded to Ring Fabric. If you have implemented a linear cascade, connect the last switch in the cascade to the first switch to create a ring fabric. For a branched cascade, extensive ISL re-cabling may be required.
- Cascade to Tree Backbone Fabric. Whether you have implemented a linear cascade or branched cascade, determine which switch or switches will be utilized as the backbone (typically no devices) and which switches will be edge switches. Connect all edge switches to the backbone switch or switches; connect all devices to the edge switches. This conversion is less disruptive if you add new switches to the fabric for the backbone and use all of the existing switches as edge switches. In this case, you can simply connect one end of the existing ISLs to the new backbone switches.
- Meshed to Ring Fabric. A meshed fabric can be converted to a ring fabric by simply removing the cross-connected ISLs, leaving the outer connected ISLs connected as a ring. The available ports can be utilized as additional redundant ring ISLs or for additional devices.
- Meshed to Tree Backbone Fabric. Determine which switch or switches will be utilized as the backbone (typically no devices) and which switches will be edge switches. Connect all edge switches to the backbone switch or switches; connect all devices to the edge switches. This conversion is less disruptive if you add new switches to the fabric for the backbone and use all of the existing switches as edge switches. In this case, you can simply connect one end of the existing ISLs to the new backbone switches.
- Ring to Meshed Fabric. If you have implemented two ISLs between all switches in the ring, move one end from an ISL between any two switches to the appropriate switch based on the final mesh design. Repeat this for all of the second ISLs between any two switches. There may be an optimal place to “break” the ring relative to re-cabling. Evaluate different scenarios prior to performing the actual conversion.
- Ring to Tree Backbone Fabric. Determine which switch or switches will be utilized as the backbone (typically no devices) and which switches will be edge switches. Connect all edge switches to the backbone switch or switches; connect all devices to the edge switches. This conversion is less disruptive if you add new switches to the fabric for the backbone and use all of the existing switches as edge switches. In this case, you can simply connect one end of the existing ISLs to the new backbone switches. It is also less disruptive if you have implemented 2 ISLs between all switches in the ring in your original design.

Troubleshooting

The following section describes troubleshooting steps for isolating problems related to storage access. When initially building a SAN, lack of access either to individual storagesets or entire storage systems is not uncommon. This can usually be traced to an incorrect device setting or an inadvertent cabling or configuration setup error in the initial hardware configuration. The steps listed will assist you in isolating access problems.

1. On the server:
    a. From the server, determine if lack of access is to all of the storage (the entire

b. Execute a “switchshow” command on the switch and verify that the server HBA is logged into the fabric correctly. Verify the correct port connection: F-Port or L-Port private.

   F-Port: MA6000, MA/RA8000, EMA/ESA12000 set to FABRIC Topology.

   L-Port, x private, x phantom: MA6000, MA/RA8000, EMA/ESA12000 set to LOOP_HARD Topology.

c. For MA6000, MA/RA8000, EMA/ESA12000:

   Verify the connections to the storage system. Execute a “show connections” command at the CLI and verify that the server connection is “online.” Verify the connections are named correctly.

4. On the storage system:

   a. Verify correct controller settings and configuration, “show this” and “show other.”

   b. Verify that the controller ports are online and configured for the correct topology setting.

   c. Verify that the storagesets are online to the appropriate controller without errors. Verify that the storagesets are correctly configured and enabled for access, “show unit dn.” Verify that access and unit offset parameters are correct and that the appropriate storage controller port is indicated in the connection name you have enabled the unit for access to.

5. General Fibre Channel switch verification:

   a. If zoning is in effect, verify that the effective zone matches the enabled zone, “cfgshow.”

   b. Verify that all zone definitions are correct.

   c. Verify that zoning alias names are assigned to the correct WWIDs.

   d. Verify that the servers and storage being accessed are in the same zone. If zoning is in effect, the WWID must be in a zone that is in the enabled configuration or it will not have access to the fabric.

   e. From the switch Web Tools GUI, examine the name server table. Verify that the appropriate WWIDs are listed and what zones they are in. Verify that the zones required are in the enabled configuration.

f. Fabric segmentation occurs when you connect together two switches or two fabrics and one of the following mismatch conditions exists between them:

- Zoning configuration mismatch
- Zoning type mismatch
- Zoning content mismatch
- Switch configuration parameter mismatches

If you are experiencing fabric segmentation, carefully review and compare these settings in each of the two switches or fabrics.

6. QuickLoop verification:

NOTE: QuickLoop is only required for HP-UX private loop attachment.

a. Verify that the QuickLoop license is installed.

b. Verify that the switch ports are set to QuickLoop mode.

c. If using QuickLoop with two Fibre Channel switches, verify that the switches are in a QuickLoop partnership.

Appendix A

Supported Products

Heterogeneous Open SAN Products

All Compaq SAN topologies support a heterogeneous mix of Compaq and multi-vendor hardware platforms and operating systems, and a mix of Compaq storage system product types. This appendix provides the list of products supported in a Heterogeneous SAN. Refer to Chapter 4, *Heterogeneous SAN Platform Rules*, for configuration information and rules specific to each hardware platform and operating system version, storage products, interconnects, and interoperability for all products in the SAN.

NOTE: For the latest product support list, refer to http://www.compaq.com/storage.

Supported Operating Systems

The operating systems supported in the Compaq Heterogeneous SAN are:

- Compaq OpenVMS
- HP-UX
- IBM AIX
- Microsoft Windows NT/Windows 2000
- Novell NetWare
- Red Hat Linux and SUSE Linux
- SGI IRIX
- Sun Solaris
- Tru64 UNIX

Supported Cluster Products

- TruCluster Software Products Version 1.6 for Tru64 UNIX Version 4.0F/G, and TruCluster Server Version 5.0A/5.1 for Tru64UNIX Version 5.0A/5.1)
- Compaq OpenVMS
- HP MC/ServiceGuard
- Microsoft Cluster Server (MSCS)
- Novell NetWare Clusters
- Sun Clusters

Storage Products

The storage products supported in the Compaq Heterogeneous SAN include the Compaq entry level, mid-range, and enterprise level RAID Arrays.

The storage products supported in the Compaq Heterogeneous SAN are:

- Compaq StorageWorks Modular Array 6000 (MA6000)
- Compaq StorageWorks Modular Array 8000 (MA8000)
- Compaq StorageWorks RAID Array 8000 (RA8000)
- Compaq StorageWorks Enterprise Modular Array 12000 (EMA12000)
- Compaq StorageWorks Enterprise Storage Array 12000 (ESA12000)
- Compaq SANworks Secure Path software
- Compaq SANworks Management Appliance
- Compaq SANworks Open SAN Manager
- Compaq SANworks Resource Monitor
- Compaq SANworks Storage Allocation Reporter
- Compaq SANworks Data Replication Manager (DRM)
- Compaq SANworks Enterprise Volume Manager (EVM)
- Compaq SANworks Virtual Replicator (VR)
- Compaq SANworks Command Scripter
- Compaq Enterprise Backup Solutions (EBS)
- HP PV Links multi-path software (HP-UX 10.20 only)

Interconnects and Components

Host Bus Adapters

The Fibre Channel Host Bus Adapters (HBAs) supported in the Compaq heterogeneous Open SAN are:

- Compaq 380574-001/DS-KGPSA-BC (Emulex LP7000) Windows NT/Windows 2000, Tru64 UNIX, OpenVMS
- Compaq 168794-B21/DS-KGPSA-CA (Emulex LP8000) Tru64 UNIX, OpenVMS
- Compaq 176479-B21/DS-KGPSA-CB (Emulex LP8000) Windows NT/Windows 2000
- Compaq 120186-B21/291 (64-bit), 223180-B21/291 (32-bit) Novell NetWare
- Compaq 380575-001/SWSA4-SB (JNI FC-1063) (32-bit) Sbus Sun Solaris
- Compaq 123503-001/DS-SWSA4-SC (JNI FC64-1063) (64-bit) Sbus Sun Solaris
- Compaq 380576-001/SWSA4-PC (JNI FCI-1063) (32-bit) PCI Sun Solaris
- Compaq 167433-B21 (QLogic QLA2200F/66) Red Hat, SUSE Linux x86/Alpha
- Compaq 218409-B21 (QLogic QLA220F/66) HP-UX
- Compaq 197819-B21 (Cambex PC1000F) Fabric IBM AIX
- HP A3404A FC-AL HSC Bus, K Class HP-UX
- HP A3591A/B FC-AL HSC Bus, D Class HP-UX
- HP A3636A FC-AL HSC Bus, T Class HP-UX
- HP A3740A FC-AL PCI, L Class HP-UX
- HP A5158A FC-AL PCI A/L/V/N Class HP-UX
- QLogic 2200F/66 SGI PCI- FC-1POPT PCI IRIX
- QLogic 2200F/66 SGI XT-FC-1POPT XIO IRIX

NOTE: The Compaq branded HBAs listed above are supplied with Compaq specific drivers and firmware. These are the only HBAs supported for the specified operating systems.

Fibre Channel Switches

The Compaq Fibre Channel switches supported in the Compaq Heterogeneous SAN are:

- Fibre Channel Switch 8 Port
- Fibre Channel Switch 16 Port
- Fibre Channel SAN Switch 8
- Fibre Channel SAN Switch 16
- Fibre Channel SAN Switch 8-EL
- Fibre Channel SAN Switch 16-EL

Gigabit Interface Converters (GBICs)

- Short-wave (850nm)
- Long-wave (1310nm)
- Very Long Distance (1550nm)

Gigabit Link Module (GLM)

- Short-wavelength (850nm)

SAN Interfaces/Fiber Optical Cables

- Fibre Channel connection via 50/125 or 62.5/125 multi-mode, and 9/125 single-mode fiber optic cable.

Data Replication Manager (DRM) Interfaces/Transports

- Fibre Channel connection via 50, 62.5 micron multi-mode or 9 micron single-mode fiber optic cable
- Fibre Channel connection via Wave Division Multiplexing (WDM) and Dense Wave Division Multiplexing (DWDM)
- ATM over a single T1/E1 Wide Area Network (WAN)
- ATM over multiple T1/E1 WAN (Inverse Multiplexing)
- ATM over T3/E3 WAN
- ATM over fractional and/or shared T3/E3 and OC3 WAN

Heterogeneous SAN Product Support

The following table lists the currently available storage products supported in a Heterogeneous SAN by platform type and operating system version.

For the most current information on HBAs, firmware, and drivers see this table.

Table A–1 Heterogeneous SAN Product Support

Platform or Operating System	MA6000, MA/RA8000 EMA/ESA12000 ACS Version 8.5F, L, S	DRM[1] ACS Version 8.5P	EVM[2]	EBS products
Compaq OpenVMS 7.2-1, 7.2-1H1 Multi-Path	Supported, Embedded Multi-Path driver	Supported	Not Supported	Not Supported
Tru64 UNIX 4.0F/G TruCluster Software Products Version 1.6	Supported	Supported	Supported	Veritas Netbackup, Legato Networker
Tru64 UNIX 5.0A, 5.1 TruCluster Server Version 5.0A/5.1, Multi-Path	Supported Embedded Multi-Path driver	Supported	Not Supported	Legato Networker
HP-UX 10.20, 11.0 Multi-Path Clusters	Supported, HP PVLinks (10.20 only) Multi-Path driver	Not Supported	Not Supported	Not Supported
IBM AIX 4.2.1, 4.3.0, 4.3.1, 4.3.2, 4.3.3	Supported	Not Supported	Not Supported	Not Supported
Linux: Redhat Alpha/Intel 6.2	Supported	Not Supported	Not Supported	Not Supported
Linux: SUSE Alpha/Intel 6.3	Supported	Not Supported	Not Supported	Not Supported
Microsoft Windows NT 4.0 SP5, SP6a Multi-Path MSCS	Supported Secure Path Multi-Path driver	Supported	Supported	Veritas Netbackup, Legato Networker

Table A–1 Heterogeneous SAN Product Support (Continued)

Platform or Operating System	MA6000, MA/RA8000 EMA/ESA12000 ACS Version 8.5F, L, S	DRM[1] ACS Version 8.5P	EVM[2]	EBS products
Microsoft Windows 2000 SP1 Multi-Path MSCS	Supported Secure Path Multi-Path driver	Supported	Supported	Veritas Netbackup, Legato Networker
Novell NetWare 4.2, 5.x Multi-Path Clusters	Supported Secure Path Multi-Path driver	Not Supported	Not Supported	Not Supported
SGI IRIX 6.5.7, 6.5.8	Supported	Not Supported	Not Supported	Not Supported
SUN Solaris 2.6, 7, 8. (32/64bit) Multi-Path SUN Clusters	Supported Secure Path Multi-Path driver	(2.6, 7) Supported	Supported	Veritas Netbackup, Legato Networker (Sun 2.6, 7)

1. MA/RA8000, EMA/ESA12000 only.
2. For MA/RA8000 and EMA/ESA12000 supports Cloning and Snapshots. For MA6000 supports Cloning feature only.

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