

Compaq StorageWorks

Application Note

*Storage Area Network Configurations for MA6000, MA/RA8000,
EMA/ESA12000 on Windows NT/Windows 2000 - Intel*

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Compaq Computer Corporation

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Introduction

This application note describes fibre channel switch based Storage Area Network (SAN) configurations for MA6000, MA/RA8000, and EMA/ESA12000 storage systems on Windows NT/Windows 2000 Intel platforms. For mixed platform heterogeneous SAN configurations or for configurations with more than four switches in a single SAN fabric refer to the *Heterogeneous Open SAN Design Reference Guide* and the applicable platform-specific application notes listed in Table 4.

Enterprise Network Storage Architecture (ENSA)

The Compaq Enterprise Network Storage Architecture is key to supporting Compaq's NonStop eBusiness strategy; through ENSA, Compaq leverages industry standards to allow deployment of storage where applications need it. ENSA uses the Compaq StorageWorks product family to deliver the storage solutions that address non-stop computing requirements like availability, reliability, performance, scalability, manageability, and data backup/restore capabilities. ENSA addresses the storage issues that our customers expect to face now and in the future. Compaq SANs address today's issues including:

- Data protection
- High availability
- Increased distance
- High connectivity
- High bandwidth
- Multi-vendor platform support
- Enterprise backup support
- Economical capacity growth
- Scalability
- Investment protection

With the MA6000, MA/RA8000, and EMA/ESA12000 Fibre Channel storage products and the integration of Enterprise Backup Solutions into the SAN, Compaq has taken the next evolutionary step in delivery of the ENSA vision. Our customers can now realize the full benefits of a scalable Storage Area Network providing the robust backbone needed to address dispersed server operation with shared storage access and backup across the enterprise.

Product Overview

The MA6000, MA/RA8000, and EMA/ESA12000 Fibre Channel storage systems are based on a common architecture and offer customers centralized management, high availability, and exceptional performance and scalability in open systems environments. These products provide a Fibre Channel storage solution with industry leading SAN support utilizing both Fibre Channel Fabric (switch) and FC-AL (arbitrated loop) technology.

These storage systems incorporate the latest in RAID technology providing RAID levels 0, 1, 0+1, adaptive 3/5, and non-RAID disks. Compaq's implementation of RAID capability assures that data availability will be maintained despite hardware failure. Features such as read ahead cache and mirrored write back cache improve or minimize the affect on performance while preserving data availability and supporting high availability.

The storage system platform kits contain the necessary operating system specific software and documentation needed to install, configure, and monitor your storage system. All platform kits include the StorageWorks Command Console (SWCC) for storage management operations including configuring, status inquiry and notification facilities. SWCC provides a user oriented graphical user interface (GUI) simplifying the most complex of storage management operations.

Microsoft Cluster Server (MSCS)

A Windows NT/Windows 2000 MSCS cluster enables two servers to share an MA6000, MA/RA8000 or EMA/ESA12000 Fibre Channel storage system through a Fibre Channel bus. If a server failure should occur, the storage I/O is re-routed through to the functioning server. This process, called cluster failover, requires no resource downtime ensuring the high availability of data.

The storage systems are supported in Windows NT/Windows 2000 MSCS cluster configurations. All of the cluster configurations provide full cluster failover capabilities through a Fibre Channel bus connected to both cluster servers.

In addition to cluster failover, the RAID array controllers can be configured in transparent failover mode to protect against the unlikely event of a single controller failure. This feature eliminates controllers as single points of failure and is invoked without the need for server intervention.

For the highest single point of failure (NSPOF) availability, two separate hardware paths between the cluster servers and the storage system can be configured using Compaq's Secure Path for Windows NT. This configuration provides two separate physical paths between the servers and the storage.

Secure Path for Windows NT/Windows 2000

StorageWorks Secure Path is a high availability software product providing continuous data access for MA6000, MA/RA8000 and EMA/ESA12000 Fibre Channel storage products configured on Windows NT/Windows 2000 platforms. Redundant hardware, advanced RAID technology and automated failover capability are used to enhance fault tolerance and availability. Secure Path effectively eliminates controllers, interconnect hardware and host bus adapters as single points of failure in the storage system.

Key to Secure Path's functionality is the capability of MA6000, MA/RA8000, and EMA/ESA12000 Fiber Channel dual HSG60 or HSG80 controllers to operate in the active/active Multiple-Bus failover mode. This failover mode allows each controller to be configured on its own bus and to process I/O independently under normal operation. Available storage units are "preferred" to one or the other of the

two controllers which determines which controller path is used for access at system boot time. During runtime, storage units may be moved between paths at anytime through use of the management utility without disrupting operations.

Controllers in multiple-bus failover mode monitor each other and automatically failover storage units from the failed member of a controller pair. The Secure Path software detects the failure of I/O operations to complete on a failed path and automatically re-routes all traffic to the surviving path. Controller and path failover is completed seamlessly, without process disruption or data loss.

The Secure Path management utility provides continuous monitoring capability and identifies failed paths and failed-over storage units. To facilitate static load balancing, storage units can be moved between paths using simple “drag-and-drop” operations.

The integration of Secure Path, Windows NT/Windows 2000 Clustering, and StorageWorks RAID Array Fibre Channel technology provides the maximum level of fault-tolerance, data availability, and performance required for mission-critical environments.

Enterprise Backup Solutions

The Enterprise Backup Solution for Legato NetWorker is an integration of industry-standard application software and hardware that provides a complete enterprise class tape solution. The implementation combines tape and disk storage on a single SAN providing backup capabilities for up to seven Windows NT/Windows 2000 Intel or Compaq Tru64 UNIX servers and two disk storage systems using a single shared tape library. The Legato NetWorker and SmartMedia software applications manage the backup operations for the solution. Future releases will support increased capabilities.

SAN Concepts

A Storage Area Network interconnects multiple shared storage environments and servers into a storage network. All storage can be managed from a single location or from multiple locations. All of the storage becomes available to any server, regardless of physical location.

SAN Management

SAN management tools and product features provided with the MA6000, MA/RA8000, and EMA/ESA12000 storage systems include the following:

- SAN Storage and Switch Management

SWCC – Utilized to manage and monitor storage systems, storagesets, and SAN fibre channel switches including configuration, status inquiry and notification facilities.

- SAN Enterprise Backup Management

Legato NetWorker and SmartMedia software manages and automates the backup-and-restore process using Compaq servers, disk arrays, tape libraries and Fibre Channel interconnect hardware.

- SAN Access Management

Switch Fabric Zoning – The Fibre Channel switch Zoning feature provides a means to control SAN access at the node port level. Zoning can be used to separate one physical Fabric into many virtual Fabrics consisting of selected server and storage ports. This capability allows you to setup barriers between different operating environments, to deploy logical Fabric subsets by creating defined server and/or storage groups, or to create temporary server and storage zones for tape backup. Zones

may be configured dynamically and the number of zones and zone membership are effectively unlimited. Nodes can be in multiple zones to allow for overlapping depending on the desired access control. Use of Zoning is supported in both homogeneous Windows NT/Windows 2000 SAN configurations and heterogeneous mixed platform SAN configurations.

Selective Storage Presentation (SSP) – The RAID Array SSP feature provides a means to control access at the storage set level. SSP is an exclusive Compaq storage system feature that allows multiple servers or host bus adapters (HBA) to share access to the same RAID array reliably, with each server or HBAs storage sets (LUNs) 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 array. The host mode is specially tailored to the storage communication techniques of the operating system. The LUN offset feature allows higher numbered LUNs in a RAID Array to be presented in a range required by specific operating systems. The SSP feature also provides a means to track the numerous Fibre Channel HBAs within servers attached to a SAN by identifying each by Worldwide ID (WWID).

Additional information about these products is available in the documentation listed in Table 4.

SAN Performance Considerations

The performance of an application on a system that utilizes MA6000, MA/RA8000 or EMA/ESA12000 Fibre Channel storage can be limited by many different components of the system and the configuration of the SAN. Some of the possible components limiting factors include the host CPU(s), memory size, Fibre Channel HBA, RAID controllers, or the specific configuration of disks used behind the controllers. At the SAN level, performance can be limited by the number and arrangement of Fibre Channel switches and Inter-Switch Links (ISL) in the Fabric, and the way servers and storage systems are connected to the Fabric. The limiting factor can move to any of these areas depending on the workload. Identifying the limits will assist in determining the best configuration for a given application.

Table 1 lists the upper limit performance specifications for the components of the storage systems based on testing using standard storage performance tests and methodologies. These numbers should be used to compare component level performance as a means to determine the best configuration from a performance perspective. User application tests may not necessarily reach these levels of performance as applications may perform additional levels of processing for each I/O. The controller specifications listed show both cache (no disk access) and media (with disk access) limitations.

The limits are based on I/O performance (I/Os per second) - typical of small transfer applications such as databases and mail, and bandwidth performance (MBs per second) - typical of large transfer applications such as video and graphics.

Table 1 Performance Limits of Fibre Channel Fabric Components

Transfer Size	IO/sec (small transfer sizes, random access)		MB/sec (large transfer sizes, sequential access)	
	Read	Write	Read	Write
Fibre Channel HBA - KGPSA-BC	15,500	14,250	86	51
Fibre Channel Switch (see note) Fibre Channel Switch ISL (see note)	400,000 25,000	400,000 25,000	1600 100	1600 100
Single HSG80 Controller (1 Active Port)	12,000 Cache 4,100 Media	9,000 Cache 4,000 Media	77 Cache 54 Media	50 Cache 44 Media
Single HSG80 Controller (2 Active Ports)	12,000 Cache 4,100 Media	9,000 Cache 4,000 Media	98 Cache 54 Media	100 Cache 47 Media
Dual HSG80 Controllers (2 Active/2 Standby Ports)	24,000 Cache 8,200 Media	18,000 Cache 8,000 Media	154 Cache 102 Media	101 Cache 88 Media
Dual HSG80 Controllers (4 Active Ports)	24,000 Cache 8,200 Media	18,000 Cache 8,000 Media	195 Cache 102 Media	178 Cache 88 Media
Fibre Channel HBA - KGPSA-BC	15,500	14,250	86	51
Fibre Channel Switch (see note) Fibre Channel Switch ISL (see note)	400,000 25,000	400,000 25,000	1600 100	1600 100

NOTE: Fibre channel switch and ISL performance limits are theoretical. Actual measured performance is lower due to limits unrelated to the switch.

SAN Configuration Guidelines

The following sections provide information about configuring small SANs including the base Fabric design selection, fibre channel Fabric rules, platform and disk storage connectivity rules, Enterprise Backup integration rules and Compaq Secure Path for Windows NT/Windows 2000 rules. The configuration information is presented in the form of rules to provide for flexibility and customization depending on the specific customer need. In addition to the listed rules, also shown are examples of recommended SAN configurations based on the number and arrangement of fibre channel switches in a Fabric. The example "SAN Fabric Configurations" illustrates proper application of the listed rules with regard to fibre channel switch arrangement, switch interconnection in a Fabric, and platform/storage connections. The exact SAN Fabric configuration used for your specific application should begin with one of the base SAN configurations shown. In choosing a Fabric configuration you should consider capacity, connectivity, availability, distance, backup, and performance needs as well as future growth requirements.

NOTE: This document describes SAN configurations that contain a maximum of four switches in a single SAN fabric. For larger SAN fabric configurations with more than four switches, refer to the *Heterogeneous Open SAN Design Reference Guide, AA-RMPNA-TE*.

It is not required that you configure server and storage in the SAN exactly as depicted in the illustrations; however it is strongly recommended that the switch interconnection rules and platform connectivity rules be strictly adhered to.

This application note describes homogeneous Windows NT/Windows 2000 SAN configurations. It is expected that customers may desire to implement a heterogeneous SAN consisting of many different operating system platforms. Whether implementing a homogeneous or heterogeneous SAN, it is necessary to adhere to the platform specific rules and maximums for each given platform within the SAN.

SAN Design Selection Process

It is suggested that the following general steps be followed when initially designing a SAN.

1. Considering capacity, connectivity, availability, distance, performance, and backup requirements, select the SAN Fabric configuration that best fits your needs. Refer to the configuration illustrations, notes, Fabric rules, and platform server and storage connectivity rules. Using the maximum server and maximum storage counts shown as the upper bound limits determine the specific number of servers or storage required number for your particular installation.

- If you want a lower server count than the maximum listed: You may increase the storage count, but only to the upper limit indicated for maximum storage, and provided you do not exceed the platform limits listed in Table 2 for HBAs/Server and Controller Ports/HBA. If you want a lower storage count than the maximum listed: You may increase the server count, but only to the upper limit indicated for maximum servers, and provided you do not exceed the platform limits listed in Table 2 for Servers/Storage System

- If you want a lower storage count than the maximum listed: You may increase the server count, but only to the upper limit indicated for maximum servers, and provided you do not exceed the platform limits listed in Table 2 for Servers/Storage System.

If capacity or connection needs are greater than provided in a four switch Fabric, refer to the *Heterogeneous Open SAN Design Reference Guide, AA-RMPNA-TE*.

If you are configuring a homogeneous Windows NT/Windows 2000 Intel SAN, refer to the Windows NT/Windows 2000 Intel Server/Storage configuration rules in this document to determine how best to configure servers and storage. Line 1 in Table 2 lists the configuration maximums for Windows NT/Windows 2000 Intel platforms in a homogeneous SAN configuration.

If you are configuring a heterogeneous SAN, refer to the appropriate platform application note(s) and the *Heterogeneous Open SAN Design Reference Guide, AA-RMPNA-TE* listed in Table 3. Line 1 in Table 2 lists the configuration maximums for Windows NT/Windows 2000 Intel platforms in a heterogeneous SAN configuration.

2. If implementing a SAN for high availability storage using Compaq Secure Path for Windows NT/Windows 2000, refer to the Compaq Secure Path for Windows NT/Windows 2000 Rules.
3. If implementing a SAN integrating Compaq Enterprise Backup Solution on your SAN, refer to the Enterprise Backup Solution Integration Rules.
4. Select the desired method(s) of SAN management and access control based on your specific needs. Use SWCC for storage set management, and controller based SSP or switch based Zoning (or both) for disk storage access control. Use Secure Path Manager to manage high availability, use Legato NetWorker and SmartMedia software to manage the backup-and-restore process.

SAN Configuration Rules and Maximums

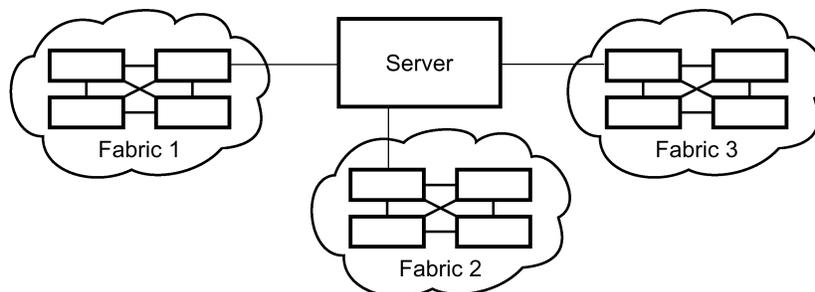
The following sections list the SAN design rules as they apply to Fabric configurations, Windows NT/Windows 2000 Intel platforms for servers and storage, enterprise backup integration, and high availability storage.

Fabric Rules

- Up to 20-fibre channel switches total in a single Fabric - a SAN with all switches interconnected. All Compaq Fibre Channels SAN switch models are supported inter-mixed.

NOTE: Compaq Fibre Channel Switch 8 and 16 port models are not supported in fabrics with greater than four switches. Refer to the *Heterogeneous Open SAN Design Reference Guide, AA-RMPNA-TE* for more information.

- A server can attach to multiple multi-switches Fabrics (Figure 1). The number of separate Fabrics per server or total number of switches per server in separate Fabrics is based on the specific server model capabilities and the maximum number of Fibre Channel HBAs supported.
- Within a single Fabric, maximum of four or seven switch hops between servers and storage, A hop is defined as one or more connections between two Fibre Channel switches, for example; five switches cascaded = four hops. Server to Fibre Channel switch segments and Storage to Fibre Channel switch segments are not counted as hops.
- Within a single Fabric where switches are interconnected, each Fibre Channel switch must have a unique domain number (Domain_ID).
- Up to 16 ISLs between any two switches, up to eight active to the same destination.
- Minimum cable segment length is two meters.
- Up to 200 meters per cable segment using short-wavelength laser GBICs and 62.5-micron multi-mode fiber optic cable.
- Up to 500 meters per cable segment using short-wavelength laser GBICs and 50 micron multi-mode fiber optic cable.
- Up to 10 km per ISL cable segment using long-wavelength laser GBICs and 9 micron single-mode fiber optic cable. 10 km links are only supported in switch to switch connections.
- Up to 100 km cable segment using very long distance GBICs and 9 micron single-mode fibre optic cable. 100 km links are only supported in switch to switch connections. Maximum of one hop is supported for 100km distances.



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Figure 1. One Server to Multiple 4-Switch Fabrics

Windows NT/Windows 2000 Intel Server/Storage Rules

Table 2 describes the Windows NT/Windows 2000 Intel platform maximums when in a homogenous SAN and when using Windows NT/Windows 2000 Intel platforms in a heterogeneous mixed platform SAN.

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
Microsoft Windows NT 4.0, SP5, SP6a Windows 2000 Advanced Server, SP1	4	4	8	8	16
Heterogeneous SAN					See Note ⁵

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 16 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 16 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 16 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. 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 number for the operating systems that are sharing the storage system.
- All configurations are supported under Windows NT 4.0 with a minimum of SP5, and under Windows 2000 with a minimum of SP1.
 - For Windows NT and Windows 2000, all server connections into the SAN use a Fibre Channel Fabric based HBA. FC-AL and Fibre Channel FL-Port HBA connections into the SAN are not supported for Windows NT/Windows 2000 platforms
 - The maximum number of Fibre Channel HBAs per server is four, or total allowed in the server if less than four. Use Selective Storage Presentation (see below) to assign specific LUNs exclusively to each HBA
 - The maximum number of active controller ports per Fibre Channel HBA is four

- Any combination of Windows NT/Windows 2000 Servers - standalone or clustered, and storage systems is allowed per SAN configuration, provided these rules are followed:

A maximum of 16 Windows NT/Windows 2000 servers (assumes one Fibre Channel HBA per server for non-HA and two Fibre Channel HBAs per server for HA) per MA6000, MA/RA8000 or EMA/ESA12000 dual controller storage system, with a maximum of eight servers configured on each active port. See “Extended Configurations” description below when greater than four servers have access to the same HSG60 or HSG80 controller host port pair

All specific SAN configuration rule limits are followed. Refer to the individual SAN Fabric configurations

- Extended Configurations - If you configure greater than four (up to eight) Windows NT/Windows 2000 servers (assuming one Fibre Channel HBA per server) for access to a single host port on an MA6000, MA/RA8000, or EMA/ESA12000 Fibre Channel storage system, select the “Extended Configuration” check box in the StorageWorks Windows NT/Windows 2000 Platform Kit Fibre Channel Software Setup utility custom installation setup. Select this option to adjust registry settings for your KGPSA host bus adapter to operate in an "Extended Configuration" environment. Each Windows NT/Windows 2000 server in this configuration must have the option selected.

All configurations require the *Connection Name Operating System* parameter set to “WINNT”.

- When configuring HSG60 or HSG80 controllers for access from Windows NT / Windows 2000 servers only, the controller SCSI mode should be set to “SCSI-2” and the Command Console LUN (CCL) must be disabled. When configuring controllers for access from Windows NT / Windows 2000 and other platforms that require “SCSI-3” mode, set the controllers to SCSI-3 mode. When set in SCSI-3 mode the CCL will be fixed at LUN 0. This will reduce the total number of LUNs available by one for all server connections.
- Each active controller host port presents one SCSI Target ID with up to eight LUNs to each server (Fibre Channel HBA) that has a connected path through the Fabric to the port.
- The maximum number of LUNs per HSG60 or HSG80 controller pair is 128.
- Dual redundant controllers can be configured for Transparent Failover Mode or Multiple-Bus Failover Mode. Multiple-bus Failover mode requires Compaq Secure Path for Windows NT / Windows 2000 on the server.
- Each storage system can be configured using SWCC or the Command Line Interface (CLI) through either the HSG60 or HSG80 controller maintenance serial port or a TCP/IP interface.
- All configurations utilize V8.5F (HSG80) or V8.5L (HSG60) Array Controller Software configured for FABRIC topology.
- ACS V8.5 provides for up to 64 connection name entries. For dual controllers in Transparent Failover Mode, up to two connection entries are created for each server HBA, thus a total of 32 server HBAs are visible to a storage system at any given time. In Multiple-Bus Failover Mode, up to four connection entries are created for each server HBA, so a total of 16 server HBAs are visible.

NOTE: The maximum number of server HBAs supported on a storage system is 16.

Each storage system in the SAN will automatically add connection name entries upon initial power up. As a result, in certain SAN configurations it is possible to exceed the number of available connection name entries in a storage system prior to the addition of entries for the specific server HBAs that you want access to. This could result in the inability of a storage system to properly connect to a desired server HBA in the SAN. To avoid this, you can configure specific server HBAs and specific storage systems into Fibre Channel Switch Zones of up to 32 Servers when in Transparent Failover and up to 16 Servers when in Multiple-bus Failover.

- Rename connection names. By default new connection names are automatically added to the controller connection name table by the controllers when they detect a path to an adapter from each active controller host port. The default connection name assigned by the controllers will be “!NEWCONnn”, where nn is a number from 1 to 64. After the controllers detect all paths, rename each connection name to be more meaningful to the configuration i.e., SERVER1P1, SERVER1P2, etc. (connection names can be a maximum of 9 characters).
- Selective Storage Presentation - for configurations with more than one Fibre Channel HBA in a server or more than one server accessing through the same HSG80 controller host port:
 - Use the Connection Name *Unit Offset* value to set the range of unit numbers to be visible from each server or HBA (using the CLI, “SET *connection-name* UNIT_OFFSET = *n*”)
 - Use the Unit *Connection Name* parameter to allow exclusive access to units from each server or HBA (using the CLI, “SET unit-number DISABLE_ACCESS_PATH = ALL ENABLE_ACCESS_PATH = *connection-name*”).

NOTE: Shared access between different servers to the same storage unit (LUN) requires specific application software (i.e., MSCS) to ensure proper data preservation.
- Logical units (LUN) can consist of single disks (JBOD), a storage set of multiple disks or a partition (up to eight), configured for a specific RAID level of 0, 1, 0 + 1, or 3/5
- The maximum storage capacity stated (2.6 TB) assumes 36GB disks, increases in disk drive capacity will increase overall storage capacity for the same enclosure footprint

Enterprise Backup Solution Integration Rules

- Supports Legato NetWorker backup for up to seven Windows NT or Tru64 UNIX Servers.
- Supports all Compaq Fibre Channel 16-port and 8-port switch models inter-mixed.
- Connected to the SAN using Fibre Channel switch Fabric topology connection.
- Up to 10 km between Fibre Channel switch and a tape controller using long-wavelength laser GBICs and 9 micron single-mode fiber optic cable.
- Up to two Fibre Channel Tape Controllers
- Maximum of one TL895 library
- Up to seven tape drives
- Maximum of one switch hop between servers and a tape controller
- Supports backup for up to two MA6000, MA/RA8000 or one EMA/ESA12000 (four controller pairs) storage systems.

NOTE: Use of Fibre Channel Switch Zoning with tape backup is not currently supported.

Compaq Secure Path for Windows NT/Windows 2000 Rules

All High Availability Multiple-Bus Failover configurations require Compaq Secure Path for Windows NT/Windows 2000. The minimum revision required is V3.1 for Windows NT and Windows 2000.

NOTE: Refer to the Secure Path documentation listed in Table 4 for specific installation procedures.

- For version 3.1 of Secure Path, one instance of the Secure Path Manager can manage multiple standalone servers or multiple clustered servers. Use more than one instance if you need to concurrently manage environments that include both standalone servers and clustered servers. All instances can be run from a single Client if desired.

- All Secure Path configurations utilizing four active controller ports connected to the same server or servers offer the flexibility to use the four active ports for either increased total LUN count, or increased PATH accessibility to a maximum of eight LUNs.

For *Maximum LUN Count* use distinct controller port unit offsets and access control on controller port 1 and controller port two to configure up to 16 LUNs total, eight available through each pair of port paths. This means you can configure up to eight LUNs on the two port 1 paths, and another eight LUNs on the two port 2 paths. It is suggested that for units accessed through controller host port 1 you use unit number and offset values in the range of 0 – 99. For units accessed through controller host port 2 use unit number and offset values in the range 100 – 199. For static controller load balancing individual LUNs should be distributed across each path of a port pair using the “Preferred Path” controller feature.

For *Maximum Controller Port PATH Accessibility* to the same set of LUNs, you can configure all four controller ports for access to the same eight LUNs using the same unit offset on all four controller ports. In addition to the static controller load balancing feature, in this configuration you can enable dynamic port load distribution that distributes I/O load to each LUN across both ports on the same controller. The dynamic load distribution feature is available for non-clustered servers only.

- Distribute units equally across both controllers for proper static load balancing using the Unit Preferred Path parameter to assign units to a specific controller at initial boot
- SSP - Stagesets (LUNs) must be enabled for access from both paths using the Unit Connection Name parameter feature
- For two (or more) server Secure Path configurations, it is suggested that the first adapter in each server be connected to the first (same) fibre channel switch, the second two adapters to the second switch, etc. For example:

Server 1 Fibre Channel HBA 1 to Fibre Channel Switch 1 - Switch Port 1
 Server 1 Fibre Channel HBA 2 to Fibre Channel Switch 2 - Switch Port 1
 Server 2 Fibre Channel HBA 1 to Fibre Channel Switch 1 - Switch Port 2
 Server 2 Fibre Channel HBA 2 to Fibre Channel Switch 2 - Switch Port 2

It is highly recommended that the cabling scheme shown in each Secure Path multiple-bus configuration be followed as depicted. This is not required; however, it does aid in understanding logical to physical LUN and path mapping for maintenance purposes.

- When utilizing Compaq Secure Path in single fabric configurations you must define two separate logical paths using fabric zoning.
- For Windows 2000 when utilizing Compaq Secure Path in single or dual fabric configurations with both Multiple-bus Failover and Transparent Failover storage systems, the Transparent Failover storage systems must be in a different fabric zone.

Configuration Descriptions

Table 3 lists six SAN Fabric configuration examples for MA6000, MA/RA8000 and EMA/ESA12000 storage systems when using Windows NT/Windows 2000 Intel platforms. The configurations are based on the rules listed in the SAN Configuration Guidelines section. They show the limits with regard to:

- Total number and arrangement of fibre channel switches in a single Fabric, or multiple Fabrics for high availability
- Maximum number of servers and storage systems per Fabric configuration

- Recommended Fabric switch configurations optimized for general purpose, maximum capacity, maximum connectivity, highest availability, backup, or highest performance

The configurations are listed in order based on the number of switches in the Fabric. This follows a logical progression where you may desire to initially configure a small SAN containing a single Fibre Channel switch, then add a second switch for high availability or increased connectivity, and additional switches as capacity and connectivity needs increase.

NOTE: This document describes SAN configurations that contain a maximum of four switches in a single SAN fabric. For larger SAN fabric configurations with more than four switches, refer to *Heterogeneous Open SAN Design Reference Guide, AA-RMPNA-TE*.

The maximum server counts and maximum storage counts listed for each configuration show the upper bound limits - either maximum servers or maximum storage, for that switch arrangement. Depending on your connectivity or storage capacity needs you may choose to implement your SAN maximized for one or the other, or a lesser number of either. All configurations allow the flexibility to trade-off server and storage system count based on total Fibre Channel switch port availability; however you cannot exceed the upper bound limits listed or the platform limits in Table 2 for each configuration.

All configurations support a mix of both clustered and non-clustered (MSCS) servers. All configurations shown are supported with all Compaq supplied 16-port and 8-port Fibre Channel switches.

Table 3 Index of RA8000/ESA12000 SAN Fabric Configurations for Windows NT/Windows 2000 Intel

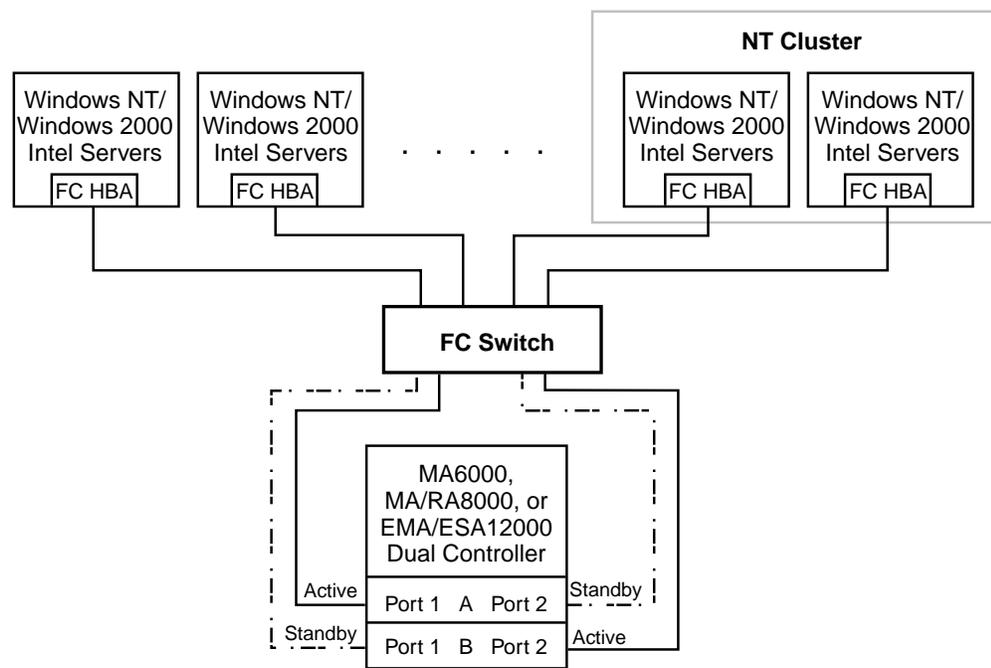
SAN Fabric Configuration #	Description	Page
1	One Fibre Channel Switch, Controller Transparent Failover Mode, Integrated EBS	15
2	Two Fibre Channel Switches, High Availability Fault Tolerant Fabric, Secure Path, Controller Multiple-Bus Failover Mode, Integrated EBS	17
3	Two Fibre Channel Switches, Cascaded, Controller Transparent Failover Mode, Integrated EBS	20
4	Four Fibre Channel Switches, Cascaded High Availability Fault Tolerant Fabric, Secure Path, Controller Multiple-Bus Failover Mode, Integrated EBS	23
5	Three Fibre Channel Switches, Meshed Fabric, Controller Transparent or Multiple-Bus Failover Mode	27
6	Four Fibre Channel Switches, Meshed Fabric, Controller Transparent or Multiple-Bus Failover Mode	30

Additional Information/References

A table of all related product documentation is included at the end of this application note (Table 4). Refer to these documents for more details on StorageWorks product installation and configuration.

SAN Fabric Configuration 1 - One Fibre Channel Switch, Controller Transparent Failover Mode, Integrated EBS

SAN Fabric Configuration 1 (Figure 2) is a general-purpose configuration that provides connectivity for multiple servers, disk storage, and tape storage all on a single SAN. Up to 12 separate non-cooperating servers or up to six pairs of clustered cooperating servers can be connected through a 16-port switch providing access from all servers to a single storage system. With an 8-port Fibre Channel switch up to four servers can be connected to one storage system. With either switch type the number of storage systems can be increased if the number of servers is reduced to provide additional switch ports for storage. The HSG60 or HSG80 array controllers within the storage system are configured in Transparent failover mode providing full controller redundancy in the unlikely event of either controller failing.



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Figure 2. One Switch Fabric Configuration Example

SAN Configuration 1 Server/Storage Connectivity Rules

- Any mix of Windows NT/Windows 2000 Intel Servers - standalone or clustered, and storage systems using these maximums. Assumes one Fibre Channel HBA per server, an even storage port count, and no EBS ports.
- 16-port Fibre Channel Switch, total number of switch ports available for Servers and Storage is 16
Maximum Server Connectivity,

Up to 12 Servers and one Storage System (4 storage ports/2 Active, 2 Standby)

[16 – 4 storage ports = 12 server ports]

Maximum of eight servers configured on any one active controller host port

Or Maximum Storage Capacity,

Up to four Storage Systems (14 storage ports/7 Active, 7 Standby) and 2 Servers
[16 – 2 server ports = 14 storage ports]

- 8-port Fibre Channel Switch, total number of switch ports available for Servers and Storage is eight

Maximum Server Connectivity,

Up to four Servers and one Storage System (4 storage ports/2 Active, 2 Standby)
[8 – 4 storage ports = 4 server ports]

Or Maximum Storage Capacity,

Up to two Storage Systems (6 storage ports/3 Active, 3 Standby) and two Servers
[8 – 2 server ports = 6 storage ports]

- All HSG80 array controllers configured in Transparent Failover Mode
- EBS Integration Supported

SAN Configuration 1 Fabric Rules

- Total Switches = one, 16-port or 8-port
- Maximum Distances:

Up to 500 meters per Fibre Channel cable segment, 1 km total server to storage using 50 micron multi-mode fiber optic cable. Refer to general Fabric rules for other cable types.

SAN Configuration 1 Notes

- When configured with greater than one Windows NT/Windows 2000 Server or Fibre Channel HBA, use SSP to assign exclusive access to units (LUNs) to specific server Fibre Channel HBAs.

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

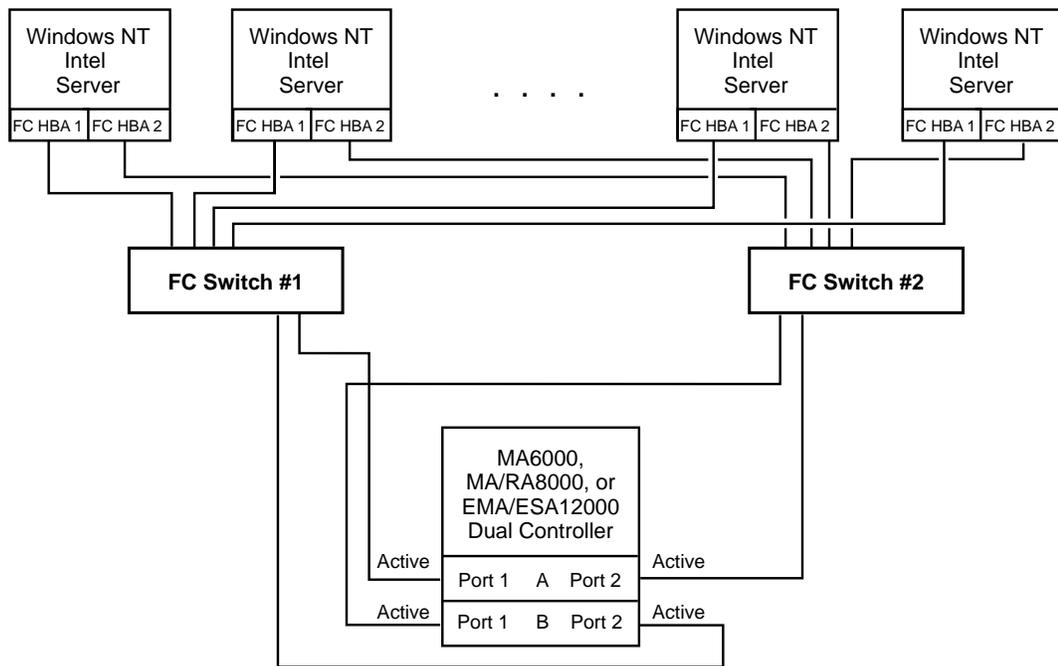
- When configured with greater than four Windows NT/Windows 2000 Servers per active controller host port, classified as an “NT Extended Configuration” (refer to the StorageWorks Windows NT/Windows 2000 Platform Kit Fibre Channel Software Setup Utility)
- For servers accessing controller host port 1 use unit number and offset values in the range of 0 – 99, for controller host port 2 use number and offset values in the range 100 -199
- Performance considerations, assuming relatively equal server load:

If using a single storage system, for balanced performance across all servers configure half of the servers on each of the controller port pairs. If using multiple storage systems configure an equal number of servers on each storage system.

The recommended maximum number of controller host ports configured per Fibre Channel HBA is two for high bandwidth applications and four for high throughput applications.

SAN Fabric Configuration 2 – Two Fibre Channel Switches, High Availability Fault Tolerant Fabric, Secure Path, Controller Multiple-Bus Failover Mode, Integrated EBS

SAN Fabric configuration 2 (Figure 3) is a high availability no single point of failure configuration that uses two separate Fabrics to provide two data paths between servers and disk storage configured in Multiple-Bus failover mode. Tape storage can be configured on one of the Fabrics to provide backup and restore capabilities. Up to 14 separate (non-cooperating) servers or up to seven pairs of clustered (cooperating) servers can be connected through two 16-port Fibre Channel switches with one storage system. With 8-port Fibre Channel switches up to six servers can be connected to one storage system. With either switch type the number of storage systems can be increased if the number of servers is reduced to provide switch ports for storage. This SAN configuration utilizes the high availability features of controller Multiple-Bus failover and Compaq Secure Path for Windows NT/Windows 2000 software. With two Fibre Channel HBAs in each server, and two Fibre Channel switches, a second separate path to the storage is provided to each server. The two switches form isolated Fabrics providing the highest level of storage path fault tolerance should a failure occur with any path component - Fibre Channel HBA, Fibre Channel Switch, Fabric path interconnect, or storage controller. Non-HA configured servers and storage configured in Transparent Failover Mode are supported in this configuration; however access may be limited to one or the other of the two Fabrics unless two Fibre Channel HBAs are utilized, each connected to a different Fabric.



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Figure 3. Two Switch HA Fabric Configuration Example

NOTE: High availability storage using Secure Path for Windows NT/Windows 2000 and Controller Multiple-bus Failover Mode is supported in this configuration provided that switch zoning is used to define two logical paths.

SAN Configuration 2 Server/Storage Connectivity Rules

- This configuration supports any mix of Windows NT/Windows 2000 Intel Servers - standalone or clustered, configured for HA or non-HA, and any mix of Multiple-bus Failover and Transparent Failover storage systems. The calculations shown in the following section however assume: All servers configured for HA, all controllers configured in Multiple-bus failover mode, two Fibre Channel switches and two Fibre Channel HBAs per server, an even storage port count, and no EBS ports.
- 16-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 32
 - Maximum Server Connectivity,
 - Up to 14 Servers and one Storage System (4 Active storage ports)
 - $[(32 - 4 \text{ storage ports})/2 = 14 \text{ servers}]$
 - Maximum of eight Fibre Channel HBAs configured on any one active controller host port
 - Or Maximum Storage Capacity,
 - Up to six Storage Systems (24 Active storage ports) and four HA Servers
 - $[32 - 8 \text{ server ports} = 24 \text{ storage ports}]$
 - Maximum of four active controller host ports per Fibre Channel HBA
- 8-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 16
 - Maximum Server Connectivity,
 - Up to six Servers and one Storage System (4 Active storage ports)
 - $[(16 - 4 \text{ storage ports})/2 = 6 \text{ servers}]$
 - Or Maximum Storage Capacity,
 - Up to three Storage Systems (12 Active storage ports) and two HA Servers
 - $[16 - 4 \text{ server ports} = 12 \text{ storage ports}]$
- For dual path high availability, HSG60 or HSG80 controller pairs are configured in Multiple-Bus Failover Mode. For non-HA single path servers, controllers are configured in Transparent Failover Mode
- EBS Integration Supported

SAN Configuration 2 Fabric Rules

- Total Switches = 2, 16-port or 8-port
- Maximum Distances:
 - Up to 500 meters per Fibre Channel cable segment, 1 km total server to storage using 50 micron multi-mode fiber optic cable. Refer to general Fabric rules for other cable types.

SAN Configuration 2 Notes

When configured with greater than one Windows NT/Windows 2000 Server or Fibre Channel HBA, use SSP to assign exclusive access to units (LUNs) to specific server Fibre Channel HBAs.

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

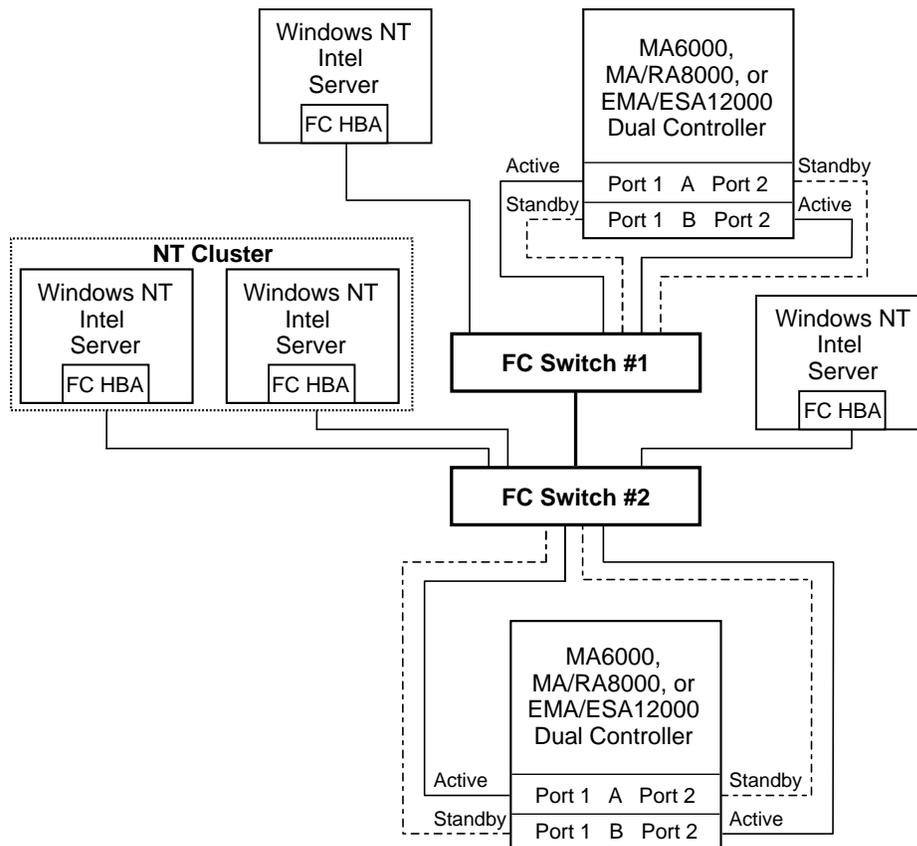
- When configured with greater than four Fibre Channel HBAs per active controller host port, classified as an “NT Extended Configuration” (refer to the StorageWorks Windows NT/Windows 2000 Platform Kit Fibre Channel Software Setup Utility)
- Uses Compaq Secure Path for Windows NT/Windows 2000 (minimum version 3.1)
- One instance of the Secure Path Manager can manage multiple standalone servers or multiple clustered servers. Use more than one instance if you need to concurrently manage environments that include both standalone servers and clustered servers. All instances can be run from a single Client if desired.
- Depending on your specific application needs, configure either for maximum LUNs or for maximum controller port PATH accessibility
 - For Maximum LUN Count – Up to 16 LUNs per server Fibre Channel HBA for each storage system with four active controller host ports. Each server is configured for access to two paths and two controller ports, using either Port 1 of both controllers or Port 2 of both controllers. Suggested distinct controller port unit number and offset value assignment: For servers accessing controller Port 1, assign unit number and offset values in the range of 0 – 99. For servers accessing controller Port 2, assign unit number and offset values in the range of 100 – 199. Use the Preferred Path unit parameter to assign units to specific controllers for static load balancing.
 - For Maximum Controller Port PATH Accessibility – Up to eight LUNs per server Fibre Channel HBA for each storage system with four active controller host ports. Suggested controller unit number and offset value assignment: All controller port connections assign unit number and offset values in the range of 0 – 199. Use SSP to set exclusive access of units to specific server Fibre Channel HBA(s). Use the Preferred Path unit parameter to assign units to specific controllers. Units should be distributed equally across controllers for static load balancing. Dynamic load distribution between two ports on the same controller is available for standalone servers.
- Performance considerations, assuming relatively equal server load:

If using a single storage system, for balanced performance across all servers, configure half of the servers on each of the controller port pairs. If using multiple storage systems configure an equal number of servers on each storage system.

The recommended maximum number of controller host ports configured per Fibre Channel HBA is two for high bandwidth applications and four for high throughput applications.

SAN Fabric Configuration 3 – Two Fibre Channel Switches, Cascaded, Controller Transparent Failover Mode, Integrated EBS

SAN Fabric configuration 3 (Figure 4) is a general purpose single Fabric cascaded switch configuration that provides increased server, disk, and tape storage connectivity capabilities. Up to 22 separate (non-cooperating) servers or up to 11 pairs of clustered (cooperating) servers can be connected through two 16-port switches providing access from all servers to two storage systems. With two 8-port Fibre Channel switches up to 10 servers can be connected to one storage system. With either switch type the number of storage systems can be increased if the number of servers is reduced to provide switch ports for storage. A minimum of one ISL is required between the two switches, more may be required based on the specific server and storage configuration and count, and the applications utilized. The ISL(s) can be up to 10 km allowing connectivity between two remote sites. The HSG60 or HSG80 array controllers within the storage system are configured in Transparent failover mode providing full controller redundancy in the unlikely event of either controller failing.



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Figure 4. Two Switches, Cascaded Fabric Configuration Example

SAN Configuration 3 Server/Storage Connectivity Rules

- Any mix of Windows NT/Windows 2000 Intel Servers - standalone or clustered, and storage systems using these maximums. Assumes one Fibre Channel HBA per server, an even storage port count, and no EBS ports.
- 16-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 30
 - Maximum Server Connectivity,
 - Up to 22 Servers and two Storage Systems (eight storage ports/four Active, four Standby)
 - [32 – 2 ISL ports – 8 storage ports = 22 server ports]
 - Maximum of 16 servers configured on one controller pair
 - Maximum of eight servers configured on any one active controller host port
 - Or Maximum Storage Capacity,
 - Up to seven Storage Systems (26 Storage Ports/13 Active, 13 Standby) and four Servers
 - [32 – 2 ISL ports – 4 server ports = 26 storage ports]
 - Maximum of 4 active controller host ports per Fibre Channel HBA
- 8-port Fibre Channel Switches total number of switch ports available for Servers and Storage is 14
 - Maximum Server Connectivity,
 - Up to 10 Servers and one Storage System (4 storage ports/2 Active, 2 Standby)
 - [16 – 2 ISL ports – 4 storage ports = 10 server ports]
 - Maximum of eight servers configured on any one active controller host port
 - Or Maximum Storage Capacity,
 - Up to three Storage Systems (12 storage ports/6 Active, 6 Standby) and two Servers
 - [16 – 2 ISL ports – 2 server ports = 12 storage ports]
 - Maximum of four active controller host ports per Fibre Channel HBA
- All HSG60 or HSG80 array controllers configured in Transparent Failover Mode
- EBS Integration Supported

SAN Configuration 3 Fabric Rules

- Total Switches = 2, 16-port or 8-port
- Maximum number of ISLs between the two switches = 16, up to eight active to the same destination
- Maximum Distances:
 - Up to 500 meters per Fibre Channel cable segment, 1.5 km total server to storage when using 50 micron multi-mode fiber optic cable. Refer to general Fabric rules for other cable types.
 - Up to 10 km per inter-switch link, 11 km total server to storage when using 9 micron single mode fiber optic cable and long wavelength GBICs.
 - Up to 100 km cable segment using very long distance GBICs and 9 micron single-mode fibre optic cable. 100 km links are only supported in switch to switch connections. Maximum of one hop is supported for 100km distances.

SAN Configuration 3 Notes

- Each Fibre Channel Switch must have a unique domain number (Domain_ID).
- When configured with greater than one Windows NT/Windows 2000 Server or Fibre Channel HBA, use SSP to assign exclusive access to units (LUNs) to specific server Fibre Channel HBAs.

NOTE: Shared access between different servers to the same storage unit (LUN) requires specific application software (i.e., MSCS) to ensure proper data preservation.
- When configured with greater than four Windows NT/Windows 2000 Servers per active controller host port, classified as an “NT Extended Configuration” (refer to the StorageWorks Windows NT/Windows 2000 Platform Kit Fibre Channel Software Setup Utility)
- For servers accessing controller host port 1 use unit number and offset values in the range of 0 – 99, for controller host port 2 use number and offset values in the range 100 -199
- Performance considerations, assuming relatively equal server load:

If using two storage systems, for balanced performance across all servers, configure half of the servers on each of the storage systems and equally on the controller port pairs.

The recommended maximum number of controller host ports configured per Fibre Channel HBA is two for high bandwidth applications and four for high throughput applications.

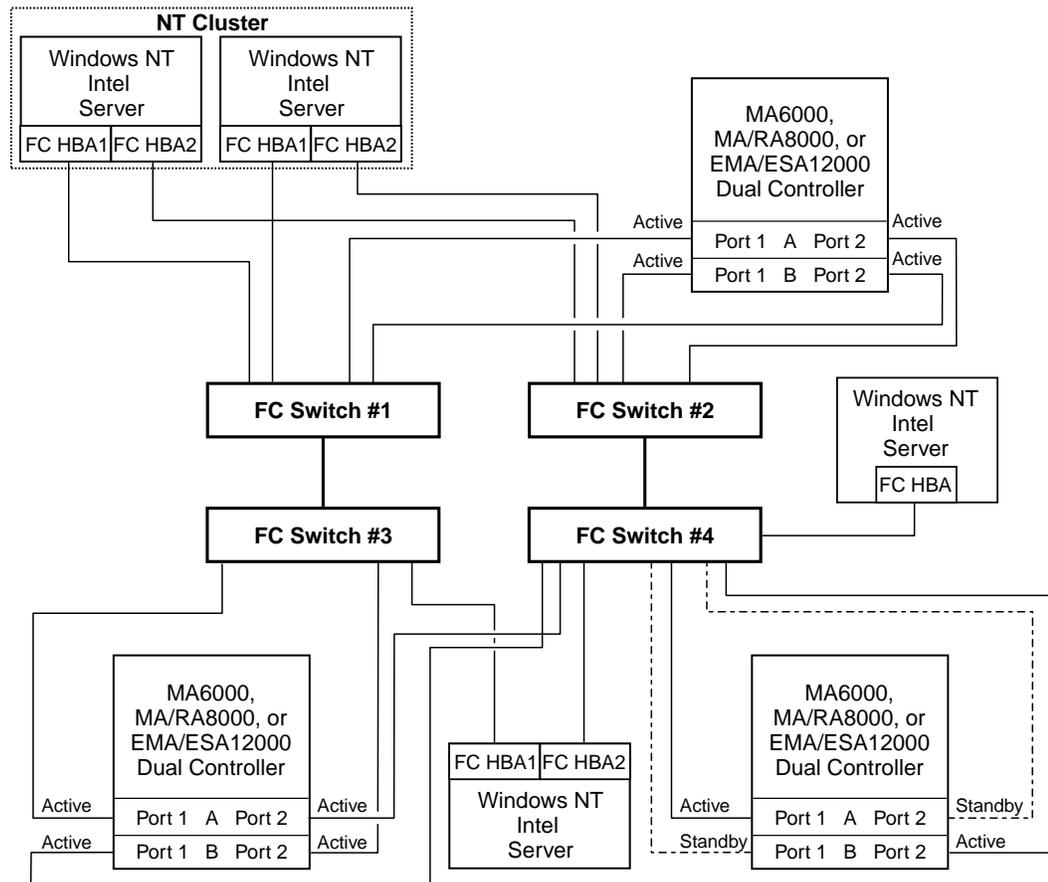
Use these general performance rules to determine the optimum number of ISLs required between both switches:

- For balanced SAN performance configure one storage system on each Fibre Channel switch.
- For the highest available performance, whenever possible, devices that exchange the highest amount of data should be connected to the same Fibre Channel switch, for example, servers and the storage assigned to them should be configured on the same Fibre Channel switch, otherwise:
- For high bandwidth applications – One ISL between switches for every two storage controller ports on one switch being accessed by a server on the other switch.
- For high throughput applications – One ISL between switches for every six storage controller ports on one switch being accessed by a server on the other switch.

SAN Fabric Configuration 4 – Four Fibre Channel Switches, Cascaded High Availability Fault Tolerant Fabric, Secure Path, Controller Multiple-Bus Failover Mode, Integrated EBS

SAN Fabric configuration 4 (Figure 5) is a high availability no single point of failure cascaded switch configuration that provides increased server, disk, and tape storage connectivity capabilities. This configuration uses two separate Fabrics to provide two data paths between servers and disk storage configured in Multiple-Bus failover mode. Tape storage can be configured on one of the Fabrics to provide backup and restore capabilities. Up to 26 separate (non-cooperating) servers or up to 13 pairs of clustered (cooperating) servers can be connected through four 16-port Fibre Channel switches to two storage systems. With 8-port Fibre Channel switches up to six servers can be connected to one storage system. With either switch type the number of storage systems can be increased if the number of servers is reduced to provide switch ports for storage. This SAN configuration utilizes the high availability features of controller Multiple-Bus failover and Compaq Secure Path for Windows NT/Windows 2000 software. With two Fibre Channel HBAs in each server and four Fibre Channel switches in two separate isolated Fabrics, a second separate path to the storage is provided to each server. The two switch pairs form isolated Fabrics providing the highest level of storage path fault tolerance should a failure occur with any path component - Fibre Channel HBA, Fibre Channel Switch, Fabric path interconnect, or storage controller. Non-HA configured servers and storage configured in Transparent Failover Mode are supported in this configuration; however access may be limited to one or the other of the two Fabrics unless two Fibre Channel HBAs are utilized, each connected to a different Fabric.

NOTE: High availability storage using Secure Path for Windows NT/Windows 2000 and Controller Multiple-bus Failover Mode is supported in this configuration provided that switch zoning is used to define two logical paths.



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Figure 5. Four Switches, Cascaded HA Fault Tolerant Fabric Configuration Example

SAN Configuration 4 Server/Storage Connectivity Rules

- This configuration supports any mix of Windows NT/Windows 2000 Intel Servers - standalone or clustered, configured for HA or non-HA, and any mix of Multiple-bus Failover and Transparent Failover storage systems. The calculations shown in the following section however assume: All servers configured for HA, all controllers configured in Multiple-bus failover mode, two Fibre Channel switches and two Fibre Channel HBAs per server, an even storage port count, and no EBS ports.

- 16-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 60

Maximum Server Connectivity,

Up to 26 Servers and two Storage Systems (eight Active storage ports)

$[(64 - 4 \text{ ISL ports} - 8 \text{ storage ports})/2 = 26 \text{ servers}]$

Maximum of 16 servers configured on any one controller pair

Maximum of eight servers configured on any one active controller host port

Or Maximum Storage Capacity,

Up to 12 Storage Systems (48 Storage Ports) and six HA Servers

$[64 - 4 \text{ ISL ports} - 12 \text{ server ports} = 48 \text{ storage ports}]$

Maximum of four active controller host ports per Fibre Channel HBA

- 8-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 28
Maximum Server Connectivity,
 - Up to 12 Servers and one Storage System (four storage ports)
 - $[(32 - 4 \text{ ISL ports} - 4 \text{ storage ports})/2 = 12 \text{ server ports}]$
 - Maximum of eight servers configured on any active controller host port
 Or Maximum Storage Capacity,
 - Up to six Storage Systems (22 storage ports) and three HA Servers
 - $[32 - 4 \text{ ISL ports} - 6 \text{ server ports} = 22 \text{ storage ports}]$
 - Maximum of four active controller host ports per Fibre Channel HBA
- For dual path high availability, HSG60 or HSG80 controller pairs are configured in Multiple-Bus Failover Mode, for single path servers (non-HA) controllers are configured in Transparent Failover Mode
- EBS Integration Supported

SAN Configuration 4 Fabric Rules

- Total Switches = 4, 16-port or 8-port
- Maximum number of ISLs between the two switches in each path = 16, up to eight active to the same destination
- Maximum Distances:
 - Up to 500 meters per Fibre Channel cable segment, 1.5 km total server to storage when using 50 micron multi-mode fiber optic cable. Refer to general Fabric rules for other cable types.
 - Up to 10 km per inter-switch link, 11 km total server to storage when using 9 micron single mode fiber optic cable and long wavelength GBICs.
 - Up to 100 km cable segment using very long distance GBICs and 9 micron single-mode fibre optic cable. 100 km links are only supported in switch to switch connections. Maximum of one hop is supported for 100km distances.

SAN Configuration 4 Notes

- Each Fibre Channel Switch within a path must have a unique domain number (Domain_ID)
- When configured with greater than one Windows NT/Windows 2000 Server or Fibre Channel HBA, use SSP to assign exclusive access to units (LUNs) to specific server Fibre Channel HBAs.
 - NOTE:** Shared access between different servers to the same storage unit (LUN) requires specific application software (i.e., MSCS) to ensure proper data preservation.
- When configured with greater than four Windows NT/Windows 2000 Servers per active controller host port, classified as an “NT Extended Configuration” (refer to the StorageWorks Windows NT/Windows 2000 Platform Kit Fibre Channel Software Setup Utility)
- Uses Compaq Secure Path for Windows NT/Windows 2000 (minimum version 3.1)
- One instance of the Secure Path Manager can manage multiple standalone servers or multiple clustered servers. Use more than one instance if you need to concurrently manage environments that include both standalone servers and clustered servers. All instances can be run from a single Client if desired.
- Depending on your specific application needs, configure either for maximum LUNs or for maximum controller port PATH accessibility

- ❑ For Maximum LUN Count – Up to 16 LUNs per server Fibre Channel HBA for each storage system with four active controller host ports. Each server is configured for access to two paths and two controller ports, using either Port 1 of both controllers or Port 2 of both controllers. Suggested distinct controller port unit number and offset value assignment: For servers accessing controller Port 1, assign unit number and offset values in the range of 0 – 99. For servers accessing controller Port 2, assign unit number and offset values in the range of 100 – 199. Use the Preferred Path unit parameter to assign units to specific controllers for static load balancing.
- ❑ For Maximum Controller Port PATH Accessibility – Up to eight LUNs per server Fibre Channel HBA for each storage system with four active controller host ports. Suggested controller unit number and offset value assignment: All controller port connections assign unit number and offset values in the range of 0 – 199. Use SSP to set exclusive access of units to specific server Fibre Channel HBA(s). Use the Preferred Path unit parameter to assign units to specific controllers. Units should be distributed equally across controllers for static load balancing. Dynamic load distribution between two ports on the same controller is available for standalone servers.
- Depending on the specific number of servers and storage systems utilized in this SAN configuration, it is possible to exceed the available total number of connection name entries in a storage system. (See Windows NT/Windows 2000 Server/Storage Rules). This situation can be avoided by using Fibre Channel switch Zoning to define separate Zones for each of the server groups that you wish to configure with specific storage systems.
- Performance considerations, assuming relatively equal server load:

If using two storage systems, for balanced performance across all servers, configure half of the servers on each of the storage systems and equally on the controller port pairs.

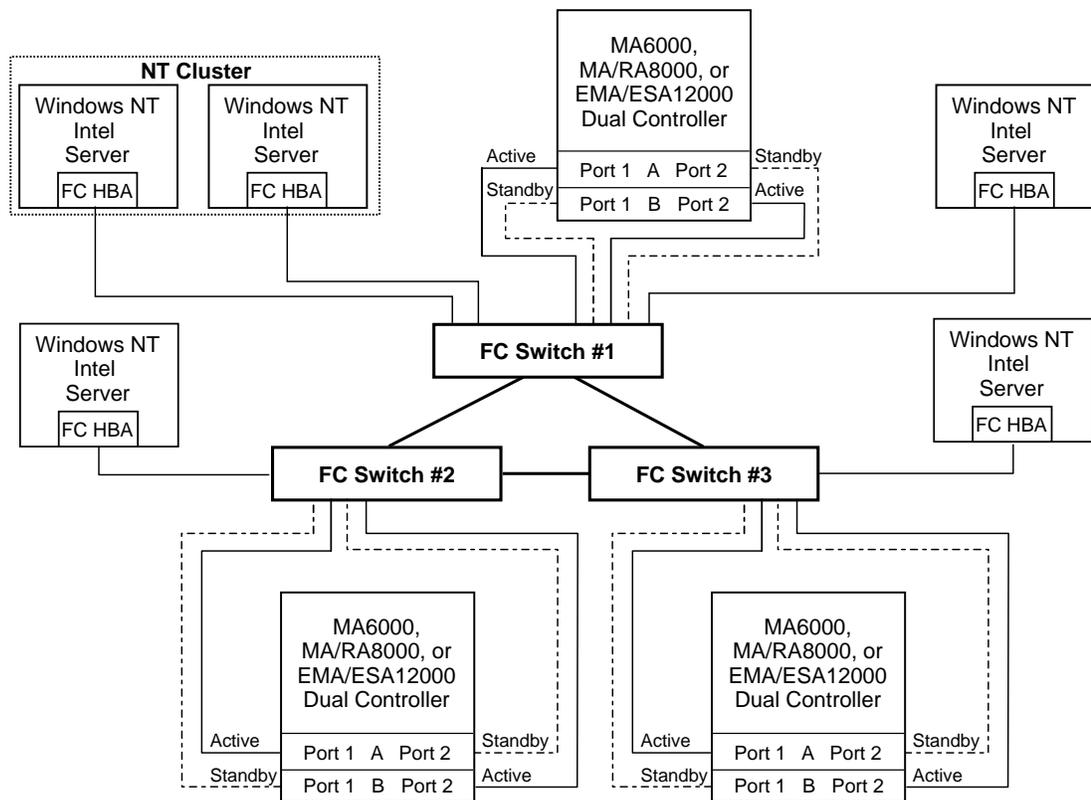
The recommended maximum number of controller host ports configured per Fibre Channel HBA is two for high bandwidth applications and four for high throughput applications.

Use these general performance rules to determine the optimum number of ISLs required between both switches:

- ❑ For balanced SAN performance configure one storage system on each Fibre Channel switch.
- ❑ For the highest available performance, whenever possible, devices that exchange the highest amount of data should be connected to the same Fibre Channel switch, for example, servers and the storage assigned to them should be configured on the same Fibre Channel switch, otherwise:
- ❑ For high bandwidth applications – One ISL between switches for every two storage controller ports on one switch being accessed by a server on the other switch.
- ❑ For high throughput applications – One ISL between switches for every six storage controller ports on one switch being accessed by a server on the other switch.

SAN Fabric Configuration 5 – Three Fibre Channel Switches, Meshed Fabric, Controller Transparent or Multiple-Bus Failover Mode

SAN Fabric configuration 5 (Figure 6) is a meshed Fabric switch configuration that provides increased server, disk, and tape storage connectivity capabilities in addition to Fabric resiliency. All of the switches in the Fabric are interconnected providing alternate paths within the Fabric. This Fabric feature automatically reconfigures a route to a good path should a component in a Fabric path fail. Up to 32 separate (non-cooperating) servers or up to 16 pairs of clustered (cooperating) servers can be connected through 3 16-port Fibre Channel switches to two storage systems. With 8-port Fibre Channel switches up to 14 servers can be connected to one storage system. With either switch type the number of storage systems can be increased if the number of servers is reduced to provide switch ports for storage. A minimum of one ISL is required between each of the 3 switches, more may be required based on the specific server and storage configuration and count, and the applications utilized. The ISL(s) can be up to 10 km allowing connectivity between three remote sites. The HSG60 or HSG80 array controllers within the storage system can be configured in Transparent or Multiple-Bus failover mode. Multiple Bus failover mode requires Compaq Secure Path for Windows NT/Windows 2000 and two Fibre Channel HBAs, each configured in a different Fabric zone.



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Figure 6. Three Switches, Meshed Fabric Configuration Example

NOTE: High availability storage using Secure Path for Windows NT/Windows 2000 and Controller Multiple-Bus Failover Mode is supported in this configuration provided that switch zoning is used to define two logical paths. For Windows 2000, Transparent Failover storage systems and the servers accessing them must be configured in fabric zones separate from zones using Multiple-Bus Failover Mode.

SAN Configuration 5 Server/Storage Connectivity Rules

- Any mix of Windows NT/Windows 2000 Intel Servers - standalone or clustered, configured for HA or non-HA, and any mix of Multiple-bus Failover and Transparent Failover storage systems.
- The calculations shown assume one Fibre Channel HBA per server, an even storage port count, and no EBS ports. The available port totals will be reduced if implementing this configuration with multiple paths and Multiple-Bus failover mode.
- 16-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 42
 - Maximum Server Connectivity,
 - Up to 32 Servers and two Storage Systems (eight storage ports/four Active, four Standby) [48 – 6 ISL ports – 8 storage ports = 34, use 32 server ports maximum, two unused]
 - Maximum of 16 servers configured on any one controller pair
 - Maximum of eight servers configured on any active controller host port
 - Or Maximum Storage Capacity,
 - Up to nine Storage Systems (36 storage ports/18 Active, 18 Standby) and six Servers [48 – 6 ISL ports – 6 server ports = 36 storage ports]
 - Maximum of four active controller host ports per Fibre Channel HBA
- 8-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 18
 - Maximum Server Connectivity,
 - Up to 14 Servers and one Storage System (4 storage ports/2 Active, 2 Standby) [24 – 6 ISL ports – 4 storage ports = 14 server ports]
 - Maximum of eight servers configured on any active controller host port
 - Or Maximum Storage Capacity,
 - Up to four Storage Systems (16 storage ports/eight Active, eight Standby) and two Servers [24 – 6 ISL ports – 2 server ports = 16 storage ports]
 - Maximum of four active controller host ports per Fibre Channel HBA
- All HSG60 or HSG80 array controllers configured in Transparent or Multiple-Bus Failover Mode.

NOTE: High availability storage using Secure Path for Windows NT/Windows 2000 and Controller Multiple-Bus Failover Mode is supported in this configuration provided that switch zoning is used to define two logical paths. For Windows 2000, Transparent Failover storage systems and the servers accessing them must be configured in fabric zones separate from zones using Multiple-Bus Failover Mode.

SAN Configuration 5 Fabric Rules

- Total Switches = 3, 16-port or 8-port
- Maximum number of ISLs between any two switches = 16, up to eight active to the same destination
- Maximum Distances:
 - Up to 500 meters per Fibre Channel cable segment, 1.5 km total server to storage (2.0 km worst case) when using 50 micron multi-mode fiber optic cable. Refer to general Fabric rules for other cable types.
 - Up to 10 km per inter-switch link, 11 km total server to storage (21 km worst case) when using 9 micron single mode fiber optic cable and long wavelength GBICs.
 - Up to 100 km cable segment using very long distance GBICs and 9 micron single-mode fibre optic cable. 100 km links are only supported in switch to switch connections. Maximum of one hop is supported for 100km distances.

SAN Configuration 5 Notes

- Each Fibre Channel Switch must have a unique domain number (Domain_ID)
- When configured with greater than one Windows NT/Windows 2000 Server or Fibre Channel HBA, use SSP to assign exclusive access to units (LUNs) to specific server Fibre Channel HBAs.
 - NOTE: Shared access between different servers to the same storage unit (LUN) requires specific application software (i.e., MSCS) to ensure proper data preservation.
- When configured with greater than four Windows NT/Windows 2000 Servers per active controller host port, classified as an “NT Extended Configuration” (refer to the StorageWorks Windows NT/Windows 2000 Platform Kit Fibre Channel Software Setup Utility)
- For servers accessing controller host port 1 use unit number and offset values in the range of 0 – 99, for controller host port 2 use number and offset values in the range 100 -199
- Performance considerations, assuming relatively equal server load:
 - If using three storage systems, for balanced performance across all servers, configure one third of the servers on each of the storage systems and equally on the controller port pairs.
- The recommended maximum number of controller host ports configured per Fibre Channel HBA is two for high bandwidth applications and four for high throughput applications.

Use these general performance rules to determine the optimum number of ISLs required between both switches.

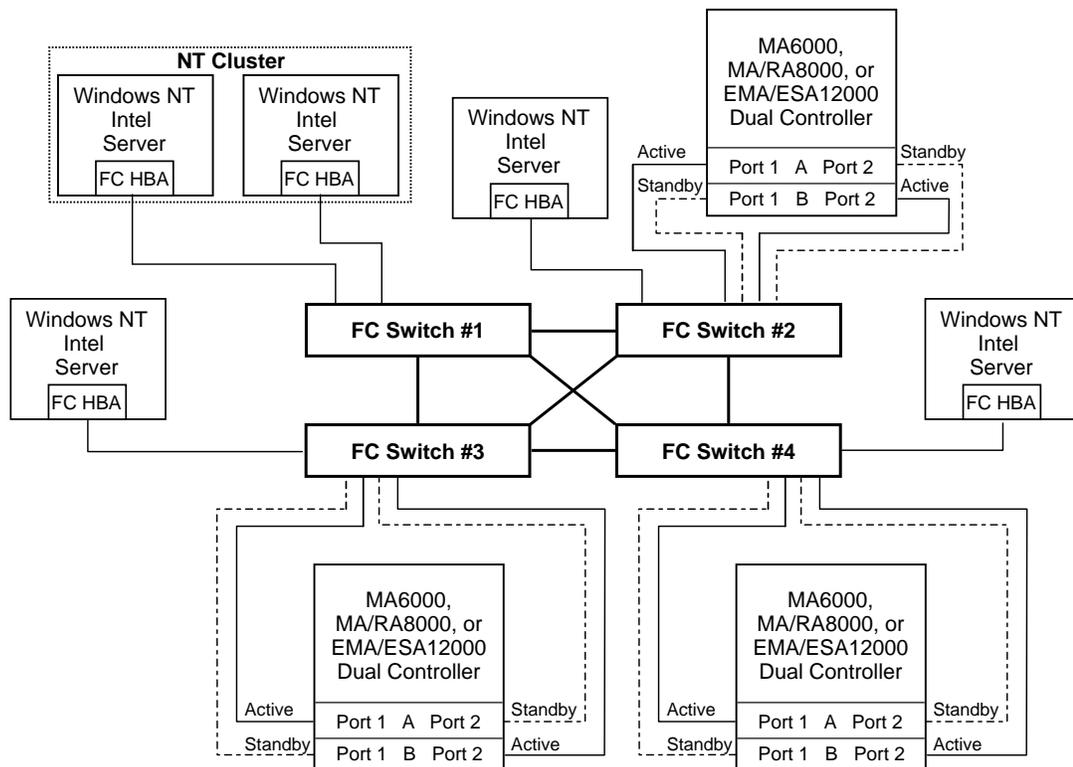
For balanced SAN performance configure one storage system on each Fibre Channel switch.

For the highest available performance, whenever possible, devices that exchange the highest amount of data should be connected to the same Fibre Channel switch, for example, servers and the storage assigned to them should be configured on the same Fibre Channel switch, otherwise:

- For high bandwidth applications – One ISL between switches for every two storage controller ports on one switch being accessed by a server on the other switch.
- For high throughput applications – One ISL between switches for every six storage controller ports on one switch being accessed by a server on the other switch.

SAN Fabric Configuration 6 – Four Fibre Channel Switches, Meshed Fabric, Controller Transparent or Multiple-Bus Failover Mode

SAN Fabric configuration 6 (Figure 7) is a meshed Fabric switch configuration that provides the maximum server and storage connectivity available in a single Fabric. All of the switches in the Fabric are interconnected providing alternate paths within the Fabric. This Fabric feature automatically reconfigures a route to a good path should a component in a Fabric path fail. Up to 40 separate (non-cooperating) servers or up to 20 pairs of clustered (cooperating) servers can be connected through four 16-port Fibre Channel switches to three storage systems. With 8-port Fibre Channel switches up to 16 servers can be connected to one storage system. With either switch type the number of storage systems can be increased if the number of servers is reduced to provide switch ports for storage. A minimum of one ISL is required between each of the four switches and a minimum of two ISLs are required to cross couple the four switches as shown. Additional ISLs may be required based on the specific server and storage configuration and count, and the applications utilized. The cross-coupled ISLs ensure that the hop count within the Fabric does not exceed two for a single path failure. The ISL(s) can be up to 10 km allowing connectivity between four remote sites. The HSG60 or HSG80 array controllers within the storage system can be configured in Transparent or Multiple-Bus failover mode. Multiple Bus failover mode requires Compaq Secure Path for Windows NT/Windows 2000 and two Fibre Channel HBAs, each configured in a different Fabric zone.



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Figure 7. Four Switches, Meshed Fabric Configuration Example

SAN Configuration 6 Server/Storage Connectivity Rules

- Any mix of Windows NT/Windows 2000 Intel Servers - standalone or clustered, configured for HA or non-HA, and any mix of Multiple-bus Failover and Transparent Failover storage.
- The calculations shown assume one Fibre Channel HBA per server, an even storage port count, and no EBS ports. The available port totals will be reduced if implementing this configuration with multiple paths and Multiple-Bus failover mode.
- 16-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 52

Maximum Server Connectivity,

Up to 40 Servers and three Storage Systems (12 storage ports/6 Active, 6 Standby)

[64 – 12 ISL ports – 12 storage ports = 40 server ports]

Maximum of 16 servers configured on any one controller pair

Maximum of eight servers configured on any active controller host port

Or Maximum Storage Capacity,

Up to 12 Storage Systems (46 storage ports/23 Active, 23 Standby) and six Servers

[64 – 12 ISL ports – 6 server ports = 46 storage ports]

Maximum of four active controller host ports per Fibre Channel HBA

- 8-port Fibre Channel Switches, total number of switch ports available for Servers and Storage is 20

Maximum Server Connectivity,

Up to 16 Servers and one Storage System (4 storage ports/2 Active, 2 Standby)

[32 – 12 ISL ports – 4 storage ports = 16 server ports]

Maximum of 16 servers configured on any one controller pair

Maximum of eight servers configured on any active controller host port

Or Maximum Storage Capacity,

Up to four Storage Systems (16 storage ports/eight Active, eight Standby) and four Servers

[32 – 12 ISL ports – 4 server ports = 16 storage ports]

Maximum of four active controller host ports per Fibre Channel HBA

- All HSG60 or HSG80 array controllers configured in Transparent or Multiple-Bus Failover Mode

NOTE: High availability storage using Secure Path for Windows NT/Windows 2000 and Controller Multiple-bus Failover Mode is supported in this configuration provided that switch zoning is used to define two logical paths. For Windows 2000, Transparent Failover storage systems and the servers accessing them must be configured in fabric zones separate from zones using Multiple-Bus Failover Mode.

SAN Configuration 6 Fabric Rules

- Total Switches = 4, 16-port or 8-port
- Maximum number of ISLs between any two switches = 15
- Maximum Distances:
 - Up to 500 meters per Fibre Channel cable segment, 1.5 km total server to storage (2.0 km worst case) when using 50 micron multi-mode fiber optic cable. Refer to general Fabric rules for other cable types
 - Up to 10 km per inter-switch link, 11 km total server to storage (21 km worst case) when using 9 micron single mode fiber optic cable and long wavelength GBICs

Up to 100 km cable segment using very long distance GBICs and 9 micron single-mode fibre optic cable. 100 km links are only supported in switch to switch connections. Maximum of one hop is supported for 100km distances.

SAN Configuration 6 Notes

- Each Fibre Channel Switch must have a unique domain number (Domain_ID)
- When configured with greater than one Windows NT/Windows 2000 Server or Fibre Channel HBA, use SSP to assign exclusive access to units (LUNs) to specific server Fibre Channel HBAs.
 - NOTE: Shared access between different servers to the same storage unit (LUN) requires specific application software (i.e., MSCS) to ensure proper data preservation.
- When configured with greater than four Windows NT/Windows 2000 Servers per active controller host port, classified as an “NT Extended Configuration” (refer to the StorageWorks Windows NT/Windows 2000 Platform Kit Fibre Channel Software Setup Utility)
- For servers accessing controller host port 1 use unit number and offset values in the range of 0–99, for controller host port 2 use number and offset values in the range 100–199.
- Depending on the specific number of servers and storage systems utilized in this SAN configuration, it is possible to exceed the available total number of connection name entries in a storage system. (See Windows NT/Windows 2000 Server/Storage Rules). This situation can be avoided by using Fibre Channel switch Zoning to define separate Zones for each of the server groups that you wish to configure with specific storage systems.
- Performance considerations, assuming relatively equal server load:
 - If using four storage systems, for balanced performance across all servers configure one quarter of the servers on each of the storage systems and equally on the controller port pairs.
 - The recommended maximum number of controller host ports configured per Fibre Channel HBA is two for high bandwidth applications and four for high throughput applications.
 - Use these general performance rules to determine the optimum number of ISLs required between both switches.
 - For balanced SAN performance configure one storage system on each Fibre Channel switch.
 - For the highest available performance, whenever possible, devices that exchange the highest amount of data should be connected to the same Fibre Channel switch, for example, servers and the storage assigned to them should be configured on the same Fibre Channel switch, otherwise:
 - For high bandwidth applications – One ISL between switches for every two storage controller ports on one switch being accessed by a server on the other switch.
 - For high throughput applications – One ISL between switches for every six storage controller ports on one switch being accessed by a server on the other switch.

Configuration References

The following documents provide further information on the configuration of RA8000 and ESA12000 Fibre Channel Storage Systems:

Table 4 Configuration Reference Material

Topic	Document Title	Order Number
Heterogeneous SAN Design	Heterogeneous Open SAN Design Reference Guide	AA-RMPNA-TE
Sun SAN Application Note	Storage Area Network Configurations for RA8000/ESA12000 on Sun Solaris	EK-SMA37-AN
HP-UX SAN Application Note	Storage Area Network Configurations for RA8000/ESA12000 on HP-UX	EK-SMA32-AN
OpenVMS SAN Application Note	Storage Area Network Configurations for RA8000/ESA12000 on OpenVMS	EK-SMA34-AN
Tru64 UNIX SAN Application Note	RA8000/ESA12000 Fibre Channel-Switch Configurations for Tru64 UNIX	EK-SMA33-AN
Novell NetWare Application Note	RA8000/ESA12000 FC-AL Configurations for Novell Netware	EK-FCALN-AA
Windows NT – Intel Standard FC-AL Configurations Application Note	RA8000/ESA12000 FC-AL Configurations for Windows NT - Intel	*AA-RHORB-TE
Windows NT – Intel High Availability FC-AL Configurations Application Note	RA8000/ESA12000 FC-AL High Availability Configurations for Windows NT - Intel	*AA-RHOSC-TE
Windows NT - Intel HSG80 Array Controller	Release Notes, HSG80 Array Controller (ACS V8.5F) for Windows NT Server - Intel	AA-RHOQB-TE or 387393-002
Windows NT - Intel RA8000/ESA12000 Installation	RA8000/ESA12000 Fibre Channel Solution Software for Windows NT – Intel Installation Reference Guide	AA-RFA9C-TE
Windows NT Clusters	RAID Array 8000/ESA12000 Fibre Channel Cluster Solutions for Windows NT	EK-NTC8K-IG
Secure Path Installation	StorageWorks Secure Path v3.0 for Windows NT – Installation and Reference Guide	AA-RL4SA-TE
HSG80 Array Controller Configuration	HSG80 Array Controller ACS Version 8.5 Configuration Guide	EK-HSG85-CG or 165144-001
HSG80 Array Controller Command Line Interface	HSG80 Array Controller ACS Version 8.5 CLI Reference Guide	EK-HSG85-RG or 165145-001
HSG80 Array Controller Maintenance	HSG80 Array Controller ACS Version 8.5 Maintenance and Service Guide	EK-HSG84-SV or 118620-002
StorageWorks Command Console	Command Console V2.2 (HSG80) for RAID Array 8000/ESA12000, User's Guide	AA-RFA2D-TE

* Refer to the website for the latest information.

