

# *Compaq StorageWorks*

## *Application Note*

### *Storage Area Network Configurations for RA/MA8000 and ESA/EMA12000 on Windows 2000 Datacenter Server*

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## Introduction

This application note describes the Fibre channel switch based Storage Area Network (SAN) configurations for Compaq StorageWorks™ RA/MA8000 and ESA/EMA12000 storage systems on Microsoft Windows 2000 Datacenter Server platforms.

## Enterprise Network Storage Architecture

The Compaq Enterprise Network Storage Architecture (ENSA) 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 addition of multi-switch fibre channel Fabric support in the RA/MA8000 and ESA/EMA12000 FC 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.

## Compaq Windows 2000 Datacenter Serve Program

The Compaq Datacenter program broadens the reach of Compaq *ProLiant*™ servers, Compaq StorageWorks storage systems and Compaq SANworks™ Enterprise Storage Solutions into a market traditionally dominated by high-cost, proprietary systems and delivers the same levels of reliability and stability at a fraction of the cost.

Cornerstones of the Compaq Datacenter solutions program include scalability, reliability and stability, availability and support. Compaq provides the most scalable x86 platforms with 8-way and 32-way ProLiant servers and StorageWorks MA8000 and EMA12000 storage arrays with breakthrough enclosure architecture that can scale from a few gigabytes up to 4.5 terabytes in a single storage system (using 36.4 GB drives). Compaq delivers the highest levels of reliability and stability possible through the Datacenter certification program and change management process. High-availability features within ProLiant servers and StorageWorks storage systems deliver access to mission-critical data. The new Datacenter support infrastructure, including a Joint Support team from Compaq and Microsoft, ensures customers have a single point of accountability for fast problem resolution.

To achieve highly reliable and available solutions, the Compaq and Microsoft Datacenter programs require fixed, certified configurations with extensive testing to enable the special customer services offerings available with the program. In addition to the use of certified versions of kernel drivers, the Datacenter program restricts the variety of SAN topologies to the few thoroughly tested configurations described in this Application Note. Up-to-date Datacenter configuration information can be found at [www.compaq.com/solutions/datacenter](http://www.compaq.com/solutions/datacenter).

## Product Overview

The RA/MA8000 and ESA/EMA12000 FC 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 FC-Fabric (switch).

The ESA/EMA12000 FC, designed for the data center, is available in three easy-to-order building blocks; each optimized for specific, high-capacity customer requirements. The ESA/EMA12000 FC offers unprecedented levels of storage, scaling in performance and capacity as user requirements increase.

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 integrity 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 integrity and supporting high availability.

The RA/MA8000 and ESA/EMA12000 FC 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 Compaq 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

Microsoft Cluster Server (MSCS) software provides a clustering technology that keeps server-based applications highly available, regardless of individual component failures. The primary function of MSCS occurs when one server in a cluster fails or is taken offline. With MSCS, one of the other servers takes over the failed/offline server's operations. Clients using server resources experience little or no interruption of their work because the resource functions move from one server to the other.

The RA/MA8000 and ESA/EMA12000 FC storage systems are supported in Windows 2000 MSCS cluster configurations. For highest availability, two hardware paths between the clustered servers and the RA/MA8000 or ESA/EMA12000 FC storage system can be configured using dual host bus adapters, dual fibre channel fabrics, dual raid controllers configured in multibus failover, and Compaq StorageWorks™ *SecurePath for Windows 2000 and Windows 2000 Datacenter Server*. This configuration provides two separate physical paths between the servers and the storage.

## SecurePath for Windows 2000 and Windows 2000 Datacenter Server

SecurePath is a high availability software product providing continuous data access for RA/MA8000 and ESA/EMA12000 FC storage products configured on Windows 2000 Datacenter Server platforms. Redundant hardware, advanced RAID technology and automated failover capability are used to enhance fault tolerance and availability. SecurePath effectively eliminates controllers, interconnect hardware, and host bus adapters as single points of failure in the storage system.

Key to SecurePath's functionality is the capability of RA/MA8000 and ESA/EMA12000 FC dual 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 SecurePath 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 SecurePath 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 SecurePath, 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.

## SAN Concepts

A Storage Area Network (SAN) 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 Performance Considerations

The performance of an application on a system that utilizes RA/MA8000 or ESA/EMA12000 FC storage can be limited by many different components of the system and the configuration of the SAN. Some of the possible component limiting factors includes the host CPU(s), memory size, FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, 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 FC 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 RA/MA8000 and ESA/EMA12000 FC 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 FC-Fabric Components**

Transfer Size	IO/sec (small transfer sizes, random access)		MB/sec (large transfer sizes, sequential access)	
	Read	Write	Read	Write
Operation Type				
FC HBA - KGPSA-BC	15,500	14,250	86	51
FC Switch (see note)	400,000	400,000	1600	1600
FC Switch ISL (see note)	25,000	25,000	100	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
EBS	TBS	TBS	TBS	TBS

### 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 SANs including the base Fabric design selection, fibre channel Fabric rules, platform and disk storage connectivity rules, Enterprise Backup integration rules and SecurePath for 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.

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 2000 Datacenter Server 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.

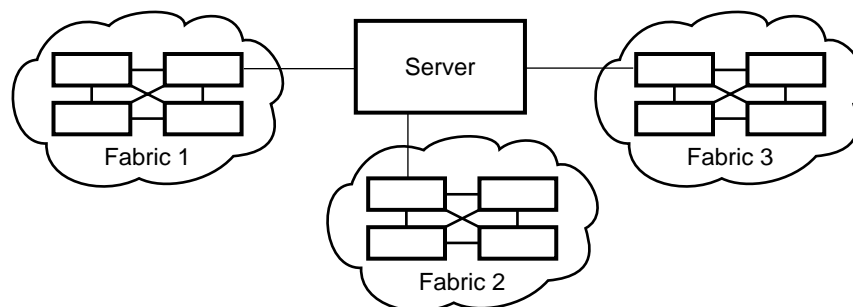
1. Considering capacity, connectivity, availability, distance, performance, and backup requirements, select the SAN Fabric configuration that best fits your needs. Refer to the configuration illustrations, notes, Fabric rules, and platform server and storage connectivity rules. Using the maximum server and maximum storage counts shown as the upper bound limits, determine the specific number of servers or storage required number for your particular installation.
  - For high availability in a Windows 2000 Datacenter Server environment, No Single Point of Failure (NSPOF) SAN configurations with SecurePath are required. Refer to the SecurePath for Windows 2000 rules.
  - For cost-sensitive Datacenter configurations where high availability and clustering is not required, a single-fabric, non-SecurePath SAN configuration is available including a single HBA in each server, SAN Switches in single or cascaded configuration, and either a single HSG80 controller or dual HSG80 controllers in Transparent Failover mode.
  - 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 capacity or connection needs are greater than provided in a 4 switch Fabric, consider implementing multiple 4-switch Fabrics (future releases will support inter-connection of multiple Fabrics into a single Fabric to provide for growth and scaling of the SAN).
2. If you are configuring a homogeneous Windows 2000 Intel SAN, refer to the 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 2000 Intel platforms in a homogeneous SAN configuration.
3. If you are configuring a heterogeneous SAN, refer to the appropriate platform application note(s) and the heterogeneous SAN application note referenced in Table 3 to ensure platform interaction. Line 2 in Table 3 lists the configuration maximums for Windows 2000 Datacenter Server platforms in a heterogeneous SAN configuration.
4. If implementing a SAN integrating Compaq Enterprise Backup on your SAN, refer to the Enterprise Backup Solution Integration Rules.
  1. Select the desired methods of SAN management and access control based on your specific needs. The Compaq SANworks™ *Management Appliance* is highly recommended for storageset management and controller based SSP or switch based Zoning (or both) for disk storage access control. SWCC is also supported. Use Compaq *SecurePath*™ *Manager* to manage high availability and Veritas™ NetBackup 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 2000 Datacenter Server platforms for servers and storage, enterprise backup integration, and high availability storage.

### Fabric Rules

- Up to 4 fibre channel switches total in a single Fabric—a SAN with all switches interconnected. All Compaq FC 16-port and 8-port switch models are supported inter-mixed.
- A server can attach to multiple multi-switch 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters supported.
- Within a single Fabric, maximum of 1 switch hop between servers and storage, maximum of 2 switch hops worst case with a single fault—a Fabric can re-route to a 2-hop path on a single link failure. A hop is defined as 1 or more connections between two FC switches, for example: 2 switches cascaded equal 1 hop. Server to FC switch segments and Storage to FC switch segments are not counted as hops.
- Within a single Fabric where switches are interconnected, each FC switch must have a unique domain number (Domain\_ID).
- Up to 16 inter-switch links (ISLs) between any 2 switches, up to 8 active to the same destination.
- Minimum cable segment length is 2 meters.
- Up to 200 meters per cable segment using short-wavelength laser GBICs and 62.5 micron multi-mode fiber optic cable. With multiple cable segments 600 meters total distance nominal, 800 meters worst case with a single fault re-route, between server and storage.
- Up to 500 meters per cable segment using short-wavelength laser GBICs and 50 micron multi-mode fibre optic cable. With multiple cable segments 1.5 km total distance nominal, 2.0 km worst case with a single fault re-route, between server and storage.
- Up to 10 km per ISL cable segment using long-wavelength laser GBICs and 9 micron single-mode fibre optic cable. With multiple cable segments 11 kilometers total distance nominal, 21 km worst case with a single fault re-route, between server and storage. 10 km links are only supported in switch to switch connections.



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Figure 1 One Server to Multiple 4-Switch Fabrics

## Window NT and Windows 2000 Server/Storage Rules

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

**Table 2 Guidelines for Windows 2000 Server Platform Supported Maximums**

Maximum Supported Number of:	Host Bus Adapters (HBA) per Server <sup>(1)</sup>	Active Controller Host Ports (HBA Targets) per HBA <sup>(2)</sup>	LUNs per HBA Target <sup>(3)</sup>	HBAs per Server per Switch Zone <sup>(4)</sup>	Active Servers per Storage System <sup>(5)</sup>
Windows 2000 SAN	2	4	8	4	16
Heterogeneous SAN					8

*Table Notes:*

- For Windows 2000 Datacenter Server configurations, the maximum number of HBAs per server limited to 2. The actual maximum number of HBAs per server may be dependent on the specific server model.
  - The recommended maximum number of active HSG80 controller host ports a single HBA can simultaneously access, the actual number of Targets available is 16, including the HBA.
  - The maximum number of LUNs per SCSI target. The maximum number of LUNs per target a host bus adapter can address in a SAN may be less.
  - The maximum number of HBAs per server that can be connected to the same switch zone.
  - This column gives the maximum number of active hosts for one storage system in a Homogenous Windows NT/2000 SAN. This assumes 1 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter per host for non-HA Transparent Failover configurations and 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters per host for HA Multiple-bus Failover configurations as required for Windows 2000 Datacenter Server configurations. The Heterogeneous SAN entry is the maximum total number of active hosts when multiple different operating system types (other than Windows NT or 2000) are accessing the same storage system.
- All configurations are supported under Windows NT 4.0 using SP4 through SP6, Windows 2000 versions using SP1, and Windows 2000 Datacenter Sever.
  - For Windows NT/2000 versions, all server connections into the SAN use the FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter. FC FL-Port HBA connections are not supported.
  - The maximum number of FC-Fabric 64-Bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters per server is 4, however for high availability Datacenter configurations it is limited to 2.
  - The maximum number of active controller ports per FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter is 4.
  - Any combination of Windows NT/2000 Servers—standalone or clustered and RA/MA8000 and ESA/EMA12000 storage systems are allowed per SAN configuration, provided these rules are followed:
    - You can have a maximum of 16 Windows NT, Windows 2000, or Datacenter 2000 Servers with one FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter per server. You can have a maximum of 8 Windows NT, Windows 2000, or Datacenter 2000 Servers with 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters per server. You can configure a maximum of 8 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters on each active port of an RA/MA8000 or ESA/EMA12000 dual controller storage system.
    - All specific SAN configuration rule limits are followed. Refer to the individual SAN Fabric configurations.
  - All Windows 2000 Datacenter Server configurations require the “Extended Configuration” check box in the StorageWorks Windows 2000 Datacenter Server Solutions Kit Fibre Channel Software Setup utility custom installation setup. Each Windows 2000 Datacenter Server in the SAN must have the option selected. Selecting this option will adjust registry settings for your [DS-KGPSA-CB] host bus adapter to operate in an “Extended Configuration” environment.
  - All configurations require the *Connection Name Operating System* parameter set to “WINNT.”
  - Set SCSI mode to SCSI-2 (default).
  - Each active controller host port presents one SCSI Target ID with up to eight LUNs to each server (FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter) that has a connected path through the Fabric to the port.



- The maximum number of LUNs per HSG80 controller pair is 128.
- Dual redundant controller can be configured for Transparent Failover Mode or Multiple-Bus Failover Mode. Multiple-Bus Failover mode requires SecurePath for Windows 2000 on each server.
- Each storage system can be configured using the SWCC or the Command Line Interface (CLI) through either the HSG80 controller maintenance serial port or a TCP/IP interface.
- ACS V8.5 provides for up to 64 connection name entries. For dual controllers in Transparent Failover Mode, up to 2 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 4 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 FC 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 for example, SERVER1P1, SERVER1P2, etc. (connection names can be a maximum of 9 characters).
- Selective Storage Presentation - for configurations with more than 1 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter 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 (for example, MSCS) to ensure proper data preservation.

- LUNs (logical units) can consist of single disks (JBOD), a storageset of multiple disks or a partition (up to 8), configured for a specific RAID level of 0, 1, 0 + 1, or 3/5.

## Enterprise Backup Solution Integration Rules

- Supports Veritas NetBackup version 3.4.1, Veritas Backup Exec version 8.5 Legato Networker version 6.0.1, CA ARCserve IT 2000 for up to 16 Windows 2000 Datacenter servers
- Supports all Compaq FC 16-port and 8-port switch models inter-mixed
- Connected to the SAN using FC switch Fabric topology connection
- Up to 10 km between FC switch and a tape controller using long-wavelength laser GBICs and 9 micron single-mode fiber optic cable
- Maximum of 1 ESL9326 library with up to 16 drives requires 3 Modular Data Routers
- Up to 7 tape drives

- Maximum of 1 switch hop between servers and a Modular Data Router

**NOTE**

Veritas NetBackup supports up to 2-node clusters. For 4-node clusters, use NetBackup configured as two sets of 2-node clusters.

## SecurePath for Windows 2000 Rules

- All High Availability Multibus Failover configurations for Windows 2000 Datacenter require SecurePath for Windows 2000 version 3.1 with Software Update 2.

**NOTE**

Refer to the SecurePath documentation listed in Table 4 for specific installation procedures.

- For version 3.1 of SecurePath with Software Update 2, one instance of the SecurePath 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 SecurePath configurations utilizing 4 active controller ports connected to the same server or servers offer the flexibility to use the 4 active ports for either increased total LUN count, or increased PATH accessibility to a maximum of 8 LUNs.

For *Maximum LUN Count* use distinct controller port unit offsets and access control on controller port 1 and controller port 2 to configure up to 16 LUNs total, 8 available through each pair of port paths. This means you can configure up to 8 LUNs on the two port 1 paths, and another 8 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 4 controller ports for access to the same 8 LUNs using the same unit offset on all 4 controller ports. In addition to the static controller load balancing feature, in this configuration you can enable dynamic port load distribution, which 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—Storagesets (LUNs) must be enabled for access from both paths using the Unit Connection Name parameter feature.
- For two (or more) server SecurePath 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter 1 to FC Switch 1–Switch Port 1  
 Server 1 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter 2 to FC Switch 2–Switch Port 1  
 Server 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter 1 to FC Switch 1–Switch Port 2  
 Server 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter 2 to FC Switch 2–Switch Port 2

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

## Configuration Descriptions

Table 3 lists four SAN Fabric configuration examples for RA/MA8000 and ESA/EMA12000 storage systems when using Windows 2000 Datacenter Server 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 FC switch, then add a second switch for high availability or increased connectivity, and additional switches as capacity and connectivity needs increase.

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 FC 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 are supported with all Compaq supplied 16-port and 8-port FC switches.

**Table 3 Index of RA/MA8000, ESA/EMA12000 SAN Fabric Configurations for Windows 2000 Datacenter Server**

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3	Four FC Switches, Cascaded High Availability Fault Tolerant Fabric, SecurePath, Controller Multiple-Bus Failover Mode, Integrated EBS	16
4	Eight FC Switches, Cascaded High Availability Fault Tolerant Fabric, SecurePath, Controller Multiple-Bus Failover Mode, Integrated EBS	20

## Additional Information/References

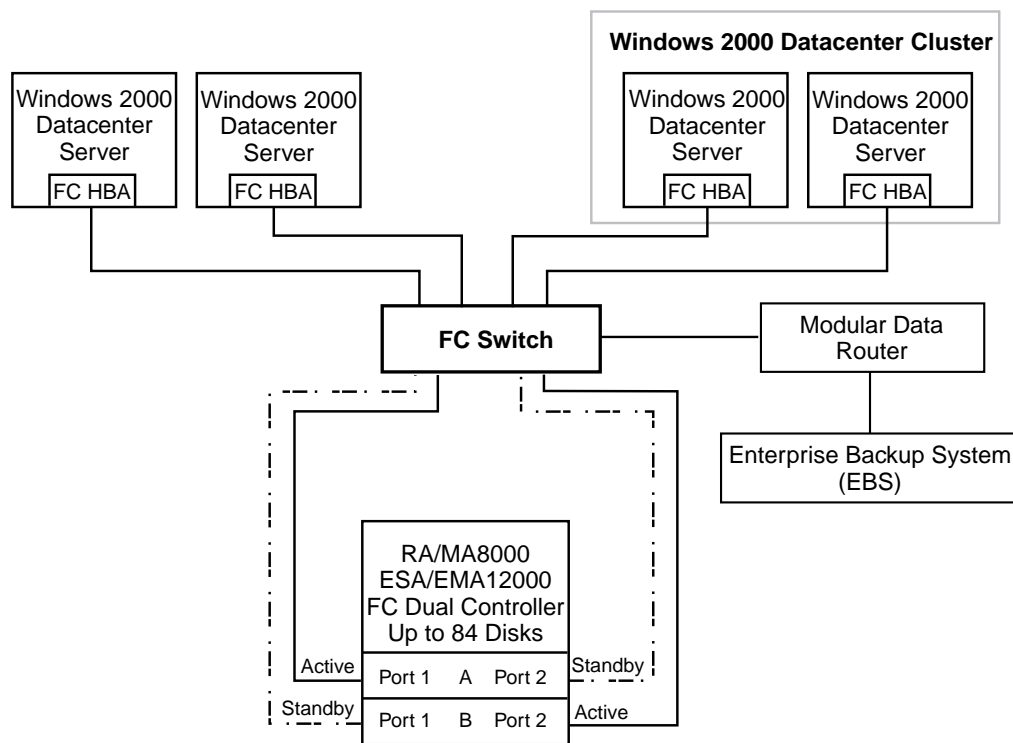
A table of all related product documentation is included at the end of this application note. Refer to these documents for more details on StorageWorks product installation and configuration.

## SAN Fabric Configuration 1 - One FC 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 servers can be connected through a 16-port switch providing access from all servers to a single storage system. With a 16-port FC switch up to 4 servers can be connected to 1 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 HSG80 array controllers within the RA8000 or ESA12000 storage enclosure are configured in Transparent failover mode providing full controller redundancy in the unlikely event of either controller failing.

### NOTE

Compaq Windows 2000 Datacenter 2-node to 4-node clustered configurations are not supported with this SAN configuration. Clustered configurations require dual HBAs, split fabric, SecurePath, and dual HSG80 controllers in Multibus failover mode as described in SAN Fabric Configurations 2 and 3.



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Figure 2 One FC Switch Fabric Configuration Example

### NOTE

One or two HSG80 controllers are supported in an MA/EMA storage array. If two controllers are installed, they must be configured in Transparent Failover mode.

## SAN Configuration 1 Server/Storage Connectivity Rules

- Any mix of Windows NT Intel or Windows 2000 servers and storage systems using these maximums. Assumes 1 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter per server, dual HSG80 controllers, and no EBS ports.
- 16-port FC Switch, total number of switch ports available for Servers and Storage is 16
  - Maximum Server Connectivity,
    - Up to 12 Servers and 1 Storage System (4 storage ports/2 Active, 2 Standby)
    - [16 – 4 storage ports = 12 server ports]
    - Maximum of 8 servers configured on any one active controller host port
  - Or Maximum Storage Capacity,
    - Up to 4 Storage Systems (14 storage ports/7 Active, 7 Standby) and 2 Servers
    - [16 – 2 server ports = 14 storage ports]
- 8-port FC Switch, total number of switch ports available for Servers and Storage is 8
  - Maximum Server Connectivity,
    - Up to 4 Servers and 1 Storage System (4 storage ports/2 Active, 2 Standby)
    - [8 – 4 storage ports = 4 server ports]
  - Or Maximum Storage Capacity,
    - Up to 2 Storage Systems (6 storage ports/3 Active, 3 Standby) and 2 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 = 1, 16-port or 8-port
- Maximum Switch Hops (nominal) = 0
- Maximum Switch Hops (worst case) = 0
- Maximum Distances:
  - Up to 500 meters per FC cable segment, 1 km total server to storage using 50 micron multi-mode fibre optic cable.
  - Refer to general Fabric rules for other cable types.

## SAN Configuration 1 Notes

- When configured with greater than 1 Windows NT Server or FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, use SSP to assign exclusive access to units (LUNs) to specific server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters.

### NOTE

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

- 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter is 2 for high bandwidth applications and 4 for high throughput applications.

## SAN Fabric Configuration 2 – Two FC Switches, High Availability, SecurePath, Controller Multiple-Bus Failover Mode, Integrated EBS

SAN Fabric Configuration 2 (Figure 3) is a high availability storage 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, up to 7 pairs of 2-node clustered (cooperating) servers or up to 3 sets of 4-node clustered servers can be connected through two 16-port FC switches with 1 storage system. With 8-port FC switches up to 6 servers can be connected to 1 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 SecurePath for Windows 2000 software. With 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters in each server, and 2 FC switches, a second separate path to the storage is provided to each server. The 2 switches form isolated Fabrics providing the highest level of storage path fault tolerance should a failure occur with any path component—FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, FC Switch, Fabric path interconnect, or storage controller.

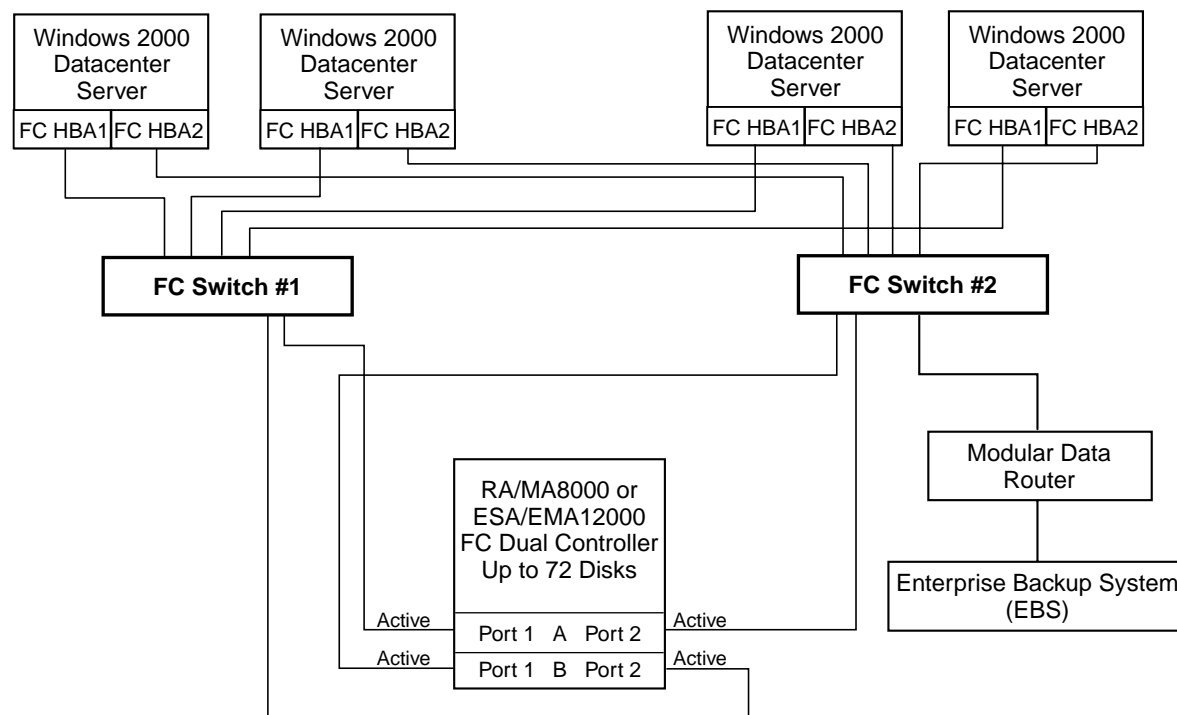


Figure 3 Two FC Switches, HA Fabric Configuration Example

### SAN Configuration 2 Server/Storage Connectivity Rules

- The calculations shown in the following section however assume: All servers configured for HA, all controllers configured in: Multiple-bus failover mode, 2 FC switches and 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters per server, an even storage port count, and no EBS ports.

- 16-port FC Switches, total number of switch ports available for Servers and Storage is 32
  - Maximum Server Connectivity,
    - Up to 14 Servers and 1 Storage System (4 Active storage ports)
    - $[(32 - 4 \text{ storage ports})/2 = 14 \text{ servers}]$
    - Maximum of 8 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters configured on any one active controller host port
  - Or Maximum Storage Capacity,
    - Up to 6 Storage Systems (24 Active storage ports) and 4 HA Servers
    - $[32 - 8 \text{ server ports} = 24 \text{ storage ports}]$
    - Maximum of 4 active controller host ports per FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter
- 8-port FC Switches, total number of switch ports available for Servers and Storage is 16
  - Maximum Server Connectivity,
    - Up to 6 Servers and 1 Storage System (4 Active storage ports)
    - $[(16 - 4 \text{ storage ports})/2 = 6 \text{ servers}]$
  - Or Maximum Storage Capacity,
    - Up to 3 Storage Systems (12 Active storage ports) and 2 HA Servers
    - $[16 - 4 \text{ server ports} = 12 \text{ storage ports}]$

## SAN Configuration 2 Fabric Rules

- Total Switches = 2, 16-port or 8-port
- Maximum Switch Hops (nominal) = 0
- Maximum Switch Hops (worst case) = 0
- Maximum Distances:  
Up to 500 meters per FC cable segment, 1 km total server to storage using 50 micron multi-mode fibre optic cable. Refer to general Fabric rules for other cable types.

## SAN Configuration 2 Notes

- When configured with greater than 1 Windows NT/2000 Server or FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, use SSP to assign exclusive access to units (LUNs) to specific server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters.

### NOTE

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

- Windows 2000 Datacenter server configurations require "Extended Configuration" (refer to the StorageWorks Windows 2000 Solutions Software Setup Utility).
- Uses SecurePath for Windows 2000 (minimum version 3.1 with Software Update 2).
- One instance of the SecurePath 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:

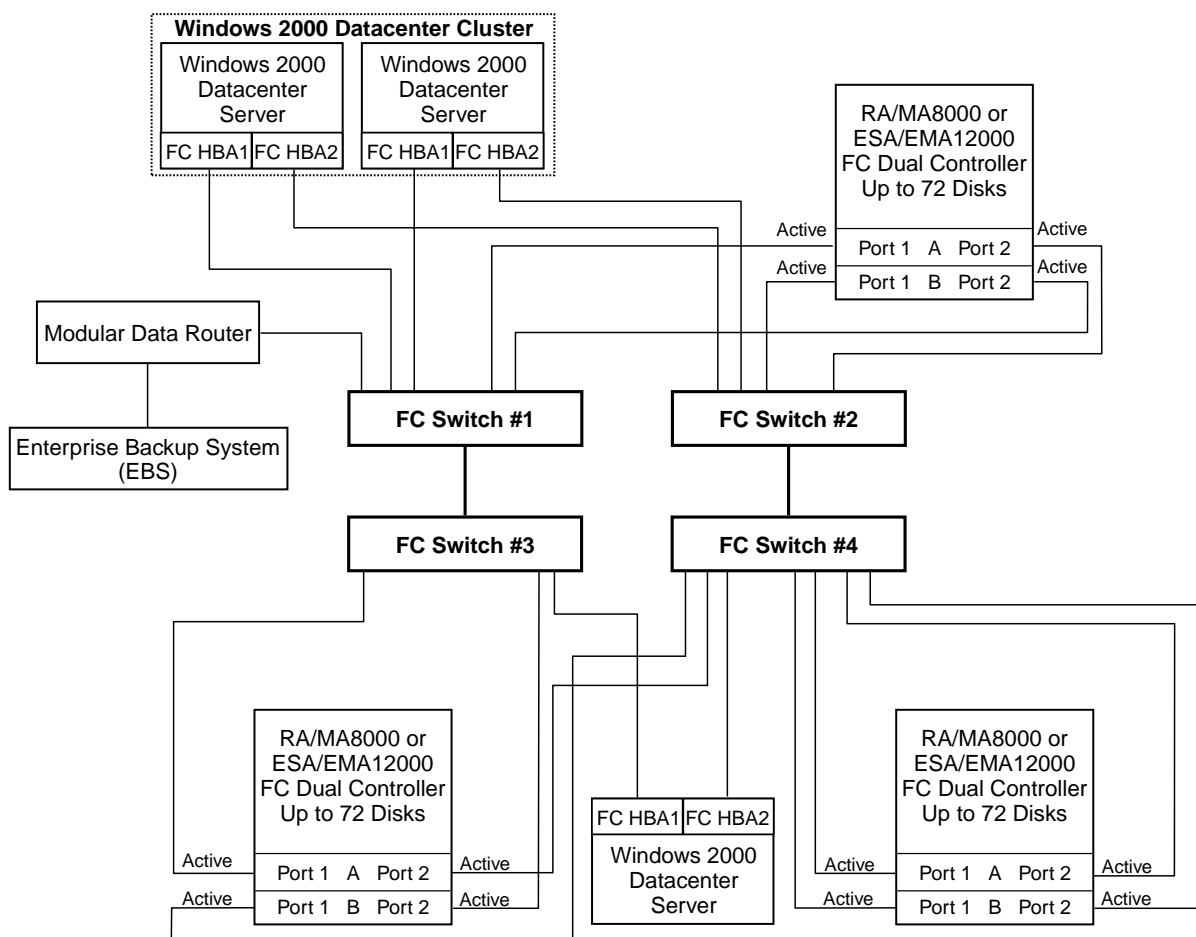
- For Maximum LUN Count—Up to 16 LUNs per server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter for each storage system with 4 active controller host ports. Each server is configured for access to two paths and two controller ports, using either Port 1 of both controllers or Port 2 of 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 8 LUNs per server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter for each storage system with 4 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters. 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter is 2 for high bandwidth applications and 4 for high throughput applications.

### **SAN Fabric Configuration 3 – Four FC Switches, Cascaded High Availability Fault Tolerant Fabric, SecurePath, Controller Multiple-Bus Failover Mode, Integrated EBS**

SAN Fabric Configuration 3 (Figure 4) is a high availability storage 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, up to 13 pairs of 2-node clustered (cooperating) servers or up to 6 sets of 4-node clustered servers can be connected through 4 16-port FC switches to 4 storage systems. With 8-port FC switches up to 6 servers can be connected to 1 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 SecurePath for Windows 2000 software. With 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters in each server and 4 FC switches in 2 separate isolated Fabrics, a second separate path to the storage is provided to each server. The 2 switch pairs form isolated Fabrics providing the highest level of storage path fault tolerance should a failure occur with any path component—FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, FC Switch, Fabric path interconnect, or storage controller.





SHR-1990B

Figure 4 Four FC Switches, Cascaded HA Fault Tolerant Fabric Configuration Example

### SAN Configuration 3 Server/Storage Connectivity Rules

- The calculations shown in the following section however assume: All servers configured for HA, all controllers configured in: Multiple-bus failover mode, 4 FC switches and 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters per server, an even storage port count, and no EBS ports.
- 16-port FC Switches, total number of switch ports available for Servers and Storage is 60

Maximum Server Connectivity,

Up to 26 Servers and 2 Storage Systems (8 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 8 servers configured on any one active controller host port

Or Maximum Storage Capacity,

Up to 12 Storage Systems (48 Storage Ports) and 6 HA Servers

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

Maximum of 4 active controller host ports per FC-Fabric 64-bit/33 MHz

PCI-to-Fibre Channel Host Bus Adapter

- 8-port FC Switches, total number of switch ports available for Servers and Storage is 28

Maximum Server Connectivity,

Up to 12 Servers and 1 Storage System (4 storage ports)

$[(32 - 4 \text{ ISL ports} - 4 \text{ storage ports})/2 = 12 \text{ server ports}]$

Maximum of 8 servers configured on any active controller host port

Or Maximum Storage Capacity,

Up to 6 Storage Systems (22 storage ports) and 3 HA Servers

$[32 - 4 \text{ ISL ports} - 6 \text{ server ports} = 22 \text{ storage ports}]$

Maximum of 4 active controller host ports per FC-Fabric 64-bit/33 MHz

PCI-to-Fibre Channel Host Bus Adapter

### SAN Configuration 3 Fabric Rules

- Total Switches = 4, 16-port or 8-port
- Maximum Switch Hops (nominal) = 1 in each path
- Maximum Switch Hops (worst case ) = 1 in each path
- Maximum number of ISLs between the two switches in each path = 16, up to 8 active to the same destination
- Maximum Distances:
  - Up to 500 meters per FC cable segment, 1.5 km total server to storage when using 50 micron multi-mode fibre 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 fibre optic cable and long wavelength GBICs.

### SAN Configuration 3 Notes

- Each FC Switch within a path must have a unique domain number (Domain\_ID).
- When configured with greater than 1 Windows NT/2000 Server or FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, use SSP to assign exclusive access to units (LUNs) to specific server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters.

#### NOTE

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

- Windows 2000 Datacenter server configurations require "Extended Configuration" (refer to the StorageWorks Windows 2000 Solutions Software Setup Utility).
- Uses SecurePath for Windows 2000 (minimum version 3.1 with Software Update 2).
- One instance of the SecurePath 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter for each storage system with 4 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 8 LUNs per server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter for each storage system with 4 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters. 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 2000 Datacenter Server/Storage Rules). This situation can be avoided by using FC switch Zoning to create 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter is 2 for high bandwidth applications and 4 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 FC switch. For the highest available performance, whenever possible, devices that exchange the highest amount of data should be connected to the same FC switch, for example, servers and the storage assigned to them should be configured on the same FC switch, otherwise:

- For high bandwidth applications—One ISL between switches for every 2 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 6 storage controller ports on one switch being accessed by a server on the other switch.

# SAN Fabric Configuration 4 – Eight FC Switches, Cascaded High Availability Fault Tolerance Fabric, SecurePath, Controller Multiple-Bus Failover Mode, Integrated EBS

SAN Fabric Configuration 4 (Figure 5) is a high availability storage 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 44 separate (non-cooperating) servers, up to 22 pairs of 2-node clustered or up to 11 4-node clustered servers may be connected through 8 16-port FC switches to 4 storage systems. With 8-port FC switches up to 10 servers may be connected to 5 storage systems, however 8-port switches may not be cost effective in this configuration. 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 SecurePath for Windows 2000 software. With 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters in each server and 8 FC switches in 2 isolated Fabrics, a second separate path to the storage is provided to each server. The 2 switch groups for isolated Fabrics providing the highest level of storage path fault tolerance should a failure occur with any path component—FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, FC Switch, Fabric path interconnect, or storage controller.

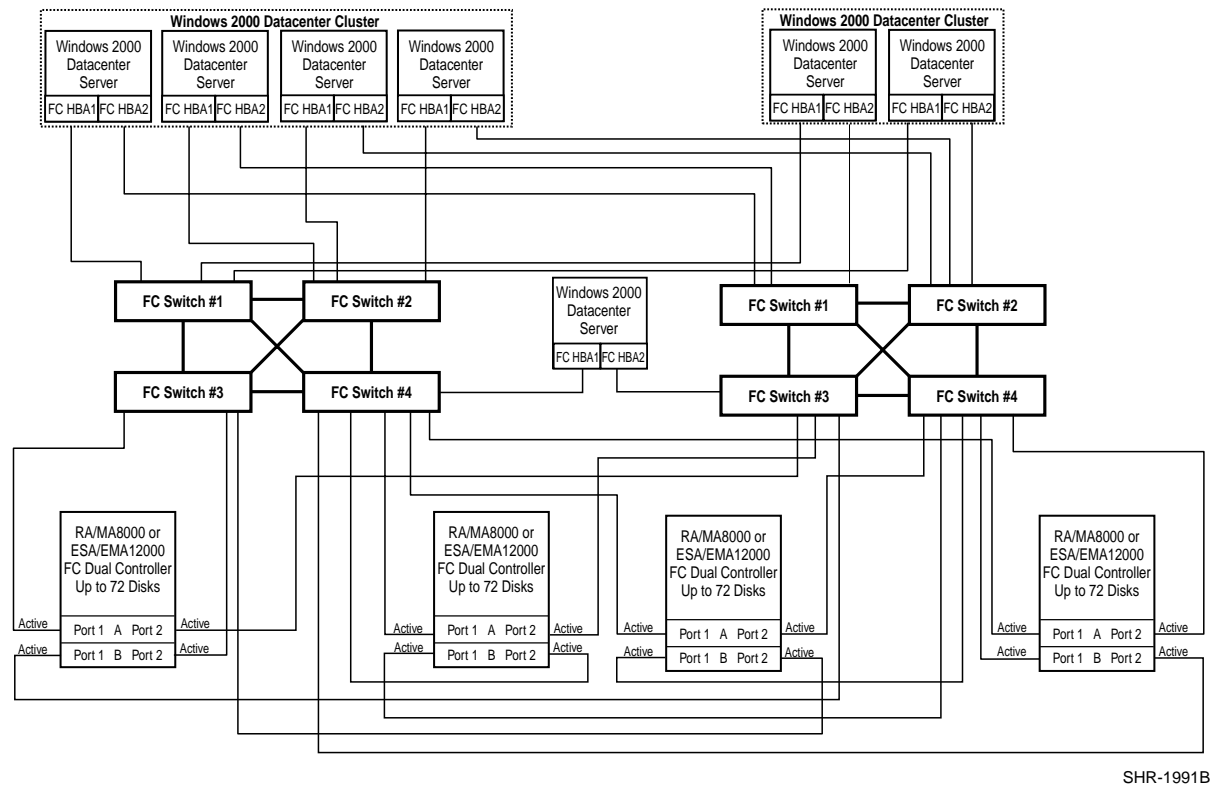


Figure 5 Eight FC Switches, Cascaded HA Fault Tolerant Fabric Configuration Example

## SAN Configuration 4 Server/Storage Connectivity Rules

- The calculations shown in the following section assume: All servers configured for HA, all controllers configured in Multiple-Bus failover mode, 8 FC switches and 2 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters per server, and even storage port count and no EBS ports.
- 16-port FC Switches, total number of switch ports available for Servers and Storage is 104
  - Maximum Server Connectivity,
    - Up to 44 Servers and 4 Storage Systems (16 Active storage ports)
    - $[(128 - 24 \text{ ISL ports} - 16 \text{ storage ports})/2 = 44 \text{ servers}]$
  - Or Maximum Storage Capacity,
    - Up to 20 Storage Systems and 12 HA Servers
    - $[128 - 24 \text{ ISL ports} - 24 \text{ server ports} = 80 \text{ storage ports}]$

## SAN Configuration 4 Fabric Rules

- Total Switches = 8, 16-port or 8-port
- Maximum Switch Hops (nominal) = 1 in each path
- Maximum Switch Hops (worst case) = 2 in each path
- Maximum number of ISLs between any two switches = 16
- Maximum Distances:
  - Up to 500 meters per FC cable segment, 1.5 km total server to storage when using 50 micron multi-mode fibre 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 fibre optic cable and long wavelength GBICs.

## SAN Configuration 4 Notes

- Each FC Switch within a path must have a unique domain number (Domain\_ID).
- When configured with greater than 1 Windows NT/2000 Server or FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter, use SSP to assign exclusive access to units (LUNs) to specific server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters.

### NOTE

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

- Windows 2000 Datacenter server configurations require "Extended Configuration" (refer to the StorageWorks Windows 2000 Solutions Software Setup Utility).
- Uses SecurePath for Windows 2000 (minimum version 3.1 with Software Update 2).
- One instance of the SecurePath 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter for each storage system with 4 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 8 LUNs per server FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter for each storage system with 4 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapters. 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 2000 Datacenter Server/Storage Rules). This situation can be avoided by using FC switch Zoning to create 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 FC-Fabric 64-bit/33 MHz PCI-to-Fibre Channel Host Bus Adapter is 2 for high bandwidth applications and 4 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 FC switch. For the highest available performance, whenever possible, devices that exchange the highest amount of data should be connected to the same FC switch, for example, servers and the storage assigned to them should be configured on the same FC switch, otherwise:

- For high bandwidth applications—One ISL between switches for every 2 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 6 storage controller ports on one switch being accessed by a server on the other switch.

## Hardware Components

PRE-CONFIGURED STORAGE PACKAGES	CPQ Part #
EMA16000 8 Dual HSG80 512MB (no ACS, no HDD) 12 x 4354 HDD Shelves per HSG80	2*-BIGMS-T1
EMA16000 4 Dual HSG80 512MB (no ACS, no HDD) 12 x 4314 HDD Shelves per HSG80	2*-BIGMS-T2
EMA16000 8 Dual HSG80 512MB (no ACS, no HDD) 12 x 4350 HDD Shelves per HSG80	2*-BIGMS-T3
EMA16000 4 Dual HSG80 512MB (no ACS, no HDD) 12 x 4310 HDD Shelves per HSG80	2*-BIGMS-T4
EMA12000 D14 60Hz: Three controller enclosures and nine dual-bus 14 bay 1" drive enclosures in a 42U Modular Storage Cabinet (Opal)	175990-B21
EMA12000 D14 50Hz: Three controller enclosures and nine dual-bus 14 bay 1" drive enclosures in a 42U Modular Storage Cabinet (Opal)	175990-B22
EMA12000 S14 60Hz: One controller enclosure and six single-bus 14 bay 1" drive enclosures in a 36U Modular Storage Cabinet (Opal)	175991-B21
EMA12000 S14 50Hz: One controller enclosure and six single-bus 14 bay 1" drive enclosures in a 36U Modular Storage Cabinet (Opal)	175991-B22
EMA12000 S10 60Hz: One controller enclosure and six single-bus 10 bay 1.6" drive enclosure in an 36U Modular Storage Cabinet (Opal)	175994-B21
EMA12000 S10 50Hz: One controller enclosure and six single-bus 10 bay 1.6" drive enclosure in an 36U Modular Storage Cabinet (Opal)	175994-B22
MA8000 60Hz: One controller enclosure and three dual-bus 14 bay 1" drive shelves in a 22U Modular Storage Cabinet (Opal)	175992-B21
MA8000 50Hz: One controller enclosure and three dual-bus 14 bay 1" drive shelves in a 22U Modular Storage Cabinet (Opal)	175992-B22
EMA12000 Blue 60Hz: One controller enclosure and three dual-bus 14 bay 1" drive shelves in a 41U Modular Storage Cabinet (Blue)	175993-B21
EMA12000 Blue 50Hz: One controller enclosure and three dual-bus 14 bay 1" drive shelves in a 41U Modular Storage Cabinet (Blue)	175993-B21
RA8000/ESA12000 Storage Components (Legacy)	

<b>CONTROLLERS &amp; ACS Software</b>	<b>CPQ Part #</b>
ACS V8.5F Controller FC-AL/SW Software. One required per HSG80 controller.	128697-B21
ACS V8.5P Controller FC-SW with Data Replication Software. One required per HSG80 controller.	128698-B21
ACS V8.5S Controller FC-SW Software with Clone + Snapshot. One required per HSG80 controller.	160091-B21
HSG80 RAID Controller w/ 256MB Cache. Order two per controller shelf	176622-B21
HSG80 Cache Bulkhead Upgrade kit. (Only if redeployed from an RA8000/12000.)	176623-B21
256MB Cache optional	380674-B21
Single external cache battery. Order one per controller.	135823-B21

<b>DISK DRIVES</b>	<b>CPQ Part #</b>
9.1GB Ultra3 SCSI 15K 1"	188120-B22
18.2GB Ultra3 SCSI 15K 1'	188122-B22
72.8GB Ultra3 SCSI 10K 1.6"	176494-B21
36.4GB Ultra3 SCSI 10K 1"	176496-B22
18.2GB Ultra3 SCSI 10K RPM 1"	142673-B22
18.2GB Ultra2 SCSI 10K RPM 1" (legacy)	128418-B22
18.2GB Ultra2 SCSI 7.2K RPM 1" (legacy)	388144-B22
9.1GB Ultra3 SCSI 10K RPM 1"	142671-B22
9.1GB Ultra2 SCSI 10K RPM 1" (legacy)	328939-B22
9.1GB Ultra2 SCSI 7.2K RPM 1" (legacy)	123065-B22
0.6" drive extenders (4 pack)	148649-B21

<b>HOST BUS ADAPTERS</b>	<b>CPQ Part #</b>
64-Bit/33-MHz PCI-to-Fibre Channel Host Bus Adapter with embedded Multi-Mode Optical Interface. Two per server for high availability, clustered configurations.	176479-B21



STORAGE ENCLOSURES A LA CART -- Only if Reconfigured Storage is not ordered.	CPQ Part #
42U Modular Storage Cabinet (opal) 60Hz	180311-B21
42U Modular Storage Cabinet (opal) 50Hz	180312-B22
36U Modular Storage Cabinet (opal) 60Hz	180313-B21
36U Modular Storage Cabinet (opal) 50Hz	180314-B22
22U Modular Storage Cabinet (opal) 60 Hz	180315-B21
22U Modular Storage Cabinet (opal) 50 Hz	180316-B22
41U Modular Storage Cabinet (blue) 60Hz	180317-B21
41U Modular Storage Cabinet (blue) 50Hz	180318-B22
2200 4U controller enclosure, 2 power cords, 2 power supplies, EMU, 3 fans.	135820-B21
4214R 3U Single Bus 14 bay drive enclosure	103381-001
Single to dual bus 4214R upgrade kit	119829-B21
4254 3U Dual Bus 14 bay drive enclosure	138151-001
4314R single bus 14 bay drive enclosure	190209-001
4354R dual bus 14 bus drive enclosure	190211-001
4310R single bus 10 bay drive enclosure	174631-B21
4350R dual bus 10 bay drive enclosure	174630-B21
4214 Redundant power supply	119826-B21
Ultra3 single bus I/O module	190212-B21
Ultra3 dual bus I/O module	190213-B21
1M SCSI Cable, 1 cable per 4314R/4210R shelf or 2 cables per 4354R/4350R shelf	168256-B21

<b>SWITCHES and INTERCONNECT</b>	<b>CPQ Part #</b>
Fibre Channel SAN Switch 8	158222-B21
Fibre Channel SAN Switch 16	158223-B21
SAN Switch Integrated /32	230616-B21
SAN Switch Integrated /64	230617-B21
Redundant power support for 8 & 16 port SAN switches	160407-B21
Rack mount kit for 8 & 16 port SAN switches	167365-B21
FC Short-wave 2-Meter Cable	234457-B21
FC Short-wave 5-Meter Cable	234457-B22
FC Short-wave 15-Meter Cable	234457-B23
FC Short-wave 30-Meter Cable	234457-B24
FC Short-wave 50-Meter Cable	234457-B25
FC Short-wave GBIC.	380561-B21
Connection Kit with three Short-wave GBICs and two 2-Meter cables	380579-B21

<b>SAN Works Solutions Software</b>	<b>CPQ Part #</b>
SecurePath V3.1. Only if single-server in non-clustered environment. If two or more servers in a cluster, get SecurePath licenses from cluster kits.	165989-B21
SANworks Enterprise Volume Manager v1.1 Windows 2000 License	180607-B21
Data Replication Manager (DRM) (included in ACS 8.5P software)	128698-B21
SANworks Virtual Replicator v2.0A. See Quick Specs for more licensing options	191802-B21
SAN Management Appliance	189715-001

<b>EBS Solution</b>	<b>CPQ Part #</b>
Veritas NetBackup Solution Kit.	203828-001
Veritas Backup Exec Solution Kit	203824-001
Legato NetWorker Solution Kit	203826-001
CA ARCserve IT 2000 Solution Kit	203822-001
Modular Data Router (HVD)	163082-B21
Modular Data Router (LVD)	163083-B21
MDR Option Kit (HVD)	152454-B21
MDR Option Kit (LVD)	162969-B21
ESL 9198DLX Tape Library 4 40/80 drive	194993-B24
ESL 9198DLX Tape Library 8 40/80 drive	194993-B28
ESL9326D Tape Library 16 Drives. See Library Quick Specs for available options.	146205-B28
ESL 9000 Pass Through Kit for Multi-Unit Connectivity.	161268-B21
SSL2020 AIT Tape Library. See Quick Specs for available options	175196-B22
TL895 Library 7 Drives (Legacy support) See Quick Specs for available options	349350-B27
TL891 Tape Library, 2 Drives (Legacy Support) See Quick Specs for available options	152975-001
Wide Differential SCSI cable 5M (one SCSI cable per two drives).	328215-001
Wide Differential SCSI cable 10M	328215-002
Wide Differential cable, 15M	328215-003
Wide Differential cable 20M	328215-004
7 pack DLT data cartridges	295192-B21
DLT Cleaning Cartridge	199704-001

## Configuration References

The following documents provide further information on the configuration of RA/MA8000 and ESA/EMA12000 Fibre Channel Storage Systems.

**Table 4 Configuration Reference Material**

Topic	Document Title	Order Number
Heterogeneous SAN Application Note	<i>Heterogeneous Storage Area Networks</i>	<i>EK-SMA30-AN</i>
Sun SAN Application Note	<i>Storage Area Network Configurations for RA8000/ESA12000 on Sun Solaris</i>	<i>EK-SMA37-AN</i>
HP-UX SAN Application Note	<i>Storage Area Network Configurations for RA8000/ESA12000 on HP-UX</i>	<i>EK-SMA32-AN</i>
OpenVMS SAN Application Note	<i>Storage Area Network Configurations for RA8000/ESA12000 on OpenVMS</i>	<i>EK-SMA34-AN</i>
Tru64 UNIX SAN Application Note	<i>RA8000/ESA12000 FC-Switch Configurations for Tru64 UNIX</i>	<i>EK-SMA33-AN</i>
Novell Netware Application Note	<i>RA8000/ESA12000 FC-AL Configurations for Novell Netware</i>	<i>EK-FCALN-AA</i>
Windows NT – Intel Standard FC-AL Configurations Application Note	<i>RA8000/ESA12000 FC-AL Configurations for Windows NT – Intel</i>	<i>*AA-RHORB-TE</i>
Windows NT – Intel High Availability FC-AL Configurations Application Note	<i>RA8000/ESA12000 FC-AL High Availability Configurations for Windows NT - Intel</i>	<i>*AA-RH0SC-TE</i>
Windows NT - Intel HSG80 Array Controller	<i>Release Notes, HSG80 Array Controller (ACS V8.5F) for Windows NT Server - Intel</i>	<i>AA-RH0QB-TE or 387393-002</i>
Windows NT - Intel RA8000/ESA12000 Installation	<i>RA8000/ESA12000 Fibre Channel Solution Software for Windows NT – Intel Installation Reference Guide</i>	<i>AA-RFA9C-TE</i>
Windows NT Clusters	<i>RAID Array 8000/ESA12000 Fibre Channel Cluster Solutions for Windows NT</i>	<i>EK-NTC8K-IG</i>
SecurePath Installation	<i>StorageWorks SecurePath v3.0 for Windows NT – Installation and Reference Guide</i>	<i>AA-RL4SA-TE</i>
HSG80 Array Controller Configuration	<i>HSG80 Array Controller ACS Version 8.5 Configuration Guide</i>	<i>EK-HSG85-CG or 165144-001</i>
HSG80 Array Controller Command Line Interface	<i>HSG80 Array Controller ACS Version 8.5 CLI Reference Guide</i>	<i>EK-HSG85-RG or 165145-001</i>
HSG80 Array Controller Maintenance	<i>HSG80 Array Controller ACS Version 8.5 Maintenance and Service Guide</i>	<i>EK-HSG84-SV or 118620-002</i>
StorageWorks Command Console	<i>Command Console V2.2 (HSG80) for RAID Array 8000/ESA12000, User's Guide</i>	<i>AA-RFA2D-TE</i>

Note: Refer to the Compaq website for the latest information.