

# hp StorageWorks

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## Application Note - Enterprise/Modular Storage RAID Array Fibre Channel Arbitrated Loop Configurations

Part Number: AA-RS1ZA-TE

**First Edition August 2002**

**Product Version:** ACS 8.7

This application notes consolidates seven older platform-specific FC-AL Application Notes and provides examples of typical Enterprise/Modular Storage RAID Array configurations. The following older FC-AL Application Notes have been absorbed in this consolidation:

- Enterprise/Modular Storage RAID Array FC-AL HA Configurations for Windows NT/2000 - Intel Application Note, Part Number: AA-RHOSE-TE
- Enterprise/Modular Storage RAID Array FC-AL Configurations for Windows NT/2000 Application Note, Part Number: AA-RHORC-TE
- Enterprise/Modular Storage RAID Array FC-AL Configurations for Tru64 UNIX Application Note, Part Number: AA-RPHLA-TE
- Enterprise/Modular Storage RAID Array FC-AL Configurations for Sun Solaris Application Note, Part Number: EK-FCALH-AA. B01
- Enterprise/Modular Storage RAID Array FC-AL Configurations for Novell NetWare Application Note, Part Number: EK-FCALN-AA D01
- Enterprise/Modular Storage RAID Array FC-AL Configurations for HP-UX Application Note, Part Number: AA-RPHKA-TE
- Enterprise/Modular Storage RAID Array FC-AL HA Configurations for IBM AIX Application Note, Part Number: EK-SMA38-AN B01

For the latest version of these Application Notes and other ACS documentation, visit the storage website at: <http://www.compaq.com/storage/...>



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## Application Note - Enterprise/Modular Storage RAID Array Fibre Channel Arbitrated Loop Configurations

First Edition August 2002

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Table 1–1 describes where to find examples of specific operating system configurations:

**Table 1–1: Where to find specific configurations by operating system**

Operating System	Specific configurations begin on
IBM AIX	page 1–11
HP-UX	page 1–39 (High Availability)
Novell Netware	page 1–20
Sun Solaris	page 1–52 (High Availability); page 1–55 (Veritas Cluster)
Tru64 UNIX	page 1–57 (High Availability)
Windows NT/2000	page 1–25; page 1–62 (Microsoft Cluster Server)

### Intended Audience

Storage administrators should have the following experience:

- configuring RAID storage systems, specifically using the Command Line Interface (CLI);
- experience in using the individual operating systems; and
- an understanding of Fibre Channel terminology and concepts.

## Related Documentation

In addition to this FC-AL Application Note, additional information can be found in:

- ACS v8.7 controller documentation (software delivered via PCMCIA cards)
- HSG80 CLI Reference Guide, EK-G80CL-RA.B01
- HSG80 Maintenance and Service Guide, EK-G80MS-SA.B01
- HSG80 Troubleshooting and Reference Guide, EK-G80TR-SA.B01
- SWCC v2.5 documentation (client software delivered in solutions kits)
- Command Console User Guide, AA-RFA2J-TE
- Command Console Release Notes, AV-RPBKB-TE
- Command Console Help Files, AA-RS20A-TE and AA-RS21A-TE
- Host-specific documentation (SWCC Agent and HBA software delivered in solutions kits)
- Installation and Configuration Guide for each operating system
- Solution Software Release Notes for each operating system
- FC-AL Application Note (AA-RS1ZA-TE), this document

Additional support required by HSG80 ACS Solution Software Version 8.7, but delivered through external programs, include the following:

- Heterogeneous “rules based” SAN configurations
- Host-Bus Adapter (HBA) products
- Applicable Storage Utility Management Suite (SUMS) components
- Vendor-specific switch products
- Data Replication Manager (DRM) under ACS 8.7P
- Enterprise Volume Manager (EVM) under ACS 8.7S
- Enterprise Backup Solution (EBS)

## Enterprise Network Storage Architecture (ENSA)

Enterprise/Modular Storage RAID Array (RA/MA8000 and ESA/EMA12000) products are the latest in fully integrated Fibre Channel RAID storage solutions. These products provide the key initial step in delivering the Compaq's ENSA vision. ENSA addresses the issues that customers expect to face now and in the future.

### Product Overview

The Enterprise/Modular Storage RAID Array Fibre Channel systems are based on a common architecture and offer customers centralized management, high availability, exceptional performance and scalability in open systems environments. These products provide a Fibre Channel storage solution with industry leading Storage Area Network (SAN) support using Fibre Channel Arbitrated Loop (FC-AL) technology.

The RA/MA8000 Fibre Channel is a mid-range storage system available in a pedestal enclosure for departmental use in the office. It can also be installed in server racks for data centers. An easy-to-deploy, flexible solution for open systems, the RA/MA8000 currently supports up to 1.3 TB of storage with the use of 18GB disks.

The ESA/EMA12000 Fibre Channel, 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 Fibre Channel 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. The 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 performance while preserving data and high availability support.

Platform kits include software and documentation created for each specific operating system that can be used with the StorageWorks RAID arrays.

The platform kits contain the necessary operating system software and documentation needed to install, configure, and monitor your storage system. All kits include the StorageWorks Command Console (SWCC) for storage management operations including configuring, status inquiry and notification facilities.

## StorageWorks RAID Product Details

The Enterprise/Modular Storage RAID Array systems use the HSG80 RAID controller running Array Controller Software (ACS) V8.7. The ACS software is designed to support multiple platforms providing features including: dual controller operation, two controller failover modes – Transparent and Multiple-Bus, mirrored write back cache, read ahead cache, RAID implementation, disk mirroring, and disk partitioning capabilities. In addition, ACS manages host interconnect and protocol services to provide data for event notification and status as displayed by SWCC.

The HSG80 controller has two Fibre Channel host ports providing up to a total of nearly 200 Mbytes per second of available bandwidth. Disk drives are connected to the controller through 6 UltraSCSI channels providing up to 40 Mbytes per second per channel of available bandwidth. Servers can use multiple host bus adapters (host bus adapters) to multiple RA/MA8000 Fibre Channel systems for unlimited storage capacity.

RA/MA8000 Fibre Channel controllers come with 64 MB of cache. Cache options allow for 128 MB, 256 MB and 512MB of cache in each controller. ESA/EMA12000 Fibre Channel controllers come with 256 MB of cache. Cache options allow for 512MB of cache in each controller. Cache features include read ahead and mirrored write back cache for use in optimizing performance where redundant capabilities are required for high availability system configurations. In the rare event that a storage controller fails the mirrored data is immediately available to the remaining controller for continuing operation.

The RA/MA8000 Fibre Channel pedestals and rackables come in both single controller and in dual controller models to allow the customer to select the level of high availability required for his application. A single controller model can be upgraded to a dual controller model when warranted by the application.

High availability is supported by the use of redundancy and hot swappable components. The RA/MA8000 Fibre Channel disk enclosures include redundant cooling, and have 5 power supplies providing N+1 redundancy. Power can be upgraded to full redundancy with the addition of 3 more supplies and a 2nd power distribution unit for AC input redundancy. StorageWorks components are “hot” swappable including storage controllers when operating as a redundant pair.

The Enterprise/Modular Storage RAID Array Fibre Channel can be configured and monitored using the StorageWorks Command Console (SWCC). SWCC is included in the HSG80 Software Solutions Platform kit. Using this client/server tool, RAID sets can be configured locally or over a TCP/IP network. The client provides an easy to use graphical interface. It can be used to monitor the RAID storage systems and notify you of events by updating a video display, sending electronic mail or alerting via a pager. The Command Console Client includes applications (or Storage Windows) that communicate with the Command Console Agent software running on the server/host platform.

The Command Console client is available on Windows 95/98 and on Intel platforms running Windows NT/2000. A Storage Window for the HSG80 controller supports the Array Controller Software (ACS) V8.7 and offers integration with Compaq's Insight Manager (CIM). Insight Manager can receive SNMP traps from the Command Console Agent and Insight Manager services can directly launch SWCC for notification or configuring operations.

## Configuration Notes

- All single controller storage configurations can be upgraded to dual controller configurations.
- Controller pairs can be configured for either Dual Redundant Failover Mode *or* Multiple-bus Failover Mode. When controllers are in Dual Redundant Failover Mode, this is referred to as “Transparent Failover Mode.”
- All configuration diagrams show a frontal view of the storage system.
  - Controller Host Port 1 is the left port; Controller Host Port 2 is the right port.
  - Controller A is the top controller; Controller B is the bottom controller.
- Each storage system can be configured using the Storage Works Command Console (SWCC) or the Command Line Interface (CLI) with the HSG80 controller maintenance serial port or a TCP/IP interface.
- All configurations require Array Controller Software (ACS) V8.7 for the FC-AL topology.
- All configurations require RA/MA8000 or ESA/EMA12000 Fibre Channel Solution Software V8.7 for the particular operating system.
- All configurations use short wavelength lasers and multi-mode Fibre Channel optical cables. They do not include Fibre Channel Switch technology or single-mode optical cables and long wavelength laser technology. Additionally, cascading Fibre Channel hubs are not supported in these configurations.
- All configurations require Arbitrated Loop Physical Addresses (ALPAs). There is one ALPA for each device on a loop. Each ALPA is configured as LOOP\_HARD and must be unique. (See Appendix D: Arbitrated Loop Physical Addresses.)
  - Controller Defaults: Host Port 1 has an ALPA of 71; Host Port 2 has an ALPA of 72. IBM AIX requires changes to default ALPAs.
  - In configurations with two Storage Systems, this document uses the following convention for: first Storage System, ALPA D5 for Port 1 and ALPA D6 for Port 2; and, second Storage System: ALPA D3 for Port 1 and ALPA D4 for Port 2.

```
Set controllername port_1_topology=loop_hard
Set controllername port_1_al_pa=71
Set controllername port_2_topology=loop_hard
Set controllername port_2_al_pa=72
Set connection name operating_system=NETWARE (or HP or WINNT)
```
- All configurations require the connection name operating system parameter to be set to (operating system). (Example, CLI: SET *connection-name* OPERATING\_SYSTEM = WINNT)
- By default the HSG80 Command Console LUN (CCL) is enabled. You can disable it (in SCSI-2 mode) using the CLI command (CLI: SET *controller* NOCOMMAND\_CONSOLE\_LUN).
- The HSG80 controllers support a range of 200 unit numbers. In Transparent Failover Mode, the units D0-D99 are assigned to Port 1 and units D100-D199 are assigned to Port 2. In Multiple-Bus Failover Mode, all 200 unit numbers may be visible to all ports. Connection offsets are used to restrict access/visibility.

- For configurations with more than one server on the same loop:
  - Use the SET *connection-name Unit\_Offset* value to set the range of unit numbers to be visible from each Server (CLI: SET *connection-name* UNIT\_OFFSET = *n*) This will provide a first level of access control from Server to Storage.
  - To define a second level of access control from Server to Storage, it is possible to define a specific combination of Storage Unit and Host by enabling an ACCESS\_PATH. The steps are:
    - (1) Disable/Clear all current access\_paths, (CLI: SET *unit-number* DISABLE\_ACCESS\_PATH = ALL); and,
    - (2) Set a specific Host access (through the connection name), (CLI: SET *unit-number* ENABLE\_ACCESS\_PATH = *connection-name*).
- For single controller configurations with two active controller host ports on the same loop, use the *connection-name Unit\_Offset* value to set the range of unit numbers to be visible from controller host port 2.
- For two storage system (4 controller) configurations with more than one controller host port on the same loop, set the ALPA for each controller host port in the second enclosure to a different LOOP\_HARD address (CLI: SET *controller* PORT\_1\_AL\_PA = *xy*)
- Record the Fibre Channel HBA Worldwide Identification (WWID) address. Some HBAs display the WWID on the HBA itself.
- Use the recorded WWID to identify the connection name displayed from the CLI at the controller using the CLI: SHOW CONNECTIONS command.
- By default, new connection names are automatically added to the controller connection name table as !NEWCON*nn* (where *nn* is a number from 1 to 32). The controller adds a connection when a path to an adapter from each active controller host port is detected. Once you have identified each connection using the Fibre Channel HBA WWID, rename the connection names to a name meaningful to the specific configuration. (CLI: RENAME *old-name new-name*. Connection names may contain nine (9) characters). In some cases, host name and Port value may suffice (WESTP1, WESTP2, EASTP1, EASTP2, etc.).
- Each active controller host port on a loop presents one SCSI Target ID with up to sixty-four (64) LUNs to each Fibre Channel HBA on the same loop. LUNs (logical units) can consist of single disks (JBOD), a storageset of multiple disks or a partition (up to 64), configured for a specific RAID level of 0, 0 + 1, or 3/5.
- There are two points of view when speaking of Fibre Channel connections:
  - The first view is taken from the server side. The server has a configuration file that allows the operating system to identify targets and logical units used for I/O. The targets and logical units may be configured as desired within the maximum values for the operating system and restrictions of the Fibre Channel specifications. This means that while there may be 6 targets (ALPAs) on a Fibre Channel arbitrated-loop, the configuration file may/may not list all 6 targets. In short, a specific server may not look for or try to access a specific target.
  - The second view is from the controller side. On a loop, the controller knows about each host-adapter combination (HAC) that it can communicate with. The controller creates one connection on each active controller port for each HAC. Thus, if there are four servers on a loop, each with a Fibre Channel adapter, the controller will create four connections for the servers for each active controller port. If there is one active port, the controller will establish 4 connections. If there are two active ports, the controller will create 8 connections.

By combining the server and controller viewpoints, there is the flexibility of using all connections. If all the targets in the server's configuration file are defined and mapped to all available connections, there is complete use of the available connections. On the other hand, if access is

restricted from the server point of view, server configurations may be edited so that there are fewer targets than connections available, leaving unused connections. Those connections are still available, but for reasons of load balancing or access control, are not used.

In the configurations of this application note, the server's point of view is used to limit access to certain targets. This also means that when implementing a configuration, only the connections used need to be identified, not all of them. Thus, the naming of connections is done for only those connections that are active in the specific configuration. Disregard the unused connections.

**NOTE:** The CLI provides the ability to delete a connection. This deletion is good **ONLY** until the controller reinitializes. When a controller reboots, it rebuilds its connection table for all devices that it can access.

## Configuration Maximums

HSG80 controller maximum configuration rules include:

- 128 visible LUNs/200 assignable unit numbers
  - SCSI-2 mode, if the CCL is enabled, the result is 127 visible LUNs and one CCL.
  - (Windows platform-only) - SCSI-2 mode, the CCL is disabled, resulting in 128 visible LUNs.
  - SCSI-3 mode, the result is 126 visible LUNs and two CCLs.
  - (Windows platform-only) -SCSI-3 mode, the CCL is enabled, resulting in 127 visible LUNs for multiple-bus (126 visible LUNs for transparent failover )and one CCL.
- 1.024 TB storageset size
- 96 host connections
- 84 physical devices
- 20 RAID 3/5 storagesets
- 30 RAID 3/5 and RAID 1 storagesets
- 45 RAID 3/5, RAID 1, and RAID 0 storagesets

**NOTE:** The previous two configuration rules before this note are subject to a combined maximum, in that the 30 RAID 3/5 and RAID 1 storageset combination and the 45 RAID 3/5, RAID 1 and RAID 0 storageset combination are limited to no more than 20 RAID 3/5 storagesets in the individual combination.

- 8 partitions of a storageset or individual disk
- 6 physical devices per RAID 1 storageset (mirrorset)
- 14 physical devices per RAID 3/5 storageset (RAIDset)
- 24 physical devices per RAID 0 storageset (stripeset)
- 45 physical devices per RAID 0+1 storageset (striped mirrorset)

The Fibre Channel Loop maximum configuration rules include:

- 500 meters per optical cable segment, 50 micron, multi-mode.  
175 meters per optical cable segment, 62.5 micron, multi-mode.
- 1 kilometer distance between Server and Storage.
- 4 Fibre Channel Host Based Adapters per loop.

The Transparent or Multi-Bus Failover Mode maximum configuration rules include:

- 4 Servers on a single FC-AL loop
  - 2 Storage Systems
  - 4 Controllers with 2 Active controller ports per controller pair
- 8 Servers on two FC-AL loops
  - 1 Storage System per loop
  - 2 Controllers with 2 Active controller ports

## Configuration Example - IBM AIX

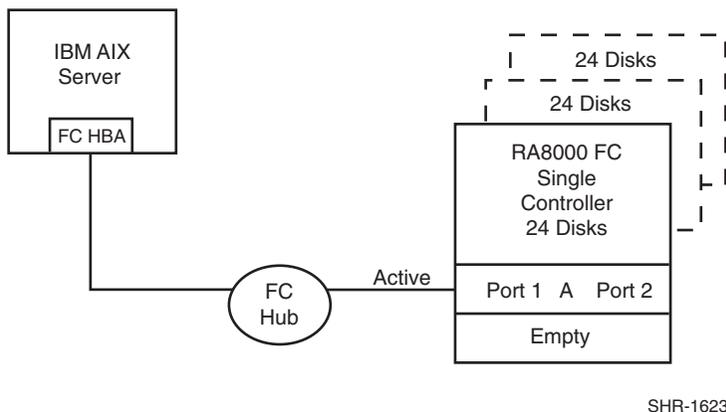
Table 1–2 lists examples of the most common IBM AIX Enterprise/Modular Storage RAID Array Fibre Channel configurations.

**Table 1–2: Typical RA/MA8000 / ESA/EMA12000 FC-AL IBM AIX Configurations**

Configuration #	Description
1	One Server, Single Controller
2	One Server, Dual Controller, Transparent Failover
3	One Server, Two Dual Controller, Pairs Transparent Failover
4	Two Servers, Single Controller, Shared Storage Enclosure
5	Two Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure
6	Up to Four Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure
7	Up to Four Servers, Two Dual Controller Pairs, Transparent Failover, Shared Storage Enclosure
8	Up to Eight Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

### One Server, Single Controller

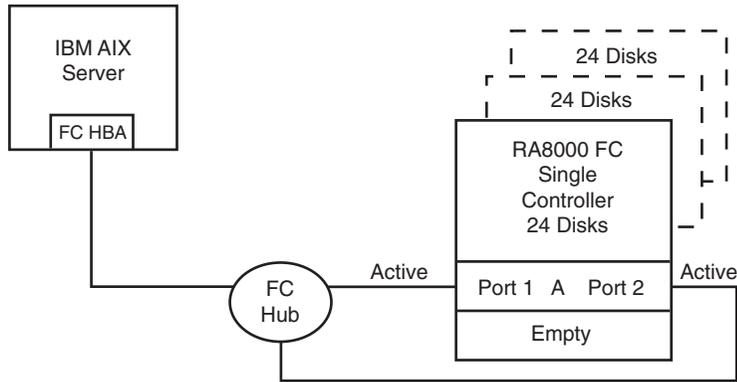
The single controller configuration (Figure 1–1) is an entry-level RA/MA8000 Fibre Channel or ESA/EMA12000 that can be expanded to accommodate additional storage capacity or performance needs as required. The configuration consists of an RA/MA8000 or ESA/EMA12000 storage enclosure with a single HSG80 array controller on a single Fibre Channel loop. In the initial configuration a single controller host port (Port 1) is active providing up to 32LUNs across up to 24 disks. An additional 48 disks can be added using two expansion enclosures. Additional servers can be added to this configuration as required using the existing hub (refer to Configuration 6 in Table 1–2).



**Figure 1–1: Configuration 1**

In this configuration, 1 logical connection is available with up to 32LUNs (Cambex). This Host-Hub-Storage configuration is developed in later configurations. Suggested controller unit number assignment: Port 1, units D0 – D15.

LUN capacity can be doubled by adding a third Fibre Channel cable from the hub to Port 2 of the controller, resulting in the configuration shown in Figure 1–2.



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**Figure 1–2: Configuration 1 with Double LUN Capacity**

In this configuration, 2 logical connections are available with up to 64 LUNs (Cambex). Suggested controller unit numbers: Port 1, units D0 – D15; Port 2, units D100 – D115.

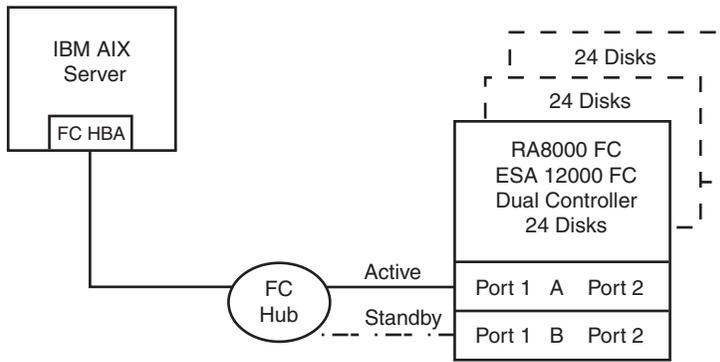
### Configuration 1 Notes

- Single Fibre Channel loop
- Single HSG80 controller; controller failover is not available.
- Up to 500 meters per 50-micron cable segment
- Up to 72 disks with 2 optional expansion enclosures

### One Server, Dual Controller, Transparent Failover

This two-controller configuration (Figure 1–3) provides dual redundant controllers configured in Transparent Failover mode. The configuration consists of an RA/MA8000 Fibre Channel or ESA/EMA12000 storage enclosure with two HSG80 array controllers on a single loop. In normal operation Controller A provides the active path for all storagesets to the server through Port 1. A second controller, Controller B is a hot standby. Controller B will automatically become active in the event of a failure in Controller A. All units being accessed through Port 1 of Controller A will become accessible through Port 1 of Controller B.

In Figure 1–3, a single controller host port, Port 1 is active providing up to 32 LUNs (Cambex) across up to 24 disks. An additional 48 disks can be added using two expansion enclosures. Additional servers can be added to this configuration as required using the existing hub (refer to Configuration 6 in Table 1–2).

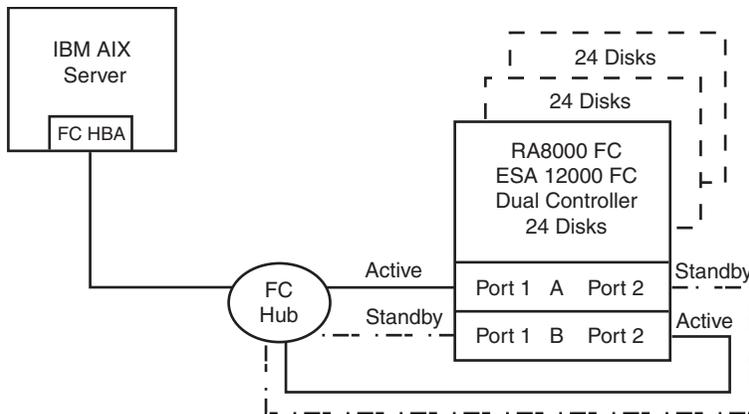


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**Figure 1–3: Configuration 2**

In this configuration, 32 LUNs (Cambex) are supported with 1 active controller host port. Suggested controller unit numbers: Port 1, units D0 – D15

Utilization of the second controller, Controller B, as an active controller to increase performance and double LUN capacity can be accomplished without sacrificing redundancy. Two Fibre Channel cables, one connected to Controller A, Port 2, and one connected to Controller B, Port 2, result in the configuration shown in Figure 1–4. This configuration provides full controller redundancy in the event either controller fails. During failover, the surviving controller will transition the standby port to the active state providing access to all units for the server.



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**Figure 1–4: Configuration 2 with Increased Performance and Double LUN Capacity**

In this configuration, 2 logical connections are available with up to 64 LUNs (Cambex). Suggested controller unit numbers: Port 1, units D0 – D15; Port 2, units D100 – D115

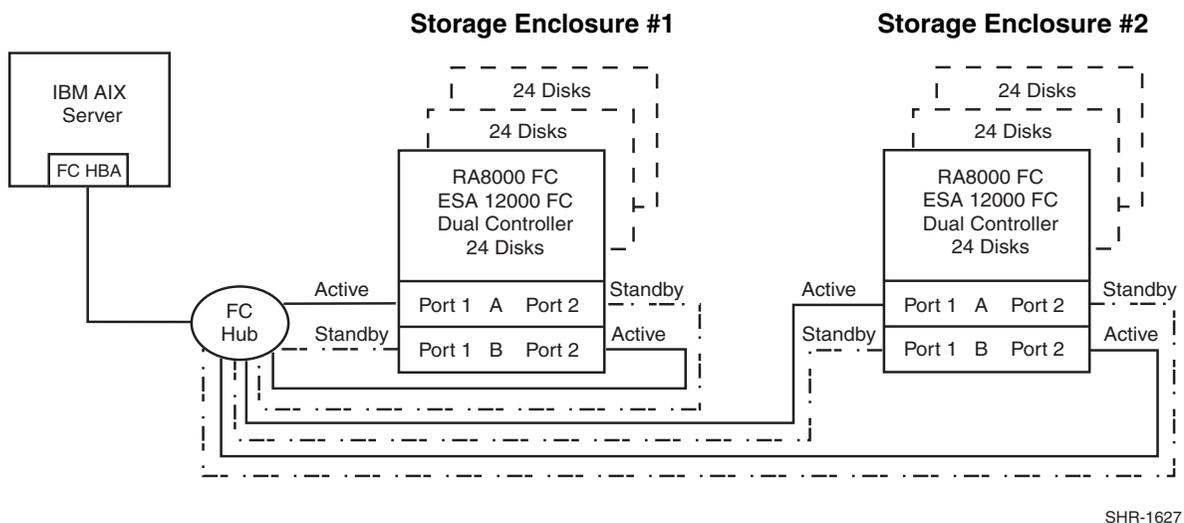
### Configuration 2 Notes

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per 50-micron cable segment

- Up to 72 disks with 2 optional expansion enclosures
- By default, setting the controller pair in Transparent Failover Mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2

## One Server, Two Dual Controller Pairs, Transparent Failover

Configuration 3 (Figure 1–5) is a two dual-controller configuration with two dual-redundant controller pairs using two RA/MA8000 pedestal enclosures or a single ESA/EMA12000 enclosure. The controllers are configured in Transparent Failover Mode providing controller redundancy in each storage enclosure. This configuration takes advantage of the high capacity of a single Fibre Channel loop allowing for expansion of storage capacity without the addition of another hub. As with Configuration 2, full controller redundancy and two controller capacity is provided in both storage enclosures. In this configuration four active controller ports provide up to 128 LUNs across up to 48 disks. An additional 96 disks can be added using four expansion enclosures. Additional servers can be added to this configuration as required using the existing hub (refer to Configuration 7 in Table 1–2).



**Figure 1–5: Configuration 3**

In this configuration, 4 logical connections are available. There are 2 per storage enclosure with up to 64 LUNs each.

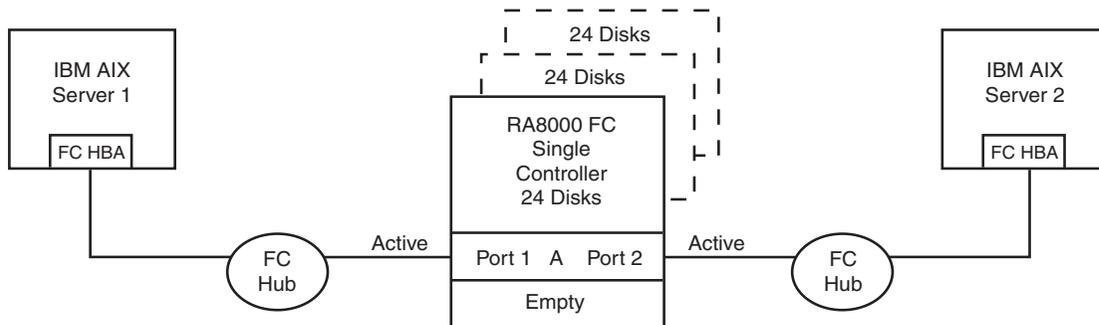
By default, setting the controller pairs in Transparent Failover Mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2.

### Configuration 3 Notes

- Single Fibre Channel loop
- Two Dual HSG80 controller pairs configured in Transparent Failover Mode
- Up to 500 meters per 50-micron cable segment
- Up to 144 disks with 4 optional expansion enclosures

## Two Servers, Single Controller, Shared Storage Enclosure

Configuration four (Figure 1–6) uses the second controller host port to provide storage to a second separate (non-cooperating) server. The two servers share the storage enclosure in that each server has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering and Target identification. This configuration uses two separate Fibre Channel loops. Additional servers can be added to this configuration as required using the existing hubs (refer to Configuration 8).



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**Figure 1–6: Configuration 4**

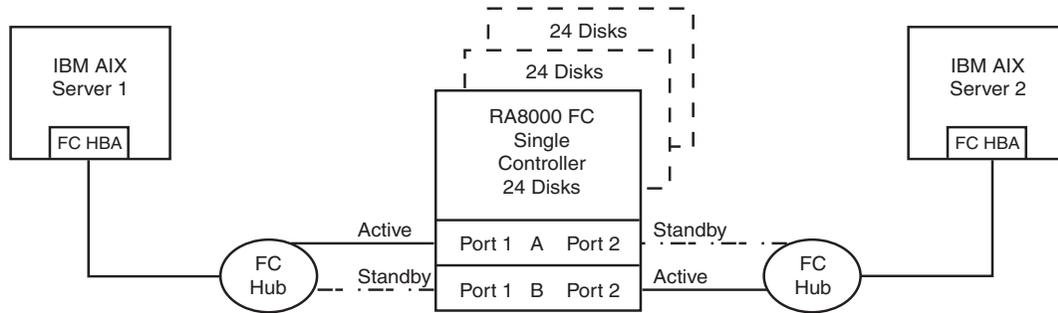
### Configuration 4 Notes

- Two Fibre Channel loops
- Shared storage enclosure
- Single HSG80 controller, controller failover is not available
- Up to 500 meters per 50-micron cable segment
- Up to 72 disks with 2 optional expansion enclosures
- Up to 64 LUNs total, 32 available to each server.

## Two Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

Configuration 5 (Figure 1–7) uses a dual controller pair to provide storage and controller redundancy to a second, separate (non-cooperating) server. The two servers share the storage enclosure in that each server has exclusive access to its own LUNs through the use of mutually exclusive LUN and Target numbering. This configuration uses two separate Fibre Channel loops. Each server has access to its own dedicated controller. In the event of a controller failover, the surviving controller will continue to provide full access to units of both servers.

In normal operation Controller A provides the active path for all storagesets assigned to Server 1 through Port 1. Controller B provides the active path for all storagesets assigned to Server 2 through Port 2. Each server also has a dedicated standby port in the event that there is a controller failover. Additional servers can be added to this configuration as required using the existing hubs (refer to Configuration 8 in Table 1–2).



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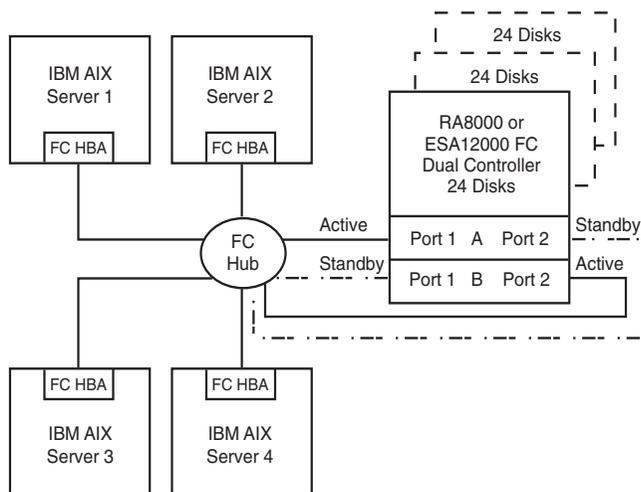
Figure 1–7: Configuration 5

### Configuration 5 Notes

- Two Fibre Channel loops; Shared storage enclosure; Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per 50-micron cable segment; Up to 72 disks with 2 optional expansion enclosures; Up to 64LUNs total, 32 available to each server.
- By default, setting the controller pair in Transparent Failover Mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2.

## Up to Four Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

Configuration 6 (Figure 1–8) builds on Configurations 2 and 5 using a dual controller pair on a single loop to provide storage and controller redundancy for up to four separate (non-cooperating) servers. The four servers share the storage enclosure in that each server has exclusive access to its own set of LUNs. This is made possible by setting explicit *connection-name* unit\_offsets to give each server an accessible range of unit numbers. As with all dual controller configurations, controller failover and performance benefits are inherent.



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Figure 1–8: Configuration 6

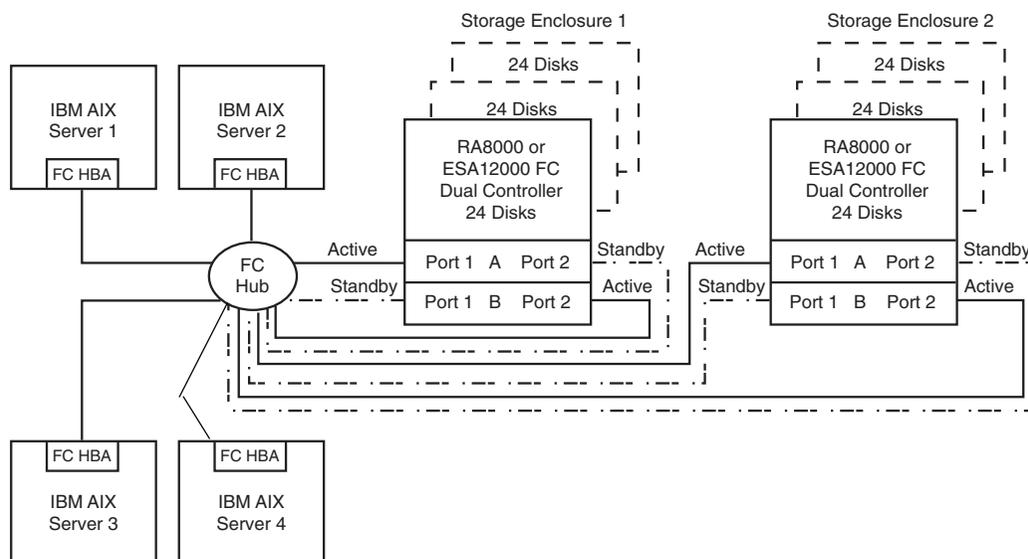
In the following setup, two servers have access to units D0-D99 and two servers have access to units D100-D199. Using unit offsets, each server has a unique set of targets.

## Configuration 6 Notes

- Single Fibre Channel loop
- Shared storage enclosure
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per 50-micron cable segment
- Up to 72 disks with 2 optional expansion enclosures
- Up to 128 LUNs total. Up to 64 available to any server.
- In this configuration, 8 logical connections are available, 2 to each server
- By default, setting the controller pair in Transparent Failover Mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2.
- For clarity, explicitly rename your connection names for the servers. Note that there are 8 logical connections available, but you will use only one per Server.

## Up to Four Servers, Two Dual Controller Pairs, Transparent Failover, Shared Storage Enclosure

Configuration 7 (Figure 1–9) builds on Configurations 3 and 6 using two dual controller pairs on a single loop to provide storage and controller redundancy for up to four, separate (non-cooperating) servers. The four servers share the storage enclosures in that each server has exclusive access to its own set of LUNs within each enclosure. This is made possible by the setting of connection-name unit pair offsets to give each server an accessible range of unit numbers. The addition of a second controller pair doubles the disk and LUN capacity available to the four servers.



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**Figure 1–9: Configuration 7**

Table 1–3 provides an alternate setup of Configuration 7, where servers access both storage enclosures using 16 connections.

**Table 1–3: Configuration 7 Alternate Set Up**

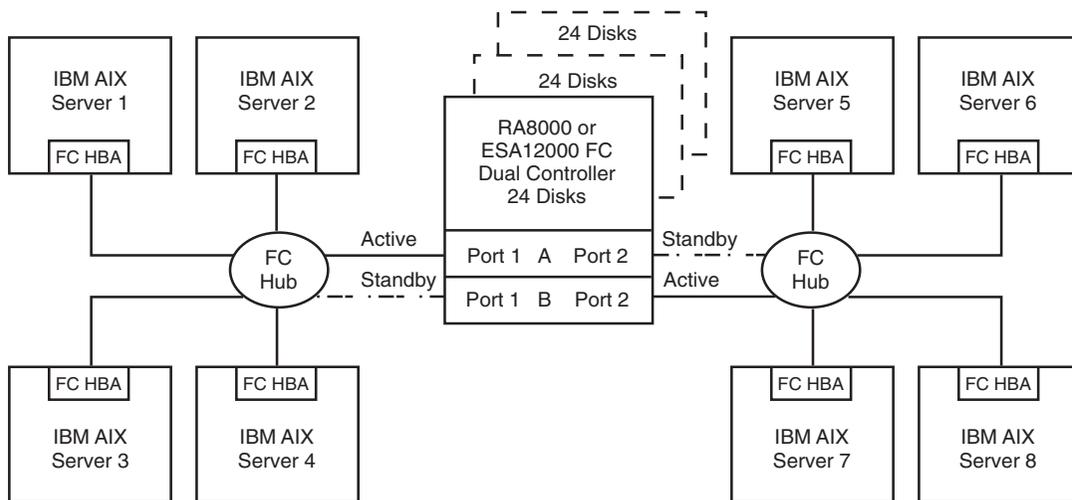
Node/HW	Storage Enclosure 1	Storage Enclosure 2	Servers 1....4
ALPAs	D5, D6	D3, D4	HBA WWID
Targets	65, 64, 10, 9	63, 62, 12, 11	62, 63, 64, 65
Connections	Servers 1...4	Servers 1...4	Both Storage Enclosures
Unit Offsets	P1: D0- D63 (4 * 16) P2: D100- D163 Server 1 P1 Offset 0 Server 2 P1 Offset 16 Server 3 P1 Offset 32 Server 4 P1 Offset 48 Server 1 P2 Offset 100 Server 2 P2 Offset 116 Server 3 P2 Offset 132 Server 4 P2 Offset 148	P1: D0- D63 (4 * 16) P2: D100-D163 Server 1 P1 Offset 0 Server 2 P1 Offset 16 Server 3 P1 Offset 32 Server 4 P1 Offset 48 Server 1 P2 Offset 100 Server 2 P2 Offset 116 Server 3 P2 Offset 132 Server 4 P2 Offset 148	

### Configuration 7 Notes

- Single Fibre Channel loop
- Shared storage enclosure
- Two Dual HSG80 controller pairs configured in Transparent Failover Mode
- Up to 500 meters per 50-micron cable segment
- Up to 144 disks with 4 optional expansion enclosures
- Up to 256 LUNs, 128 available to any server.
- In this configuration, 16 connections exist. A server may have 4 connections but in this example, each server is configured to access only 2 each. An alternate configuration, shown at the end of this section, uses the complete 16 connections.
- By default, setting the controller pairs in Transparent Failover Mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2.
- Configuration 7 is an extension of Configuration 6. We will modify the server configurations so that pairs of servers have the same Targets. LUN numbering is identical for each enclosure but when viewed from each Server the LUNs are assigned under different Target IDs.

## Up to Eight Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

Configuration 8 (Figure 1–10) builds on Configurations 5 and 6 using a dual controller pair on two Fibre Channel loops to provide storage and controller redundancy to two groups of up to four, separate (non-cooperating) servers. The eight servers share the storage enclosure in that each server has exclusive access to its own set of LUNs. This is made possible by the setting *connection-name* unit offsets to give each server an accessible range of unit numbers.



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**Figure 1–10: Configuration 8**

### Configuration 8 Notes

- Two Fibre Channel loops
- Shared storage enclosure
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per 50-micron cable segment
- Up to 72 disks with 2 optional expansion enclosures
- Up to 128 LUNs, 32 available to each server.
- In this configuration, 8 connections are available, 1 to each server.
- By default, setting the controller pair in Transparent Failover Mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2.

## Configuration Example - Netware

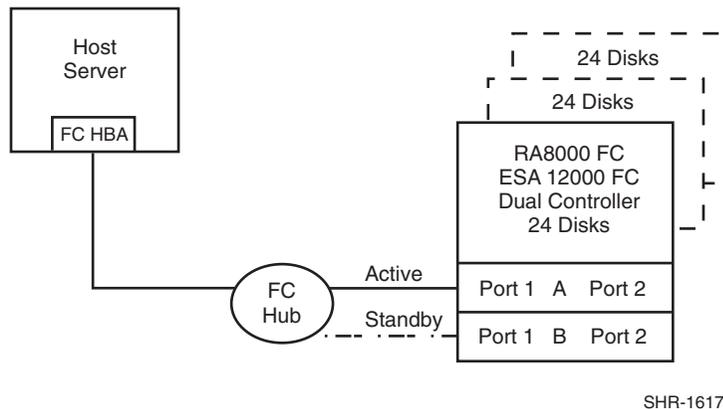
Table 1–4 lists the most common Enterprise/Modular Storage RAID Array Fibre Channel configurations. Netware configurations are used for these examples.

**Table 1–4: Typical RA/MA8000 / ESA/EMA12000 FC-AL Netware Configurations**

Configuration #	Description
1	One Server, Dual Controller, Transparent Failover
2	Configuration 1 with double LUN capacity
3	Up to four servers, Dual Controller, Transparent Failover, Clustered or Shared Storage
4	Up to Eight Servers, Dual Controller, Transparent Failover, Clustered or Shared Storage

### One Server, Dual Controller, Transparent Failover

This two-controller configuration (Figure 1–11) provides dual redundant controllers configured in Transparent Failover mode. The configuration consists of an Enterprise/Modular Storage RAID Array enclosure with two HSG80 array controllers on a single loop. In normal operation Controller A provides the active path for all storage sets to the server through Port 1. A second controller, Controller B is a hot standby. Controller B will automatically become active in the event of a failure in Controller A. All units being accessed through Port 1 of Controller A will become accessible through Port 1 of Controller B. In the initial configuration a single controller host port (Port 1) is active providing access to up to 24 disks. An additional 48 disks can be added using two expansion enclosures. Additional servers can be added to this configuration using the existing hub.

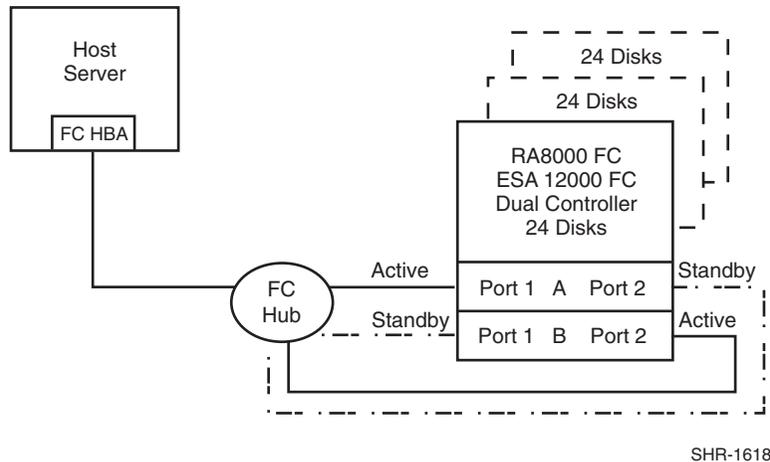


**Figure 1–11: Configuration 1**

### Configuration 1 with Double LUN Capacity

Use of a second controller (Controller B) as an active controller can double LUN capacity and can be accomplished without sacrificing redundancy. Two Fibre Channel cables, one connected to Controller A Port 2, and one connected to Controller B Port 2, result in Configuration 2, shown in Figure 1–12.

This configuration provides full controller redundancy in the event that Controller A or Controller B fails. In either failover scenario the surviving controller will transition a standby port to the active state providing access to all units to the server.



**Figure 1–12: Configuration 2 (Double LUN Capacity)**

### Configurations 1 and 2 Notes

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion enclosures

### Shared Storage

The Enterprise/Modular Storage RAID Array in a Fibre Channel Arbitrated Loop can share its storage among different servers attached to the same Fibre Channel hub. The configuration of the Enterprise/Modular Storage RAID Array depends on the desired application. In a cluster configuration, all storage must be accessible from each server. The Novell Cluster Server provides the controlled access to each storage unit. Non-clustered server configurations require use of the Selective Storage Presentation feature.

### NetWare Cluster Services

Novell Cluster server requires that shared storage devices to be accessible from all servers in the cluster. You do not need to use the Selective Storage Presentation feature for a Novell Cluster.

NetWare Cluster Services (NCS) is the cluster software system implemented on servers to ensure high availability and manageability of critical network resources, including data (volumes), applications, server licenses, and services. It is a multinode, NDS-enabling clustering product of NetWare 5 that supports failover, failback, and migration (load balancing) of individually managed cluster resources. NCS provides important features to help you ensure and manage the availability of your network resources. These features include:

- Support for shared disk configurations or local disk configurations.
- Multinode all-active cluster. Any server in the cluster can restart resources (applications, services, IP addresses, and volumes) from a failed server in the cluster.

- Single point of administration through a Java-based ConsoleOne cluster configuration and monitoring graphical user interface.
- The ability to tailor a cluster to the specific applications and hardware infrastructure that fit your organization.
- Dynamic assignment and reassignment of server storage on an as-needed basis.

## Shared Storage, No Cluster

Sharing an Enterprise/Modular Storage RAID Array with multiple servers in a non-clustered environment requires that you use Selective Storage Presentation.

Selective Storage Presentation is a feature that prevents unauthorized systems from accessing a storage device on a shared RAID array. Normally, many operating systems running on hosts “grab” all the storage they can discover. Furthermore, when these operating systems grab the storage, they tend to write their own information on the devices. This could corrupt the data.

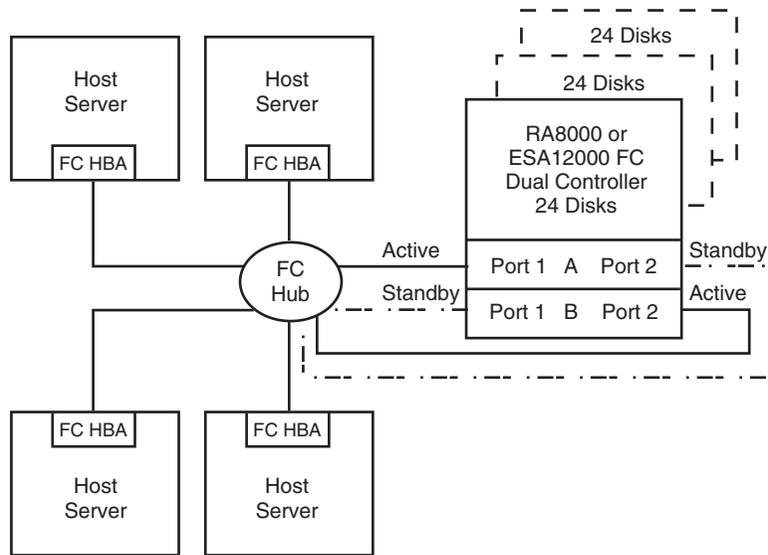
Selective Storage Presentation with HSG80 Array Controllers provides methods for:

- Accessing control for each host connection allows: No Access, Full Access, or Selective Connection Access.
- Setting up host modes for each connection to the array. A particular host mode corresponds to a specific operating system that is tailored to the communication techniques of the operating system.
- Facilitating Fibre Channel protocols for less sophisticated operating systems by providing a LUN offset.
- The host sees a LUN at an offset from the internal LUN within the array. This is necessary because some operating systems only see LUNs in a specific range of LUN numbers.
- Host connections are made when an adapter logs into the array controller over one or more of the controller’s ports. When this connection is made, the controller makes an entry in its internal connection table which is kept in the NonVolatile RAM (NVRAM) of each array.
- Each host connection is identified to the controller in two ways. The first, and most important method, uses the World Wide Identifier (WWID) of the adapter that has logged into the array controller, an ID that is unique to every adapter in the world. The controller uses this ID to recognize the connection as a unique connection. The second method uses the name of the connection. Each host may have more than one adapter; however, each adapter makes its own connection to the array controller, and each connection is treated separately by the controller.

The Enterprise/Modular Storage RAID Array can share storage with both Microsoft Windows NT/2000 and NetWare servers on the same loop, with a maximum of four servers per loop.

## Up to Four Servers, Dual Controller, Transparent Failover, Clustered or Selective Storage

Configuration 3 (Figure 1–13) uses a dual controller pair on a single loop to provide storage and controller redundancy for up to four separate servers. The four servers share the storage enclosure in that each server has exclusive access to its own set of LUNs. This is made possible by the setting of exclusive “host access” at the unit level to give each server an access to individual storage units, or by using the cluster software. Additional levels of access control are necessary for this configuration because all servers are sharing the single Fibre Channel loop. As with all dual controller configurations, controller failover and performance benefits are inherent.



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**Figure 1–13: Configuration 3**

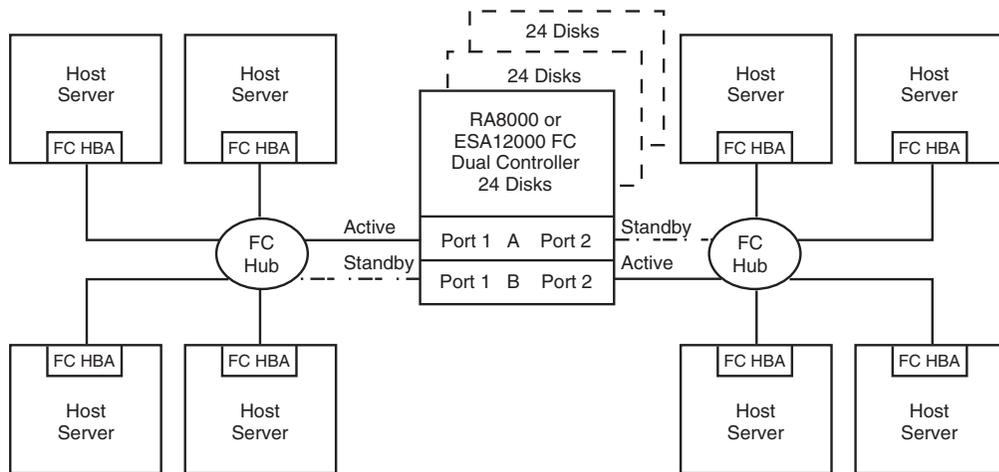
**NOTE:** Enterprise/Modular Storage RAID Array can support Windows NT/2000 and NetWare servers on the same loop

### Configuration 3 Notes

- Single Fibre Channel loop
- Shared storage enclosure
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion enclosures
- In this configuration, 8 logical connections are available

### Up to Eight Servers, Dual Controller, Transparent Failover, Clustered or Selective Storage

Configuration 4 (Figure 1–14) uses a dual controller pair on two Fibre Channel loops to provide storage and controller redundancy to two groups of up to four separate servers. The eight servers share the storage enclosure; in that each server has exclusive access to its own set of LUNs. This is made possible by the setting of exclusive “host access” at the unit level to give each server an access to individual storage units, or by using the cluster software. Additional levels of access control are necessary for this configuration because each group of four servers is sharing the same loop.



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**Figure 1–14: Configuration 4**

**NOTE:** Enterprise/Modular Storage RAID Array can support NT and NetWare on the same loop.

### Configuration 4 Notes

- Two Fibre Channel loops
- Shared storage enclosure
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion enclosures
- Up to 64 LUNs 8 available to each server with 2 active controller host ports
- In this configuration 8 connections are available

## Configuration Example - Windows NT/2000

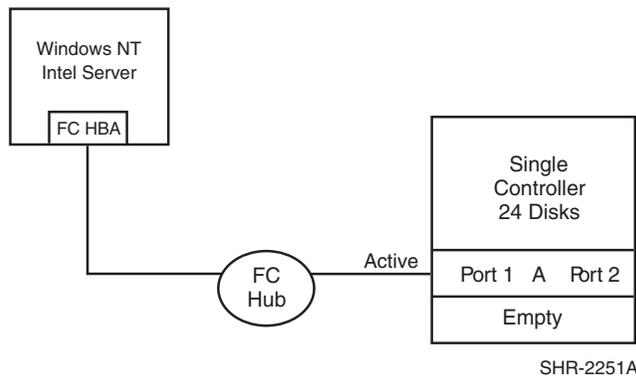
Table 1–5 lists the most common Enterprise/Modular Storage RAID Array Fibre Channel configurations. Windows NT/Windows 2000 configurations are used for these examples.

**Table 1–5: Typical RA/MA8000 / ESA/EMA12000 FC-AL Windows NT/2000 Configurations**

Configuration #	Description
1	One Server, Single Controller
2	One Server, Dual Controller, Transparent Failover
3	One Server, Two Dual Controller Pairs, Transparent Failover
4	Two Servers, Single Controller, Shared Storage Enclosure
5	Two Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure
6	Up to Four Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure
7	Up to Four Servers, Two Dual Controller Pairs, Transparent Failover, Shared Storage Enclosure
8	Up to Eight Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

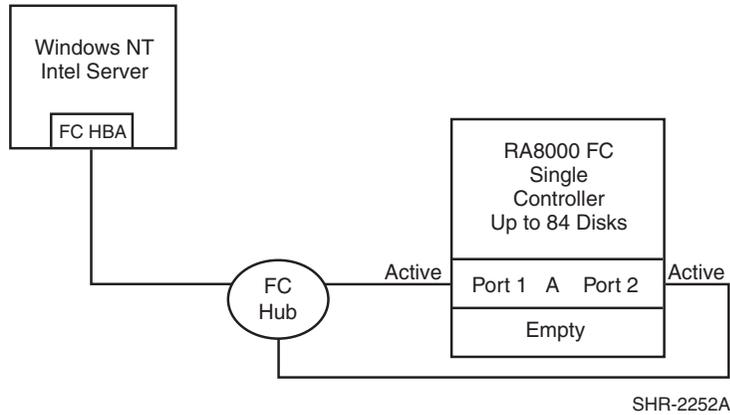
### One Server, Single Controller

The single controller configuration (Figure 1–15) is an entry-level Enterprise/Modular Storage RAID Array that can be expanded to accommodate additional storage capacity or performance needs as required. The configuration consists of an Enterprise/Modular Storage RAID Array enclosure with a single HSG80 array controller on a single Fibre Channel loop. In the initial configuration a single controller host port (Port 1) is active providing up to 8 large LUNs across up to 84 disks. An additional 48 disks can be added using two expansion enclosures. Additional servers can be added to this configuration as required using the existing hub (refer to Configuration 6 in Table 1–5).



**Figure 1–15: Configuration 1**

LUN capacity can be doubled by the use of a third Fibre Channel cable connected to the second controller host port (Port 2), resulting in the configuration shown in Figure 1–16.



**Figure 1–16: Configuration 1 with Double LUN Capacity**

### Configuration 1 Notes

- Single Fibre Channel loop
- This configuration consists of a single HSG80 controller, controller failover is not available
- Up to 500 meters per cable segment
- Up to 84 disks with 2 optional expansion enclosures
- Without large LUNs, up to 8 LUNs with 1 active controller host port (first diagram). Suggested controller unit number assignment: Port 1 units D0 – D7. In this configuration, 1 logical connection is available
- Without large LUNs, up to 16 LUNs with 2 active controller host ports (second diagram). Suggested controller unit number assignment: Port 1 units D0 – D7, Port 2 units D100 – D107. In this configuration, 2 logical connections are available
- Utilization of controller host port 2 requires a third cable and enabling of the port through the Command Line Interface (CLI) using the following commands:
 

```
SET THIS PORT_2_TOPOLOGY = LOOP_HARD
SET THIS PORT_2_AL_PA = 72
```
- In the Figure 1–15 configuration, one logical connection is available
- In the Figure 1–16 configuration, two logical connections are available
- Rename the connection names, for example: SERVER1P1, SERVER1P2
- Set the connection name unit offset value for port 2, SET SERVER1P2 UNIT\_OFFSET = 100

### Configuration 1 Performance Considerations

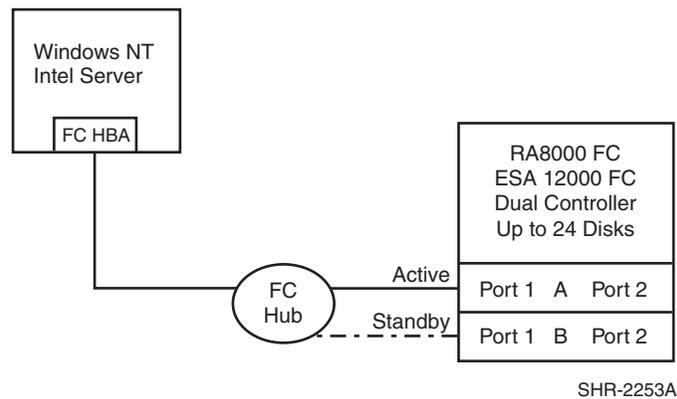
The configuration as shown in Figure 1–15 uses a single controller host port. This results in a throughput limit of 12,000(cache)/4,100(media) I/O/sec and a data rate limit of 77(cache)/54(media) MB/sec. using the second controller host port, as shown in Figure 1–16, results in a performance increase up the Fibre Channel Host Bus Adapter limit of 86 MB/sec for data rate. The I/O rate limit however would be maintained at the single controller limit of 12,000(cache)/4,100(media) I/O/sec.

This is a general-purpose configuration that can be used for typical I/O applications and typical bandwidth applications. Using the second controller host port will increase performance to allow for moderately intensive I/O and moderately intensive bandwidth applications.

An alternative to the configuration shown in the second diagram is to segregate the controller host ports on separate loops by adding a second Fibre Channel Host Bus Adapter in the server and connect this to a second separate hub cabled to controller host Port 2. This would increase the performance to the single controller 2 active port limit of 98(cache)/54(media MB/sec. The I/O/sec rate would remain at 12,000(cache)/4,100(media) I/O/sec.

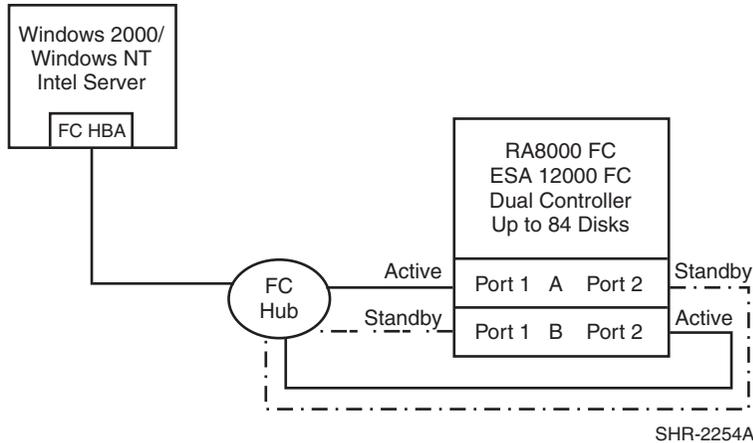
## One Server, Dual Controller, Transparent Failover

This two-controller configuration (Figure 1–17) provides dual redundant controllers configured in Transparent Failover mode. The configuration consists of an Enterprise/Modular Storage RAID Array enclosure with two HSG80 array controllers on a single loop. In normal operation Controller A provides the active path for all storage sets to the server through Port 1. A second controller, Controller B is a hot standby. Controller B will automatically become active in the event of a failure in Controller A. All units being accessed through Port 1 of Controller A will become accessible through Port 1 of Controller B. In the initial configuration a single controller host port (Port 1) is active providing up to 8 LUNs across up to 84 disks. An additional 48 disks can be added using two expansion enclosures. Additional servers can be added to this configuration as required using the existing hub (refer to Configuration 6 in Table 1–5).



**Figure 1–17: Configuration 2**

Using the second controller (Controller B) as an active controller to increase performance and double LUN capacity can be accomplished without sacrificing redundancy. Two Fibre Channel cables, one connected to Controller A Port 2, and one connected to Controller B Port 2, result in the configuration shown in Figure 1–18. This configuration provides full controller redundancy in the event that Controller A or Controller B fails. In either failover scenario the surviving controller will transition a standby port to the active state providing access to all units to the server.



**Figure 1–18: Configuration 2 with Increased Performance and Double LUN Capacity**

## Configuration 2 Notes

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per cable segment
- Up to 84 disks
- Up to 8 LUNs with 1 active controller host port (Figure 1–17). Suggested controller unit number assignment: Port 1 units D0 – D7
- Without large LUNs, up to 64 LUNs with 2 active controller host ports (Figure 1–18). Suggested controller unit number assignment is to balance LUNs between ports.
- Using controller host Port 2 requires two Fibre Channel cables per Figure 1–18, Configuration 2
- By default, setting the controller pair in Transparent Failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2
- In the Figure 1–17 configuration, 1 logical connection is available
- In the Figure 1–18 configuration, 2 logical connections are available
- Rename the connection names. for example: SERVER1P1, SERVER1P2

## Configuration 2 Performance Considerations

The configuration, as shown in the Figure 1–18, uses a single controller host port resulting in a throughput limit of 12,000(cache)/4,100(media) I/O/sec and a data rate limit of 77(cache)/54(media) MB/sec. Using the second controller host port, as shown in the Figure 1–18, results in a performance increase up the Fibre Channel Host Bus Adapter limit of 15,500 I/O/sec and 86 MB/sec data rate.

This is a general-purpose configuration that can be used for typical I/O applications and typical bandwidth applications. Using the second controller will increase performance to allow for moderately intensive I/O and moderately intensive bandwidth applications.

An alternative to the configuration shown in the Figure 1–18, is to segregate the controller host ports on separate loops by adding a second Fibre Channel Host Bus Adapter in the server and connecting to a second separate hub cabled to controller host Port 2. This would increase the performance to the dual controller 2 active port limit of 24,000(cache)/8,200(media) I/O/sec and 154(cache)/102(media) MB/sec.

## One Server, Two Dual Controller Pairs, Transparent Failover

Configuration 3 (Figure 1–19) is a two dual-controller configuration providing two dual-redundant controller pairs using two RA pedestal enclosures or a single ESA enclosure. The controllers are configured in Transparent Failover mode providing controller redundancy in each storage enclosure. This configuration takes advantage of the high capacity of a single Fibre Channel loop allowing for expansion of storage capacity without the addition of another hub. As with Configuration 2, full controller redundancy and two controller capacity is provided in both storage enclosures. In this configuration four active controller ports provide up to 32 LUNs across up to 48 disks. An additional 96 disks can be added using four expansion enclosures. Additional servers can be added to this configuration as required using the existing hub (refer to Configuration 7 in Table 1–5).

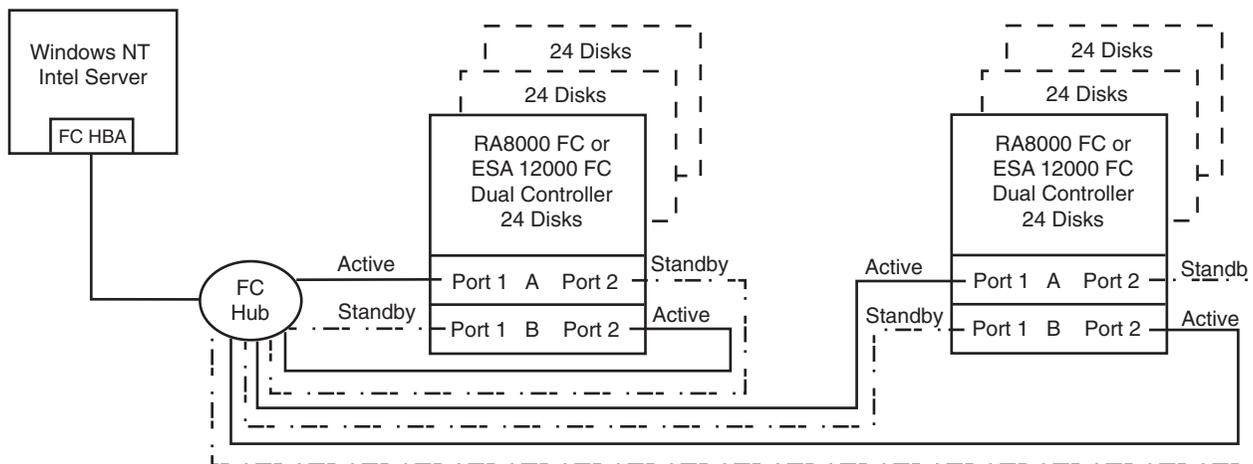


Figure 1–19: Configuration 3

### Configuration 3 Notes

- Single Fibre Channel loop.
- Two Dual HSG80 controller pairs configured in Transparent Failover Mode.
- Up to 500 meters per cable segment.
- Up to 168 disks.
- Up to 64 LUNs with 4 active controller host ports. Suggested controller unit number assignment: In each storage enclosure, balance units between host ports.
- By default, setting the controller pairs in Transparent Failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2.
- In this configuration 4 logical connections are available, 2 in each enclosure.

- For each enclosure (controller pair), rename the connection names, for example: SERVER1P1, SERVER1P2, SERVER2P1, SERVER2P2, and so forth.
- For the second controller enclosure set each controller host port ALPA to a different hexadecimal address then set on the first enclosure. Suggested settings: Controller Enclosure 1 Port 1 = 71, Port 2 = 72, Controller Enclosure 2 Port 1 = 73, Port 2 = 74
- The configuration of units for both controller pairs can be set identical to that described above. This is possible because the Fibre Channel Host Bus Adapter will see each active controller host port as a unique target ID with a unique set of LUNs. Although LUN numbering is identical for each controller pair, when viewed by the server the LUNs on the active controller host ports in the second enclosure are assigned under different SCSI target IDs.

### Configuration 3 Performance Considerations

This configuration uses two dual controller pairs with an overall limit of the Fibre Channel Host Bus Adapter of 15,500 I/O/sec and 86 MB/sec data rate. The primary advantage of this configuration is the added storage and LUN capacity.

This is a general-purpose configuration that can be used for moderately intensive I/O applications and typical bandwidth applications. It is more suited for I/O intensive applications and high capacity requirements.

### Two Servers, Single Controller, Shared Storage Enclosure

Configuration 4 (Figure 1–20) uses the second controller host port to provide storage to a second separate (non-cooperating) server. The two servers share the storage enclosure in that each server has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering. This configuration uses two separate Fibre Channel loops. Additional servers can be added to this configuration as required using the existing hubs (refer to Configuration 8 in Table 1–5).

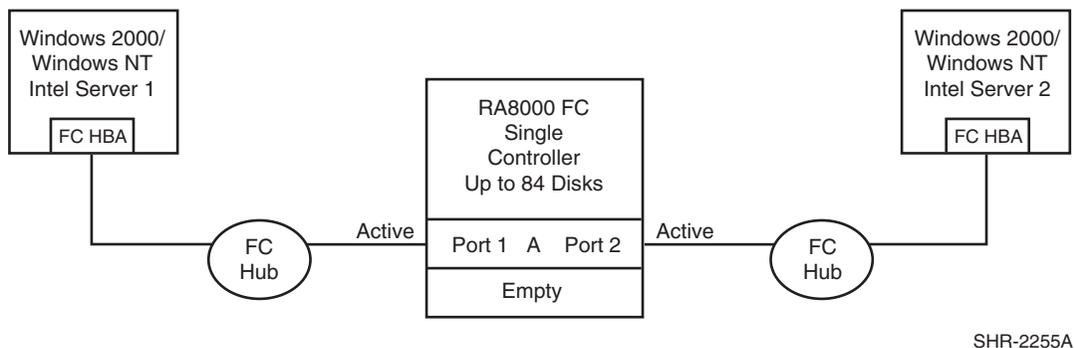


Figure 1–20: Configuration 4

### Configuration 4 Notes

- Two Fibre Channel loops.
- Shared storage enclosure.
- This configuration consists of a single HSG80 controller, controller failover is not available.
- Up to 500 meters per cable segment.
- Up to 84 disks with 2 optional expansion enclosures.

- Up to 128 LUNs total, 64 available to each server with 2 active controller host ports. Suggested controller unit number assignment: balance LUNS between host ports.
- In this configuration 2 logical connections are available.
- Utilization of controller host Port 2 requires a third cable and enabling of the port through the Command Line Interface (CLI) using the following commands:  

```
SET THIS PORT_2_TOPOLOGY = LOOP_HARD  
SET THIS PORT_2_AL_PA = 72
```
- Rename the connection names, for example: SERVER1P1, SERVER2P2.
- Set the connection name unit offset value for port 2, SET SERVER2P2 UNIT\_OFFSET = 100

#### **Configuration 4 Performance Considerations**

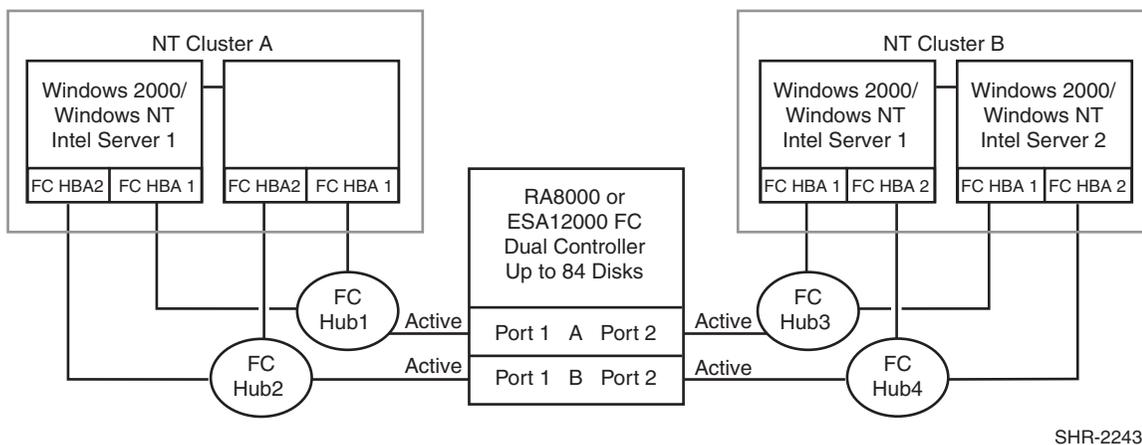
This configuration uses a single controller with two active controller host ports. The overall limit is based on the single controller, two active port limit of 12,000(cache)/4,100(media) I/O/sec and 98(cache)/54(media) MB/sec data rate. The primary advantage of this configuration is the ability to share the storage enclosure between two independent servers.

This is a general-purpose configuration that can be used for typical I/O and intensive bandwidth applications. It is more suited for bandwidth intensive applications.

## Two Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

Configuration 5 (Figure 1–21) uses a dual controller pair to provide storage and controller redundancy to a second separate (non-cooperating) server. The two servers share the storage enclosure in that each server has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering. This configuration uses two separate Fibre Channel loops. Each server has access to its own dedicated controller. In the event of a controller failover, the surviving controller will continue to provide full access to units to both servers.

In normal operation Controller A provides the active path for all storage sets assigned to server 1 through Port 1. A second controller, Controller B provides the active path for all storage sets assigned to server 2 through Port 2. Each server also has a dedicated standby port in the event that there is a controller failover. Additional servers can be added to this configuration as required using the existing hubs (refer to Configuration 8 in Table 1–5).



**Figure 1–21: Configuration 5**

### Configuration 5 Notes

- Two Fibre Channel loops
- Shared storage enclosure.
- Dual HSG80 controllers configured in Transparent Failover Mode.
- Up to 500 meters per cable segment.
- Up to 84 disks with 2 optional expansion enclosures.
- Up to 128 LUNs total, 64 available to each server with 2 active controller host ports. Suggested controller unit number assignment: balance LUNS between host ports.
- In this configuration 2 logical connections are available.
- Rename the connection names, for example: SERVER1P1, SERVER2P2.
- By default, setting the controller pair in Transparent Failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2.
- Utilization of the second controller host port requires a second Windows NT Intel Server, Fibre Channel host bus adapter, hub and cables.

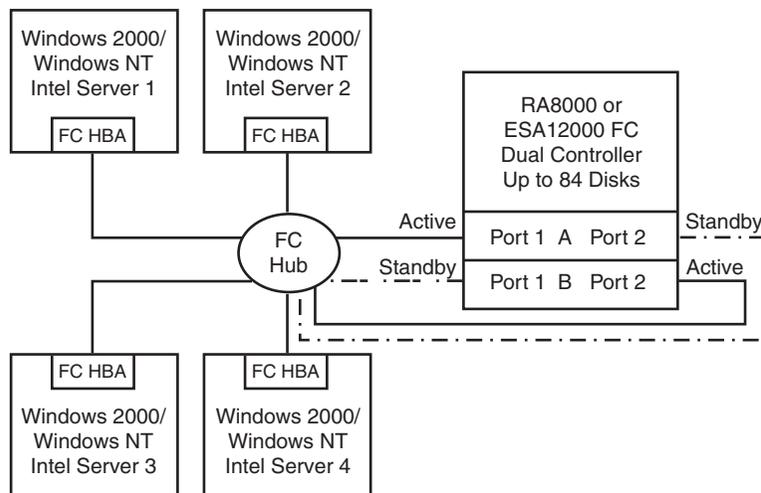
## Configuration 5 Performance Considerations

This configuration uses dual controllers with two active and two standby controller host ports. The overall limit is based on the dual controller, two active port limit of 24,000(cache)/8,200(media) I/O/sec and 154(cache)/102(media) MB/sec data rate. The primary advantage of this configuration is the ability to share the storage enclosure between two independent servers without any performance degradation.

This is a general-purpose configuration that can be used for intensive I/O applications and very intensive bandwidth applications.

## Up to Four Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

Configuration 6 (Figure 1–22) builds on Configurations 2 and 5 using a dual controller pair on a single loop to provide storage and controller redundancy for up to four separate (non-cooperating) servers. The four servers share the storage enclosure in that each server has exclusive access to its own set of LUNs. This is made possible by the setting of explicit “host access” at the unit level and using connection name “unit offsets” to give each server an accessible range of unit numbers. Additional levels of access control are necessary for this configuration because all servers are sharing the single Fibre Channel loop. As with all dual controller configurations, controller failover and performance benefits are inherent.



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**Figure 1–22: Configuration 6**

### Configuration 6 Notes

- Single Fibre Channel loop.
- Shared storage enclosure.
- Dual HSG80 controllers configured in Transparent Failover Mode.
- Up to 500 meters per cable segment.
- Up to 84 disks with 2 optional expansion enclosures.
- Up to 128 LUNs total, 32 available to each server with 2 active controller host ports.

- In this configuration 8 logical connections are available.
- Rename the connection names, for example: SERVER1P1, SERVER1P2, SERVER2P1, and so forth.
- Set the connection name unit offset values. By default, setting the controller pair in Transparent failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2. Use the default connection unit offset values for one of the servers and set new unit offset values for connections to the other three servers as shown below.
- Set exclusive unit access for each unit to a specific server connection name. For example: for unit D0 ENABLE = SERVER1P1; for unit D100 ENABLE = SERVER2P2.
- Set each Fibre Channel Host Bus Adapter ALPA to a unique hexadecimal hard address. Suggested settings: HBA1 = 01, HBA2 = 02, HBA3 = 04, HBA4 = 08.
- Suggested unit numbering and connection parameters would result in the units being distributed equally across controller host ports as follows:

Server 1: Port 1 units D0 – D7, Port 2 units D100 – D107

Connection name, unit offset value: SERVER1P1, 0. SERVER1P2, 100

Server 2: Port 1 units D10 – D17, Port 2 units D110 – D117

Connection name, unit offset value: SERVER2P1, 10. SERVER2P2 110

Server 3: Port 1 units D20 – D27, Port 2 units D120 – D127

Connection name, unit offset value: SERVER3P1, 20. SERVER3P2, 120

Server 4: Port 1 units D30 – D37, Port 2 units D130 – D137

Connection name, unit offset value: SERVER4P1, 30. SERVER4P2, 130

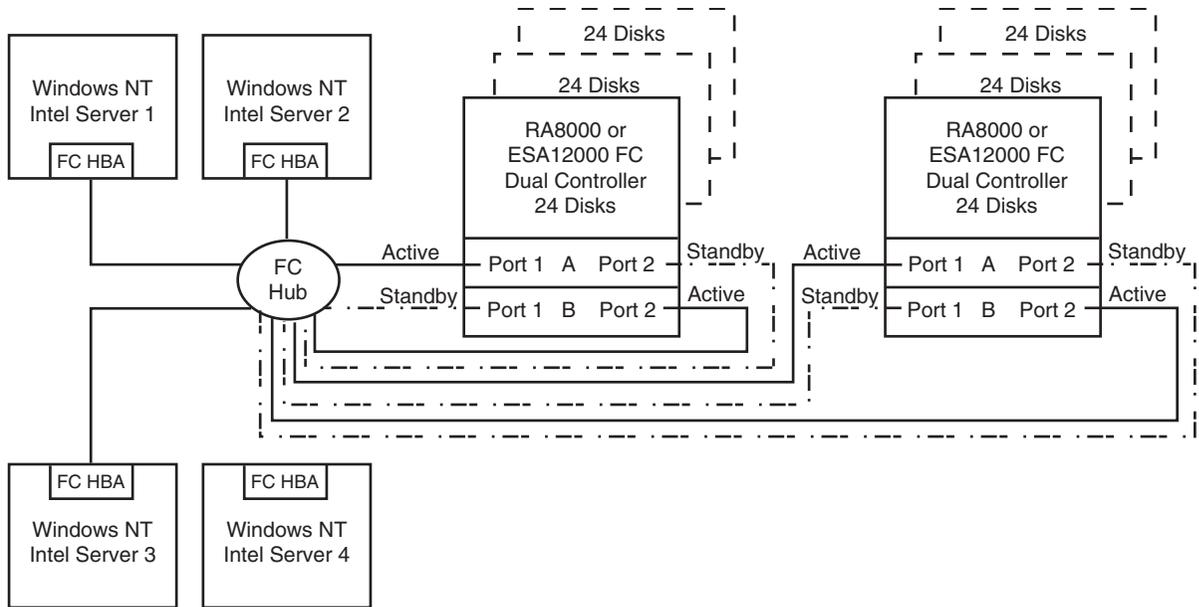
## Configuration 6 Performance Considerations

This configuration uses dual controllers with two active and two standby controller host ports. The overall limit is based on the dual controller, 2 active port limit of 24,000 I/O/sec and the theoretical single loop limit of 100 MB/sec data rate. The primary advantage of this configuration is the ability to connect up to four servers on a single Fibre Channel loop.

This is a high connectivity configuration that can be used for intensive I/O and very intensive bandwidth applications. It is more suited for bandwidth intensive applications.

## Up to Four Servers, Two Dual Controller Pairs, Transparent Failover, Shared Storage Enclosure

Configuration 7 (Figure 1–23) builds on Configurations 3 and 6, using two dual controller pairs on a single loop to provide storage and controller redundancy for up to four separate (non-cooperating) servers. The four servers share the storage enclosures in that each server has exclusive access to its own set of LUNs within each enclosure. This is made possible by the setting of explicit “connection name access” at the unit level and using connection name “unit offsets” to give each server an accessible range of unit numbers. Additional levels of access control are necessary for this configuration because all servers are sharing the single Fibre Channel loop. The addition of a second controller pair doubles the disk and LUN capacity available to the four servers.



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**Figure 1–23: Configuration 7**

### Configuration 7 Notes

- Single Fibre Channel loop.
- Shared storage enclosure.
- Two Dual HSG80 controller pairs configured in Transparent Failover Mode.
- Up to 500 meters per cable segment.
- Up to 168 disks.
- Up to 256 LUNs, 64 available to each server with 4 active controller host ports.
- In this configuration 16 connections are available, 8 in each enclosure.
- The configuration of units for both enclosures can be set identical to that described in Configuration 6. This is possible because each server will see each active controller host port as a unique target ID with a unique set of LUNs. Although LUN numbering is identical within each enclosure, when viewed by each server the LUNs on the active controller host ports in the second enclosure are assigned under different SCSI target IDs.
- For each enclosure (controller pair), rename the connection names, for example: SERVER1P1, SERVER1P2, SERVER1P1, SERVER1P2, and so forth.
- For the second controller enclosure set each controller host port ALPA to a different hexadecimal address then set on the first enclosure. Suggested settings: Controller Enclosure 1 Port 1 = 71, Port 2 = 72, Controller Enclosure 2 Port 1 = 73, Port 2 = 74.
- Set each Fibre Channel Host Bus Adapter ALPA to a unique (hexadecimal) hard address. Suggested settings: HBA1 = 01, HBA2 = 02, HBA3 = 04, HBA4 = 08.

- Set the connection name unit offset values. By default, setting the controller pairs in Transparent failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2. Use the default connection unit offset values for one of the servers and set new unit offset values for connections to the other three servers as shown below.
- Set exclusive unit access for each unit to a specific server connection name. For example: for unit D0 ENABLE = SERVER1P1; for unit D100 ENABLE = SERVER1P2.
- Suggested unit numbering and connection parameters would result in the units being distributed equally across enclosures and controller host ports as follows:

#### **Controller Enclosure 1**

ALPA settings: Controller Host Port 1 = 71, Port 2 = 72

Server 1, Enclosure 1: Port 1 units D0 – D7, Port 2 units D100 – D107  
Connection names, unit offset values: SERVER1P1, 0. SERVER1P2, 100

Server 2, Enclosure 1: Port 1 units D10 – D17, Port 2 units D110 – D117  
Connection names, unit offset values: SERVER2P1, 10. SERVER2P2 110

Server 3, Enclosure 1: Port 1 units D20 – D27, Port 2 units D120 – D127  
Connection names, unit offset values: SERVER3P1, 20. SERVER3P2, 120

Server 4, Enclosure 1: Port 1 units D30 – D37, Port 2 units D130 – D137  
Connection names, unit offset values: SERVER4P1, 30. SERVER4P2, 130

#### **Controller Enclosure 2**

ALPA settings: Controller Host Port 1 = 73, Port 2 = 74

Server 1, Enclosure 2: Port 1 units D0 – D7, Port 2 units D100 – D107  
Connection names, unit offset values: SERVER1P1, 0. SERVER1P2, 100

Server 2, Enclosure 2: Port 1 units D10 – D17, Port 2 units D110 – D117  
Connection names, unit offset values: SERVER2P1, 10. SERVER2P2 110

Server 3, Enclosure 2: Port 1 units D20 – D27, Port 2 units D120 – D127  
Connection names, unit offset values: SERVER3P1, 20. SERVER3P2, 120

Server 4, Enclosure 2: Port 1 units D30 – D37, Port 2 units D130 – D137  
Connection names, unit offset values: SERVER4P1, 30. SERVER4P2, 130

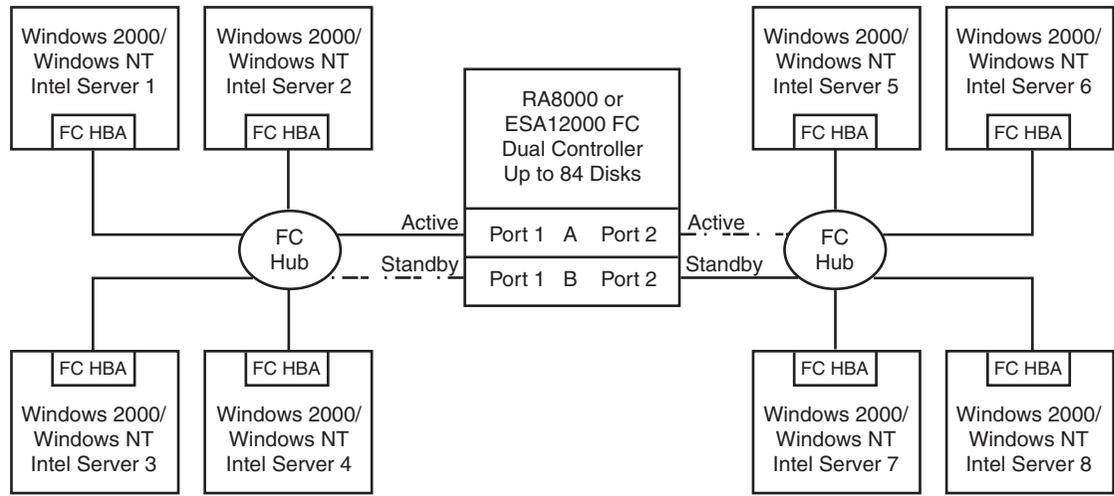
### **Configuration 7 Performance Considerations**

This configuration uses 2 dual controller pairs with an overall limit based on a theoretical single loop limit of 25,000 I/O/sec and 100 MB/sec data rate. The primary advantages of this configuration are the ability to connect up to four servers and two storage systems on a single Fibre Channel loop, and the added storage and LUN capacity.

This is a high connectivity configuration that can be used for moderately intensive I/O applications and intensive bandwidth applications. It is more suited for I/O applications.

## Up to Eight Servers, Dual Controller, Transparent Failover, Shared Storage Enclosure

Configuration 8 (Figure 1–24) builds on Configurations 5 and 6 using a dual controller pair on two Fibre Channel loops to provide storage and controller redundancy to two groups of up to four separate (non-cooperating) servers. The eight servers share the storage enclosure in that each server has exclusive access to its own set of LUNs. This is made possible by the setting of explicit “host access” at the unit level and using connection name “unit offsets” to give each server an accessible range of unit numbers. Additional levels of access control are necessary for this configuration because each group of four servers is sharing the same loop.



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**Figure 1–24: Configuration 8**

### Configuration 8 Notes

- Two Fibre Channel loops.
- Shared storage enclosure.
- Dual HSG80 controllers configured in Transparent Failover Mode.
- Up to 500 meters per cable segment.
- Up to 84 disks.
- Up to 128 LUNs 16 available to each server with 2 active controller host ports.
- In this configuration 8 connections are available.
- Rename the connection names, for example: SERVER1P1, SERVER2P1, SERVER5P2, and so forth.
- Set the connection name unit offset values. By default, setting the controller pair in Transparent failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2. Use the default connection unit offset values for one of the servers on each loop and set new unit offset values for connections to the other six servers as shown below.

- Set exclusive unit access for each unit to a specific server connection name, for example: for unit D0 ENABLE = SERVER1P1, for unit D100 ENABLE = SERVER5P2.
- Set each Fibre Channel Host Bus Adapter ALPA to a unique hexadecimal hard address. Suggested settings: HBA1 = 01, HBA2 = 02, HBA3 = 04, HBA4 = 08.
- Suggested unit numbering and connection parameters would result in the units being distributed equally across enclosures and controller host ports as follows:

Server 1: Port 1 units D0 – D7  
Connection name, unit offset value: SERVER1P1, 0

Server 2: Port 1 units D10 – D17  
Connection name, unit offset value: SERVER2P1, 10

Server 3: Port 1 units D20 – D27  
Connection name, unit offset value: SERVER3P1, 20

Server 4: Port 1 units D30 – D37  
Connection name, unit offset value: SERVER4P1, 30

Server 5: Port 2 units D100 – D107  
Connection name, unit offset value: SERVER5P2, 100

Server 6: Port 2 units D110 – D117  
Connection name, unit offset value: SERVER6P2 110

Server 7: Port 2 units D120 – D127  
Connection name, unit offset value: SERVER7P2, 120

Server 8: Port 2 units D130 – D137  
Connection name, unit offset value: SERVER8P2, 130

## Configuration 8 Performance Considerations

This configuration uses dual controllers with two active and two standby controller host ports. The overall limit is based on the dual controller, two active port limit of 24,000(cache)/8,200(media) I/O/sec and 154(cache)/102(media) MB/sec data rate. The primary advantage of this configuration is the ability to share the storage enclosure and connect up to eight independent servers across two Fibre Channel loops.

This is a general-purpose configuration that can be used for intensive I/O applications and very intensive bandwidth applications. It is more suited for bandwidth intensive applications however it offers adequate performance for I/O applications as well.

## Appendix A: Examples of HA Configurations

This appendix provides examples of High Availability configurations, for the following operating systems:

- HP-UX, beginning on page 39
- Sun Solaris, beginning on page 52
- Tru64 UNIX, beginning on page 57

### HP-UX

This section lists examples of the most common HP-UX Enterprise/Modular Storage RAID Array Fibre Channel high availability (HA) configurations.

**Table 1–6: Typical FC-AL HP-UX Configurations**

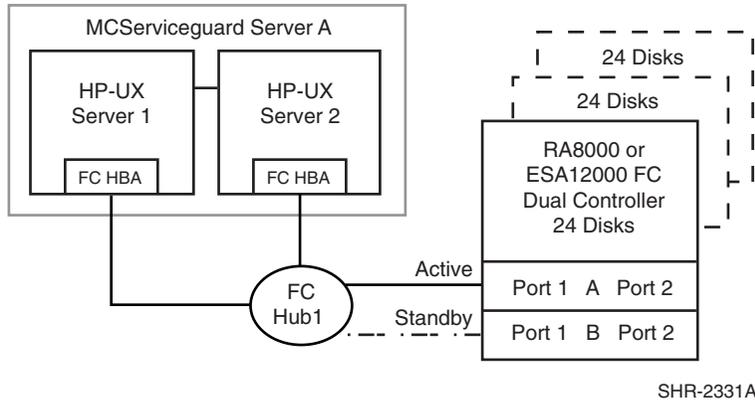
Configuration	Description
1	Two Servers, MC/Serviceguard, Transparent Failover
2	Four Servers, MC/Serviceguard, Transparent Failover, One Shared Storage Enclosure
3	Two Servers, MC/Serviceguard, Multiple-Bus Failover
4	Four Servers, MC/Serviceguard, Multiple-Bus Failover
5	Up to Four Servers, Multiple-Bus Failover, One Shared Storage Enclosure
6	Up to Four Servers, Multiple-Bus Failover, Two Shared Storage Enclosures
7	Up to Eight Servers, Multiple-Bus Failover, Two Shared Storage Enclosures

**NOTE:** All configurations have one or more HSG80 Storage Systems with dual-controllers bound in either Transparent Failover or Multiple\_bus Failover Mode.

### HA Configuration 1 - Two Servers, MC/Serviceguard Cluster Server, Transparent Failover

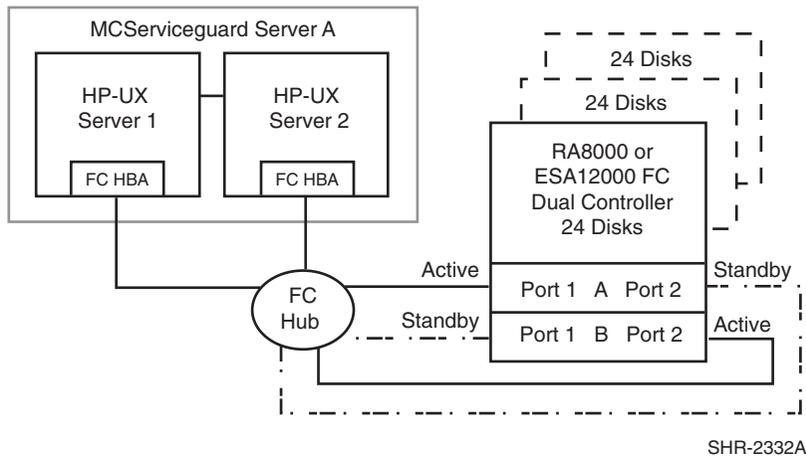
HA Configuration 1 (Figure 1–25) provides dual redundant controllers configured in Transparent Failover mode. The configuration consists of a single Enterprise/Modular Storage RAID Array enclosure with two HSG80 array controllers connected to two servers running MC/Serviceguard Application software. In normal operation Controller A provides the active path for all storage sets to the server pair through Controller A, Port 1. A second controller, Controller B, is a hot standby. In the event of a failure in Controller A, Controller B will automatically become active.

All units that are being accessed through Port 1 of Controller A will become accessible through Port 1 of Controller B. In the event of a server failure, MC/Serviceguard will transfer access to units through the surviving server. In the initial configuration a single controller host port (Port 1) is active providing up to 64 LUNs across up to 24 disks. An additional 48 disks can be added using two expansion enclosures.



**Figure 1–25: HA Configuration 1**

With the addition of two Fibre Channel cables, Controller B, can become an active controller to increase performance and double LUN capacity. Two additional Fibre Channel cables, one connected to Controller A Port 2, and one connected to Controller B Port 2, result in the configuration shown in Figure 1–26. This configuration provides full controller redundancy in the event that Controller A or Controller B fails. In either failover scenario the surviving controller will transition a standby port to active providing access to all units in the MC/Serviceguard pair.



**Figure 1–26: HA Configuration 1 with Increased Performance and Doubled LUN Capacity**

## HA Configuration 1 Notes

### Figure 1–25:

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- MC/Serviceguard application software installed
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets

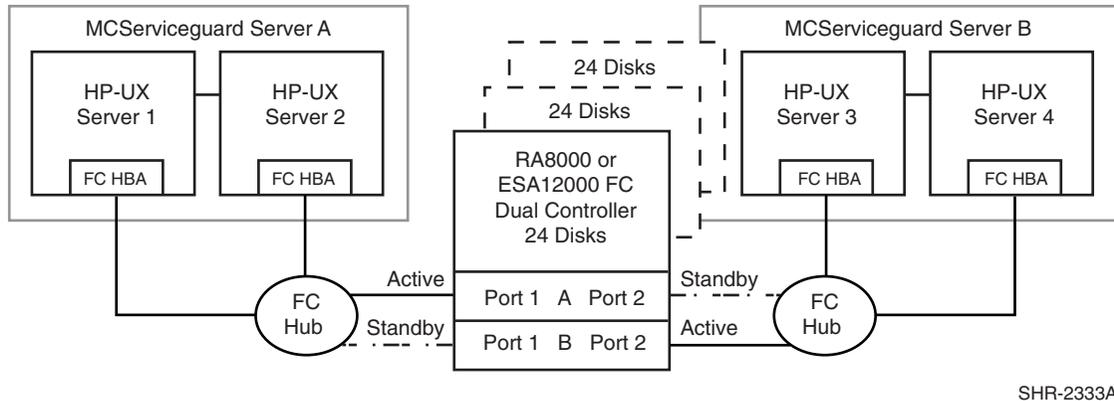
- Up to 64 LUNs with 1 active controller host port.
- Suggested controller unit number assignment: Port 1 units D0 – D63. Two (2) logical connections are available
- Rename the connection names, SERVER1P1, SERVER1P2
- Run *SaveCfg* as required to account for the required LUNs

**Figure 1–26:**

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- MC/Serviceguard application software installed
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets
- Up to 128 LUNs with 2 active controller host ports. Suggested controller unit number assignment:
- Port 1 units D0 – D63, Port 2 units D100 – D163. (Four (4) logical connections are available).
- Utilization of controller host Port 2 requires two additional Fibre Channel cables
- Setting the controller pair in Transparent Failover mode will, by default automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2
- Rename the connection names, SERVER1P1, SERVER1P2, SERVER2P1, SERVER2P2
- Run *SaveCfg* as required to account for the required LUNs

## HA Configuration 2 - Four Servers, MC/Serviceguard, Transparent Failover, Shared Storage Enclosure

The dual-controller configuration (Figure 1–27) uses two pairs of controller host ports to provide storage for a second server pair under MC/Serviceguard control. Each Server pair can be configured with up to 64 LUNs. The two MC/Serviceguards share the storage enclosure in that each cluster has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering. The controllers are configured in Transparent Failover mode providing controller redundancy for both clusters. In the event of a controller failover, the surviving controller will continue to provide full access to units in both Veritas clusters. In the event of a server failure, MC/Serviceguard failover will be invoked to provide access to units through the surviving server. In this configuration two active controller ports provide up to 128 LUNs (64 per server pair) across up to 24 disks. An additional 48 disks can be added using two expansion enclosures to increase storage capacity.



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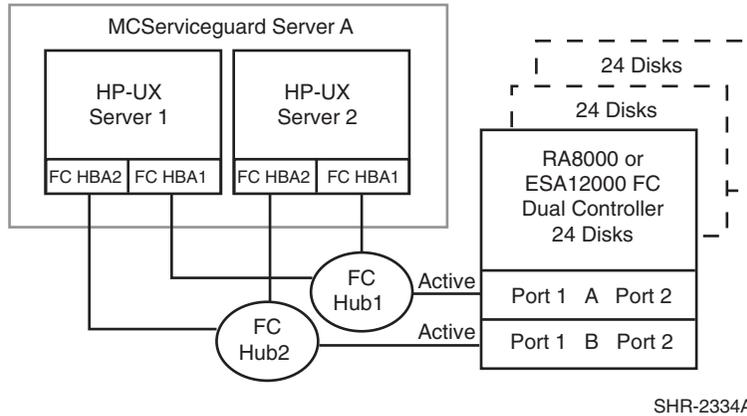
Figure 1–27: HA Configuration 2

### HA Configuration 2 Notes

- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- MC/Serviceguard application software for two server pairs installed
- Shared storage enclosure
- Two Fibre Channel loops
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion enclosures
- Up to 128 LUNs total/64 per server pair with 2 active controller host ports.
- Suggested controller unit number assignment  
Server pair A, Controller A Port 1 units D0 – D63.  
Server pair B, Controller B Port 2 units D100 – D163
- By default, setting the controller pair in Transparent Failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2
- In this configuration 4 logical connections are available
- Rename the connection names, SERVER1P1, SERVER2P1, SERVER3P2, SERVER4P2
- Run *SaveCfg* as required to account for the required LUNs

### HA Configuration 3 - Two Servers, MC/Serviceguard, Multiple-Bus Failover

HA Configuration 3 (Figure 1–28) combines the benefits of MC/Serviceguard pairing and controller redundancy to provide the highest level of availability. The configuration uses two separate physical paths to the storage. In the event of a failure of any component within the access path – Fibre Channel host bus adapter, cables, hub, or controller host port interface, all units on the failing path will become accessible through the alternate path. In the event of a server failure, MC/Serviceguard failover will be invoked to provide access to units through the surviving server.



**Figure 1–28: HA Configuration 3**

### HA Configuration 3 Notes

- Two Fibre Channel loops
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets
- Up to 64 LUNs with 2 active controller host ports.
- Suggested controller unit number assignment: Port 1 units D0 – D63
- Set the Unit Preferred Path. Use the Preferred Path unit parameter to assign units to specific controllers. Units should be distributed equally across controllers for load balancing. For example:  
Prefer units D0 – D31 to Controller A  
Prefer units D32 – D63 to Controller B
- In this configuration 4 logical connections are available
- Rename the connection names, SERV1P1A, SERV1P1B, SERV2P1A, SERV2P1B
- Run *SaveCfg* as required to account for the required LUNs

### HA Configuration 4 - Four Servers, MC/Serviceguard, Multiple-Bus Failover, Two Independent Server Pairs, Shared Storage Enclosure

HA Configuration 4 (Figure 1–29) builds on configurations 2 and 3, combining the benefits of MC/Serviceguard software, controller redundancy, and sharing of the storage enclosure. The configuration provides two independent server pairs with two separate physical paths to the storage through two pairs of controller host ports. In the event of a failure of any component within the access path – Fibre Channel host bus adapter, cables, hub, or controller host port interface, all units on the failing path will become accessible through the alternate path. In the event of a server failure, cluster failover will be invoked to provide access to units through the surviving server. Each MC/Serviceguard pair can be configured with up to 64 LUNs. The two server pairs share the storage enclosure as each

server pair has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering. An additional 48 disks can be added using two expansion enclosures to increase storage capacity.

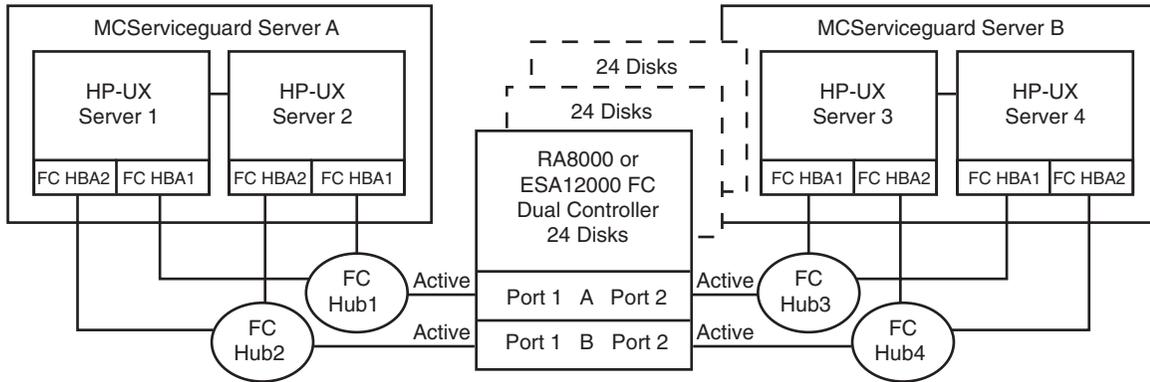


Figure 1–29: HA Configuration 4

### HA Configuration 4 Notes

- Four Fibre Channel loops
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- MC/Serviceguard application software installed
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets
- Up to 128 LUNs total/64 server pair with 4 active controller host ports.
- Suggested controller unit number assignment:

Port 1 units D0 – D63,

Port 2 units D64 – D127

Set the Unit Preferred Path. Use the Preferred Path unit parameter to distribute units equally across controllers for load balancing, as follows:

Prefer units D0 – D31 to Controller A

Prefer units D32 – D63 to Controller B

Prefer units D64 – D95 to Controller A

Prefer units D96 – D127 to Controller B

(In this configuration 8 logical connections are available)

- Rename the connection names, for example, SERV1P1A, SERV1P1B, SERV2P1A, SERV2P1B, SERV3P2A, SERV3P2B, SERV4P2A, SERV4P2B
- Set exclusive unit access for each unit to specific server connection names; for unit D0 ENABLE = SERV1P1A, SERVP1B, SERV2P1A, SERV2P1B, for unit D32 ENABLE = SERV3P2A, SERV3P2B, SERV4P2A, SERV5P2B.

- If you are using SWCC to create units, by default units are enabled on all known connection names. You must explicitly disable connection names enabled for units to prevent access.
- Set the connection name unit offset values for each connection as shown below

**NOTE:** The suggested unit numbering and connection parameters results in the units being distributed equally across clusters/controller host ports as follows:

Server 1: Port 1 units D0 – D63

Connection names, unit offset values: SERV1P1A, 0. SERV1P1B, 0

Server 2: Port 1 units D0 – D63

Connection names, unit offset values: SERV2P1A, 0. SERV2P1B, 0

Server 3: Port 2 units D64 – D127

Connection names, unit offset values: SERV3P2A, 64. SERV3P2B, 64

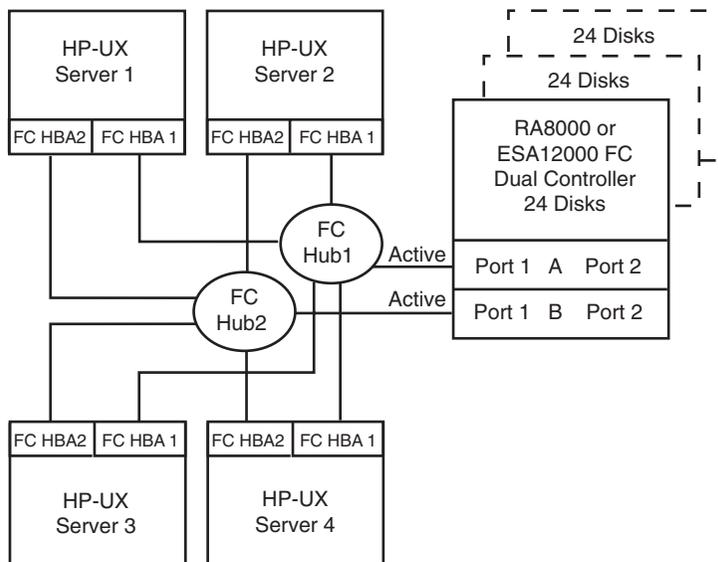
Server 4: Port 2 units D64 – D127

Connection names, unit offset values: SERV4P2A, 64. SERV4P2B, 64

- Run *SaveCfg* as required to account for the required LUNs.

## HA Configuration 5 - Up to Four Servers, Multiple-Bus Failover, Shared Storage Enclosure

HA Configuration 5 (Figure 1–30) provides storage for up to four separate (non-cooperating) servers on two Fibre Channel loops. The four servers share the storage enclosure in that each server has exclusive access to its own set of LUNs. This is made possible by the setting of explicit “connection name access” at the unit level and using connection name “unit offsets” to give each server an accessible range of unit numbers. Additional levels of access control are necessary for this configuration because all servers are sharing the two Fibre Channel loops. The configuration uses two separate paths to the storage from each server. In the event of a failure of any component within the access path – host bus adapter, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path.



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**Figure 1–30: HA Configuration 5**

## HA Configuration 5 Notes

- Two Fibre Channel loops
- Shared storage enclosure
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets
- Up to 128 LUNs, 32 available to each server with 2 active controller host ports.
- Set the Unit Preferred Path. Use the Preferred Path unit parameter to distribute units equally across controllers/ports for load balancing

Prefer units D0 – D15 to Controller A

Prefer units D16 – D31 to Controller B

Prefer units D32 – D47 to Controller A

Prefer units D48 – D63 to Controller B

Prefer units D64 – D79 to Controller A

Prefer units D80 – D95 to Controller B

Prefer units D96 – D111 to Controller A

Prefer units D112 – D127 to Controller B

- In this configuration 8 logical connections are available
- Rename the connection names, SRV1A1P1A, SRV1A2P1B, SRV2A1P1A, SRV2A2P1B, SRV3A1P1A, SRV3A2P1B, SRV4A1P1A, SRV4A2P1B
- Set exclusive unit access for each unit to specific server connection names, for unit D0 ENABLE = SRV1A1P1A, SRV1A2P1B, for unit D32 ENABLE = SRV2A1P1A, SRV2A2P1B.
- If you are using SWCC to create units, by default units are enabled on all known connection names. You must explicitly disable connection names enabled for units to prevent access.
- Set the connection name unit offset values for each connection as shown below.

**NOTE:** The suggested unit numbering and connection parameters results in the units being distributed equally across servers and controller host ports, as follows:

Server 1: Port 1 units D0 – D31

Connection names, unit offset values: SRV1A1P1A, 0. SRV1A2P1B, 0

Server 2: Port 1 units D32 – D63

Connection names, unit offset values: SRV2A1P1A, 32. SRV2A2P1B, 32

Server 3: Port 1 units D64 – D95

Connection names, unit offset values: SRV3A1P1A, 64. SRV3A2P1B, 64

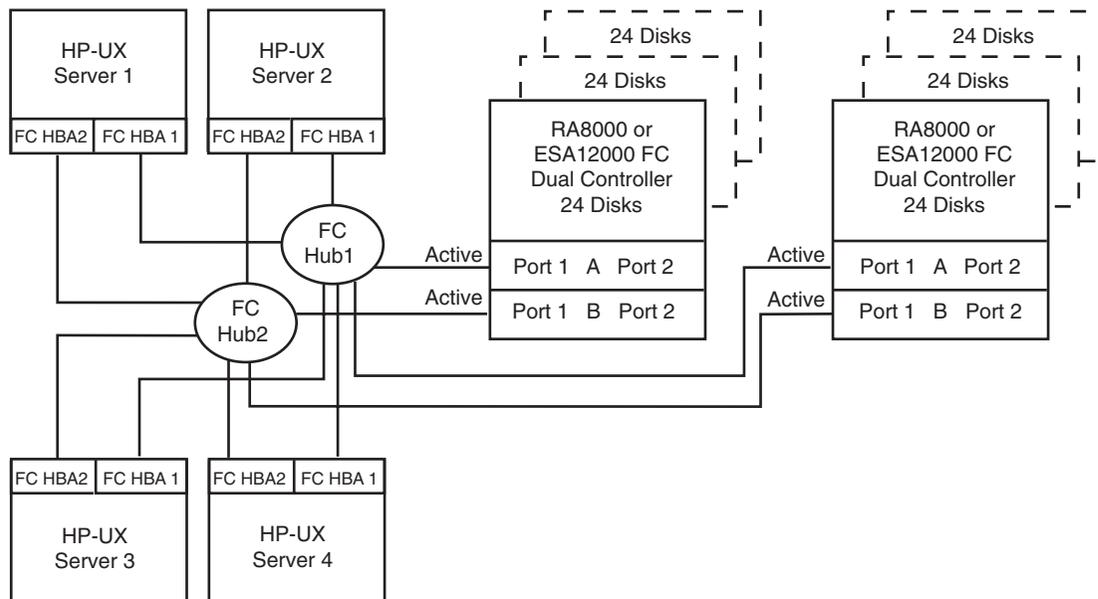
Server 4: Port 1 units D96 – D127

Connection names, unit offset values: SRV4A1P1A, 96. SRV4A2P1B, 96

- Run *SaveCfg* as required to account for the required LUNs.

## HA Configuration 6 - Up to Four Servers, Multiple-Bus Failover, Two Shared Storage Enclosures

HA Configuration 6 (Figure 1–31) builds on Configuration 5 by adding storage capacity using a second enclosure and second pair of controllers. The second pair of controllers are connected to two Fibre Channel loops providing redundant paths for up to four separate (non-cooperating) servers. The four servers share both storage enclosures in that each server has exclusive access to its own LUNs in each enclosure through the use of mutually exclusive LUN numbering, explicit unit host access, and the use of connection unit offsets. Additional levels of access control are necessary for this configuration because all servers are sharing the two Fibre Channel loops. The configuration uses two separate paths to the storage from each server. In the event of a failure of any component within the access path – host bus adapter, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path.



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**Figure 1–31: HA Configuration 6**

### HA Configuration 6 Notes

- Two Fibre Channel loops
- Shared storage enclosure
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- Two HSG80 controller pairs configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 144 disks with 4 optional expansion cabinets
- Up to 256 LUNs, 64 available to each server with 4 active controller host ports. Refer to Configuration 6 for a suggested way to define the units that distributes them equally across servers/host ports. Unit configurations and numbering can be identical for each storage enclosure, as each server will see each active controller host port as a unique target ID with a unique set of LUNs.

- For each storage enclosure (controller pair), set the Unit Preferred Path. Use the Preferred Path unit parameter to distribute units equally across controllers/ports for load balancing.

For Example:

Prefer units D0 – D15 to Controller A

Prefer units D16 – D31 to Controller B

Prefer units D32 – D47 to Controller A

Prefer units D48 – D63 to Controller B

Prefer units D64 – D79 to Controller A

Prefer units D80 – D95 to Controller B

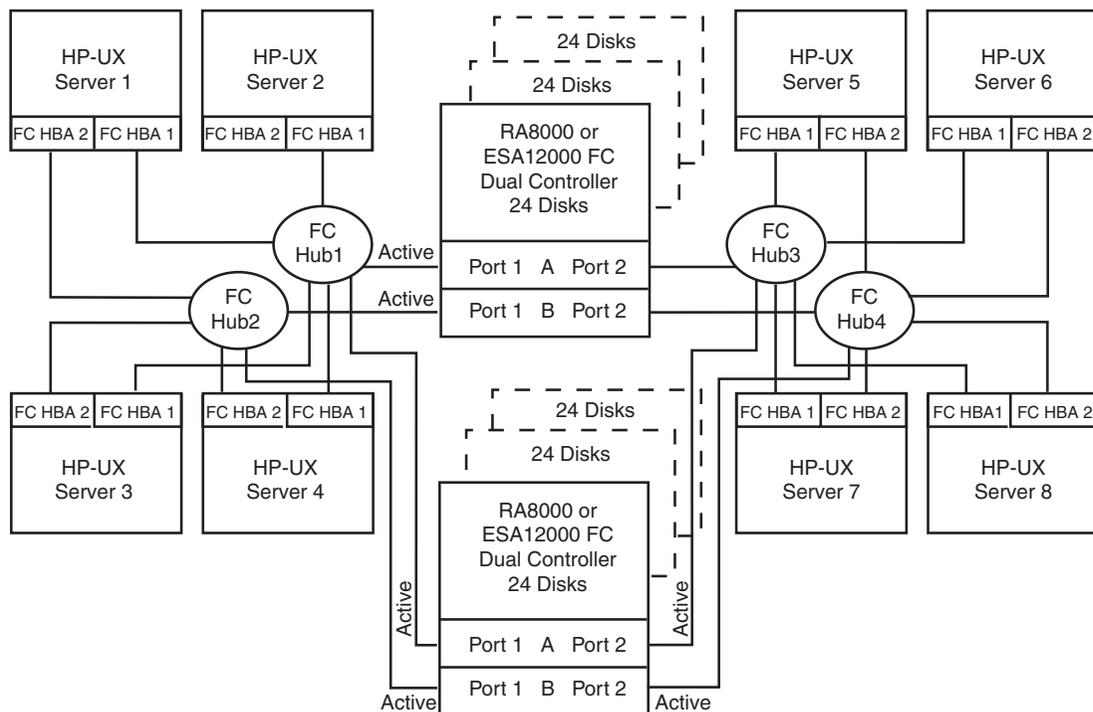
Prefer units D96 – D111 to Controller A

Prefer units D112 – D127 to Controller B

- In this configuration 16 logical connections are available, 8 in each enclosure
- For each storage enclosure (controller pair), rename the connection names, SRV1A1P1A, SRV1A2P1B, SRV2A1P1A, SRV2A2P1B, SRV3A1P1A, SRV3A2P1B, SRV4A1P1A, SRV4A4P1B
- Set exclusive unit access for each unit to specific server connection names, for unit D0 ENABLE = SRV1A1P1A, SRV1A2P1B, for unit D32 ENABLE = SRV2A1P1A, SRV2A2P1B. If you are using SWCC to create units, by default units are enabled on all known connection names. You must explicitly disable connection names enabled for units to prevent access.
- For the second enclosure set each controller host port ALPA to a different address than set on the first enclosure. Suggested settings: Enclosure 1 Port 1 = 71, Port 2 = 72. Enclosure 2 Port 1 = 73, Port 2 = 74
- Set the connection name unit offset values for each connection as shown below
- Suggested unit numbering and connection parameters would result in the units being distributed equally across enclosures and controller host ports as follows:
- Run *SaveCfg* as required to account for the required LUNs

## HA Configuration 7 - Up to Eight Servers, Multiple-Bus Failover, Two Shared Storage Enclosures

Configuration 7 (Figure 1–32) builds on Configurations 5 and 6 using two dual controller pairs on four loops to provide storage path and controller redundancy for up to eight separate (non-cooperating) servers. The eight servers share both storage enclosures in that each server has exclusive access to its own LUNs in each enclosure through the use of mutually exclusive LUN numbering, explicit unit host access, and the use of connection unit offsets. Additional levels of access control are necessary for this configuration because each group of four servers is sharing two Fibre Channel loops. The configuration uses two separate paths to the storage from each server. In the event of a failure of any component within the access path – host bus adapter, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path.



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**Figure 1–32: HA Configuration 7**

### HA Configuration 7 Notes

- Four Fibre Channel loops
- Shared Storage Enclosure
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for HP-UX installed
- Two HSG80 controller pairs configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 144 disks with 4 optional expansion cabinets

- Up to 128 LUNs, 32 available to each server with 8 active controller host ports. Refer to Configuration 6 for a suggested way to define the units that distributes them equally across servers/host ports. Unit configurations and numbering can be identical for each storage enclosure, as each server will see each active controller host port as a unique target ID with a unique set of LUNs.
- For each storage enclosure (controller pair), set the Unit Preferred Path. Use the Preferred Path unit parameter to distribute units equally across controllers/ports for load balancing. Example:

Prefer units D0 – D7 to Controller A

Prefer units D8 – D15 to Controller B

Prefer units D16 – D23 to Controller A

Prefer units D24 – D31 to Controller B

Prefer units D32 – D39 to Controller A

Prefer units D40 – D47 to Controller B

Prefer units D48 – D55 to Controller A

Prefer units D56 – D63 to Controller B

Prefer units D64 – D71 to Controller A

Prefer units D72 – D79 to Controller B

Prefer units D80 – D87 to Controller A

Prefer units D88 – D95 to Controller B

Prefer units D96 – D103 to Controller A

Prefer units D104 – D111 to Controller B

Prefer units D112 – D119 to Controller A

Prefer units D120 – D127 to Controller B

(In this configuration 32 logical connections are available, 16 in each enclosure).

- For each enclosure (controller pair), rename the connection names, SRV1A1P1A, SRV1A2P1B, SRV2A1P1A, SRV2A2P1B, SRV3A1P1A, SRV3A2P1B, SRV4A1P1A, SRV4A2P1B
- Set exclusive unit access for each unit to specific server connection names, for unit D0 ENABLE = SRV1A1P1A, SRV1A2P1B, for unit D32 ENABLE = SRV2A1P1A, SRV2A2P1B. If you are using SWCC to create units, by default units are enabled on all known connection names. You must explicitly disable connection names enabled for units to prevent access.
- For the second enclosure set each controller host port ALPA to a different address than set on the first enclosure. Suggested:  
Enclosure 1 Port 1 = 71, Port 2 = 72.  
Enclosure 2 Port 1 = 73, Port 2 = 74
- Set the connection name unit offset values at each enclosure for each connection as shown below. Suggested unit numbering and connection parameters would result in the units being distributed equally across enclosures and controller host ports as follows:  
Enclosure 1: ALPA settings: Controller Host Port 1 = 71, Port 2 = 72  
Enclosure 2: ALPA settings: Controller Host Port 1 = 73, Port 2 = 74  
Server 1: Port 1 units D0 – D15  
Connection names, unit offset values: SRV1A1P1A, 0. SRV1A2P1B, 0

Server 2: Port 1 units D16 – D31

Connection names, unit offset values: SRV2A1P1A, 16. SRV2A2P1B, 16

Server 3: Port 1 units D32 – D47

Connection names, unit offset values: SRV3A1P1A, 32. SRV3A2P1B, 32

Server 4: Port 1 units D48 – D63

Connection names, unit offset values: SRV4A1P1A, 48. SRV4A2P1B, 48

Server 5: Port 2 units D64 – D79

Connection names, unit offset values: SRV5A1P2A, 64. SRV5A2P2B, 64

Server 6: Port 2 units D80 – D95

Connection names, unit offset values: SRV6A1P2A, 80. SRV6A2P2B, 80

Server 7: Port 2 units D96 – D111

Connection names, unit offset values: SRV7A1P2A, 96. SRV7A2P2B, 96

Server 8: Port 2 units D112 – D127

Connection names, unit offset values: SRV8A1P2A, 112. SRV8A2P2B, 112

- Run *SaveCfg* as required to account for the required LUNs

## Sun Solaris

This section lists examples of the most common Sun Solaris Enterprise/Modular Storage RAID Array Fibre Channel high availability (HA) configurations.

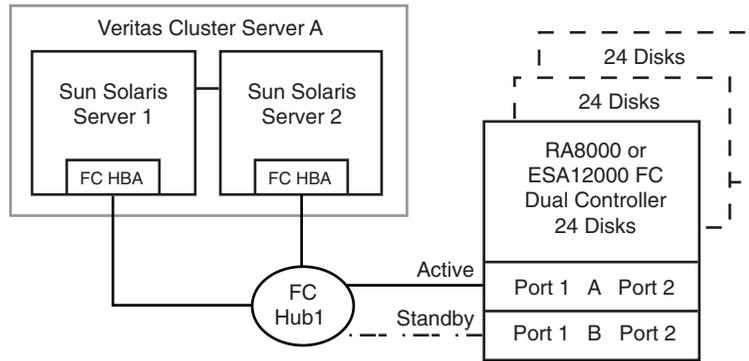
**NOTE:** These examples apply to JNI HBAs in transparent failover only.

**Table 1–7: Typical FC-AL Sun Solaris Configurations**

Configuration	Description
1	Two Servers, Veritas Cluster Server, Transparent Failover
2	Four Servers, Veritas Cluster Server, Transparent Failover, One Shared Storage Enclosure

### HA Configuration 1- Two Servers, Veritas Cluster Server, Transparent Failover

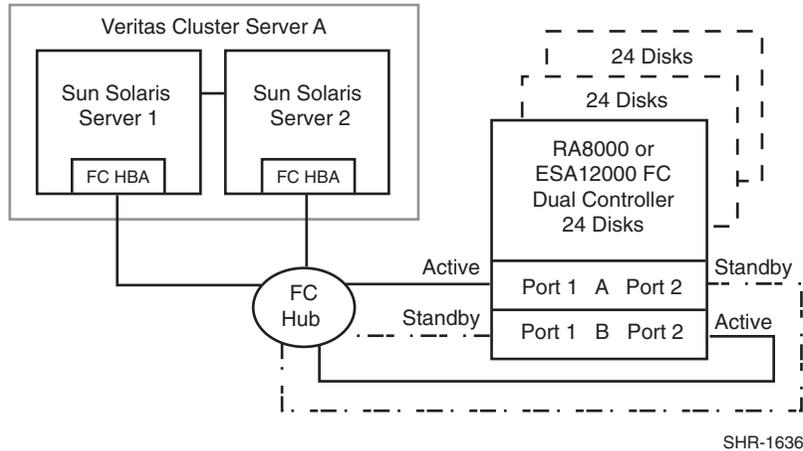
HA Configuration 1 (Figure 1–33) provides dual redundant controllers configured in Transparent Failover mode. The configuration consists of a single Enterprise/Modular Storage RAID Array storage enclosure with two HSG80 array controllers connected to two servers running Veritas Cluster Server Application software. In normal operation Controller A provides the active path for all storagesets to the server pair through Controller A, Port 1. A second controller, Controller B, is a hot standby. In the event of a failure in Controller A, Controller B will automatically become active. All units being accessed through Port 1 of Controller A will become accessible through Port 1 of Controller B. In the event of a server failure, Veritas Cluster Server will transfer access to units through the surviving server. In the initial configuration a single controller host port (Port 1) is active providing up to 64 LUNs across up to 24 disks. An additional 48 disks can be added using two expansion enclosures.



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**Figure 1–33: HA Configuration 2**

With the addition of two Fibre Channel cables, Controller B, can become an active controller to increase performance and double LUN capacity. Two additional Fibre Channel cables, one connected to Controller A Port 2, and one connected to Controller B Port 2, result in the configuration shown in Figure 1–34. This configuration provides full controller redundancy in the event that Controller A or Controller B fails. In either failover scenario the surviving controller will transition a standby port to active providing access to all units in the Veritas Cluster Server pair.



**Figure 1–34: HA Configuration 2 with Increased Performance and Doubled LUN Capacity**

### HA Configuration 1 Notes

**Figure 1–33** shows the following configurations.

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for Sun Solaris installed
- Veritas Cluster Server application software installed
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets
- Up to 64 LUNs with 1 active controller host port.
- Suggested controller unit number assignment: Port 1 units D0 – D63. Two (2) logical connections are available
- Rename the connection names, that is, SERVER1P1, SERVER1P2
- Run `/opt/steam/bin/config.sh` to account for the required LUNs.

**Figure 1–34** shows the following configurations:

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for Sun Solaris installed
- Veritas Cluster Server application software installed
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets
- Up to 128 LUNs with 2 active controller host ports. Suggested controller unit number assignment: Port 1 units D0 – D63, Port 2 units D100 – D163. 4 logical connections are available.
- Utilization of controller host Port 2 requires two additional Fibre Channel cables

- Setting the controller pair in Transparent Failover mode will, by default automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2
- Rename the connection names, that is, SERVER1P1, SERVER1P2, SERVER2P1, SERVER2P2
- Run `/opt/steam/bin/config.sh` to account for the required LUNs.

## HA Configuration 2- Four Servers, Veritas Cluster Server, Transparent Failover, Shared Storage Enclosure

The dual-controller configuration (Figure 1–35) uses two pairs of controller host ports to provide storage for a second server pair under Veritas Cluster Server control. Each Server pair can be configured with up to 64 LUNs. The two Veritas Cluster Servers share the storage enclosure in that each cluster has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering. The controllers are configured in Transparent Failover mode providing controller redundancy for both clusters. In the event of a controller failover, the surviving controller will continue to provide full access to units in both Veritas clusters. In the event of a server failure, Veritas Cluster Server failover will be invoked to provide access to units through the surviving server. In this configuration two active controller ports provide up to 128 LUNs (64 per server pair) across up to 24 disks. An additional 48 disks can be added using two expansion enclosures to increase storage capacity.

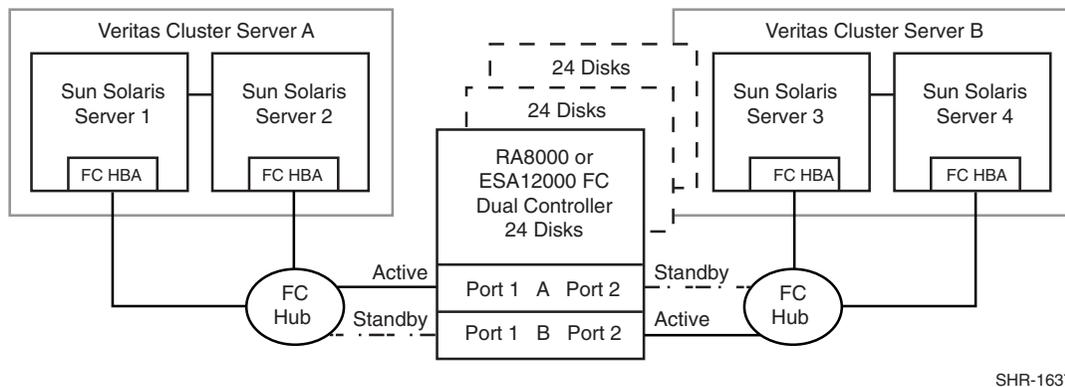


Figure 1–35: HA Configuration 3

### HA Configuration 2 Notes

- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for Sun Solaris installed
- Veritas Cluster Server application software for two server pairs installed
- Shared storage enclosure
- Two Fibre Channel loops
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion enclosures
- Up to 128 LUNs total/64 per server pair with 2 active controller host ports.

- Suggested controller unit number assignment:  
Server pair A, Controller A Port 1 units D0 – D63  
Server pair B, Controller B Port 2 units D100 – D163
- By default, setting the controller pair in Transparent Failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2
- In this configuration 4 logical connections are available
- Rename the connection names, that is, SERVER1P1, SERVER2P1, SERVER3P2, SERVER4P2
- Run `/opt/steam/bin/config.sh` to account for the required LUNs.

## HA Application Options for Sun

This section discusses the following High Availability Application Options:

- Secure Path Version 2.1 or 5.0A for Sun Solaris
- Veritas Cluster Server V1.0.1 for Solaris V2.8

### Secure Path Version 2.1 or 5.0A for Sun Solaris

StorageWorks Secure Path is a high availability software product providing continuous data access for Enterprise/Modular Storage RAID Array FC products configured on Sun Solaris. Redundant hardware, advanced RAID technology and automated failover capability are used to enhance data availability. Secure Path effectively eliminates controllers, interconnect hardware and host bus adapters as single points of failure in the storage system.

The key is the capability of Enterprise/Modular Storage RAID Array 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 using the Secure Path Management Tool.

Controllers in Multiple-bus failover mode monitor each other and automatically failover storage units from the failed member of a controller pair. The 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 the Management Tool.

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

### Veritas Cluster Server V1.0.1 for Solaris V2.8

Veritas Cluster Server is a high-availability cluster solution that provides proactive management of application services. The Veritas Cluster Server Java-based management GUI provides a single point of management for the entire cluster configuration. Veritas Cluster Server:

- Is architecture-independent supporting up to 32 servers and compatible with single server, parallel and distributed applications.
- Supports cascading and multi-directional application failover and application services can be manually migrated to alternate servers for maintenance purposes.

- Provides a comprehensive availability management solution designed to minimize both planned and unplanned down time.
- Can accommodate new and existing Sun and third-party hardware and can be easily adapted to meet site-specific requirements.
- Minimizes deployment time with features such as a self-replicating single configuration file per configuration, installation wizards and templates, auto-discovery of new cluster resources, and off-the-shelf agents to fault manage the industry's most popular applications.

## Tru64 UNIX

This section lists examples of the most common Tru64 UNIX Enterprise/Modular Storage RAID Array Fibre Channel high availability (HA) configurations.

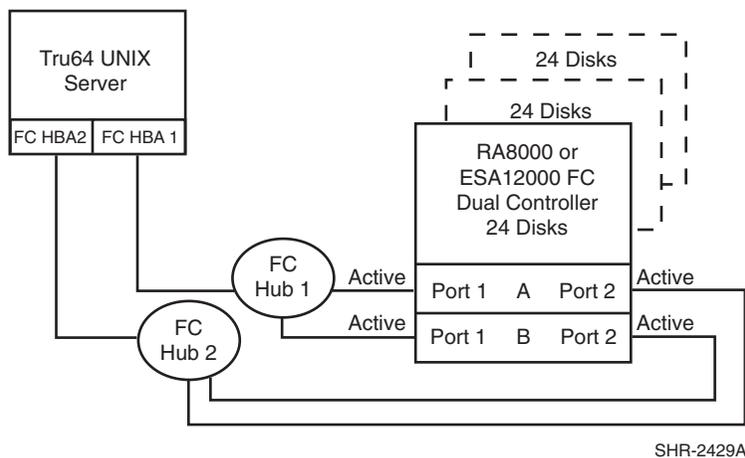
**Table 1–8: Typical FC-AL Tru64 UNIX Configurations**

Configuration	Description
1	One Server, one HSG80 pair
2	Two Servers, one HSG80 pair
3	Two Servers, two HSG80 pairs
4	Two Servers, two HSG80 pairs, dual HBAs

**NOTE:** All configurations have one or more HSG80 Storage Systems with dual-controllers bound in Multiple\_bus Failover Mode.

### HA Configuration 1 - One Server, One HSG80 Pair

Configuration 1 (Figure 1–36) represents an entry-level Enterprise/Modular Storage RAID Array configuration that can be expanded to support additional storage capacity or performance needs as required. The configuration consists of a single Enterprise/Modular Storage RAID Array enclosure with two HSG80 array controllers configured in Multiple-Bus Failover mode. The initial configuration supports up to 24 disks. Support for an additional 48 disks can be added using two expansion enclosures.



**Figure 1–36: Configuration 1**

### HA Configuration 1 Notes

- Two Fibre Channel loops
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for Tru64 UNIX installed.
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode.
- Up to 500 meters per cable segment.
- Up to 72 disks with 2 optional expansion cabinets.

- Set the Unit Preferred Path. Use the Preferred Path unit parameter to assign units to specific controllers. Units should be distributed equally across controllers.
- Rename the connection names, that is, SERV1P1A, SERV1P1B.
- Dual HBAs set to loop mode.

## HA Configuration 2 - Two Servers, One HSG80 Pair

Configuration 2 (Figure 1–37) provides dual redundant controllers configured in multiple-bus failover node. The configuration consists of a single Enterprise/Modular Storage RAID Array storage enclosure with two HSG80 array controllers connected to two servers in a TruCluster configuration.

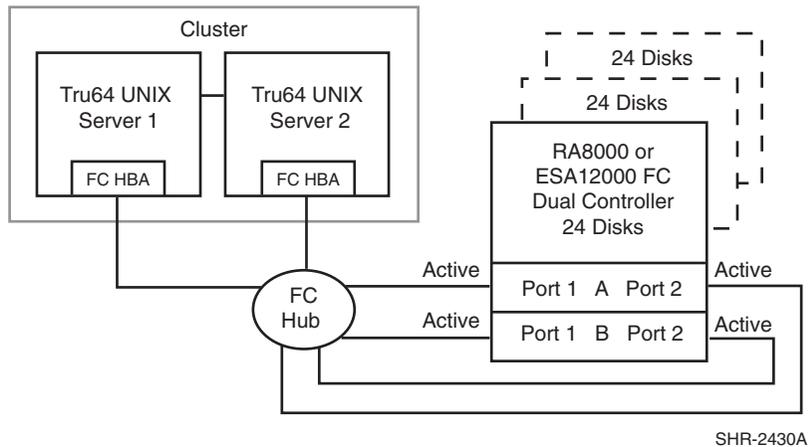


Figure 1–37: Configuration 2

### HA Configuration 2 Notes

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for Tru64 UNIX
- TruCluster software installed
- Up to 500 meters per cable segment
- Up to 72 disks with 2 optional expansion cabinets
- Rename the connection names, that is, SERVER1P1, SERVER1P2

## HA Configuration 3 - Two Servers, Two HSG80 Pairs

Configuration 3 (Figure 1–38) demonstrates the use of two HSG80 storage systems connected to a two node TruCluster configuration using Fibre Channel Arbitrated Loop (FC-AL) using two seven port hubs.

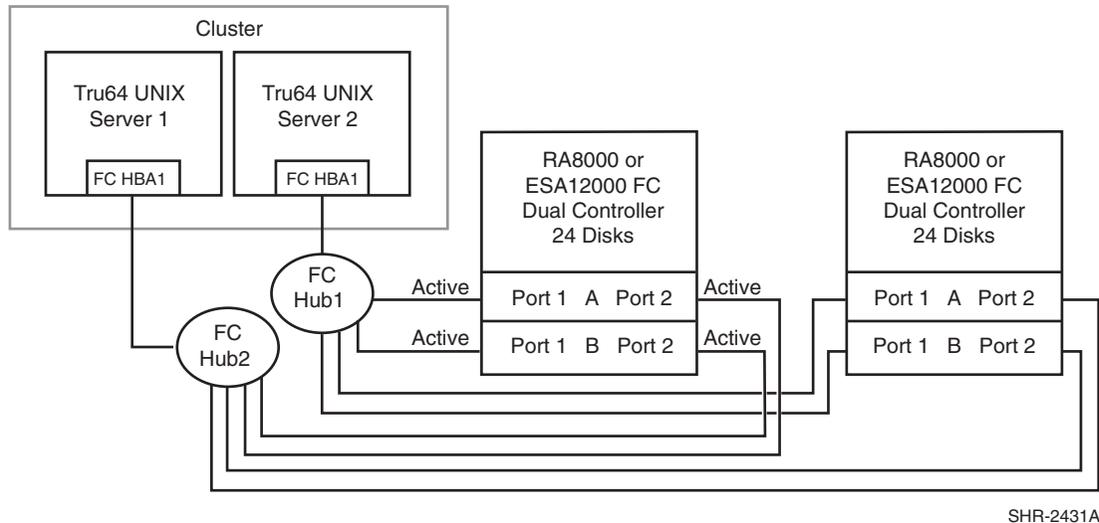


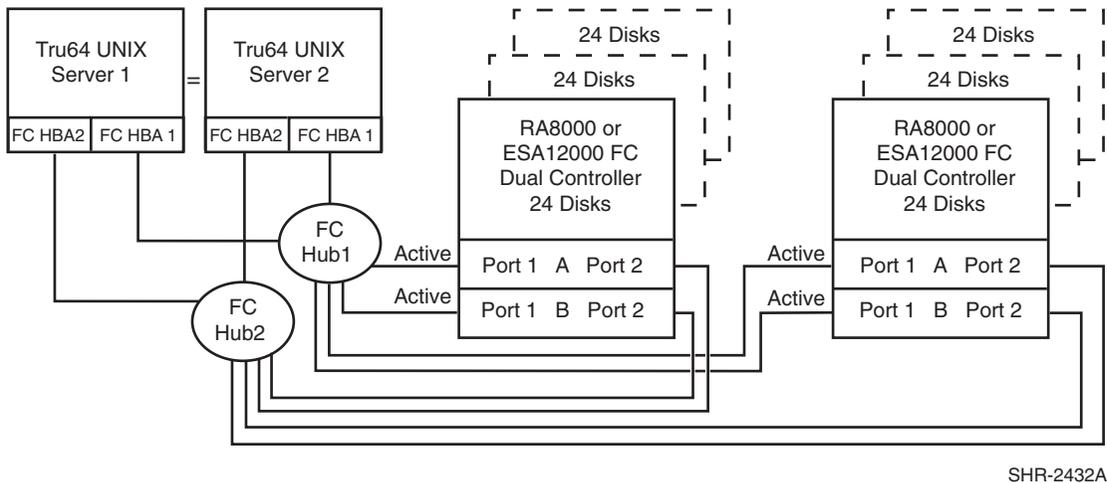
Figure 1–38: Configuration 3

### HA Configuration 3 Notes

- Two Fibre Channel loops.
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for Tru64 UNIX installed.
- TruCluster configuration.
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode.
- Up to 500 meters per cable segment.
- Up to 72 disks with 2 optional expansion cabinets per HSG80 pair.
- Set the Unit Preferred Path. Use the Preferred Path unit parameter to assign units to specific controllers. Units should be distributed equally across controllers.
- Rename the connection names, that is, SERV1P1A, SERV1P1B, SERV2P1A, SERV2P1B.
- One HBA per host set to loop mode.
- One memory channel cluster connection.

## HA Configuration 4 - Two Servers, Two HSG80 Pairs, Dual HBAs

Configuration 4 (Figure 1–39) builds on configurations 3 by using dual HBAs in the hosts, dual memory channel cluster connections and dual FC-AL hubs in a TruCluster configuration



**Figure 1–39: Configuration 4**

### HA Configuration 4 Notes

- Two Fibre Channel loops.
- Two shared storage enclosures.
- Enterprise/Modular Storage RAID Array HSG80 Solution Software V8.7 for Tru64 UNIX installed.
- TruCluster configuration.
- Two HSG80 controller pairs configured in Multiple-Bus Failover mode.
- Up to 500 meters per cable segment.
- Up to 144 disks with 4 optional expansion cabinets.
- For each storage enclosure (controller pair), set the Unit Preferred Path. Use the Preferred Path unit parameter to distribute units equally across controllers/ports.

For example:

Prefer units D0–D15 to Controller A

Prefer units D16–D31 to Controller B

Prefer units D32–D47 to Controller A

Prefer units D48–D63 to Controller B

Prefer units D64–D79 to Controller A

Prefer units D80–D95 to Controller B

Prefer units D96–D111 to Controller A

Prefer units D112–D127 to Controller B

- For each storage enclosure (controller pair), rename the connection names, that is, SRV1A1P1A, SRV1A2P1B, SRV2A1P1A, SRV2A2P1B, SRV3A1P1A, SRV3A2P1B, SRV4A1P1A, SRV4A4P1B.
- For the second enclosure set each controller host port ALPA to a different address than set on the first enclosure. Suggested settings: Enclosure 1 Port 1 = 71, Port 2 = 72. Enclosure 2 Port 1 = 73, Port 2 = 74, etc.
- Two HBAs per host, set to loop mode.
- Two memory channel cluster connections.

## Appendix B: Microsoft Cluster Server (MSCS)

A Windows NT/Windows 2000 MSCS cluster enables two servers to share an Enterprise/Modular Storage RAID Array Fibre Channel 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 Enterprise/Modular Storage RAID Array Fibre Channel systems are supported in four 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 availability, two hardware paths between the cluster servers and the Enterprise/Modular Storage RAID Array Fibre Channel system can be configured using Secure Path for Windows NT/Windows 2000. This configuration provides two separate physical paths between the servers and the storage.

### Secure Path for Windows NT/ Windows 2000

Secure Path is a high availability software product providing continuous data access for Enterprise/Modular Storage RAID Array Fibre Channel 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 Enterprise/Modular Storage RAID Array Fibre Channel 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.

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.

### Performance Considerations

The performance of an application on a system that includes Enterprise/Modular Storage RAID Array Fibre Channel can be limited by many different components of the system. Some of the possible component limitations include the host CPU(s), memory size, the host bus adapter(s) (HBA), the Fibre Channel bus, the RAID controller, or the specific configuration of disks used behind the controller. The limiting factor can move to any of these components depending on the workload. Identifying the limits will assist in determining the best configuration for a given application.

Table 1–9 lists the upper limit performance specifications for the components of the Enterprise/Modular Storage RAID Array Fibre Channel 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.

**Table 1–9: Performance Maximums of FC-AL Components**

Transfer Size	IO/sec (small transfer sizes, random access)		MB/sec (large transfer sizes, sequential access)	
	Read	Write	Read	Write
Operation Type				
Fibre Channel Host Bus Adapter - KGPSA-BC (LP7000)	15,500	14,250	86	51
Fibre Channel Hub	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

**NOTE:** Fibre Channel Hub performance limits are theoretical. Actual measured performance is lower due to limits unrelated to the hub.

To further aid in evaluating the performance aspects of specific configurations, additional information is included within each configuration section. The configurations are rated 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. Note that other factors, such as connectivity needs, may require trade-offs be made such that performance is a secondary consideration.

## MSCS HA Configuration Descriptions

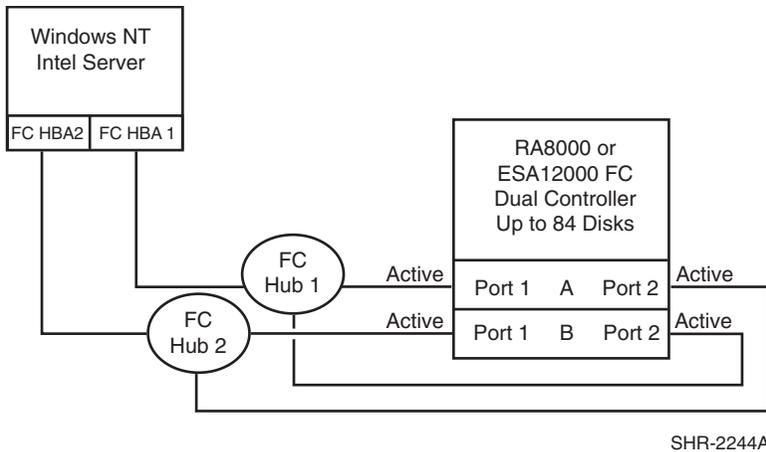
Table 1–10 lists the most common Enterprise/Modular Storage RAID Array Fibre Channel Windows NT/Windows 2000 high availability configurations.

**Table 1–10: Common Enterprise/Modular Storage RAID Array FC-AL Windows NT/Windows 2000 HA Configurations**

High Availability Configuration #	Description
1	One Server, Secure Path, Dual Controller, Multiple-Bus Failover
2	Two Servers, MSCS, Dual Controller, Transparent Failover
3	Four Servers, MSCS, Dual Controller, Transparent Failover, Two Independent Clusters, Shared Storage Enclosure
4	Two Servers, MSCS, Secure Path, Dual Controller, Multiple-Bus Failover
5	Two Servers, MSCS, Secure Path, Four Dual Controller, Pairs Multiple-Bus Failover
6	Four Servers, MSCS, Secure Path, Dual Controller, Multiple-Bus Failover, Two Independent Clusters, Shared Storage Enclosure
7	Up to Four Servers, Secure Path, Dual Controller, Multiple-Bus Failover, Shared Storage Enclosure
8	Up to Four Servers, Secure Path, Two Dual Controller Pairs, Multiple-Bus Failover, Shared Storage Enclosure
9	Up to Eight Servers, Secure Path, Two Dual Controller Pairs, Multiple-Bus Failover, Shared Storage Enclosure

### HA Configuration 1 – One Server, Secure Path, Dual Controller, Multiple-Bus Failover

HA Configuration 1 (Figure 1–40) represents an entry-level Enterprise/Modular Storage RAID Array high availability configuration that can be expanded to support additional storage capacity or performance needs as required. The configuration consists of a single Enterprise/Modular Storage RAID Array enclosure with two HSG80 array controllers configured in Multiple-Bus Failover mode. The configuration uses two separate paths (two Fibre Channel loops) to the storage. In the event of a failure of any component within the access path – host bus adapter, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path. The initial configuration provides up to 84 disks.



**Figure 1–40: HA Configuration 1**

### HA Configuration 1 Notes

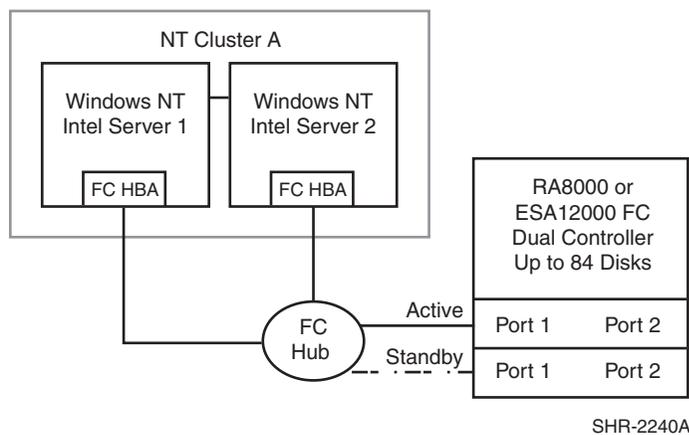
- Two Fibre Channel loops
- Uses Secure Path for Windows NT/Windows 2000 (minimum revision 3.0). Dynamic load distribution is available in this configuration when configured for maximum controller port paths
- One instance of Secure Path Manager can control all paths
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 84 disks
- 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 with 4 active controller host ports. Suggested distinct controller port unit number and offset value assignment: Port 1 units D0 – D7, unit offset = 0, Port 2 units D100 – D107, unit offset = 100. Use the Preferred Path unit parameter to assign units to specific controllers for static load balancing. Prefer units D0 – D3, D100 – D103 to Controller A, prefer units D4 – D7, D104 – D107 to Controller B.
  - For Maximum Controller Port PATH Accessibility – Up to 8 LUNs with 4 active controller host ports and dynamic load distribution between two ports on the same controller. Suggested controller unit number and offset value assignment: All controller port connections use unit offset = 0 and have access to units D0 – D7. Use the Preferred Path unit parameter to assign units to specific controllers. Units should be distributed equally across controllers for static load balancing. Prefer units D0 – D3 to Controller A, prefer units D4 – D7 to Controller B. Enable dynamic load distribution.
- In this configuration 4 logical connections are available
- Rename the connection names, for example: SERVA1P1A, SERVA1P2B, SERVA2P1B, SERVA2P2A
- Set the same ALPA for each Fibre Channel host bus adapter. Suggested settings: HBA1 = 01, HBA2 = 01

## HA Configuration 1 Performance Considerations

This configuration uses dual controllers with four active controller host ports. The overall limit is based on the two active host bus adapter limit of 31,000 I/O/sec and 172 MB/sec data rate. The primary advantage of this configuration is the ability to provide redundant independent paths to the storage. This is a general-purpose configuration that can be used for intensive I/O applications and very intensive bandwidth applications.

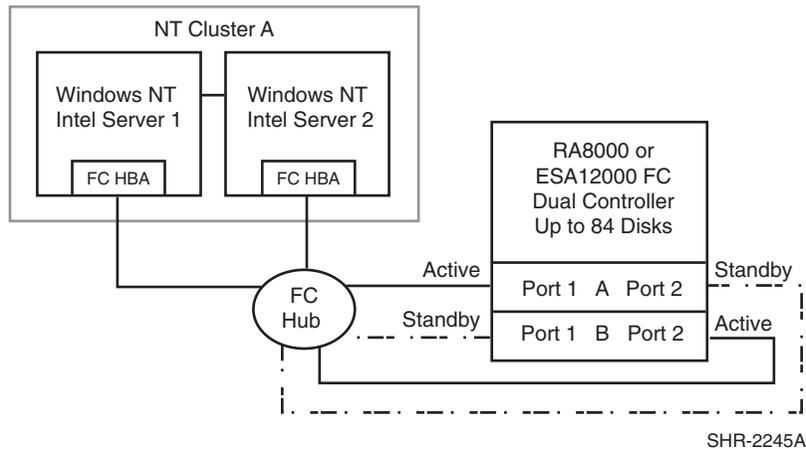
## HA Configuration 2 – Two Servers, MSCS, Dual Controller, Transparent Failover

HA Configuration 2 (Figure 1–41) provides dual redundant controllers configured in Transparent Failover mode. The configuration consists of a single Enterprise/Modular Storage RAID Array enclosure with two HSG80 array controllers connected to two servers running MSCS software. In normal operation Controller A provides the active path for all storagesets to the cluster through Controller A, Port 1. A second controller, Controller B, is a hot standby. In the event of a failure in Controller A, Controller B will automatically become active. All units being accessed through Port 1 of Controller A will become accessible through Port 1 of Controller B. In the event of a server failure, cluster failover will be invoked to provide access to units through the surviving server. In the initial configuration a single controller host port (Port 1) is active providing up to 8 LUNs across up to 84 disks. An additional 48 disks can be added using two expansion enclosures.



**Figure 1–41: HA Configuration 2**

With the addition of two Fibre Channel cables, the second controller, Controller B, can become an active controller to increase performance and double LUN capacity. Two additional Fibre Channel cables, one connected to Controller A Port 2, and one connected to Controller B Port 2, result in the configuration shown in Figure 1–42. This configuration provides full controller redundancy in the event that Controller A or Controller B fails. In either failover scenario the surviving controller will transition a standby port to active providing access to all units in the cluster.



**Figure 1–42: HA Configuration 2 with Increased Performance and Doubled LUN Capacity**

### HA Configuration 2 Notes

- Single Fibre Channel loop
- Dual HSG80 controllers configured in Transparent Failover Mode
- MSCS
- Up to 500 meters per cable segment
- Up to 84 disks
- Up to 8 LUNs with 1 active controller host port (Figure 1–41). Suggested controller unit number assignment: Port 1 units D0 – D7. In this configuration 2 logical connections are available
- Up to 16 LUNs with 2 active controller host ports (Figure 1–42). Suggested controller unit number assignment: Port 1 units D0 – D7, Port 2 units D100 – D107. In this configuration, 4 logical connections are available
- Utilization of Controller A Host Port 2, and Controller B Host Port 2, requires two additional Fibre Channel cables
- By default, setting the controller pair in Transparent Failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set unit offset values to 0 for Port 1 and 100 for Port 2
- In the Figure 1–41 configuration, two logical connections are available; in the Figure 1–42 configuration, four logical connections are available, rename the connection names, for example: SERVER1P1, SERVER1P2, SERVER2P1, SERVER2P2
- Set each Fibre Channel host bus adapter ALPA to a unique hexadecimal hard address. Suggested settings: Server 1 HBA = 01, Server 2 HBA = 02

## HA Configuration 2 Performance Considerations

The configuration in Figure 1–42 uses a single active controller host port, resulting in a throughput limit of 12,000(cache)/4,100(media) I/O/sec, and a data rate limit of 77(cache)/54(media) MB/sec. Utilizing the second controller host port as shown in Figure 1–43, results in a performance increase up the dual controller two active port limit of 24,000 I/O/sec and a theoretical single loop of 100 MB/sec data rate.

This is a general-purpose configuration that can be used for typical I/O applications and typical bandwidth applications. Using the second controller will increase performance to allow for intensive I/O applications and moderately intensive bandwidth applications.

## HA Configuration 3 – Four Servers, MSCS, Dual Controller, Transparent Failover, Two Independent Clusters, Shared Storage Enclosure

This dual-controller configuration (Figure 1–43) uses the two pairs of controller host ports to provide storage for a second, independent Windows NT/Windows 2000 Cluster. Each Windows NT/Windows 2000 Cluster can be configured with up to 8 LUNs. The two clusters share the storage enclosure in that each cluster has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering. The controllers are configured in Transparent Failover mode providing controller redundancy for both clusters. In the event of a controller failover, the surviving controller will continue to provide full access to units in both clusters. In the event of a server failure, cluster failover will be invoked to provide access to units through the surviving server. In this configuration two active controller ports provide up to 16 LUNs across up to 84 disks. An additional 48 disks can be added using two expansion enclosures to increase storage capacity.

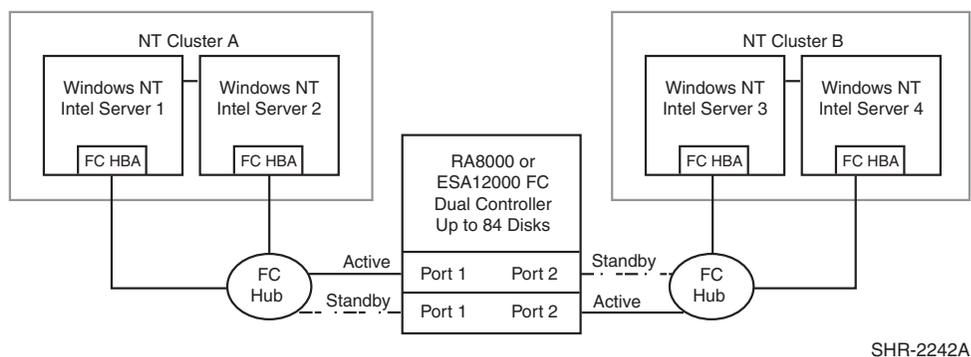


Figure 1–43: HA Configuration 3

## HA Configuration 3 Notes

- Two MSCS clusters
- Shared storage enclosure
- Two Fibre Channel loops
- Dual HSG80 controllers configured in Transparent Failover Mode
- Up to 500 meters per cable segment
- Up to 84 disks with 2 optional expansion enclosures
- Up to 16 LUNs total/8 per cluster with 2 active controller host ports. Suggested controller unit number assignment: Cluster A, Controller A Port 1 units D0 – D7. Cluster B, Controller B Port 2 units D100 – D107

- By default, setting the controller pair in Transparent Failover mode will automatically configure Port 1 and Port 2 of both controllers to the Active and Standby state indicated, and set the unit offset values to 0 for Port 1 and 100 for Port 2
- In this configuration 4 logical connections are available, rename the connection names, for example: SERVER1P1, SERVER2P1, SERVER3P2, SERVER4P2
- Set exclusive access for each unit to specific server connection names. For example: for unit D0 ENABLE = SERVER1P1, SERVER2P1; for unit D100 ENABLE = SERVER3P2, SERVER4P2
- For each loop, set each Fibre Channel host bus adapter ALPA to a unique hexadecimal hard address. Suggested settings: Server 1 HBA = 01, Server 2 HBA = 02

### HA Configuration 3 Performance Considerations

This configuration uses Dual Controllers with two active and two standby controller host ports. The overall limit is based on the dual controller, two active port limit of 24,000(cache)/8,200(media) I/O/sec and 154(cache)/102(media) MB/sec data rate. The primary advantage of this configuration is the ability to share the storage enclosure between two independent clusters without any performance degradation.

This is a general-purpose configuration that can be used for intensive I/O applications and very intensive bandwidth applications.

### HA Configuration 4 – Two Servers, MSCS, Secure Path, Dual Controller, Multiple-Bus Failover

This dual-controller configuration (Figure 1–44) offers four active controller host ports.

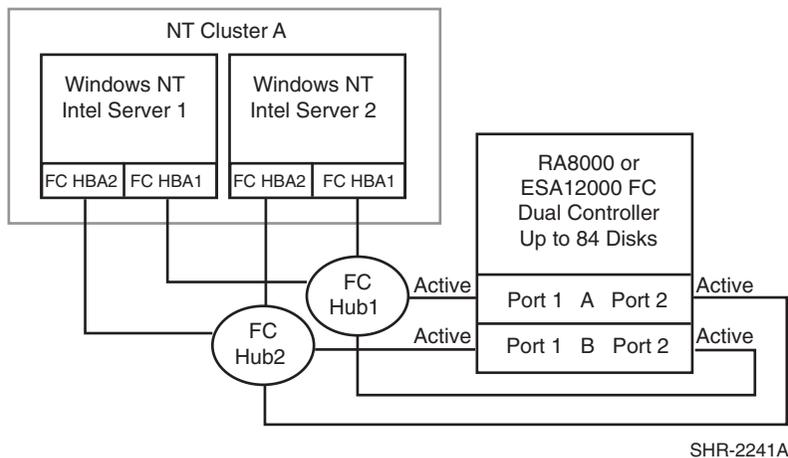


Figure 1–44: HA Configuration 4

### HA Configuration 4 Notes

- Two Fibre Channel loops
- Uses Secure Path for Windows NT/Windows 2000 (minimum revision 3.0). Dynamic load distribution is not available in this configuration
- One instance of Secure Path Manager can control all paths
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode

- Up to 500 meters per cable segment
- Up to 84 disks
- Depending on your specific application needs, configure either for maximum LUNs or for maximum controller port paths.
  - For Maximum LUN Count – Up to 16 LUNs with 4 active controller host ports. Suggested distinct controller port unit number and offset value assignment: Port 1 units D0 – D7, unit offset = 0, Port 2 units D100 – D107, unit offset = 100. Use the Preferred Path unit parameter to assign units to specific controllers for static load balancing. Prefer units D0 – D3, D100 – D103 to Controller A, prefer units D4 – D7, D104 – D107 to Controller B.
  - For Maximum Controller Port PATH Accessibility – Up to 8 LUNs with 4 active controller host ports. Suggested controller unit number and offset value assignment: All controller port connections use unit offset = 0 and have access to units D0 – D7. Use the Preferred Path unit parameter to assign units to specific controllers. Units should be distributed equally across controllers for static load balancing. Prefer units D0 – D3 to Controller A, prefer units D4 – D7 to Controller B.
- In this configuration 8 logical connections are available, rename the connection names, for example: SRV1A1P1A, SRV1A2P1B, SRV1A1P2B, SRV1A2P2A, and so forth.
- In each server set the ALPA for each Fibre Channel host bus adapter to the same hexadecimal hard address, but unique on the loop. Suggested settings: Server 1 HBA1 = 01, HBA2 = 01, Server 2 HBA1 = 02, HBA2 = 02.

## HA Configuration 4 Performance Considerations

This configuration uses dual controllers with four active controller host ports. The overall limit is based on the dual controller, two active port limit of 24,000(cache)/8,200(media) I/O/sec and 195(cache)/102(media) MB/sec data rate. The primary advantage of this configuration is the ability to provide redundant independent paths to the storage and redundant servers.

This is a general-purpose configuration that can be used for intensive I/O applications and extremely intensive bandwidth applications.

## HA Configuration 5 – Two Servers, MSCS, Secure Path, Four Dual Controller Pairs, Multiple-Bus Failover

Configuration 5 (Figure 1–45) builds on Configuration 4 using four Fibre Channel host bus adapters in each cluster server connected to four dual controller pairs on four loops to provide storage path and controller redundancy with high storage capacity. The configuration uses two separate paths to each storage enclosure from each server in the cluster. In the event of a failure of any component within the access path – host bus adapter, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path. In the event of a server failure, cluster failover will provide access to all storage from the surviving server.

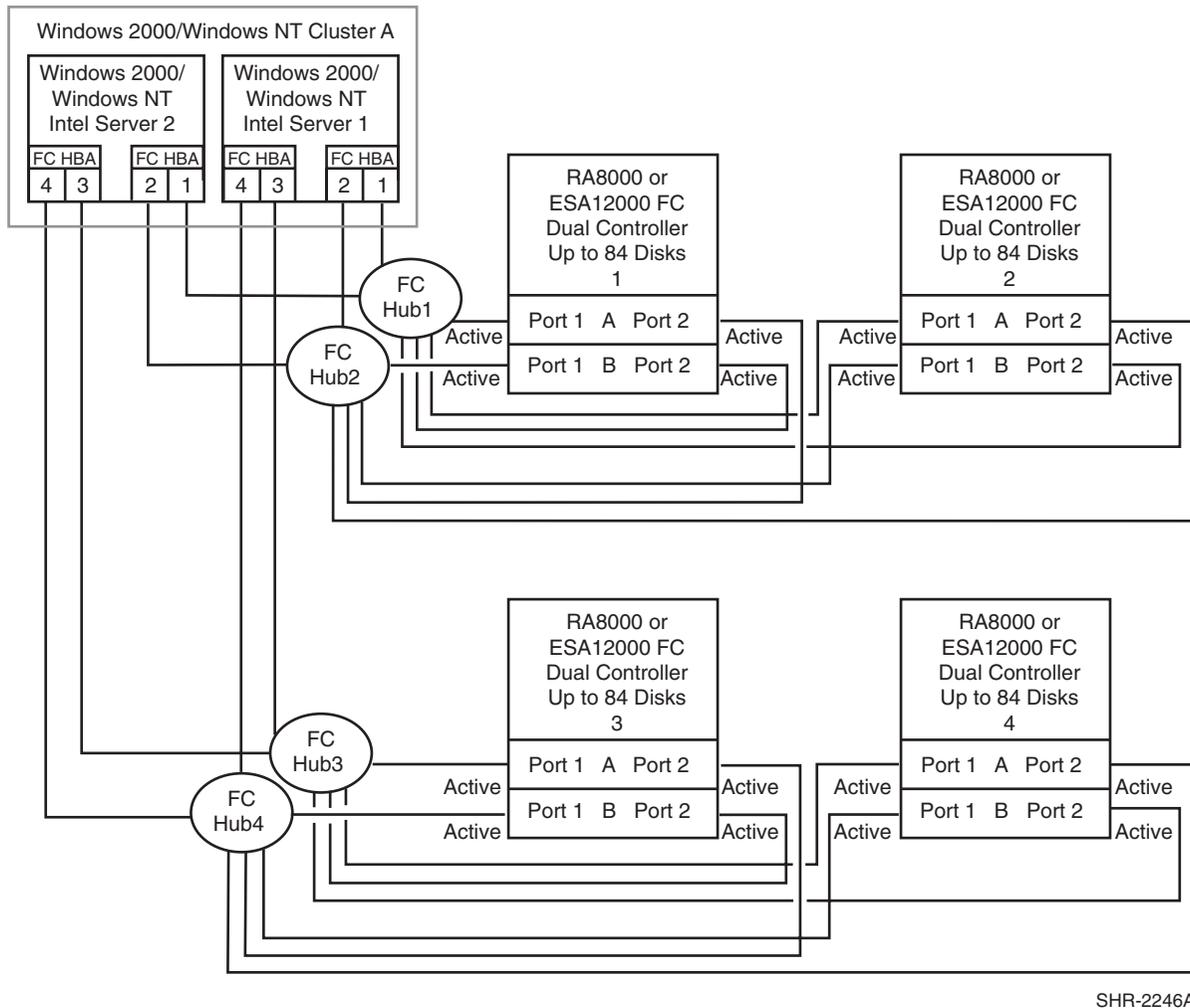


Figure 1–45: HA Configuration 5

### HA Configuration 5 Notes

- Four Fibre Channel loops
- Uses Secure Path for Windows NT/Windows 2000 (minimum revision 3.0). Dynamic load distribution is not available in this configuration
- One instance of Secure Path Manager can control all paths
- Four Dual HSG80 controller pairs configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 336 disks
- In this configuration 32 logical connections are available, 8 in each enclosure. For each enclosure (controller pair), rename the connection names as shown below
- In each server set the ALPA for each Fibre Channel host bus adapter to the same hexadecimal hard address, but unique on the loop. Suggested settings: Server 1 HBA1 = 01, HBA2 = 01, HBA3 = 01, HBA4 = 01 Server 2 HBA1 = 02, HBA2 = 02, HBA3 = 02, HBA4 = 02

- For the second controller enclosures, Enclosures 2 and 4, set each controller host port ALPA to a different address than set on the first enclosures, Enclosures 1 and 3:

Controller Enclosure 1: Controller Host Port 1 = 71, Port 2 = 72

Controller Enclosure 2: Controller Host Port 1 = 73, Port 2 = 74

Controller Enclosure 3: Controller Host Port 1 = 71, Port 2 = 72

Controller Enclosure 4: Controller Host Port 1 = 73, Port 2 = 74

- Depending on your specific application needs, configure either for maximum LUNs or for maximum controller port paths.
- For Maximum LUN Count – Up to 64 LUNs with 4 active controller host ports. The suggested unit numbering and connection parameters that result in the units being distributed equally across enclosures and controller host ports follow:

For all Controller Enclosures, Server 1 and Server 2 units:

Port 1 units D0 – D7, Port 2 units D100 – D107

Prefer units D0 – D3, D100 – D103 to Controller A

Prefer units D4 – D7, D104 – D107 to Controller B

For Controller Enclosures 1 and 2, connection names, unit offset values: SRV1A1P1A, 0. SRV1A2P1B, 0. SRV1A1P2B, 100. SRV1A2P2A, 100. SRV2A1P1A, 0. SRV2A2P1B, 0. SRV2A1P2B, 100. SRV2A2P2A, 100.

Set exclusive access for each unit to the appropriate connection names, for example:

D0 ENABLE = SRV1A1P1A, SRV1A2P1B, SRV2A1P1A, SRV2A2P1B

D100 ENABLE = SRV1A1P2B, SRV1A2P2A, SRV2A1P2B, SRV2A2P2A

For Controller Enclosures 3 and 4, connection names, unit offset values: SRV1A3P1A, 0. SRV1A4P1B, 0. SRV1A3P2B, 100. SRV1A4P2A, 100. SRV2A3P1A, 0. SRV2A4P1B, 0. SRV2A3P2B, 100. SRV2A4P2A, 100.

Set exclusive access for each unit to the appropriate connection names, for example:

D0 ENABLE = SRV1A3P1A, SRV1A4P1B, SRV2A3P1A, SRV2A4P1B

D100 ENABLE = SRV1A3P2B, SRV1A4P2A, SRV2A3P2B, SRV2A4P2A

- For Maximum Controller Port PATH Accessibility – Up to 32 LUNs when configured for maximum paths, the suggested unit numbering and connection parameters that result in 8 LUNs being accessible through 4 ports in each controller enclosure follow:

For all Controller Enclosures, Server 1 and Server 2 units D0 – D7

Prefer units D0 – D3 to Controller A

Prefer units D4 – D7 to Controller B

For Controller Enclosures 1 and 2, connection names, unit offset values: SRV1A1P1A, 0. SRV1A2P1B, 0. SRV1A1P2B, 0. SRV1A2P2A, 0. SRV2A1P1A, 0. SRV2A2P1B, 0. SRV2A1P2B, 0. SRV2A2P2A, 0.

Set exclusive access for each unit to the appropriate connection names, for example:

D0 ENABLE = SRV1A1P1A, SRV1A2P1B, SRV2A1P1A, SRV2A2P1B, SRV1A1P2B, SRV1A2P2A, SRV2A1P2B, SRV2A2P2A

For Controller Enclosures 3 and 4, connection names, unit offset values: SRV1A3P1A, 0. SRV1A4P1B, 0. SRV1A3P2B, 0. SRV1A4P2A, 0. SRV2A3P1A, 0. SRV2A4P1B, 0. SRV2A3P2B, 0. SRV2A4P2A, 0.

Set exclusive access for each unit to the appropriate connection names, for example:

D0 ENABLE = SRV1A3P1A, SRV1A4P1B, SRV2A3P1A, SRV2A4P1B, SRV1A3P2B, SRV1A4P2A, SRV2A3P2B, SRV2A4P2A

- Unit configurations and numbering can be identical for each storage enclosure, as each server will see each active controller host port as a unique target ID with a unique set of LUNs.

## HA Configuration 5 Performance Considerations

This configuration uses 4 dual controller pairs with an overall aggregate limit based on a theoretical four-loop limit of 62,400 I/O/sec and 400 MB/sec data rate. The primary advantage of this configuration is the ability to connect up to four storage systems with redundant independent paths to the servers.

This is a high availability, high capacity configuration that can be used for extremely intensive I/O applications and extremely intensive bandwidth applications.

## HA Configuration 6 – Four Servers, MSCS, Secure Path, Dual Controller, Multiple-Bus Failover, Two Independent Clusters, Shared Storage Enclosure

HA Configuration 6 (Figure 1–46) builds on configurations 3 and 4, combining the benefits of MSCS clustering, Secure Path for Windows NT/Windows 2000 software, controller redundancy, and sharing of the storage enclosure. The configuration provides two independent clusters with two separate physical paths to the storage through two pairs of controller host ports. In the event of a failure of any component within the access path – Fibre Channel host bus adapter, cables, hub, or controller host port interface, all units on the failing path will become accessible through the alternate path. In the event of a server failure, cluster failover will be invoked to provide access to units through the surviving server. Each Windows NT/Windows 2000 Cluster can be configured with up to 8 LUNs. The two clusters share the storage enclosure in that each cluster has exclusive access to its own LUNs through the use of mutually exclusive LUN numbering. An additional 48 disks can be added using two expansion enclosures to increase storage capacity.

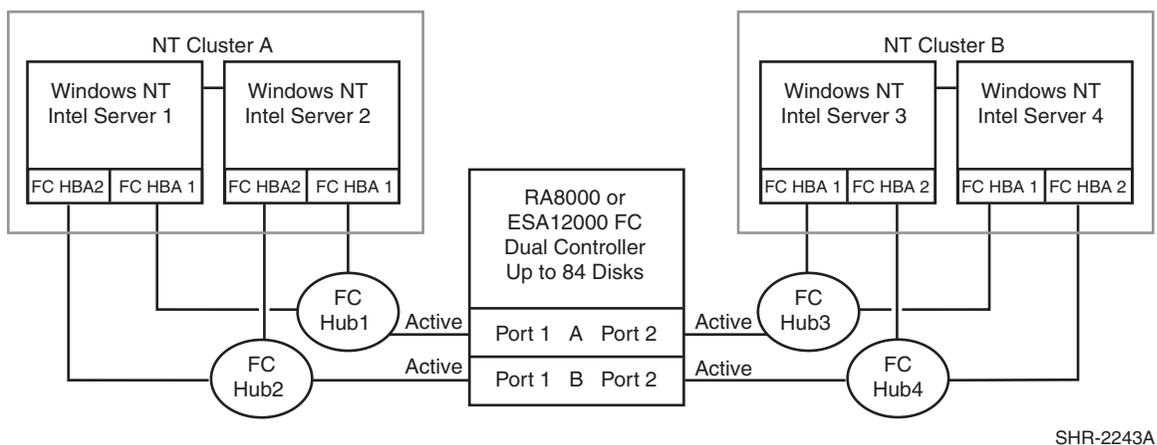


Figure 1–46: HA Configuration 6

## HA Configuration 6 Notes

- Four Fibre Channel loops
- Uses Secure Path for Windows NT/Windows 2000 (minimum version 3.0). Dynamic load distribution is not available in this configuration
- One instance of Secure Path Manager can control all paths
- Dual HSG80 controllers configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 84 disks
- Up to 16 LUNs total/8 per Cluster with 4 active controller host ports. Suggested controller unit number and offset value assignment: Port 1 units D0 – D7, unit offset = 0, Port 2 units D100 – D107, unit offset 100
- Set the Unit Preferred Path. Use the Preferred Path unit parameter to distribute units equally across controllers for load balancing
  - Prefer units D0 – D3 to Controller A
  - Prefer units D4 – D7 to Controller B
  - Prefer units D100 – D103 to Controller A
  - Prefer units D104 – D107 to Controller B
- In this configuration 8 logical connections are available, rename the connection names, for example:
  - SERV1P1A, SERV1P1B, SERV2P1A, SERV2P1B
  - SERV3P2A, SERV3P2B, SERV4P2A, SERV4P2B
- Set exclusive unit access for each unit to specific server connection names. For example: for unit D0 ENABLE = SERV1P1A, SERV1P1B, SERV2P1A, SERV2P1B; for unit D100 ENABLE = SERV3P2A, SERV3P2B, SERV4P2A, SERV4P2B
- Set the connection name unit offset values for each connection as shown below
- In each server set the ALPA for each Fibre Channel host bus adapter to the same hexadecimal hard address, but unique on the loop. Suggested settings: Server 1 HBA1 = 01, HBA2 = 01, Server 2 HBA1 = 02, HBA2 = 02, and so forth.
- Suggested unit numbering and connection parameters would result in the units being distributed equally across clusters/controller host ports as follows:
  - Server 1: Port 1 units D0 – D7
  - Connection names, unit offset values: SERV1P1A, 0. SERV1P1B, 0
  - Server 2: Port 1 units D0 – D7
  - Connection names, unit offset values: SERV2P1A, 0. SERV2P1B, 0
  - Server 3: Port 2 units D100 – D107
  - Connection names, unit offset values: SERV3P2A, 100. SERV3P2B, 100
  - Server 4: Port 2 units D100 – D107
  - Connection names, unit offset values: SERV4P2A, 100. SERV4P2B, 100

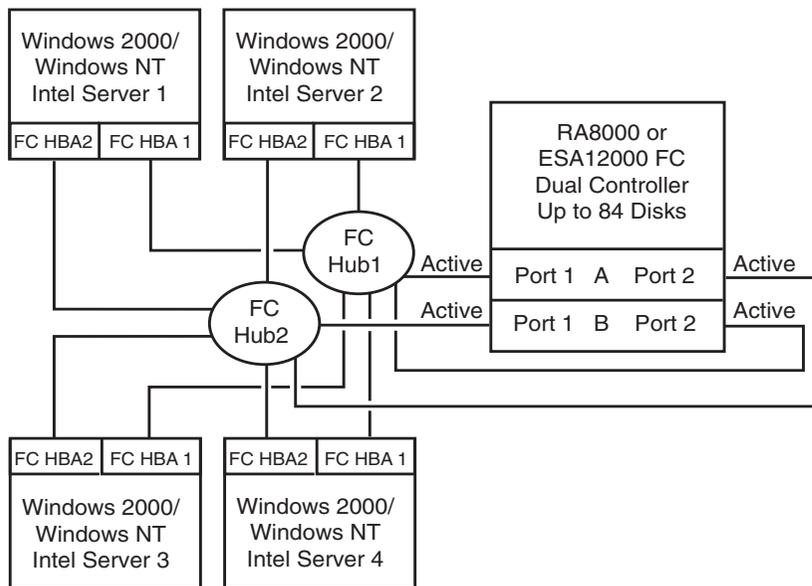
## HA Configuration 6 Performance Considerations

This configuration uses dual controllers with four active controller host ports. The overall limit is based on the dual controller, four active port limit of 24,000(cache)/8,200(media) I/O/sec and 195(cache)/102(media) MB/sec data rate. The primary advantage of this configuration is the ability to share the storage enclosure to connect two independent clusters with redundant independent paths to the storage.

This is a general-purpose configuration that can be used for intensive I/O applications and extremely intensive bandwidth applications.

## HA Configuration 7 – Up to Four Servers, Secure Path, Dual Controller, Multiple-Bus Failover, Shared Storage Enclosure

HA Configuration 7 (Figure 1–47) builds on Configuration 1 providing storage for up to four separate (non-cooperating) servers on two Fibre Channel loops. The four servers share the storage enclosure in that each server has exclusive access to its own set of LUNs. This is made possible by the setting of explicit “connection name access” at the unit level and using connection name “unit offsets” to give each server an accessible range of unit numbers. Additional levels of access control are necessary for this configuration because all servers are sharing the two Fibre Channel loops. The configuration utilizes two separate paths to the storage from each server. In the event of a failure of any component within the access path – host bus adapters, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path.



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Figure 1–47: HA Configuration 7

## HA Configuration 7 Notes

- Two Fibre Channel loops
- Shared storage enclosure
- Uses Secure Path for Windows NT/Windows 2000 (minimum version 3.0). Dynamic load distribution is available in this configuration when configured for maximum controller port paths
- One instance of Secure Path Manager can control all paths

- Dual HSG80 controllers configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 84 disks
- In this configuration 16 logical connections are available
- In each server, set the ALPA for each Fibre Channel host bus adapter to the same hexadecimal hard address, but unique on the loop suggested settings, Server 1 HBA1 = 01, HBA2 = 01, Server 2 HBA1 = 02, HBA2 = 02, and so forth.
- Depending on your specific application needs, configure either for maximum LUNs or for maximum controller port paths
- For Maximum LUN Count – Up to 64 LUNs, 16 available to each server with 4 active controller host ports. The suggested unit numbering and connection parameters that result in the units being distributed equally across controller host ports follow:

Server 1 Port 1 units D0 – D7, Port 2 units D100 – D107

Prefer units D0 – D3, D100 – D103 to Controller A

Prefer units D4 – D7, D104 – D107 to Controller B

Connection names, unit offset values: SRV1A1P1A, 0. SRV1A2P1B, 0. SRV1A1P2B, 100. SRV1A2P2A, 100.

Set exclusive access for each unit to the listed connection names, for example: D0 ENABLE = SRV1A1P1A, SRV1A2P1B. D100 ENABLE = SRV1A1P2B, SRV1A2P2A

Server 2 Port 1 units D10 – D17, Port 2 units D110 – D117

Prefer units D10 – D13, D110 – D113 to Controller A

Prefer units D14 – D17, D114 – D117 to Controller B

Connection names, unit offset values: SRV2A1P1A, 10. SRV2A2P1B, 10. SRV2A1P2B, 110. SRV2A2P2A, 110.

Set exclusive access for each unit to the listed connection names, for example: D10 ENABLE = SRV2A1P1A, SRV2A2P1B. D110 ENABLE = SRV2A1P2B, SRV2A2P2A

Server 3 Port 1 units D20 – D27, Port 2 units D120 – D127

Prefer units D20 – D23, D120 – D123 to Controller A

Prefer units D24 – D27, D124 – D127 to Controller B

Connection names, unit offset values: SRV3A1P1A, 20. SRV3A2P1B, 20. SRV3A1P2B, 120. SRV3A2P2A, 120.

Set exclusive access for each unit to the listed connection names, for example: D20 ENABLE = SRV3A1P1A, SRV3A2P1B. D120 ENABLE = SRV3A1P2B, SRV3A2P2A

Server 4 Port 1 units D30 – D37, Port 2 units D130 – D137

Prefer units D30 – D33, D130 – D133 to Controller A

Prefer units D34 – D37, D134 – D137 to Controller B

Connection names, unit offset values: SRV4A1P1A, 30. SRV4A2P1B, 30. SRV4A1P2B, 130. SRV4A2P2A, 130.

Set exclusive access for each unit to the listed connection names, for example: D30 ENABLE = SRV4A1P1A, SRV4A2P1B. D130 ENABLE = SRV4A1P2B, SRV4A2P2A

- For Maximum Controller Port PATH Accessibility – Up to 32 LUNs, 8 available to each server with 4 active controller host ports and dynamic load distribution between two ports on the same controller. The suggested unit numbering and connection parameters that result in 8 LUNs for each server being accessible through all 4 controller ports follow:

Server 1 units D0 – D7

Prefer units D0 – D3 to Controller A

Prefer units D4 – D7 to Controller B

Connection names, unit offset values: SRV1A1P1A, 0. SRV1A2P1B, 0. SRV1A1P2B, 0. SRV1A2P2A, 0.

Set exclusive access for each unit to the listed connection names, for example: D0 ENABLE = SRV1A1P1A, SRV1A2P1B, SRV1A1P2B, SRV1A2P2A

Server 2 units D10 – D17

Prefer units D10 – D13 to Controller A

Prefer units D14 – D17 to Controller B

Connection names, unit offset values: SRV2A1P1A, 10. SRV2A2P1B, 10. SRV2A1P2B, 10. SRV2A2P2A, 10.

Set exclusive access for each unit to the listed connection names, for example: D10 ENABLE = SRV2A1P1A, SRV2A2P1B, SRV2A1P2B, SRV2A2P2A

Server 3 units D20 – D27

Prefer units D20 – D23 to Controller A

Prefer units D24 – D27 to Controller B

Connection names, unit offset values: SRV3A1P1A, 20. SRV3A2P1B, 20. SRV3A1P2B, 20. SRV3A2P2A, 20.

Set exclusive access for each unit to the listed connection names, for example: D20 ENABLE = SRV3A1P1A, SRV3A2P1B, SRV3A1P2B, SRV3A2P2A

Server 4 units D30 – D37

Prefer units D30 – D33 to Controller A

Prefer units D34 – D37 to Controller B

Connection names, unit offset values: SRV4A1P1A, 30. SRV4A2P1B, 30. SRV4A1P2B, 30. SRV4A2P2A, 30.

Set exclusive access for each unit to the listed connection names, for example: D30 ENABLE = SRV4A1P1A, SRV4A2P1B, SRV4A1P2B, SRV4A2P2A

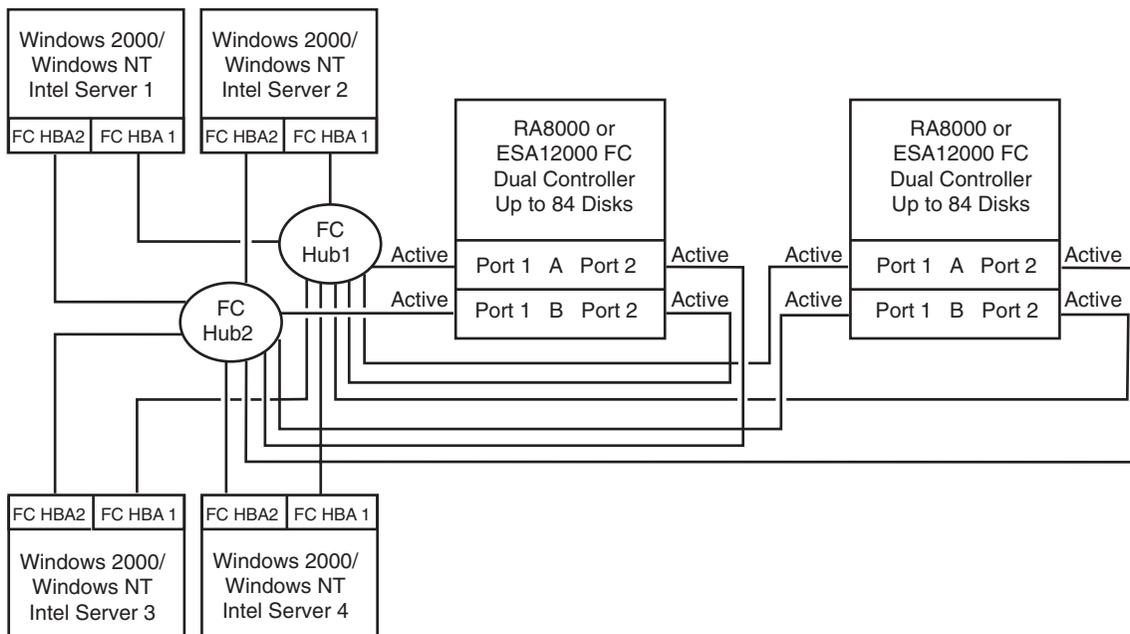
## HA Configuration 7 Performance Considerations

This configuration uses dual controllers with two active controller host ports. The overall aggregate limit is based on the dual controller, four active port limit of 24,000(cache)/8,200(media) I/O/sec and 195(cache)/102(media) MB/sec data rate. The primary advantage of this configuration is the ability to provide redundant independent paths to the storage for up to four servers.

This is a general-purpose configuration that can be used for intensive I/O applications and extremely intensive bandwidth applications.

## HA Configuration 8 – Up to Four Servers, Secure Path, Two Dual Controller Pairs, Multiple-Bus Failover, Shared Storage Enclosure

HA Configuration 8 (Figure 1–48) builds on Configuration 7 by adding storage capacity using a second enclosure and second pair of controllers. The second pair of controllers are connected to two Fibre Channel loops providing redundant paths for up to four separate (non-cooperating) servers. The four servers share both storage enclosures in that each server has exclusive access to its own LUNs in each enclosure through the use of mutually exclusive LUN numbering, explicit unit host access, and the use of connection unit offsets. Additional levels of access control are necessary for this configuration because all servers are sharing the two Fibre Channel loops. The configuration uses two separate paths to the storage from each server. In the event of a failure of any component within the access path – host bus adapter, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path.



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**Figure 1–48: HA Configuration 8**

### HA Configuration 8 Notes

- Two Fibre Channel loops
- Shared storage enclosure
- Uses Secure Path for Windows NT/Windows 2000 (minimum version 3.0). Dynamic load distribution is available in this configuration when configured for maximum controller port paths
- One instance of Secure Path Manager can control all paths
- Two Dual HSG80 controller pairs configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 168 disks
- In this configuration 16 logical connections are available, 8 in each enclosure

- In each server set the ALPA for each Fibre Channel host bus adapter to the same hexadecimal hard address, but unique on the loop. Suggested settings: Server 1 HBA1 = 01, HBA2 = 01, Server 2 HBA1 = 02, HBA2 = 02, and so forth.
- For the second controller enclosure, Enclosure 2, set each controller host port ALPA to a different address then set on the first enclosure:
- Controller Enclosure 1: Controller Host Port 1 = 71, Port 2 = 72
- Controller Enclosure 2: Controller Host Port 1 = 73, Port 2 = 74
- Depending on your specific application needs, configure either for maximum LUNs or for maximum controller port paths
  - For Maximum LUN Count – Up to 128 LUNs, 32 available to each server with 8 active controller host ports. Refer to Configuration 7, “Maximum LUN Count” Controller Enclosure settings for a suggested way to define the units that distributes them equally across controller host ports. Unit configurations and numbering can be identical for each storage enclosure, as each server will see each active controller host port as a unique target ID with a unique set of LUNs.
  - For Maximum Controller Port PATH Accessibility – Up to 64 LUNs, 16 available to each server with 8 active controller host ports and dynamic load distribution between two ports on the same controller. Refer to Configuration 7, Controller Enclosure “Maximum Controller Port PATH Accessibility” settings for a suggested way to define the units that distributes them equally across controller host ports. Unit configurations and numbering can be identical for each storage enclosure, as each server will see each active controller host port as a unique target ID with a unique set of LUNs.

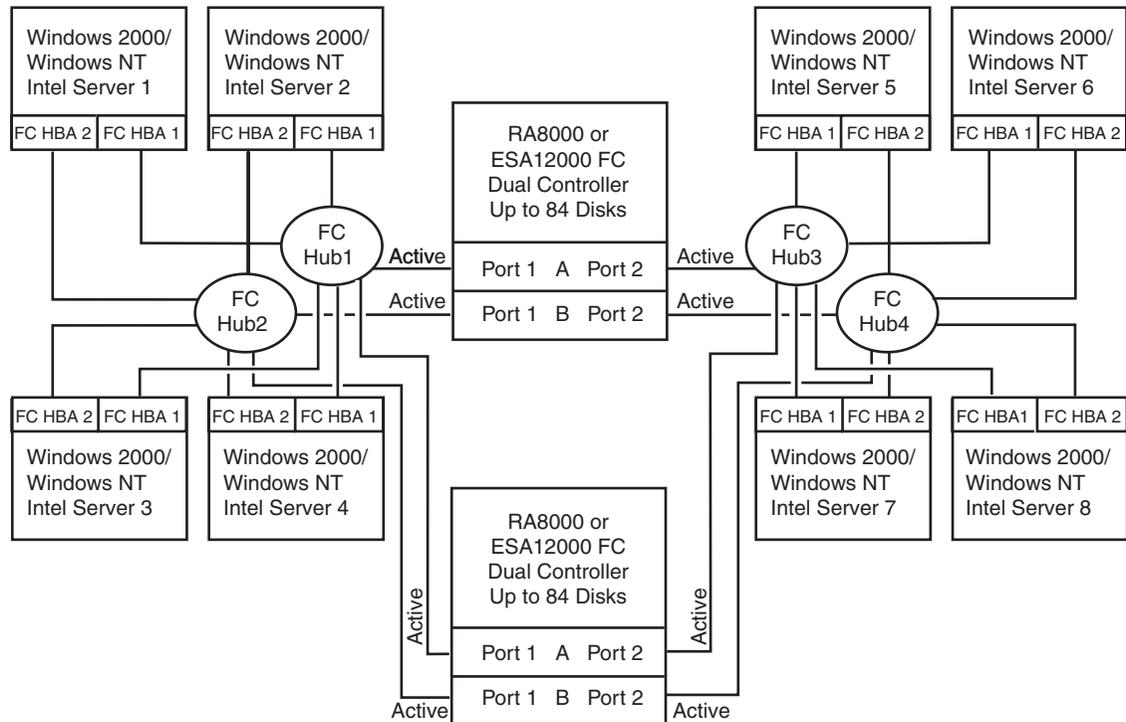
## HA Configuration 8 Performance Considerations

This configuration uses 2 dual controller pairs with an overall aggregate limit based on a theoretical two-loop limit of 33,200 I/O/sec and 200 MB/sec data rate. The primary advantage of this configuration is the ability to connect up to four servers and two storage systems with redundant independent paths to the storage.

This is a high availability, high connectivity configuration that can be used for extremely intensive I/O applications and extremely intensive bandwidth applications.

## HA Configuration 9 – Up to Eight Servers, Secure Path, Two Dual Controller Pairs, Multiple-Bus Failover, Two Shared Storage Enclosures

Configuration 9 (Figure 1–49) builds on Configurations 7 and 8 using two dual controller pairs on four loops to provide storage path and controller redundancy for up to eight separate (non-cooperating) servers. The eight servers share both storage enclosures in that each server has exclusive access to its own LUNs in each enclosure through the use of mutually exclusive LUN numbering, explicit unit host access, and the use of connection unit offsets. Additional levels of access control are necessary for this configuration because each group of four servers is sharing two Fibre Channel loops. The configuration uses two separate paths to the storage from each server. In the event of a failure of any component within the access path – host bus adapter, cables, hub, or controller host port interface, all LUNs on the failing path will become accessible through the alternate path.



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Figure 1–49: HA Configuration 9

### HA Configuration 9 Notes

- Four Fibre Channel loops
- Shared storage enclosure
- Uses Secure Path for Windows NT/Windows 2000 (minimum version 3.0). Dynamic load distribution is not available in this configuration
- One instance of Secure Path Manager can control all paths
- Two Dual HSG80 controller pairs configured in Multiple-Bus Failover Mode
- Up to 500 meters per cable segment
- Up to 144 disks with 4 optional expansion cabinets
- In this configuration 32 logical connections are available, 16 in each enclosure
- In each server set the ALPA for each Fibre Channel host bus adapter to the same hexadecimal hard address, but unique on the loop. Suggested settings: Server 1 HBA1 = 01, HBA2 = 01, Server 2 HBA1 = 02, HBA2 = 02, and so forth.
- For the second controller enclosure, Enclosure 2, set each controller host port ALPA to a different address then set on the first enclosure:
  - Controller Enclosure 1: Controller Host Port 1 = 71, Port 2 = 72
  - Controller Enclosure 2: Controller Host Port 1 = 73, Port 2 = 74
- Up to 128 LUNs, 16 available to each server with 8 active controller host ports. The suggested unit numbering and connection parameters that result in the units being distributed equally across controller host ports follow:

Server 1 Port 1 units D0 – D7

Prefer units D0 – D3 to Controller A

Prefer units D4 – D7 to Controller B

Connection names, unit offset values: SRV1A1P1A, 0. SRV1A2P1B, 0.

Set exclusive access for each unit to the listed connection names, for example: D0 ENABLE = SRV1A1P1A, SRV1A2P1B

Server 2 Port 1 units D10 – D17

Prefer units D10 – D13 to Controller A

Prefer units D14 – D17 to Controller B

Connection names, unit offset values: SRV2A1P1A, 10. SRV2A2P1B, 10.

Set exclusive access for each unit to the listed connection names, for example: D10 ENABLE = SRV2A1P1A, SRV2A2P1B

Server 3 Port 1 units D20 – D27

Prefer units D20 – D23 to Controller A

Prefer units D24 – D27 to Controller B

Connection names, unit offset values: SRV3A1P1A, 20. SRV3A2P1B, 20.

Set exclusive access for each unit to the listed connection names, for example: D20 ENABLE = SRV3A1P1A, SRV3A2P1B

Server 4 Port 1 units D30 – D37

Prefer units D30 – D33 to Controller A

Prefer units D34 – D37 to Controller B

Connection names, unit offset values: SRV4A1P1A, 30. SRV4A2P1B, 30.

Set exclusive access for each unit to the listed connection names, for example: D30 ENABLE = SRV4A1P1A, SRV4A2P1B

Server 5 Port 2 units D100 – D107

Prefer units D100 – D103 to Controller A

Prefer units D104 – D107 to Controller B

Connection names, unit offset values: SRV5A1P2B, 100. SRV5A2P2A, 100.

Set exclusive access for each unit to the listed connection names, for example: D100 ENABLE = SRV5A1P2B, SRV5A2P2A

Server 6 Port 2 units D110 – D117

Prefer units D110 – D113 to Controller A

Prefer units D114 – D117 to Controller B

Connection names, unit offset values: SRV6A1P2B, 110. SRV6A2P2A, 110.

Set exclusive access for each unit to the listed connection names, i.e D110 ENABLE = SRV6A1P2B, SRV6A2P2A

Server 7 Port 2 units D120 – D127

Prefer units D120 – D123 to Controller A

Prefer units D124 – D127 to Controller B

Connection names, unit offset values: SRV7A1P2B, 120. SRV7A2P2A, 120.

Set exclusive access for each unit to the listed connection names, i.e D120 ENABLE = SRV7A1P2B, SRV7A2P2A

Server 8 Port 2 units D130 – D137

Prefer units D130 – D133 to Controller A

Prefer units D134 – D137 to Controller B

Connection names, unit offset values: SRV8A1P2B, 130. SRV8A2P2A, 130.

Set exclusive access for each unit to the listed connection names, i.e D130 ENABLE = SRV8A1P2B, SRV8A2P2A

- Unit configurations and numbering can be identical for each storage enclosure, as each server will see each active controller host port as a unique target ID with a unique set of LUNs

## HA Configuration 9 Performance Considerations

This configuration uses 2 dual controller pairs with an overall aggregate limit based on the dual controller four active port limit (times 2) of 48,000(cache) I/O/sec and 390(cache) MB/sec data rate. The primary advantage of this configuration is the ability to connect up to eight servers and two storage systems with redundant independent paths to the storage.

This is a high availability, high connectivity configuration that can be used for extremely intensive I/O applications and extremely intensive bandwidth applications.

## Appendix C: Controller Failover Transitions

This appendix provides the procedures for setting dual-redundant HSG80 controllers from one failover state to another. Controllers can exist in one of the following failover states:

- Transparent Failover (TF);
- Multiple-Bus Failover (MBF); and,
- NoFailover (NF).

The following controller failover state changes are discussed in this appendix:

- Transparent Failover to NoFailover Mode
- Transparent Failover to Multiple-bus Failover Mode
- Multiple-bus Failover to Nofailover and then to Transparent Failover Mode

### NOTE:

- To change the failover state of a controller, connect a serial line to the top controller. This will be referenced as THIS\_CONTROLLER.
- The second controller will be referenced as the OTHER\_CONTROLLER.
- All commands directed to the RAID storage system (that is, those preceded by HSG80> prompt), must be issued through this serial connection to the top controller.

Verify the current state of the controllers by entering:

```
HSG80> SHOW THIS_CONTROLLER
```

The display from the SHOW command has a number of sections. The information required for changing a controller failover state is located in the first section, under the “Controller:” heading. A sample display for Transparent Failover is shown below, and the failover state is identified with an arrow, “->” preceding the text of note.

### Example

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
NODE_ID           = 5000-1FE1-0000-3350
ALLOCATION_CLASS  = 0
SCSI_VERSION     = SCSI-2
-> Configured for dual-redundancy with ZG80200290
-> In dual-redundant configuration
```

When a controller state is changed using the procedures described in one of the next sections, the display will be refreshed to verify that the change has completed successfully.

## Changing from Transparent Failover to NoFailover Mode

1. At the HSG80> prompt, enter:

```
HSG80> SET NOFAILOVER
```

This action will cause the OTHER\_CONTROLLER to shutdown.

2. At the HSG80> prompt, enter:

```
HSG80> SHOW THIS_CONTROLLER
```

From the resulting display, verify that the controller state has changed to no failover.

**Example:**

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
NODE_ID           = 5000-1FE1-0000-3350
ALLOCATION_CLASS   = 0
SCSI_VERSION      = SCSI-2
-> Not Configured for dual-redundancy
```

3. Restart the OTHER\_CONTROLLER by pressing the RESET button on the OTHER\_CONTROLLER.

The OTHER\_CONTROLLER will sound an alarm as it discovers the second controller but detects that it is not bound in a failover mode. The alarm (may be silenced) and the message about the controllers being misconfigured may be disregarded.

4. To verify the change in controller state, enter:

```
HSG80> SHOW THIS_CONTROLLER
```

**Example:**

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
NODE_ID           = 5000-1FE1-0000-3350
ALLOCATION_CLASS   = 0
SCSI_VERSION      = SCSI-2
-> Not Configured for dual-redundancy
-> Controller misconfigured -- other controller present
```

## Changing from Transparent Failover to Multi-bus Failover Mode

Whether there are defined UNITS or not for the RAID system, the following steps will implement Transparent Failover to Multi-bus Failover:

1. At the HSG80> prompt, enter:

```
HSG80> SET NOFAILOVER
```

This action will cause the OTHER\_CONTROLLER to shutdown.

2. At the HSG80> prompt, enter:

```
HSG80> SHOW THIS_CONTROLLER
```

From the resulting display, verify that the controller state has changed to no failover.

**Example:**

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
NODE_ID           = 5000-1FE1-0000-3350
ALLOCATION_CLASS  = 0
SCSI_VERSION     = SCSI-2
```

```
-> Not Configured for dual-redundancy
```

- Restart the OTHER\_CONTROLLER by pressing the RESET button on the OTHER\_CONTROLLER.

The OTHER\_CONTROLLER will sound an alarm as it discovers the second controller but knows that it is not bound in a failover mode. The alarm (may be silenced) and the message about the controllers being misconfigured may be disregarded.

**Example:**

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
NODE_ID           = 5000-1FE1-0000-3350
ALLOCATION_CLASS  = 0
SCSI_VERSION     = SCSI-2
```

```
-> Not Configured for dual-redundancy
```

```
Controller misconfigured -- other controller present
```

- When the OTHER\_CONTROLLER is on-line, enter the following command to put the controllers into Multi-bus Failover mode:

```
HSG80> SET MULTIBUS_FAILOVER COPY=THIS
```

This action will copy all unit and connection information to the OTHER\_CONTROLLER and restart both controllers.

After both controllers have restarted, the controller pair will be bound in Multi-bus Failover mode with consistent views of all the RAID system information.

- Verify that the controllers are now in Multi-bus failover by entering the following command:

```
HSG80> SHOW THIS_CONTROLLER
```

**Example:**

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
NODE_ID           = 5000-1FE1-0000-3350
ALLOCATION_CLASS  = 0
SCSI_VERSION     = SCSI-2
```

```
-> Configured for MULTIBUS_FAILOVER with ZG80200290
```

```
-> In dual-redundant configuration
```

6. If the RAID system had connections prior to making this transition, display the connections and examine their “offset value” (last column), by entering the following command:

```
HSG80> SHOW CONNECTIONS
```

**NOTE:** In Transparent Failover mode, the controller, by default, assigns an offset value of 0 to the left hand port and an offset value of 100 to the right hand port. In Multi-bus Failover mode, the controller assigns an offset value of 0 to all ports, unless existing connections have non-zero offset values.

Secure Path software requires connections to be reset to zero (0) so that both paths will be able to access the entire set of UNITS on the RAID system. To reset the connections to zero, enter:

```
HSG80> SET CONNECTION connection_name UNIT_OFFSET=0
```

Repeat for each connection.

## Changing from Multibus Failover Mode to Nofailover and then to Transparent Failover Mode

1. Inspect the “Connections:” display for connections on the storage system by entering the following command:

```
HSG80> SHOW CONNECTIONS
```

Delete all connections by entering the following command for each connection found:

```
HSG80> DELETE connection_name (Repeat for each connection).
```

**NOTE:** The connections will be regenerated later.

If there are units (Dn) on the storage system, they must be deleted. This is due to the inconsistencies incorporated in the volumes' WWID in different failover modes.

```
HSG80> SHOW UNITS
```

```
HSG80> DELETE Dn (for each Dn)
```

**NOTE:** The UNITS will be restored after the controller state is changed. It is advised that the Dn values and associated information as well as the storage set information be recorded for later use. The controller state change will not affect the data on the storage sets.

2. If the controllers are currently in a failover mode, enter:

```
HSG80> SET NOFAILOVER
```

This action will cause the OTHER\_CONTROLLER to shutdown.

Verify the current state of the controller by entering:

```
HSG80> SHOW THIS_CONTROLLER
```

Example:

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
NODE_ID           = 5000-1FE1-0000-3350
ALLOCATION_CLASS  = 0
SCSI_VERSION     = SCSI-2
-> Not Configured for dual-redundancy
```

- Restart the OTHER\_CONTROLLER by pressing the RESET button on the OTHER\_CONTROLLER. The OTHER\_CONTROLLER will sound an alarm as it discovers the second controller but knows that it is not bound in a failover mode. The alarm (may be silenced) and the message about the controllers being misconfigured may be disregarded.

Verify the current state of the controller by entering:

```
HSG80> SHOW THIS_CONTROLLER
```

Example:

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
```

```
NODE_ID          = 5000-1FE1-0000-3350
```

```
ALLOCATION_CLASS = 0
```

```
SCSI_VERSION     = SCSI-2
```

```
-> Not Configured for dual-redundancy
```

```
-> Controller misconfigured -- other controller present
```

- When the OTHER\_CONTROLLER is available, enter:

```
HSG80> SET FAILOVER COPY=THIS
```

This action will copy all unit and configuration information to the OTHER\_CONTROLLER restart it. When restarted, the controller pair will be bound in Transparent Failover mode.

- Verify the controller state change by entering:

```
HSG80> SHOW THIS_CONTROLLER
```

Example:

Controller:

```
HSG80 ZG83502145 Software V85F-0, Hardware E03
```

```
NODE_ID          = 5000-1FE1-0000-3350
```

```
ALLOCATION_CLASS = 0
```

```
SCSI_VERSION     = SCSI-2
```

```
-> Configured for dual-redundancy with ZG80200290
```

```
-> In dual-redundant configuration
```

- Restore the UNIT to storage set mapping that was recorded earlier. Enter:

```
HSG80> ADD UNIT Dn storage_set_name
```

---

**WARNING: Do not initialize the units. This action will destroy data on the storageset(s).**

---

- Restart both controllers to reacquire connections. Enter:

```
HSG80> RESTART OTHER_CONTROLLER
```

```
HSG80> RESTART THIS_CONTROLLER
```

An alternative method to reestablish the connections is to reboot the server(s).

## Appendix D: Arbitrated Loop Physical Addresses

Host/Server ALPAs. Lowest to Highest Priority

ALPA (hex)	Targ (hex)	Targ (dec)	ALPA (hex)	Targ (hex)	Targ (dec)
6E	42	66	3A	60	96
6D	43	67	39	61	97
6C	44	68	36	62	98
6B	45	69	35	63	99
6A	46	70	34	64	100
69	47	71	33	65	101
67	48	72	32	66	102
66	49	73	31	67	103
65	4A	74	2E	68	104
63	4B	75	2D	69	105
5C	4C	76	2C	6A	106
5A	4D	77	2B	6B	107
59	4E	78	2A	6C	108
56	4F	79	29	6D	109
55	50	80	27	6E	110
54	51	81	26	6F	111
53	52	82	25	70	112
52	53	83	23	71	113
51	54	84	1F	72	114
4E	55	85	1E	73	115
4D	56	86	1D	74	116
4C	57	87	1B	75	117
4B	58	88	18	76	118
4A	59	89	17	77	119
49	5A	90	10	78	120
47	5B	91	0F	79	121
46	5C	92	08	7A	122
45	5D	93	04	7B	123

ALPA (hex)	Targ (hex)	Targ (dec)	ALPA (hex)	Targ (hex)	Targ (dec)
43	5E	94	02	7C	124
3C	5F	95	01	7D	125

Reserved for FL\_PORT

	00	7E	126
--	----	----	-----

## HSG80 Controller ALPAs

Lowest to Highest Priority

ALPA (hex)	Targ(hex)	Targ (dec)	ALPA (hex)	Targ(hex)	Targ (dec)
EF	00	0	B1	21	33
E8	01	1	AE	22	34
E4	02	2	AD	23	35
E2	03	3	AC	24	36
E1	04	4	AB	25	37
E0	05	5	AA	26	38
DC	06	6	A9	27	39
DA	07	7	A7	28	40
D9	08	8	A6	29	41
D6	09	9	A5	2A	42
D5	0A	10	A3	2B	43
D4	0B	11	9F	2C	44
D3	0C	12	9E	2D	45
D2	0D	13	9D	2E	46
D1	0E	14	9B	2F	47
CE	0F	15	98	30	48
CD	10	16	97	31	49
CC	11	17	90	32	50
CB	12	18	8F	33	51
CA	13	19	88	34	52
C9	14	20	84	35	53
C7	15	21	82	36	54

ALPA (hex)	Targ(hex)	Targ (dec)	ALPA (hex)	Targ(hex)	Targ (dec)
C6	16	22	81	37	55
C5	17	23	80	38	56
C3	18	24	7C	39	57
BC	10	25	7A	3A	58
BA	1A	26	79	3B	59
B9	1B	27	76	3C	60
B6	1C	28	75	3D	61
B5	1D	29	74	3E	62
B4	1E	30	73	3F	63
B3	1F	31	72	40	64
B2	20	32	71	41	65