

SAN Fabric Design Rules

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The sections in this chapter contain SAN fabric design configuration rules for heterogeneous SANs implemented using the HP B-Series Product Line of Core and SAN Switch Fibre Channel switch models, for heterogeneous SANs implemented using the HP M-Series Fabric Product Line of Director and Edge Fibre Channel switches, and for the HP C-Series switch models from Cisco.

Support is provided for SAN fabrics consisting exclusively of the Fibre Channel switches listed in Table 9, [StorageWorks B-Series Product Line Switches](#), exclusively of the switches listed in Table 10, [HP StorageWorks M-Series Product Line Switches](#), or exclusively of the switches listed in Table 12, [HP C-Series Product Line Switches](#). Intermixing of the switches in Table 9, Table 10, or Table 12 in the same SAN consisting of multiple fabrics or in the same fabric is not supported at this time.

The configuration rules for a SAN begin with the SAN fabric rules. These are then modified depending on the specific topology implementation rules, platform or operating system and storage system rules described here and in Chapter 4, “[Heterogeneous SAN Platform and Storage System Rules](#)”, and the requirements of applications being run on the SAN. Read the documentation and release notes for all hardware and software products that are being utilized in the SAN for additional configuration information details. See the Preface, “[Related Documents](#)” for a list of related documentation.

SNIA SSF Configurations

The Storage Networking Industry Association (SNIA) sponsors the Supported Solutions Forum (SSF). SSF is a storage industry program that improves the interoperability of Fiber Channel products. HP is a member of SNIA and SSF.

HP supports a number of Fibre Channel switch models in configurations that are compliant with the guidelines defined by the SNIA Supported Solutions Forum. SSF has defined numerous with heterogeneous servers and heterogeneous storage systems.

For additional information on this program, refer to <http://www.snia.org/ssf>

Supported Switch Models – B-Series Product Line

HP supports a range of 1 Gbps and 2 Gbps SAN B-Series Product Line Fibre Channel switch models. These switch models represent products supported by both pre-merger HP and pre-merger Compaq. The relationship between the pre-merger and post-merger switch products is shown in Table 9. Refer to the section, [SAN Fabric Rules – B-Series Product Line](#), for specific switch model support rules.

Table 9: StorageWorks B-Series Product Line Switches

HP StorageWorks Switch Name		Number of Ports
HP StorageWorks MSA SAN switch 2/8		8
HP StorageWorks SAN Switch 2/8 EL, 2/8 Power Pak		8
HP StorageWorks SAN Switch 2/16, 2/16 Power Pak		16
HP StorageWorks SAN Switch 2/32, 2/32 Power Pak		32
HP StorageWorks Core Switch 2/64, 2/64 Power Pak		64 (2 switches per chassis, for a total of 128 ports per chassis)
HP Switch Name	Compaq StorageWorks Switch Name	Number of Ports
HP Brocade 2400 (HP reseller)	CPQ StorageWorks SAN Switch 8	8
N/A	CPQ StorageWorks SAN Switch 8-EL	8
HP Brocade 2800 (HP reseller)	CPQ StorageWorks SAN Switch 16	16
N/A	CPQ StorageWorks SAN Switch 16-EL	16
HP Surestore FC Switch 6164 (64 ISL Ports)	CPQ StorageWorks SAN Switch Integrated/32 (64 ISL Ports)	32 (counts as 6 switches and 2 hops when applying configuration rules)
HP Surestore FC Switch 6164 (32 ISL Ports)	CPQ StorageWorks SAN Switch Integrated/64 (32 ISL Ports)	64 (counts as 6 switches and 2 hops when applying configuration rules)
HP Surestore FC 1Gb/2Gb Entry Switch 8B	N/A	8
N/A	CPQ StorageWorks SAN Switch 2/8-EL	8
N/A	CPQ StorageWorks SAN Switch 2/16-EL	16
HP Surestore FC 1Gb/2Gb Switch 8B	N/A	8
HP Surestore FC 1Gb/2Gb Switch 16B	CPQ StorageWorks SAN Switch 2/16	16

SAN Fabric Rules – B-Series Product Line

All switch models shown in Table 9 are supported in the hp StorageWorks SAN provided that the same firmware versions and switch settings for each switch model family are utilized for the corresponding switch models listed. For additional information on operating system HBA/driver/firmware/software support, refer to individual array Streams connectivity documents available through HP field representatives or partners via the [HP internal SPOCK website](#).

- For SAN fabrics consisting exclusively of Compaq switch models or a mix of pre-merger HP and pre-merger Compaq switch models (Compaq StorageWorks switch name, HP switch name, or Brocade switch name sold by HP in the above table), use the Compaq default switch settings. Configuration files with these settings are available from HP services.

- For SAN fabrics consisting exclusively of pre-merger HP switch models (HP switch name or Brocade switch name sold by HP in the above table), utilize pre-merger HP switch settings. Configuration files with these settings are available from HP services.

Note: The HP StorageWorks switches listed utilize common settings by default.

Fabric Maximums - B-Series Product Line

There are presently two rules sets for SAN fabric maximums:

- The hp StorageWorks SAN fabric rules for SANs consisting exclusively of StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, MSA1000, RA4000, or RA4100 storage systems. These can be considered a superset of the common HP-Compaq StorageWorks SAN fabric rules.
- Common HP-Compaq StorageWorks SAN fabric rules for SANs consisting of exclusively HP XP or VA storage systems or a mix of HP XP or VA and StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, MSA1000, RA4000, or RA4100 storage systems. These rules can be considered a subset of the HP StorageWorks SAN fabric rules.

Note: HP is working towards a single fully merged set of SAN configuration rules for all supported storage systems, with increased scaling and storage product support beyond what is presently supported.

Fabric Maximums when using exclusively StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, MSA1000, RA4000, or RA4100 storage systems:

Note: Refer to Chapter 4 for specific fabric configuration rules regarding Continuous Access EVA VCS V3.

The following rules are for SAN fabrics implemented with versions 2.6.1, 3.1, and 4.1 switch FW unless otherwise stated.

1. Up to 28 switches and up to 1280 total ports in a single SAN fabric. Each fabric may contain any combination of supported 1 Gbps and 2 Gbps switch models listed, provided the individual switch model fabric limits listed below are not exceeded.
2. The hp StorageWorks core switch 2/64 – maximum of 6 chassis total per fabric, each chassis contains 2 logical switches, thus 6 chassis add 12 to the fabric switch count. Maximum fabric configuration is 6 chassis with 16 other 8-port, 16-port, or 32-port switches.

The Core PID addressing mode is required on all other switches in the same fabric with the hp StorageWorks core switch 2/64. Refer to [SAN Core and SAN Switch Addressing Mode](#).

3. For SAN fabrics containing any 1 Gbps switch models utilizing 2.6.1x or later firmware, the maximum number of user ports supported is 728.

For SAN fabrics containing exclusively 2 Gbps switch models, the maximum number of user ports supported is 1200.

4. For SAN fabrics with Security enabled, the maximum number of user ports supported is 728 and the Security database sizes are limited as follows.
 - In a mixed fabric with 1 Gbps switches, the maximum size of the security database is 32 KB, with only 16 KB active.
 - In a 2 Gbps only mixed fabric, the security database size can be 128 KB, with 64 KB active.
 - For all 1 Gbps/2Gbps mixed fabrics, the maximum number of Device Connection Control (DCC) policies is limited to 620.
5. Zoning database size limits - For SAN fabrics containing 1 Gbps switch models utilizing 2.6.1x or later firmware, or 2 Gbps switch models utilizing 3.1x or later firmware, the zoning database size must not exceed 96 KB.
For SAN fabrics containing 2 Gbps switch models utilizing 4.1x or later firmware, the zoning database size must not exceed 128 KB.
6. StorageWorks SAN Switch Integrated 32 or 64, HP Surestore FC Switch 6164 – maximum of 4 chassis total per fabric, each chassis adds 6 switches to the fabric switch count. Maximum fabric configuration is 4 chassis with 4 other SAN switch model switches.
7. Up to 7 switch hops (8 switches) maximum between any two devices in a SAN fabric. Each SAN Switch Integrated 32 or 64 or HP Surestore FC Switch 6164 model switch utilized in a fabric adds up to 2 hops to the hop count between devices depending on the specific device-to-switch connections and device-to-device access. (refer to Chapter 2, Figure 6 and Figure 7).

Fabric Maximums when using exclusively HP XP or VA storage systems, or a mixture of HP XP or VA and StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, MSA1000, RA4000, or RA4100 storage systems:

Note: Refer to Chapter 4 for specific fabric configuration rules regarding Continuous Access EVA VCS V3.

The following rules are for SAN fabrics implemented with versions 2.6.1, 3.1, and 4.1 switch FW unless otherwise stated.

1. Up to 16 switches and up to 640 total ports in a single SAN fabric. Each fabric may contain any combination of supported 1 Gbps and 2 Gbps switch models listed, provided the individual switch model fabric limits listed below are not exceeded.
2. The hp StorageWorks core switch 2/64 – maximum of 2 chassis total per fabric, each chassis contains 2 logical switches, adding 2 to the fabric switch count. Maximum fabric configuration is 2 chassis with 12 other 8-port, 16-port, or 32-port switches (4x12).

The Core PID addressing mode is required on all other switches in the same fabric with the hp StorageWorks core switch 2/64. Refer to [SAN Core and SAN Switch Addressing Mode](#).

3. For SAN fabrics with Security enabled, the Security database sizes are limited as follows.
 - In a mixed fabric with 1 Gbps switches, the maximum size of the security database is 32 KB, with only 16 KB active.
 - In a 2 Gbps only mixed fabric, the security database size can be 128 KB, with 64 KB active.
 - For all 1 Gbps/2Gbps mixed fabrics, the maximum number of Device Connection Control (DCC) policies is limited to 620.
4. Zoning database size limits - For SAN fabrics containing 1 Gbps switch models utilizing 2.6.1x or later firmware, or 2 Gbps switch models utilizing 3.1x or later firmware, the zoning database size must not exceed 96 KB.
For SAN fabrics containing 2 Gbps switch models utilizing 4.1x or later firmware, the zoning database size must not exceed 128 KB.
5. StorageWorks SAN Switch Integrated 32 or 64, HP Surestore FC Switch 6164 – maximum of 2 chassis total per fabric, each chassis adds 6 switches to the fabric switch count. Maximum fabric configuration is 2 chassis with 4 other SAN switch model switches.
6. Up to 3 switch hops (4 switches) maximum between any two devices in a SAN fabric. Each SAN Switch Integrated 32 or 64 or HP Surestore FC Switch 6164 model switch utilized in a fabric adds up to 2 hops to the hop count between devices depending on the specific device-to-switch connections and device-to-device access. (refer to Chapter 2, Figure 6 and Figure 7).

Additional Fabric Rules

1. StorageWorks SAN Switch 2/8-EL – By default, this switch is supported in SAN fabrics with up to 4 switches total only. A license upgrade is available to allow these switches to be upgraded for support in larger fabrics with greater than 4 switches total.
2. HP Surestore FC 1Gb/2Gb Entry Switch 8B – Supported with a single E-port connection.
3. Compaq Fibre Channel Switch 8 or Fibre Channel Switch 16 models– up to 4 switches total per fabric using these model switches only, or when intermixed with 1 Gbps SAN switches.

Note: Intermixing of Compaq Fibre Channel Switch 8 and Fibre Channel Switch 16 models and 1 Gbps StorageWorks SAN Switch models requires compatibility mode (VC Encoded Address Mode) be set in the SAN Switches (refer to the SAN Switch documentation). Intermixing of 1 Gbps Compaq Fibre Channel Switch 8 or Fibre Channel Switch 16 switch models and 2 Gbps switch models is not supported

4. The Compaq FC-AL Switch 8 is supported for cascaded attachment to the SAN through a single FL-port on a Compaq SAN Switch 8, SAN Switch 16, SAN Switch 8-EL, or SAN Switch 16-EL. In this configuration, RA4000/4100 storage systems are accessible only from servers attached directly to the FC-AL switch.

Note: Cascaded attachment of the FC-AL Switch 8 connected to 2 Gbps switch models is not supported

5. Within a single fabric where switches are interconnected, each switch must have a unique domain number (Domain ID) and a unique World Wide Name (WWN). All switch configuration parameters in each switch must be the same.

Note: Do not configure any switches with a domain ID of 8. HP systems reserve domain 8 for Private Loop devices.

6. Optional switch features may be used on any switch in the fabric if the feature is supported on that switch. This includes features such as ISL Trunking, QuickLoop, Fabric Watch, Advanced Performance Monitoring, and Extended Fabrics. Refer to the switch model specific documentation to determine which features are available for a given switch model.
7. Any mix of servers and storage systems is allowed in a SAN provided the specific platform, operating system, and storage system fabric limits and rules are followed. Refer to the appropriate sections in this guide and the documentation listed in the section "Related Documents" in the preface.
8. HP requires that all switches in a single fabric or multi-fabric SAN use the same switch firmware revision for each switch model family. Two successive fabric firmware versions can be temporarily used in one fabric or multiple fabrics in a SAN during switch firmware rolling upgrades.

SAN Core and SAN Switch Addressing Mode

When using products from the B-series Product Line, or pre-merger HP products from Brocade, two different addressing modes are available. As SAN configurations grow to include more switches, we recommend that the "Core Switch" addressing mode should be used. This is obtained by setting the Core Switch PID configuration parameter bit.

All previous switches supplied by HP and Compaq were shipped with the Core Switch PID configuration bit cleared. When the switches are operated in this mode, certain restrictions apply regarding the maximum number of switches in a fabric and the maximum number of ports on a switch. If a StorageWorks Core Switch 2/64 or StorageWorks SAN switch 2/32 is used anywhere in a fabric, then all the switches in the fabric must have the Core Switch PID configuration bit set. Because HP believes that the use of large port count switches will only become more common as time goes on, all switches are shipped with the bit set.

SAN managers with existing fabrics must decide whether to change the Core Switch PID bit now or later. The trade-offs are as follows.

- All switches in a fabric must have the same Core Switch PID bit setting, whether it is set or cleared, otherwise the fabric will segment. It must be set on all switches if a StorageWorks Core Switch 2/64 or StorageWorks SAN switch 2/32 is part of the fabric.
- If you have two fabrics, you can change the Core Switch PID on one fabric at a time, so the SAN storage system can continue to operate during the changeover.
- HP-UX and IBM systems use the address bits to identify logical units, when the addressing bits are changed the logical unit definitions must also be changed. This requires a reboot of the servers and cannot be done without taking down the entire SAN storage system in a planned maintenance scenario.
- If you don't set the Core PID on your existing switches now, you will need to clear this bit on any new switches that you add, since they ship with the Core PID bit set.

HP recommends that this change be done now, to avoid potential problems in the future. Additional information on the Core Switch PID is available on the HP SAN Storage website.

Supported Switch Models – M-Series Fabric Product Line

HP supports a range of 1 Gbps and 2 Gbps M-Series Fabric Product Line Fibre Channel switch models. These switch models represent products supported by both pre-merger HP and pre-merger Compaq. The relationship between the pre-merger and post-merger switch products is shown in Table 10. Refer to the section, [SAN Fabric Rules – M-Series Fabric Product Line](#), for specific switch model support rules.

Table 10: HP StorageWorks M-Series Product Line Switches

hp StorageWorks Switch Name		Number of Ports
hp StorageWorks edge switch 2/16		16
hp StorageWorks edge switch 2/24		24
hp StorageWorks edge switch 2/32		32
hp StorageWorks director 2/64		64
hp StorageWorks director 2/140		140
HP Switch Name	Compaq Switch Name	Number of Ports
N/A	McDATA ES-3016 (CPQ reseller)	16
N/A	McDATA ES-3032 (CPQ reseller)	32
McDATA ED-5000 (McDATA reseller)		32
HP Surestore FC64	CPQ StorageWorks SAN Director 64	64

SAN Fabric Rules – M-Series Fabric Product Line

All switch models shown in Table 10 are supported in the HP StorageWorks SAN provided that the same firmware versions and switch settings are utilized for the corresponding switch models listed. The default switch settings for this family of switches from pre-merger HP and pre-merger Compaq are the same.

Fabric Maximums - M-Series Fabric Product Line

There are presently two rules sets for SAN fabric maximums:

- The HP StorageWorks SAN fabric rules for SANs consisting exclusively of StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, or MSA1000 storage systems. These can be considered a superset of the common HP-Compaq StorageWorks SAN fabric rules.
- Common HP-Compaq StorageWorks SAN fabric rules for SANs consisting of exclusively HP XP or VA storage systems or a mix of HP XP or VA and StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, or MSA1000 storage systems. These rules can be considered a subset of the HP StorageWorks SAN fabric rules.

Note: HP is working towards a single fully merged set of SAN configuration rules for all supported storage systems, with increased scaling and storage product support beyond what is presently supported.

Fabric Maximums when using exclusively StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, or MSA1000 storage systems:

Note: Refer to Chapter 4 for specific fabric configuration rules regarding Continuous Access EVA VCS V3.

The following rules are for SAN fabrics implemented with 05.01.00-24 switch FW and 07.01.00-9 HAFM unless otherwise stated.

1. Up to 24 switches with up to 1632 total ports and a maximum of 1024 user ports are supported in a single SAN fabric. Each fabric may contain any combination of supported 1 Gbps and 2 Gbps switch models listed, provided the individual switch model fabric limits listed below are not exceeded.

Note: With eight hp StorageWorks director 2/140 fully populated Directors, it is physically possible to exceed the 1024 user port maximum. The restriction is in the zoning configuration, as only 1024 unique zone members (user ports) can be configured. However, the remaining ports can be used as Inter Switch Link (ISL) connections in the fabric.

- hp StorageWorks director 2/64 and hp StorageWorks director 2/140 – maximum of 8 Directors total per fabric
 - Up to 16 switches with up to 512 total ports in a single fabric that includes one or more McDATA ED-5000 Directors.
2. Up to 3 switch hops (4 switches) maximum between any two devices in a SAN fabric.

Fabric Maximums when using exclusively HP XP or VA storage systems, or a mixture of HP XP or VA and StorageWorks Enterprise Virtual Array, EMA/ESA12000, EMA16000, MA/RA8000, MA6000, or MSA1000 storage systems:

Note: Refer to Chapter 4 for specific fabric configuration rules regarding Continuous Access EVA VCS V3.

The following rules are for SAN fabrics implemented with 05.01.00-24 switch FW and 07.01.00-9 HAFM unless otherwise stated.

1. Up to 16 switches with up to 1376 total ports and a maximum of 1024 user ports are supported in a single SAN fabric. Each fabric may contain any combination of supported 1 Gbps and 2 Gbps switch models listed, provided the individual switch model fabric limits listed below are not exceeded.

Note: With eight hp StorageWorks director 2/140 fully populated Directors, it is physically possible to exceed the 1024 user port maximum. The restriction is in the zoning configuration, as only 1024 unique zone members (user ports) can be configured. However, the remaining ports can be used as Inter Switch Link (ISL) connections in the fabric.

- hp StorageWorks director 2/64 and hp StorageWorks director 2/140 – maximum of 8 Directors total per fabric
 - McDATA ES-3016 and ES-3032 switches are not supported on HP XP or VA storage
2. Up to 3 switch hops (4 switches) maximum between any two devices in a SAN fabric.

Additional Fabric Rules

1. Within a single fabric where switches are interconnected, each switch must have a unique domain number (Domain ID) and a unique World Wide Name (WWN). All switch configuration parameters in each switch must be the same.

Note: Do not configure any switches with a domain ID of 8. HP systems reserve domain 8 for Private Loop devices.

2. Any mix of servers and storage systems is allowed in a SAN provided the specific platform, operating system, and storage system fabric limits and rules are followed. Refer to the appropriate sections in this guide and the documentation listed in the section "Related Documents" in the Preface.
3. HP requires that all switches in a single fabric or multi-fabric SAN use the same switch firmware revision. Two successive fabric firmware versions can be temporarily used in one fabric or multiple fabrics in a SAN during switch firmware rolling upgrades.

Specific Fabric Topology Rules

- For B-Series Product Line, Table 9 Fibre Channel switches – Up to 15 switches configured in a single ring with a Ring SAN fabric topology and no cascaded switches. Up to 22 switches in a Ring SAN fabric with cascaded switches, provided that no more than 11 switches are in a ring and no more than 11 switches are outside of the ring. One outside switch is cascaded from each of the 11 ring switches.
- For M-Series Fabric Product Line, Table 10 Fibre Channel switches – Up to 7 switches configured in a ring with a Ring SAN fabric topology.

ISL Rules

When designing a fabric using 8-port, 16-port, 24-port, and 32-port switches, all ports may be used as ISLs with a maximum of one half of the total port count as ISLs to the same destination (may be license limited on some switch models). This feature is used in the Surestore FC Switch 6164 and StorageWorks SAN Switch Integrated 32 and 64 configurations, which are made up of multiple 16-port switches in an integrated mechanical chassis package. However, there are restrictions in the use of ISLs on some higher port count Fibre Channel switch models, as shown in Table 11.

Table 11: Number of ISLs for Fibre Channel switch products

HP Switch Product Name	Compaq Switch Name	Total Number of Available Users Ports	Number of Ports That May Be Used as ISLs
hp StorageWorks core switch 2/64		64 per switch, 128 per chassis	32 per switch, 64 per chassis
McDATA ED-5000		32	4
Surestore FC64	StorageWorks SAN Director 64	64	32
hp StorageWorks director 2/64		64	32
hp StorageWorks director 2/140		140	70

Supported Switch Models – C-Series Product Line

HP currently supports two models of the C-Series Product Line 2 Gbps Fibre Channel Switches, the Cisco MDS 9509 and the MDS 9216.

Table 12: HP C-Series Product Line Switches

Switch Name	Maximum Total Number of Ports
MDS 9216	48
MDS 9509	176

SAN Fabric Rules – C-Series Fabric Product Line

The following rules are for SAN fabrics implemented with 1.0.4 switch FW unless otherwise stated.

The Cisco MDS 9509 is supported with up to 176 ports, over 7 modular chassis (3-16 and 4-32 port modules). As the non-blocking feature is not completely implemented for 32 port modules, use the 16 port module for performance intense applications.

The Cisco MDS 9216 has a basic configuration with 16 ports. It has an expansion slot that supports either a 16 or a 32 port card, for 32 or 48 ports in total.

Switch Maximums

The Cisco MDS 9509 and the MDS 9216 switches are supported in a single switch fabric only.

Zoning and VSANs

The following table (Table 13), indicates how zoning is implemented for the Cisco MDS switches.

In HP SANs, VSANs are defined as separate instances of all fabric services, including address space. HP supports only one VSAN per physical fabric.

Table 13: Zone Types on HP fabric switches

Switch Models	Configuration	Enforcement	Comments
Cisco MDS 9509 Cisco MDS 9216	Define zones using all domain#/port# Define zones using all WWNs Define zones using a combination of domain#/port# and WWNs	Access authorization at frame level in hardware	HARD zoning (loaded from name server at boot)

Mixed Storage Common SAN Rules

Refer to Chapter 4 for specific storage rules related to the C-Series switches.

Third party switch support

3rd party switches and connectivity reliability have been verified through testing. However, support is subject to the following:

- No support for 3rd party switch functionality. If a defect must be fixed within the switch product, the customer will need to work directly with the 3rd party switch support organization.
- HP will make a best effort attempt to help the customer resolve issues as they pertain to the HP supported products within the environment.
- HP can support switches and additional functionality resold through other vendors providing the customer purchases 3rd party support through the appropriate HP support group.

Example of 3rd party switches:

- McData ED5000 = EMC Connectrix ED-1032
- InRange FC 9000

1 and 2 Gbps Fabric Topology Recommendations

There are no specific topology rules related to mixing of 1 and 2 Gbps components in a fabric. HP does however strongly recommend these guidelines be followed.

- When using both 1 and 2 Gbps switches in the same fabric, utilize 2 Gbps switches in the core for Core to SAN switch or Director to edge switch topologies.
- Connect 2 Gbps switches together to take advantage of the optional ISL Trunking feature when using Fibre Channel switch models that support this feature.
- Utilize 2 Gbps switches for connections to 2 Gbps capable devices. In general, for SANs with both 1 Gbps and 2 Gbps components, the transfer rate between devices and ports on switches is determined by the speeds supported by the individual ports that are connected. If two 2 Gbps devices or switch ports are connected together the speed will be 2 Gbps for that segment in the fabric, if two 1 Gbps devices or switch ports are connected together the

speed will be 1 Gbps for that segment in the fabric. If a 2 Gbps and a 1 Gbps port are connected together the speed will be 1 Gbps for that segment. Refer to the section [General Fabric Performance Recommendations](#) in this chapter for more information.

- Zoning rules, SAN security, and SAN management for 2 Gbps switches are the same as for 1 Gbps switches.

SAN Fabric Zoning Rules

The fabric zoning feature is supported with all HP Fibre Channel switch models. Zoning can be used to logically separate devices and different hardware platforms and operating systems in the same physical SAN. Use of zoning is required under these specific conditions:

- When mixing pre-merger HP and pre-merger Compaq storage systems and servers in the same SAN fabric. Refer to Chapter 4, “[Heterogeneous SAN Platform and Storage System Rules](#)” for more information.
- When mixing different hardware platforms, operating systems or storage systems that are currently only supported in homogenous SANs, and it is unknown whether there are interaction problems. Refer to Table 19 and Table 20 for specific information about zoning in heterogeneous SANs.
- When there are known interaction problems between different hardware platforms or operating systems and specific storage system types.
- When the number of nodes or ports in the SAN fabric exceeds a storage system connection support limit. There is a connection limit for storage systems using the Enterprise Virtual Array (HSV controller) or EMA/ESA/MA/RA (HSG60/80 controller). The version of VCS or ACS controller code determines the specific limit.

Storage Management Appliance Rules and Recommendations

Whenever a Storage Management Appliance is placed in a fabric with heterogeneous servers it is recommended that a dedicated storage management zone be created. This zone is specifically for the Storage Management Appliance and the elements it is to monitor and manage.

Currently, the Storage Management Appliance communicates with the Enterprise Virtual Array (HSV controller) and EMA/ESA12000, EMA16000, MA/RA8000, MA6000 storage systems (HSG controller) in-band, that is, within the Fibre Channel fabric itself. It is not necessary or recommended to include either the switch WWNs or server HBA WWNs in this zone. Management communication to these devices from the Storage Management Appliance is done out-of-band or outside the fabric via TCP/IP.

For example, create a zone called SANAPP_#_ZONE that would contain the Appliance host bus adapter WWN and the WWNs of all the HSG or HSV controllers managed by this Storage Management Appliance. Because fabric devices can be in multiple zones, this will have no effect on other zones containing the same HSG and HSV controller WWNs.

1. Within the same fabric, Enterprise Virtual Arrays with V2.0x and V3.0x can be managed by the same instance of Command View EVA. A separate appliance is needed to manage an Enterprise Virtual Array with V1.0x.
2. Any EVA storage system can only have one active SMA managing it. Any standby SMA can be powered on, but the Command View EVA or Continuous Access user interface must not control the storage system. For further information, refer to the [hp StorageWorks Continuous Access EVA Operations Guide](#) available on the HP web.

3. A Storage Management Appliance is required to manage Enterprise Virtual Arrays. For EMA/ESA12000, EMA16000, MA/RA8000, MA6000 storage systems, it is recommended that a Storage Management Appliance be used to manage the SAN when a fabric contains more than four Fibre Channel switches. It is required when using the HSG element manager.
4. When using Storage Management Appliances, one is required for each fabric in multiple fabric SANs.
5. Multiple appliances per fabric are allowed as long as only one appliance is accessing a controller pair at a time. Zoning is required to actively isolate an appliance and its controllers from other appliances and their controllers.
6. Element Manager for HSG may manage up to 25 HSG controller pairs per appliance. The Element Manager for HSV may manage up to 16 HSV controller pairs per appliance.
7. The HSV and HSG Element Managers can operate in a dual fabric configuration.
8. A license key is required for each Enterprise Virtual Array managed by the Storage Management Appliance. Additional licenses are required to take advantage of value added software functionality.
9. For SANs with more than 1024 HBAs, an HSV controller must be zoned so that it can see no more than 1024 HBAs. It may be necessary to add a zone to a SAN to satisfy the 1024 HBA limit.

Refer to Chapter 4, [“Heterogeneous SAN Platform and Storage System Rules”](#), for rules about mixing specific platforms in a Heterogeneous SAN without the need for fabric zoning.

SAN Connectivity rules for XP/VA

HP XP and VA storage systems are supported in both the B-Series and M-Series Fabric Product Lines of Fibre Channel switches. For the C-Series Product Line switches, only the XP 128/1024 from the XP family of storage is supported.

The SAN connectivity rules for XP and VA storage systems apply uniformly to all switch products, unless specified otherwise.

In general, XP and VA are used to represent all the products in that category, but there could be some device specific exceptions.

XP array here refers to XP-256/512/48/1024/128 and VA refers to VA-7100/7400/7410.

For **supported switch firmware versions with each of the above arrays**, refer to Streams connectivity documents on <http://turbo.rose.hp.com/spock>

Also, for specific connectivity rules and any exceptions please refer to individual Streams documents available on SPOCK at <http://turbo.rose.hp.com/spock>

Connectivity rules for XP/VA

Refer to Chapter 10, [Best Practices](#), for information about fabric zoning

In general, there is no limit on maximum number of zones in a SAN and overlapped zones are supported.

Shown below are some of the configuration examples in each product category

Examples of core/san fabric switch configurations (Brocade)

16 switch mesh of fabric switches with or without combination of Director 2/64

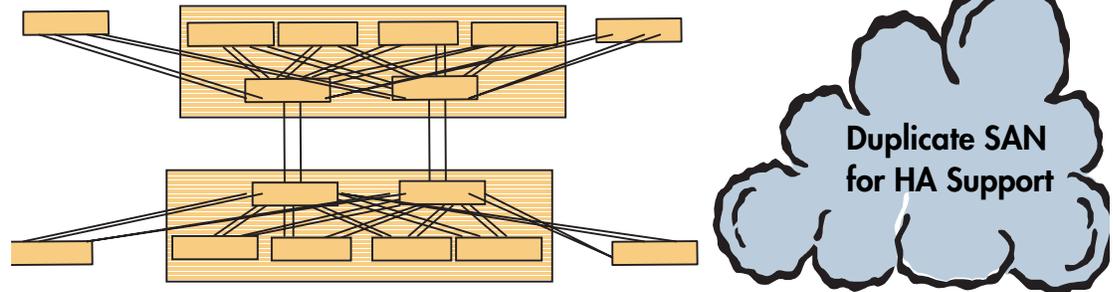


Figure 21: 16 switch mesh of fabric switches with or without combination of Director 2/64

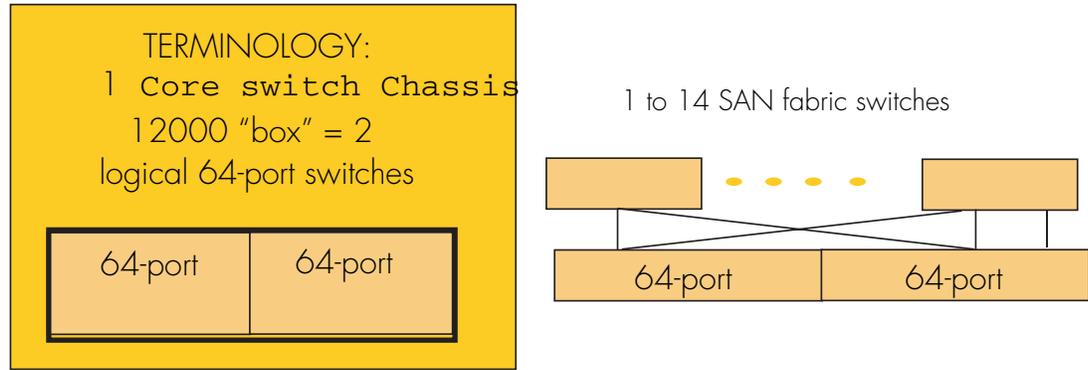


Figure 22: Core Switch definition and SAN fabric with up to 16 switches

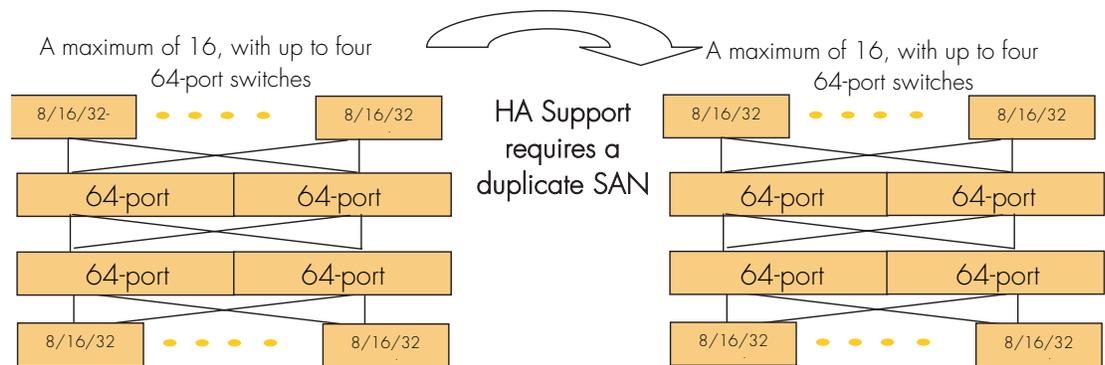


Figure 23: Two Maximum SANs for high availability

Examples of director/edge switch configurations (McDATA)

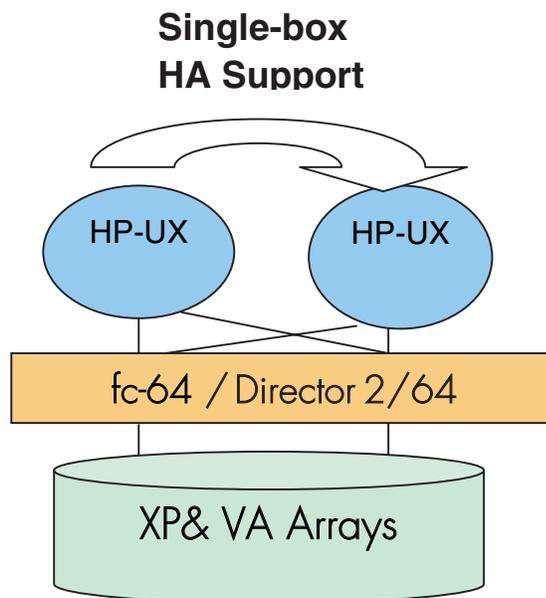


Figure 24: Single Director switch configuration

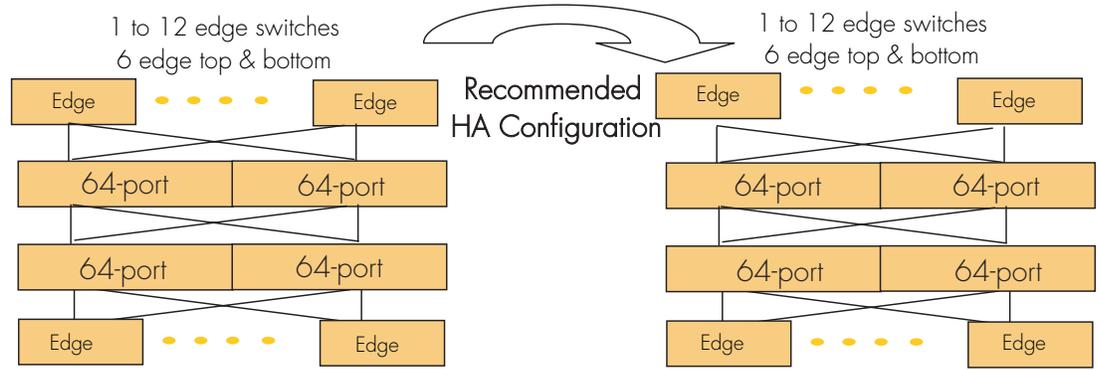


Figure 25: Director/Edge switch maximum SANs for high availability

Note: A maximum of 16 switches are supported with up to 8 directors in a single SAN.

SAN Component Interconnect Descriptions and Rules

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

Fibre Channel Switch Interface Usage Descriptions

- E-Port interface for switch to switch connectivity (also referred to as ISLs)
- F-Port interface for fabric attached device—initiators (host bus adapters) and targets (storage ports)
- FL-Port interface for public loop fabric-aware, 24-bit Fibre Channel addressable devices—initiators or Compaq FC-AL Switch 8 SAN attachment
- FL-Port interface for private loop 8-bit Fibre Channel addressable devices—private FC-AL initiators and targets. This requires use of the B-Series Product Line switches QuickLoop Feature. This is a license-enabled feature on certain switch models, refer to the specific switch model product documentation for information about support of this feature. Typically this feature is only required when a specific platform can only be configured with a private FC-AL host bus adapter driver.
- G-Port, default interface when no devices appear to be attached to the port.

Access with QuickLoop

The QuickLoop switch feature allows private FC-AL initiators and targets configured in a QuickLoop to communicate with each other through the switch. Since all initiators configured *inside* a QuickLoop are private they cannot communicate with targets outside of the QuickLoop. QuickLoop is only supported on the B-Series Product Line of Fibre Channel switch models when used with MA6000, MA8000, RA8000, EMA12000/16000, and ESA12000 RAID Array systems.

Fiber Optic Interconnect Rules

1. 2 Gbps components utilize industry standard “LC” connectors for the Fibre Channel optical connections. 1 Gbps components utilize industry standard “SC” connectors. Cables and adapters are available with SC connectors on one end and LC connectors on the other end. Refer to the 2 Gbps switch QuickSpecs documents for additional information.

Note: Certain fiber optic cable configurations may require the use of SC or LC connector sleeves to couple two cable connector ends together such as when using wall jacks or connecting to existing pre-installed cables. Duplex couplers are available from various manufacturers. Use of these couplers is supported provided the overall cable losses specified in this chapter are not exceeded in the cable segment that includes the couplers.

2. The minimum allowable bend radius of fiber optic cable is 25 mm for 50, 62.5, and 9 micron fiber optic cable.
3. There is a minimum fiber optic cable segment length between Fibre Channel devices (a transmitter and a receiver). The minimum length is 0.5 meters for 50 and 62.5 micron cable and 2.0 meters for 9 micron cable. The minimum length does not apply to patch cords through a passive patch panel; it only applies to the total distance between the transmitter and receiver of the devices being connected through the patch panel.

4. For longer 50-micron short wave multi-mode optical fiber cables up to 300 meters (2 Gbps) or up to 500 meters (1 Gbps), a third party vendor must be contacted. The cables must be duplex, tight buffered multi-mode 50/125 μm (Belcore GR-409 compliant) and the connectors must be SC or LC duplex low metal Belcore and IEC compliant.
5. For 9-micron long wave single-mode optical fiber cables up to 100 km (1 Gbps) or 35 km (2 Gbps), a third party vendor must be contacted. The cables must be duplex, tight buffered, single-mode 9/125 μm (Belcore GR-409 compliant) and the connectors must be SC or LC duplex low metal (NTT-SC Belcore 326, IEC-874-19 SC compliant).
6. The mixing of 9-micron, 50-micron, and 62.5-micron fiber cables in the same cable segment is not supported.
7. Extended Fabrics – See Chapter 8, [SAN Extension](#). Also refer to the *Extended Fabric User Guide, AA-RR7QA-TE*, for more information.

2 Gbps Fiber Optic Interconnects/Distance Rules

1. Up to 300 meters maximum distance per cable segment between devices and switches or switches and switches using 50/125 micron multi-mode fiber optic cable and short wavelength SFPs
2. Up to 150 meters maximum distance per cable segment between devices and switches or switches and switches using 62.5/125 micron multi-mode fiber optic cable and short wavelength SFPs

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

3. Up to 10 km (6.2 miles) maximum distance between two switches using 9/125 micron single-mode fiber optic cable and long wavelength SFPs.
4. Up to 35 km (21.7 miles) maximum distance between two switches using 9/125 micron single-mode fiber optic cable and extended reach SFPs.
5. For B-Series Product Line Switches:
 - Maximum of 160 km (100 miles) total distance across the SAN using multiple segments. This can be implemented using four 35km segments and two 10 km segments (6 hops.) In all cases the individual segments must be configured with the proper SFP and cable type and a maximum of 7 hops must not be exceeded across the SAN.
6. For M-Series Product Line Switches:
 - Maximum of 105 km (64 miles) total distance across the SAN using multiple segments. This can be implemented using three 35 km segments (3 hops.) In all cases the individual segments must be configured with the proper SFP and cable type and a maximum of 3 hops must not be exceeded across the SAN.

Note: Fiber-optic repeaters or WDM may be used to increase the switch-to-switch distance beyond the distances listed above. Refer to Chapter 8, [SAN Extension](#).

1 Gbps Fiber Optic Interconnects/Distance Rules

1. Up to 500 meters maximum distance per cable segment between devices and switches or switches and switches using 50/125 micron multi-mode fiber optic cable and short wavelength GBICs or GLMs¹.
2. Up to 200 meters maximum distance per cable segment between devices and switches or switches and switches using 62.5/125 micron, multi-mode fiber optic cable and short wavelength GBICs or GLMs¹.

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

3. For B-Series Product Line switches:
 - Up to 10 km (6.2 miles) maximum distance between any two switches using 9/125 micron single-mode fiber optic cable and long wavelength GBICs.
 - Up to 100 km (62 miles) distance between any two switches using 9/125 micron single-mode fiber optic cable and very long distance GBICs. A maximum of one 100 km very long distance segment per SAN.
 - Maximum of 160 km (100 miles) total distance across the SAN using multiple segments. This can be implemented using a single 100 km segment and six 10 km segments (7 hops) or other combinations such as two 50 km segments and five 10 km segments (7 hops). In all cases the individual segments must be configured with the proper GBICs and cable type and the maximum of 7 hops must not be exceeded across the SAN.
4. For M-Series Fabric Product Line switches:
 - Up to 10 km (6.2 miles) maximum distance between any two switches using 9/125 micron single-mode fiber optic cable and long wavelength SFPs.
 - Up to 35 km (21.7 miles) maximum distance between two switches using 9/125 micron single-mode fiber optic cable and extended reach SFPs.
 - Maximum of 105 km total distance across the SAN using multiple segments. This can be implemented using three 35 km segments (3 hops.) In all cases the individual segments must be configured with the proper SFP and cable type and a maximum of 3 hops must not be exceeded across the SAN.

Note: Fiber-optic repeaters or WDM may be used to increase the switch-to-switch distance beyond the distances listed above. Refer to Chapter 8, [SAN Extension](#).

Note: Refer to the Data Replication Manager (DRM) solution documentation, including the DRM Design Guide, for specific interconnect and distance rules related to DRM configurations. See:

<http://h18000.www1.hp.com/products/sanworks/drm/documentation.html>

1. GLMs are used in the HSG60 (MA6000) and HSG80 (MA/RA8000, EMA/ESA12000, EMA16000) storage controllers

Note: Refer to the Continuous Access EVA solution documentation, including the Continuous Access EVA Design Reference Guide, for specific interconnect and distance rules related to Continuous Access EVA configurations. See:

<http://h18006.www1.hp.com/products/storage/software/conaccesseva/index.html>

Fiber Optic Cable Loss Budgets

The information in this section is based on the Fibre Channel Physical Interface Specification. Refer to the specification document for more information. The maximum distances specified are based on the use of nominal bandwidth fiber optic cable. This specifies modal bandwidth of 500 MHz-km for 50 micron fiber optic cable, and 200 MHz-km for 62.5 micron fiber optic cable.

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

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

Table 14: Optical Cable Losses

Speed	Cable	Maximum Distance	Total Channel Insertion Loss	Loss per Mated Connector Pair	Notes
2 Gbps	62.5/125 micron	150 meters	2.1 dB ¹	0.75 dB	
2 Gbps	50/125 micron	300 meters	2.62 dB	0.75 dB	
2 Gbps	9/125 micron	10 km	7.8 dB	0.75 dB	
2 Gbps	9/125 micron	35 km	16 dB	0.75 dB	
1 Gbps	62.5/125 micron	200 meters	3.0 dB	0.75 dB	
1 Gbps	50/125 micron	500 meters	3.85 dB	0.75 dB	
1 Gbps	9/125 micron	10 km	7.8 dB	0.75 dB	
1 Gbps	9/125 micron	100 km	21.5 dB	0.75 dB	A minimum loss of 8 dB is required

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

Use of optical fiber patch panels is supported provided the total channel insertion loss between the transmitter and receiver for the cable segment routed through the patch panel does not exceed the maximum listed for the connector and cable type in use.

Table 15: Storage Product Interconnect/Transport Support

Interface/Transport	Storage Product		
	Heterogeneous SAN	DRM and Continuous Access EVA	Enterprise Backup Solutions (EBS)
2 Gbps Fibre Channel via 50 micron multi-mode fiber optic cable and short-wave SFPs	Up to 300 meters per cable segment	Up to 300 meters per cable segment	Up to 300 meters per cable segment
2 Gbps Fibre Channel Via 62.5 micron multi-mode fiber optic cable and short-wave SFPs	Up to 150 meters per cable segment	Up to 150 meters per cable segment	Up to 150 meters per cable segment
2 Gbps Fibre Channel via 9 micron single-mode fiber optic cable and long-wave SFPs	Up to 10 km per cable segment	Up to 10 km per cable segment	Up to 10 km per cable segment
2 Gbps Fibre Channel via 9 micron single-mode fiber optic cable and extended reach SFPs	Up to 35 km per cable segment. Refer to page 76 for maximum supported distance across the SAN	Up to 35 km per cable segment. Refer to page 76 for maximum supported distance across the SAN	Not Supported
1 Gbps Fibre Channel via 50 micron multi-mode fiber optic cable and short-wave GBICs	Up to 500 meters per cable segment	Up to 500 meters per cable segment	Up to 500 meters per cable segment
1 Gbps Fibre Channel via 62.5 micron multi-mode fiber optic cable and short-wave GBICs	Up to 200 meters per cable segment	Up to 200 meters per cable segment	Up to 200 meters per cable segment
1 Gbps Fibre Channel via 9 micron single-mode fiber optic cable and long-wave GBICs	Up to 10 km per cable segment	Up to 10 km per cable segment	Up to 10 km per cable segment
1 Gbps Fibre Channel via 9 micron single-mode fiber optic cable and very long distance GBICs	Up to 100 km per cable segment. Refer to page 77 for maximum supported distance across the SAN	Up to 100 km per cable segment. Refer to page 77 for maximum supported distance across the SAN	Up to 10 km per cable segment
1 Gbps and 2 Gbps Fibre Channel via Wavelength Division Multiplexing (WDM) and Dense Wavelength Division Multiplexing (DWDM)	Supported at 1 Gbps up to 100 km per cable segment, and at 2 Gbps up to 35 km per segment. Refer to the SAN Extension Chapter.	Supported at 1 Gbps up to 100 km per cable segment, and at 2 Gbps up to 35 km per segment. Refer to the SAN Extension Chapter.	Not Supported
ATM over single T1/E1 Wide Area Network (WAN)	Not Supported	Supported Refer to page 127 Supported on DRM with no limit on delay, and as the intersite network backbone for Continuous Access EVA up to 36 ms of delay	Not Supported

Table 15: Storage Product Interconnect/Transport Support (Continued)

Interface/Transport	Storage Product		
	Heterogeneous SAN	DRM and Continuous Access EVA	Enterprise Backup Solutions (EBS)
ATM over single T1/E1 WAN (Inverse Multiplexing)	Not Supported	Supported on DRM with no limit on delay, and as the intersite network backbone for Continuous Access EVA up to 36 ms of delay	Not Supported
ATM over T3/E3 WAN	Not Supported	Supported Refer to page 127 Supported on DRM with no limit on delay, and as the intersite network backbone for Continuous Access EVA up to 36 ms of delay	Not Supported
ATM over fractional and/or shared T3/E3 and OC3 WAN	Not Supported	Supported Refer to page 127 Supported on DRM with no limit on delay, and as the intersite network backbone for Continuous Access EVA up to 36 ms of delay	Not Supported
10/100 Copper Ethernet FC over IP	N/A	Supported on DRM with no limit on delay, and as the intersite network backbone for Continuous Access EVA up to 36 ms of delay	N/A
1 Gbps Optical Ethernet FC over IP	N/A	Supported on DRM with no limit on delay, and as the intersite network backbone for Continuous Access EVA up to 36 ms of delay	N/A

General Fabric Performance Recommendations

The performance of an application on a heterogeneous SAN is usually seen from the perspective of "storage performance". The intervening SAN and competing workloads are not usually considered. The fact is that the performance of the storage will be dependent on the interaction of all the components and applications in the SAN. Some of the possible component limiting factors include the host CPU(s), FC HBA, SAN topology, SAN traffic, RAID controllers, or the specific configuration of disks used behind the controllers. This is a dynamic workload environment and at any given moment any part of the SAN can dominate the performance. This complexity can be simplified if the environment is divided into the categories of servers, SAN infrastructure, and data storage devices. This document is primarily interested in the SAN infrastructure. There are issues with storage and servers that are unique to SAN implementations and we will address some of those as well.

SAN Infrastructure Performance

For the purposes of discussion we will assume a multi-switch fabric, since single switches always offer the highest performance with minimum latency. A multi-switch fabric has two factors that decrease overall fabric-wide infrastructure performance:

- latency through multiple switches (hops)
- oversubscription or congestion of ISLs

Performance testing and measurement by HP has shown switch latency to be less than 5% (at 1 Gbps) of the time lost due to congestion of a full frame from another path. This implies that the number of switches and hops between devices is not a major factor for performance. However, as devices send frames through more switches and hops, the chances are increased that other traffic in the SAN may be routed over the same ISL/path. This may decrease performance due to oversubscription of a particular ISL or path that is serving multiple devices.

Oversubscription has been determined to be the largest contributing factor to reduced Fibre Channel performance. When devices must contend for the same ISL or path, the best result will be that each competing device will receive 1/n of the available bandwidth on the path (where n is the number of contending devices).

While the topology and size of the SAN have been seen to affect performance, staying within the rules and recommendations outlined in this guide minimizes these factors. The topology designs have been defined to accommodate a particular data access or data locality type. Recommendations on the number of ISLs based on device-to-device access ratios serve to ensure that adequate bandwidth is available across the SAN, minimizing oversubscription.

HP recommends following these guideline in configuring your SAN.

- Whenever possible, devices that exchange the highest amount of data should be connected to the same Fibre Channel switch.
- For high bandwidth, the number of application servers should be balanced with storage by using as much one-to-one access as possible
- When devices exchanging data are on different switches:
 - Minimize the number of hops between devices
 - For high bandwidth (large transfer size) applications, configure a maximum of two active storage controller ports per ISL
 - For high throughput (small transfer size) applications, configure a maximum of 20 active storage controller ports per ISL
 - For mixed applications, configure a maximum of 4 active storage controller ports/ ISL

Performance Considerations for Mixed 1 Gbps and 2 Gbps SAN Fabrics

For SAN fabrics consisting of a mixture of 1 and 2 Gbps switches and devices, the individual fabric segment connections negotiate the speed at which specific devices communicate. The presence of 1 Gbps devices in a fabric will not force other independent 2 Gbps devices to a lower speed. That is, switch ports or user ports in a fabric capable of 2 Gbps will always communicate at their highest supported speed, 2 Gbps, when connected to other switch or user ports capable of 2 Gbps. The sustained data rate between the devices will be 200 MB/second assuming the entire path between the devices through the fabric is capable of 2 Gbps.

If you have 1 Gbps and 2 Gbps devices connected to the same 2 Gbps switch, or if an intermediate path or route between devices is 1 Gbps, the switch will buffer data coming from the 2 Gbps device to prevent overrunning the 1 Gbps port or device. Over time the sustained data rate will be 100 MB/second.

It is recommended that devices capable of 2 Gbps always be connected to 2 Gbps switches and other 2 Gbps devices. Further, ensure that the entire path or route between 2 Gbps devices consists of 2 Gbps capable ports.

Performance Specifications

To plan the SAN you need to know the capabilities of all the devices connected. The maximum performance characteristics of the some of the StorageWorks devices are listed in Table 16. User applications may not necessarily reach these levels of performance as applications may perform additional levels of processing before each I/O. The controller specifications listed show both cache (no disk access) and media (with disk access) limitations.

Note: Unlike parallel SCSI, Fibre Channel SANs provide full duplex operations (simultaneous read and write traffic). The performance numbers listed reflect half-duplex traffic flow. In some cases multiple application exchanges may well be able to see nearly twice the MBs per second figures stated herein.

Table 16: Storage Component Performance Specifications

Components	IO/sec (small transfer sizes) (maximum)	MB/sec (large transfer sizes) (maximum)
Typical Fibre Channel HBA	28,000	198
FC Switch (see note below)	1,800,000	1,600
FC ISL	110,000	100
One HSV110 of a controller pair (2 active ports)	80,000 Cache Access 36,000 Media Access	200 Cache Access 200 Media Access
Two HSV110 controllers (4 active ports)	161,000 Cache Access 55,000 Media Access	400 Cache Access 400 Media Access
Single HSG80 controller (1 active, 1 standby port)	10,700 Cache Access 5,200 Media Access	77 Cache Access 54 Media Access
Single HSG80 controller (2 active ports)	10,600 Cache Access 5,200 Media Access	98 Cache Access 54 Media Access
Dual HSG80 controller (2 active, 2 standby ports)	21,100 Cache Access 10,500 Media Access	154 Cache Access 102 Media Access
Dual HSG80 controller (4 active ports)	28,800 Cache Access 10,800 Media Access	195 Cache Access 102 Media Access
Single DLT Tape drive	N/A	5 Media Access
Single SDLT Tape drive	N/A	11 Media Access

All numbers are for planning purposes and represent each device's best-known performance.

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

The HSG80 performance numbers are based on V8.5F of the ACS. Users should expect differences when using the S or P variants of the ACS firmware.

Note: Fibre channel switch performance limits are theoretical.
