

SRDF Connectivity Solutions

Abstract

This paper is a tool for understanding the connectivity options available for deploying EMC's SRDF family of products. Local, metro and long-distance options are considered for Symmetrix Gigabit Ethernet, Fibre Channel, and ESCON deployments.

December 1, 2003

Copyright © 2002–2003 EMC Corporation. All rights reserved.

EMC believes the information in this publication is accurate as of its publication date. The information is subject to change without notice.

THE INFORMATION IN THIS PUBLICATION IS PROVIDED “AS IS.” EMC CORPORATION MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WITH RESPECT TO THE INFORMATION IN THIS PUBLICATION, AND SPECIFICALLY DISCLAIMS IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Use, copying, and distribution of any EMC software described in this publication requires an applicable software license.

EMC², EMC, Symmetrix, Celerra, CLARiiON, CLARAlert, DG, E-Infostructure, HighRoad, Navisphere, PowerPath, ResourcePak, SnapView/IP, SRDF, VisualSAN, where information lives, and The EMC Effect are registered trademarks and EMC Automated Networked Storage, EMC ControlCenter, EMC Developers Program, EMC Enterprise Storage, EMC Enterprise Storage Network, EMC OnCourse, EMC Proven, EMC Snap, Access Logix, AutoAdvice, Automated Resource Manager, AutoSwap, AVALONidm, C-Clip, CacheStorm, Celerra Replicator, Centera, CentraStar, CLARevent, Connectrix, CopyCross, CopyPoint, CrosStor, Direct Matrix, Direct Matrix Architecture, EDM, E-Lab, Enginuity, FarPoint, FLARE, GeoSpan, InfoMover, MirrorView, NetWin, OnAlert, OpenScale, Powerlink, PowerVolume, RepliCare, SafeLine, SAN Architect, SAN Copy, SAN Manager, SDMS, SnapSure, SnapView, StorageScope, SupportMate, SymmAPI, SymmEnabler, Symmetrix DMX, TimeFinder, Universal Data Tone, and VisualSRM are trademarks of EMC Corporation. All other trademarks used herein are the property of their respective owners.

Part Number C852.2

Table of Contents

Introduction	5
References	5
Symmetrix Models	5
SRDF Overview	6
Modes of Operation.....	6
Synchronous and Semisynchronous Modes	6
Adaptive Copy Secondary Modes	7
SRDF/Asynchronous	8
Switched SRDF	10
Note on Fibre Channel with Engenuity 5x66	11
Symmetrix SRDF Directors	12
Multiprotocol Channel Director (MPCD) on Symmetrix DMX Series	12
Gigabit Ethernet Director (RE) on Symmetrix 8000	13
Fibre Channel Director (RF).....	13
ESCON Director (RA)	13
SRDF Distance Implementations.....	14
Recommendations for GigE, Fibre Channel, and ESCON.....	14
SRDF with Native GigE.....	16
GigE Features	17
Speed Limit.....	17
MTU	17
TCP Connection Scaling	17
Compression	18
LAN/MAN/WAN Connectivity	19
Campus SRDF Implementations	20
Point-to-Point Fibre Channel	20
Switched SRDF	21
Switched SRDF over Fibre Channel.....	21
Switched and Concurrent SRDF	22
ESCON	23
Metropolitan Area Network SRDF Implementations.....	25
ESCON with Repeaters	26
DWDM.....	26
ESCON with (D)WDM Options.....	27
Selection Process: SRDF/ESCON	27
Fibre Channel with DWDM Options	28
Selection Process: SRDF/Fibre Channel and/or DWDM.....	28
GigE with DWDM Options	28
Wide Area Network SRDF Implementations.....	29
WAN Communications Options.....	29
T1/T3, E1/E3	30
Synchronous Optical Networks (SONET/SDH)	31
ATM-OC-3.....	31
IP	32
SRDF over IP.....	33
WAN Optimization.....	34
Bandwidth by WAN Link	34
Compression	34

FarPoint	34
SRDF QoS.....	35
SRDF/A Considerations	35
WAN Delays and Performance Impact.....	36
Protocol Conversion Impact.....	36
Distance Impact.....	36
Total Impact	36
Recommendations	37
T1/T3/E1/E3	37
DS-3/OC-3.....	37
IP	37
SRDF with TimeFinder.....	38
Appendix A: Planning Performance Planning BB_Credits and I/O Size	39
Calculating BB_Credits	39
Other Performance Considerations.....	39
Appendix B: DWDM Considerations.....	40
Configuration Envelope.....	40
Appendix C: Cable Specifications.....	41
Appendix D: Bandwidth by WAN Link	42
Table 8: Glossary	43

Introduction

EMC Symmetrix Remote Data Facility (SRDF[®]) is the industry-leading business-continuity, information-protection, and content-replication software-controlled solution. SRDF extends the physical fiber connections between Symmetrix[®] systems, using telecommunication networking technology.

Most of this white paper provides general information on SRDF configurations. The appendices provide detailed information for implementation teams.

For simplicity, this document uses the term *SRDF* to represent all EMC SRDF-related products, including: SRDF/A, SRDF/AR (multi and single), and SRDF/DM. Most of the document focuses on SRDF, but generally it applies to any of the variations.

The implementations described in this document for medium-distance or long-distance solutions can be used locally as well. Proper planning will include all useful alternatives and can often benefit from existing equipment or other local considerations. Additionally, some distance limitations quoted in this document are subject to relatively frequent change. Please contact your EMC representative for the latest distance information before planning an implementation.

References

For more information on SRDF, refer to:

- *EMC Support Matrix* at <http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>
- *EMC Networked Storage Topology Guide* at <http://powerlink.emc.com>
Follow these links: **Support, Document Library, Solutions Guides**
- *SRDF Product Guide* at <http://powerlink.emc.com>
Follow these links: **Support, Document Library, Software, SRDF**
- *Symmetrix (Model or Series) Product Guide* at <http://powerlink.emc.com>
Follow these links: **Support, Document Library, Symmetrix**

For detailed information regarding solutions that involve other qualified vendors' equipment, refer to the appropriate product specification manuals available from each vendor, or ask your site representative to contact the appropriate EMC partner vendor or EMC Technical Support/Engineering.

Symmetrix Models

This white paper refers to the Symmetrix models shown in Table 1.

Table 1. Symmetrix Model Numbers

	Symmetrix 3	Symmetrix 4.0	Symmetrix 4.8	Symmetrix 8000 Series	Symmetrix DMX Series
1/2 Bay	31x0/51x0	3330/5330	3630/5630	8230	DMX800 (rackmount)
1 Bay	32x0/52x0	3430/5430	3830/3832 ^a /5830	8430, 8530	DMX1000
2 Bay					DMX2000
3 Bay	3500/5500	3700/5700	3930/5930	8730, 8830	DMX3000

a. The 3832 is a 3830 with a split backplane.

SRDF Overview

SRDF generates a mirror image of the data at the logical volume level in one or more remote Symmetrix systems. Software commands enable these remote volumes to be made addressable to remote hosts.

SRDF supports wide area network (WAN) and multiple transports, thus increasing distance and throughput for a wider variety of applications.

Additional customer uses for SRDF:

- Remote data warehousing
- Remote test beds
- Remote report generation
- Workload sharing among hosts at the same or different sites

Modes of Operation

SRDF modes include:

- SRDF *Synchronous* mode provides disaster recovery within the customer's campus.
- SRDF *Adaptive Copy* modes provide long-distance bulk data transfers for data center relocations and content replication. Automated replication features use operations based on EMC TimeFinder™ (SRDF/AR) to provide asynchronous *point-in-time* consistent, restartable images of entire databases and enterprise data.
- SRDF *Asynchronous* mode (SRDF/A) minimizes the number of copies of customer data, maximizing data consistency over any distance, with greatly reduced cycle times.

Synchronous and Semisynchronous Modes

Primary modes for SRDF R1 devices are *synchronous* (journal 0) and *semisynchronous* (journal 1). Synchronous SRDF *writes* from the host to the source do not finish until the complete write is resident in the target Symmetrix system's cache. This means that the logical volume is busy with the host (including read-following-write operations) throughout the SRDF operation.

In Semisynchronous mode, the first write to a volume is acknowledged locally, allowing subsequent reads to be accepted. However, a second write to the same volume is deferred until the first write is complete to the target Symmetrix system's cache.

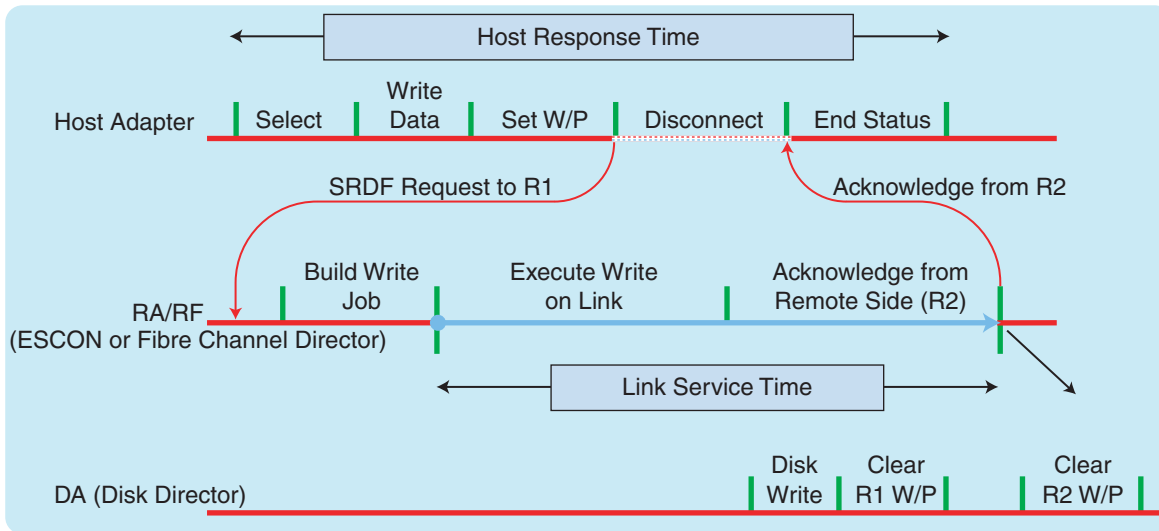


Figure 1. Synchronous Mode Operation

Adaptive Copy Secondary Modes

Adaptive Copy – Disk mode and *Adaptive Copy – Write Pending mode* are secondary SRDF modes:

- Adaptive Copy – Disk mode sets invalid track bits for updated tracks, and the Symmetrix DA (disk adapter—refer to *DA* on page 43) asynchronously places the copy task on the SRDF copy queue following destaging of the write pending records to local disk.
- In Adaptive Copy – Write Pending mode, SRDF updates are held in local cache, and the DA places all of the SRDF write pending records per cache slot into the SRDF copy queue. For open systems 32K track images, there can be a WP bit for each 4K sector (eight sectors per track), while for mainframe 56K track images there is a WP bit for each record in the variable-length CKD format.

Write Pending mode uses fewer SRDF link resources, since only the updated records per track are sent to the R2. However, utilization of local cache must be monitored more closely, since SRDF link performance directly affects local cache usage.

Adaptive Copy operation involves the DAs placing nonordered writes into the SRDF queue; therefore, data consistency is not maintained during the replication process. If the secondary mode skew value (number of invalid tracks or write pendings per volume) is set to less than the maximum of 65,536, reaching the skew value causes the Symmetrix SRDF director (refer to *Director* on page 43) to use primary mode (synchronous or semisynchronous) for all further I/O until the I/O falls below the skew value. Setting the skew value to the maximum (the default setting) maintains Adaptive Copy mode regardless of the number of invalids or write pendings.

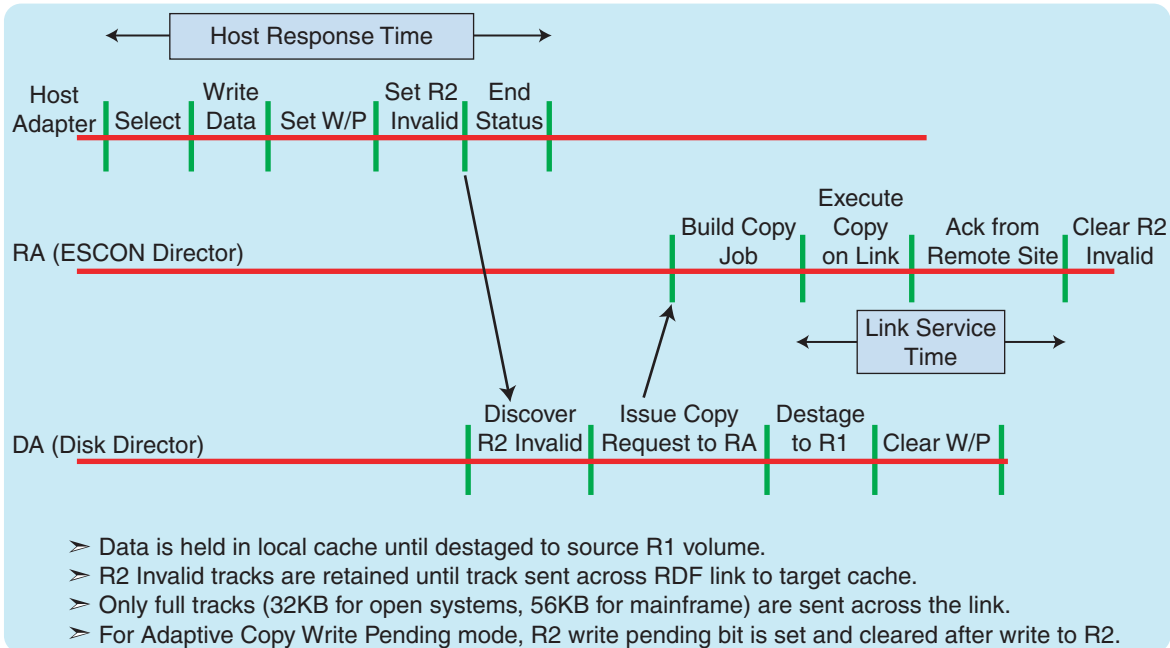


Figure 2. Adaptive Copy Disk Mode Time Line

SRDF/Asynchronous

SRDF/Asynchronous (SRDF/A) is actually a separately licensed feature, but technically can be described as another SRDF mode. SRDF/A was introduced on Symmetrix DMX™ systems with Enginuity™ level 5670. SRDF/A is an asynchronous ordered write methodology that maintains data consistency during the replication process. SRDF/A is cached-based replication that provides data consistency in preconfigured (in the Symmetrix system) cycles, or *Delta Sets*.

SRDF/A is not a subset of SRDF, but a separate product that leverages SRDF functionality.

SRDF/A has no impact on host application response time, but does require more SRDF link bandwidth than Adaptive Copy or TimeFinder-based replications using BCV R1s. Typically, bandwidth is sized by average peak write rates, while taking into account that the duration of peaks above the allocated bandwidth affects cache utilization. SRDF/A operates at the SRDF application layer, so all SRDF connectivity options using existing SRDF directors—Gigabit Ethernet (GigE), Fibre Channel, and ESCON—are supported.

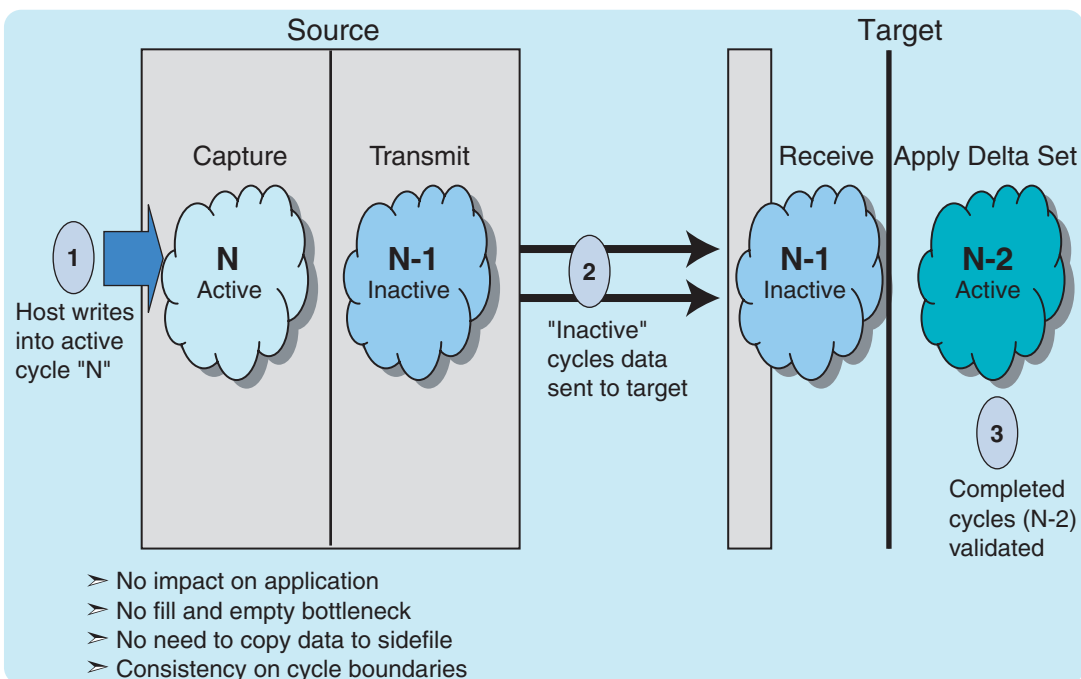


Figure 3. SRDF/A Operation

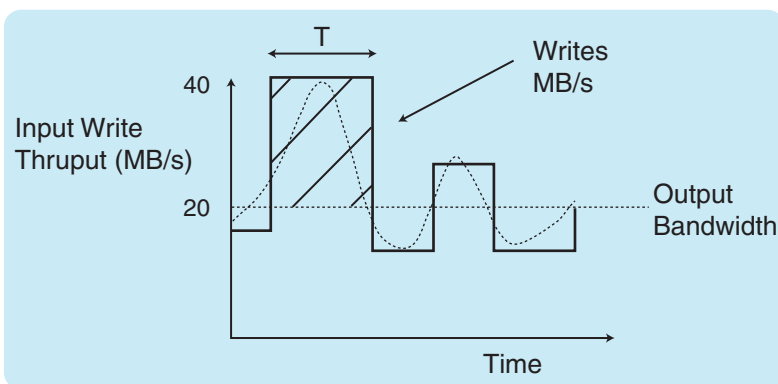


Figure 4. SRDF/A Cache Utilization vs. Bandwidth

The buffer size (extra cache) is required to support the difference between write input bandwidth and output bandwidth during specific peak write intervals of time (T).

Switched SRDF

Symmetrix 8000 series systems with Enginuity 5567 and later, as well as DMX series systems, support point-to-multipoint connectivity by allowing multiple SRDF group to be associated with a port. This function is called *switched SRDF*. Switched SRDF configurations are enabled by switched (Fibre Channel or IP) infrastructures. A Symmetrix Fibre Channel or GigE director can be configured to support SRDF communication with more than one other Symmetrix system simultaneously.

Full understanding of switched SRDF requires an explanation of SRDF *groups*. As of Enginuity 5x67, an SRDF device group is defined as a set of devices (primary or secondary) configured to communicate with another set of devices in a remote Symmetrix system. An RF director in a Symmetrix 8000 series system running Enginuity 5567 can be configured to support up to 16 SRDF device groups. With earlier Enginuity levels, only one SRDF group could be configured on each SRDF director (RA or RF), regardless of Symmetrix model.

Symmetrix 4.X systems can participate in these types of configurations if running Enginuity 5x67; however, they cannot be configured for more than one SRDF group and, therefore, cannot accept or send SRDF communication to more than one other Symmetrix system unless multiple RA or RF directors are configured and assigned to different groups, one group per each RA or RF.

Further, when using Symmetrix 4.X, the SRDF protocol remains point-to-point between RF director ports. As well, an RA (ESCON SRDF) director in either a Symmetrix 8000 or 4.X system running Enginuity 5x67 cannot support more than one SRDF device group, as the ESCON protocol does not support the equivalent of Fibre Channel switches.

A Symmetrix 3 system cannot participate in any of these configurations, since SRDF communication requires the same Enginuity level, and Enginuity 5x67 does not run on Symmetrix 3.

Figure 5 is an example of switched SRDF over a Fibre Channel infrastructure. (Note that single ISLs do not offer any redundancy, but are presented in the figure for simplicity.)

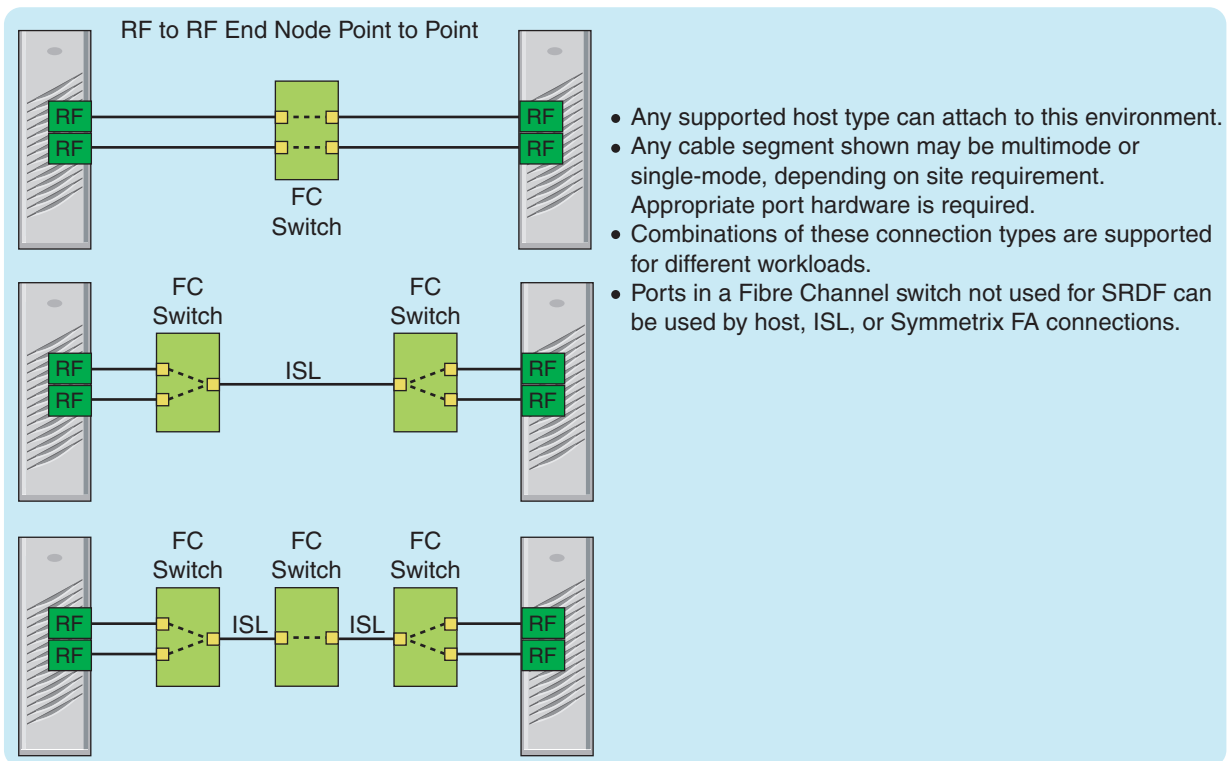


Figure 5. Switched Fibre Channel

Enginuity level 5x66 permitted SRDF traffic to go through a Fibre Channel switch. Enginuity level 5x67 can share logical connections to more than one Symmetrix system via the same SRDF port on the source Symmetrix system. Alternatively, multiple Symmetrix systems can *fan in* to one Symmetrix system. What this means is that the same RF director can be configured to support SRDF communication with more than one other Symmetrix system simultaneously through a Fibre Channel switch, providing true switched capability.

In Enginuity level 5x68, EMC ESN Manager can be used to configure the switched connections between Symmetrix systems, providing users the capability to configure their own SRDF fabric configurations. Further, Configuration Manager can configure both source (R1) and target (R2) volumes and source and target Symmetrix systems. Existing controls are used to define RA groups.

Changing a source/target SRDF relationship involves breaking the SRDF pairs. The link must be stopped, and any recondition to previous devices requires a full establish.

Note on Fibre Channel with Enginuity 5x66

With Enginuity 5x66, SRDF over switched Fibre Channel is a point-to-point protocol solution. (Symmetrix 4.x systems require Enginuity 5266 or later, and Symmetrix 8000 systems require Enginuity 5566 or later.)

The connection between Symmetrix systems through the fabric is between specific RF ports in each Symmetrix system. Failure of a Fibre Channel switch port can be bypassed simply by moving the cable to another port on the switch; SRDF and the RF directors will restore the connection.

EMC recommends configuring a single SRDF zone for all SRDF connections in a fabric. A set of Fibre Channel switches (such as EMC Connectrix™) allows greater distance with more powerful lasers and the additional buffer-to-buffer credits required to stream data over longer distances. Switches offer the capability to connect to each other at a distance of up to 200 km (depending on switch model); in practice, however, this specific configuration or latency issues can severely limit distances.

Up to three Fibre Channel switches can be located in the SRDF path between Symmetrix systems (as shown in Figure 5 on page 10), enabling four-corner and star SAN topologies. Combinations of multimode and single-mode cable segments between switches and RF directors can be employed. If using single-mode connections throughout the entire SRDF path, up to 60 km distances are supported.

Note that single-mode connections require specific Symmetrix hardware and configuration. Contact your EMC Sales Representative and/or Customer Support. Refer to Table 7 on page 41 for distance limitations regarding cable type and distances supported between components.

Symmetrix SRDF Directors

Symmetrix SRDF director hardware provides the communications transport layer for SRDF data and information exchanges between Symmetrix systems. SRDF director hardware includes any of four types of adapters, depending on the protocol:

- Multiprotocol Channel Director (MPCD), supported with Symmetrix DMX series, and configurable for SRDF over GigE. (The MPCD is also configurable for iSCSI, FICON, or combinations.)
- Gigabit Ethernet (GigE) remote adapter (RE), supported with Symmetrix 8000 series.
- Fibre Channel remote adapter (RF), supported with Symmetrix 4.0 and later.
- ESCON remote adapter (RA), supported with Symmetrix 3.0 and later.

For detailed information on SRDF director hardware, refer to the *SRDF Product Guide* (available at <http://powerlink.emc.com>, **Support, Document Library, Software, SRDF**).

The SRDF network options described in this document can be used for any host environment. SRDF uses a storage protocol based on the Gigabit Ethernet, Fibre Channel FC-4, or ESCON specifications to remotely mirror data between Symmetrix systems. The host attachment, I/O protocol, and disk data structures that each host requires are independent of the SRDF operation between Symmetrix systems.

Some restrictions apply in mixed environments with AS/400 and other host types. For more information, consult EMC Customer Support.

A single board configured in a Symmetrix system is a potential single point of failure and is not recommended in protection environments. Such a failure could occur if only one processor on the director is used for SRDF and the other processor(s) is/are used to connect to a host. The Symmetrix system should contain at least two director boards for an SRDF configuration; use one processor on each board for SRDF to provide redundant links in case a communications link fails or in the unlikely event a director fails.

Multiprotocol Channel Director (MPCD) on Symmetrix DMX Series

The Symmetrix DMX series supports the four-processor/two-port and the four-processor/four-port Multiprotocol Channel Director (MPCD) configured for GigE (MPCD-GigE), iSCSI, or FICON.

The MPCD requires Symmetrix Engenuity level 5670 or higher.

On a two-port director, one port can be configured with host interface emulation (iSCSI or FICON) while the other port is configured for SRDF emulation. Alternatively, both ports can be configured for SRDF GigE operation.

On a four-port director, the ports can also be intermixed with SRDF (GigE) and host (iSCSI or FICON) emulations.

MPCD features:

- Native SRDF IP support
- 2-port and 4-port models: combination FICON/GigE or iSCSI/GigE
All GigE ports are 850 nm multimode
- Multiple TCP connections per GigE port
- On-board hardware compression:
 - Can be configured per TCP connection
 - Will auto-disable for Symmetrix 8000 series GigE connections
 - Compression is done on the RDF level, not the TCP level

Gigabit Ethernet Director (RE) on Symmetrix 8000

The Symmetrix 8000 series supports a two-processor, two-port Gigabit Ethernet (GigE) card, with these features:

- Native SRDF IP support
- Model DP3-GBENET — Two GigE ports per card
- All 850 nm multimode ports
- Multiple TCP connections per GigE port
- 256 KB buffers for extended distance (TCP windowing)

The GigE director requires Symmetrix Engenuity level 5568.54.20 or higher.

Both ports on the GigE card can be used only as SRDF GigE ports; no other emulations are supported.

Fibre Channel Director (RF)

Symmetrix RF directors include:

- **Two-Port/Two-Processor RF** — Each processor on the two-port RF provides one host connection. One processor on a board can be configured with host interface emulation while the other processor is configured with SRDF emulation. Alternatively, both processors can be configured for SRDF operation. Fibre Channel ports are either 850 nm multimode or 1310 nm single-mode.
- **Four-Port/Two-Processor RF** — Symmetrix 8000 series systems support a four-port RF that supports SRDF operations on a single port on each processor.

One processor on a board can be configured with host interface emulation while the other is configured with SRDF emulation. Alternatively, both processors can be configured for SRDF operation.

Each processor provides two host connections if not configured for SRDF. *If one port is configured for SRDF, the other port on that processor cannot be used.*

- **Eight-Port/Four-Processor RF** — Symmetrix DMX series Fibre Channel directors support up to four SRDF/Fibre Channel links (one per processor) at 2 Gb/s. The Fibre Channel ports will auto-negotiate to match 1 Gb/s ports on older Symmetrix models.

Each processor provides two host connections if not configured for SRDF. *If one port is configured for SRDF, the other port on that processor cannot be used.*

ESCON Director (RA)

A Symmetrix 8000 or later RA contains four individual directors (processors), and a Symmetrix 3 or Symmetrix 4.X RA contains two processors. Each processor can provide one SRDF port connection. On one board, a processor can be configured with host interface emulation while the other processor(s) is configured with SRDF emulation. Alternatively, all processors on the board can be configured for SRDF emulation. All ESCON ports are 1310 nm multimode.

Each processor provides two host connections if not configured for SRDF. *If one port is configured for SRDF, the other port on that processor cannot be used.*

SRDF Distance Implementations

This paper describes three major areas of SRDF implementation, listed below and represented in Figure 6:

- **Campus** — Provides limited-distance direct attachment alternatives for *dark fiber* environments. (Refer to *Dark Fiber/Lit Fiber* on page 43.) Normally, metropolitan networks are employed for even very short distance configurations.

For more information, refer to *Campus SRDF Implementations* on page 20.

- **Metropolitan Area Network (MAN)** — Provides SRDF connectivity for distances typically less than 100 km, but up to 200 km or more, utilizing dark fiber, DWDMs, or SONET. This environment is characterized by extremely low error rates and high bandwidth of fiber configurations, so error recovery and compression are less significant in choosing SRDF connectivity options.

For more information, refer to *Metropolitan Area Network SRDF Implementations* on page 25.

- **Wide Area Network (WAN)** — Provides SRDF connectivity over long distances using telecommunications networks, such as IP, SONET, or ATM. WANs are differentiated from MANs as being *non-lossless* and limited bandwidth environments, where error-recovery, data buffering, and compression capabilities of connectivity options are extremely important.

For more information, refer to *Wide Area Network SRDF Implementations* on page 29.

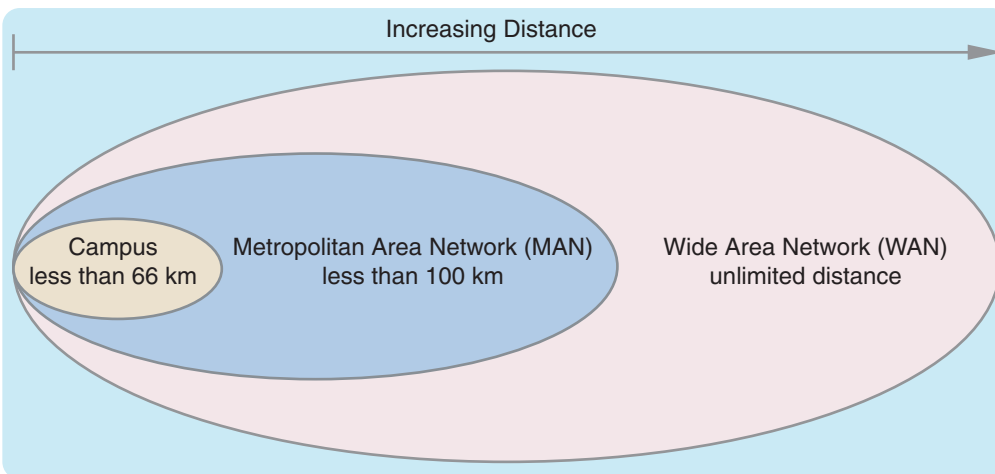


Figure 6. SRDF Implementations

Recommendations for GigE, Fibre Channel, and ESCON

GigE reduces the overall cost of the SRDF disaster recovery/business continuity solution:

- Significantly more cost-effective disaster recovery/business continuity solution by utilizing the GigE remote directors instead of traditional channel extension devices
- Further simplifies SRDF and IP configurations
- Greatly simplifies troubleshooting; can isolate any issue between Symmetrix system and network

Table 2 lists some recommendations and limitations. Also refer to Appendix C on page 41 for distance considerations and Appendix D on page 42 for WAN bandwidth recommendations.

Table 2. GigE/Fibre Channel/ESCON Recommendations

	GigE	Fibre Channel	ESCON
Campus Connectivity	LAN (standard Ethernet).	Direct (multimode or single-mode) through switched fabric.	Direct or via repeaters.
DWDM Connectivity	Direct or through Ethernet switch (no distance restrictions).	Requires Fibre Channel switch (distance determined by BB_Credit calculation).	Direct (FarPoint).
SONET Connectivity	Packets over SONET (router).	Fibre Channel/SONET converter.	ESCON/SONET converter.
WAN Connectivity	No protocol conversion devices needed for IP over distance.	FCIP or iFCP bridge or channel extender required for IP connectivity.	ESCON/IP channel extender required for IP connectivity.
Board Flexibility/ Symmetrix Slots	DMX: 2 or 4 ports. 4-port board can support FICON or iSCSI.	2, 4, or 8 ports. One SRDF port per port pair on 4-port and 8-port boards. Remaining ports can be used for Fibre Channel host/switch.	4 or 8 ports. Can be used for mainframe host or SRDF.
	Symmetrix 8000: 2-port board supports only SRDF.		
Current Infrastructure	Primarily new SRDF deployments in Symmetrix systems that have availability for these boards.	Few Symmetrix 4.X systems have Fibre Channel. Most Symmetrix 8000 and DMX systems have Fibre Channel.	Systems with ESCON: ● Symmetrix 4.X — most. ● Symmetrix 8000 — many. ● DMX — few.

SRDF with Native GigE

Native IP support for any SRDF-based product on Symmetrix systems is based upon Gigabit Ethernet (GigE) technology that enables direct Symmetrix-to-IP network attachment. This increases the options for Symmetrix-to-Symmetrix connectivity, and allows a Symmetrix system to connect to existing Ethernet infrastructure and directly access high-speed data transmission conduits via IP.

Symmetrix DMX series systems provide native IP support through the Multiprotocol Channel Director (MPCD). Symmetrix 8000 series systems provide native IP support through the GigE remote director. The MPCD and GigE remote directors provide comparable functionality, with the exception of data compression, which is a feature of the MPCD only. Unless otherwise specified, the following information applies to both Symmetrix 8000 series and Symmetrix DMX GigE remote director configurations.

All SRDF-over-IP deployments (GigE and bridged ESCON/Fibre Channel solutions) require the completion of an SRDF Qualifier document. A network assessment must also be performed by EMC TSG (Technology Services Group) to validate network parameters, ensuring a successful deployment.

Figure 7 illustrates the switched nature of GigE and point-to-multipoint support. The figure shows calculation of TCP connections and estimated performance per RE port over extended distance for sizing link requirements.

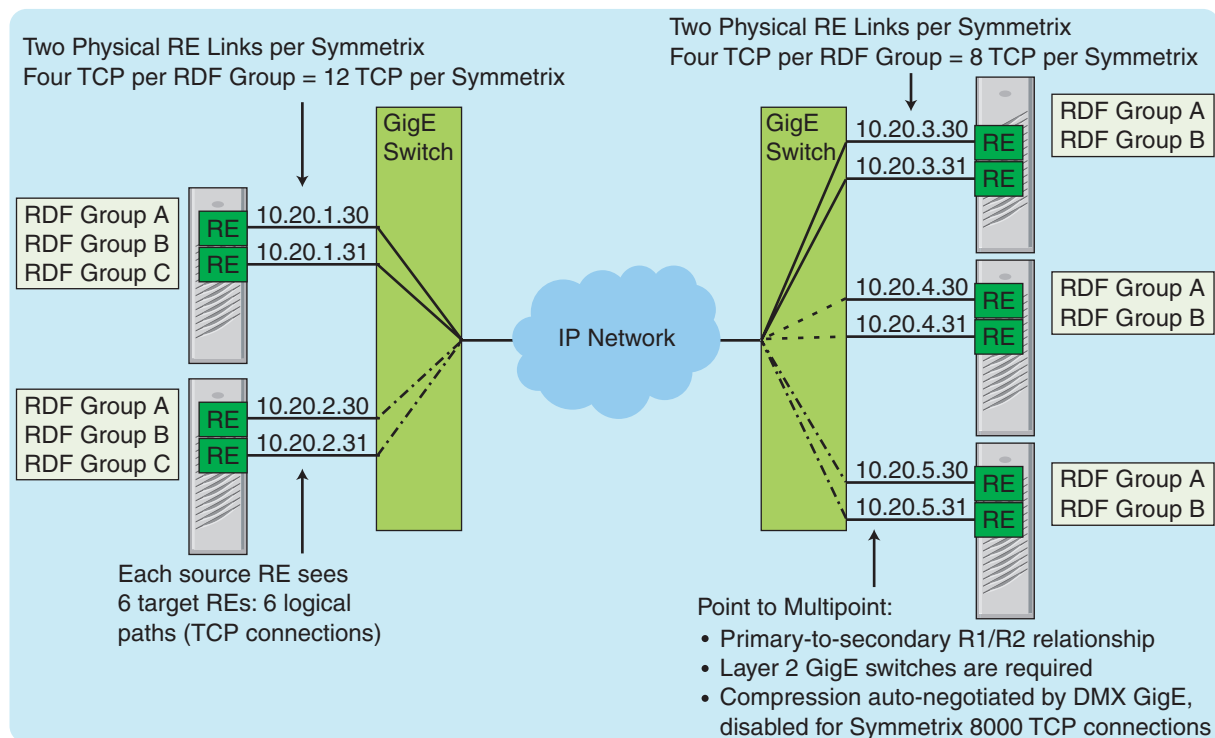


Figure 7. Switched GigE Network Configuration Example

GigE Features

Symmetrix 8000 and DMX GigE remote directors provide IEEE 802.3z-compliant connectivity directly from Symmetrix GigE ports into IP networks.

Features of the Symmetrix GigE remote directors include:

- Speed limit
- Maximum Transmission Unit (MTU) settings
- TCP connection scaling
- Compression (DMX GigE only)

Speed Limit

SRDF best practices recommend the use of dedicated bandwidth and VLANs for SRDF data transfers. It is necessary to use the speed limit feature to limit the maximum amount of traffic sent into the network.

If, for example, a 100-megabit network link is to be used, but only 50 megabits are to be utilized by SRDF traffic, setting a speed limit can guarantee that no more than 50 megabits of SRDF traffic enters the network. The speed limit feature sets a throttle on the maximum traffic flow; it does not guarantee minimum bandwidth.

The speed limit setting is configured per port, and must be set to equal values for all ports associated with the same RDF group. The sum of all available ports needs equals the bandwidth committed for SRDF.

MTU

The default packet size (MTU) transmitted by the GigE remote director is 1500 bytes. The packet size can be increased up to 9000 bytes to support jumbo frames. When configuring larger MTU, care must be taken to ensure that all network devices in the path between the Symmetrix GigE ports support the desired packet size. Packet size mismatches between network devices can cause packet fragmentation, which reduces performance.

TCP Connection Scaling

Symmetrix GigE ports create a TCP connection between port pairs of source and target Symmetrix systems for transferring SRDF data. Each TCP connection corresponds to an SRDF logical link. When Symmetrix GigE ports are connected into a switched or routed network, each source port connection can connect to multiple target ports, creating multiple TCP connections.

Multiple TCP connections are desirable as SRDF throughput scales with the number of TCP connections. Two Symmetrix GigE source ports connected to two Symmetrix GigE target ports in a point-to-point configuration will create two TCP connections. When connected through a switched network, those same source and target ports will create four TCP connections, with the potential for higher throughput.

Network paths provide the underlying infrastructure for TCP connections. The control for which connections are created lies in the Symmetrix configuration files (`IMPL.bin`). Configurations are created that map the RDF groups in the source Symmetrix system to target IP addresses in the target Symmetrix system. All ports associated with the RDF group on the source Symmetrix system will be used to attempt connection to the specified target IPs.

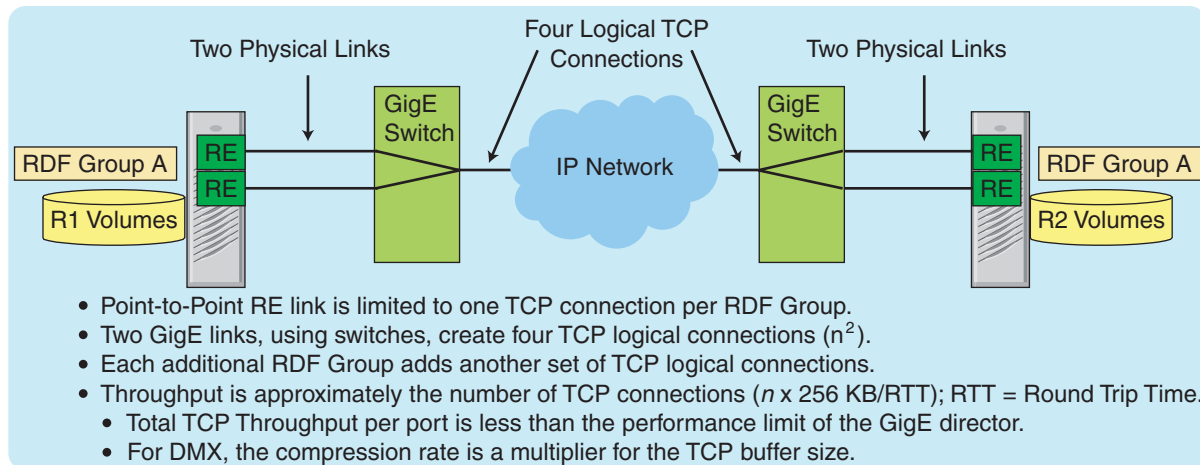


Figure 8. TCP Connection Scaling

Network Design Considerations

The Symmetrix system balances traffic loads across all available ports on a per-RDF group basis. All network paths used for an RDF group should have similar characteristics (such as delay, bandwidth, speed limit, and compression settings). For SRDF/GigE and SRDF/Fibre Channel, it is especially important to keep alternate routes similar in delay and bandwidth. Performance calculations should be based on worst-case route.

Compression

Compression of data can reduce network bandwidth requirements. Symmetrix DMX series GigE remote directors support on-board compression using the ILZS compression algorithm. SRDF data is compressed prior to encapsulation in IP packets.

When transferring data between Symmetrix DMX systems, EMC recommends that compression be turned on unless data patterns are determined to be uncompressible.

Compression must be enabled on both ends of the link. Compression can be turned on or off on a per-TCP connection basis, allowing maximum flexibility.

Symmetrix 8000 series GigE remote directors do not have on-board compression, but do support the use of external compression devices. If compression is needed, both ends of the connection must have compression devices.

When evaluating an external compression solution, consider the following:

- Where is the compression device located on the network?
- It is recommended that the compression device be dedicated to SRDF.
- How much data needs to be compressed, and what are the compression devices' maximum throughput levels?
- Most manufacturers of compression devices use a two-way sum as their maximum throughput rate. This means that you must consider both directions of data flow when calculating your throughput rate.
- Compression and decompression add latency to the transmission time of the packet across the network—usually approximately 0.125 ms per hop, or 0.5 ms round-trip. Some devices will be higher.
- Raster-based data and already compressed data usually do not compress.
- Use a 2:1 compression rate as a baseline for determining requirements.

When connecting between a DMX Gigabit Ethernet port and a Symmetrix 8000 series Gigabit Ethernet port, the DMX Gigabit Ethernet compression is negotiated to *off*. A DMX Gigabit Ethernet port will not negotiate with a third-part compression device at the other end of an SRDF transfer for compression and decompression.

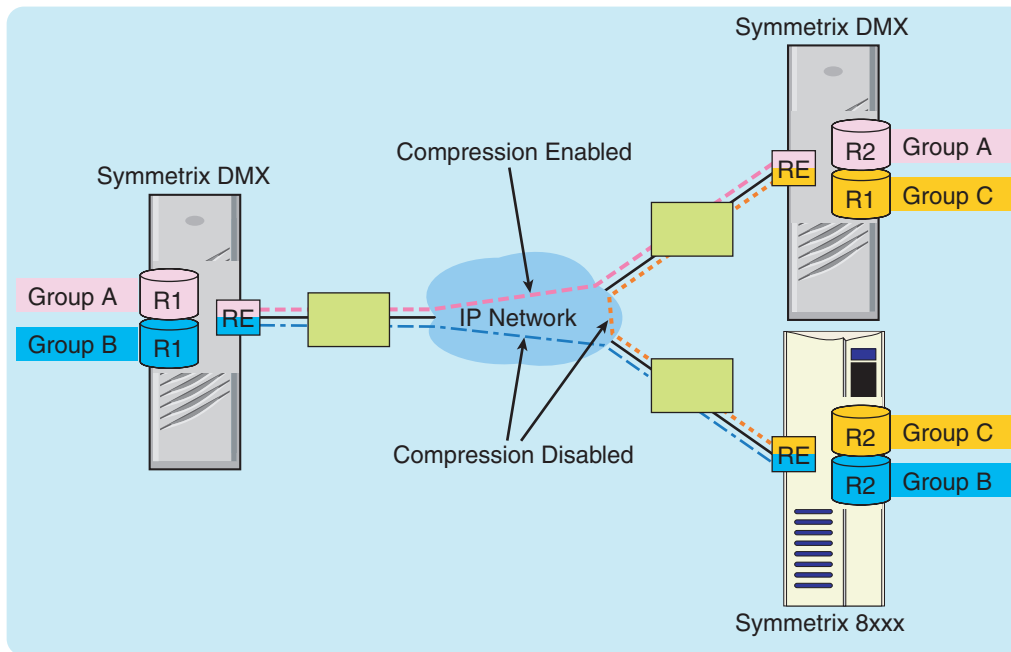


Figure 9. Compression Example

LAN/MAN/WAN Connectivity

GigE, unlike Fibre Channel or ESCON, can be used in local or long-distance environments without the need for protocol-conversion devices. Since the Symmetrix GigE director uses native IP protocol, traffic can be routed through an IP cloud of various connectivity devices over almost any distance.

Campus SRDF Implementations

The campus solution is a limited subset of metro connectivity that uses fiber-optic cabling to transmit data over short distances using Symmetrix and Connectrix direct-attach capabilities. The recommendation in all but very simple and small configurations is to use the scalability of metro solutions to better utilize available fiber.

Table 3. GigE/Fibre Channel/ESCON Recommendations for Campus Implementations

GigE	Fibre Channel	ESCON
LAN (standard Ethernet)	Direct (multimode or single-mode) through switched fabric	Direct or via repeaters

Refer to Table 8 on page 42 for bandwidth by link type.

Campus SRDF implementations include:

- **Direct GigE Attach (Point-to-Point)** — Provides SRDF connection through direct cable segment attachment between two Symmetrix GigE (RE) ports. Refer to Table 7 on page 41 for supported distances.
Note that GigE ports have higher latency than Fibre Channel ports, which will impact synchronous performance in campus configurations.
- **Direct Fibre Channel Attach (Point-to-Point)** — Provides SRDF connection through direct cable segment attach between two Symmetrix SRDF/Fibre Channel (RF) ports. Refer to Table 7 on page 41 for supported distances.
- **Switched SRDF** — Provides SRDF connections between two Symmetrix ports by way of Fibre Channel switch ports. Refer to Table 7 on page 41 for supported distances.
Switched SRDF provides point-to-multipoint protocol connection between SRDF director ports. Performance characteristics are relative to the number of switches in the SRDF link path and the distance between units on those links. Supported fabric topologies are discussed under *Metropolitan Area Network SRDF Implementations* on page 25.
- **ESCON Direct Attach** — Provides SRDF connectivity between two Symmetrix ports at a distance of up to 3 km for each cable segment.

Distance capabilities are constantly changing as technology improves. Refer to the *Distance Extension Solutions* section of the *EMC Support Matrix* (<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>) for the latest information.

Point-to-Point Fibre Channel

Symmetrix systems support SRDF over point-to-point Fibre Channel as shown in Table 4.

Table 4. Symmetrix Models and Enginuity Levels for SRDF over Fibre Channel

Symmetrix Series	Minimum Enginuity Level
4.X	5266
8000	5566
DMX	5669

The benefits of SRDF over point-to-point Fibre Channel include increased SRDF throughput for all host types and increased connectivity options for open systems hosts. In addition, Fibre Channel maintains a peer-to-peer

relationship, as opposed to the ESCON channel and control unit relationship used at the ESCON RA director level. This increases the flexibility of SRDF in cases where it is desired to have primary and secondary volumes located at each side of the SRDF link.

SRDF over Fibre Channel uses a Symmetrix RF director (described under *Fibre Channel Director (RF)* on page 13). The RF director is a Fibre Channel director (FA) configured to run SRDF emulation code. RF directors use a SCSI 3 layer running FC-4 specification point-to-point protocol. Refer to Table 7 on page 41 for information on distance limitations regarding cable types.

Fibre Channel switches (discussed under *Switched SRDF* on page 10) can also be used for SRDF, with either multimode or single-mode cable segments between units.

Switched SRDF

The ability to service SRDF traffic between multiple Symmetrix systems should not be confused with the location of primary (source, or R1) or secondary (target, or R2) devices, which remain as before.

Switched SRDF over Fibre Channel

As illustrated in Figure 10, Symmetrix A is communicating with Symmetrix B and Symmetrix C simultaneously through two RF directors. Each RF director in Symmetrix A is configured to support three SRDF groups. When Symmetrix A is communicating with Symmetrix C, either of its RF directors can communicate with either RF director in Symmetrix C.

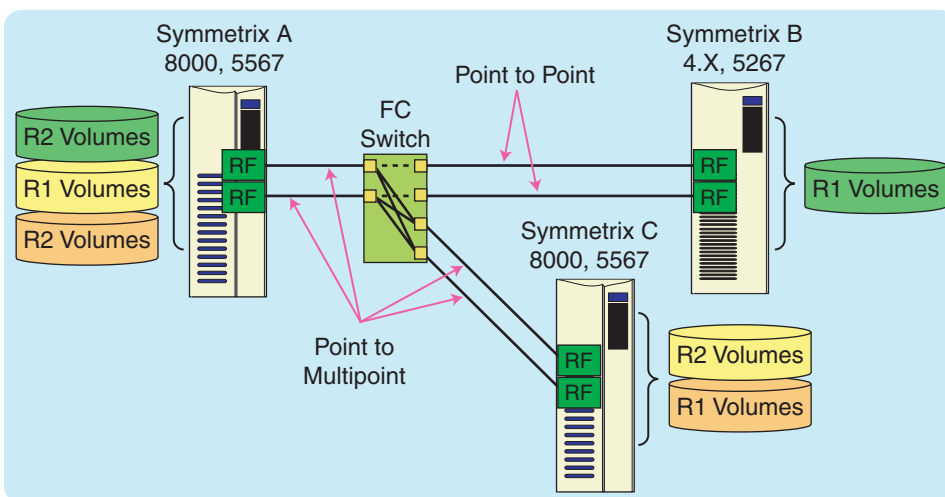


Figure 10. Switched SRDF over Fibre Channel with Enginuity 5x67

There are four logical paths from Symmetrix A to Symmetrix C (two logical paths on each RF director to each RF director in Symmetrix C). When Symmetrix A is communicating with Symmetrix B, there is a single logical path from each RF director to one other RF director. This is a point-to-point connection, the same as was provided with earlier Enginuity levels. Also note that all three Symmetrix systems have primary (source, or R1) devices. The ability to support point-to-multipoint connectivity is not related to primary (source) or secondary (target) relationships.

Switched and Concurrent SRDF

As illustrated in Figure 11, Symmetrix A is communicating with Symmetrix B and Symmetrix C simultaneously through two RF directors, as well as using Concurrent SRDF to mirror its R1s to a second set of R2s in Symmetrix D. Each RF director in Symmetrix A is configured to support two SRDF groups. When Symmetrix A is communicating with Symmetrix C, either of its RF directors can communicate with either RF director in Symmetrix C.

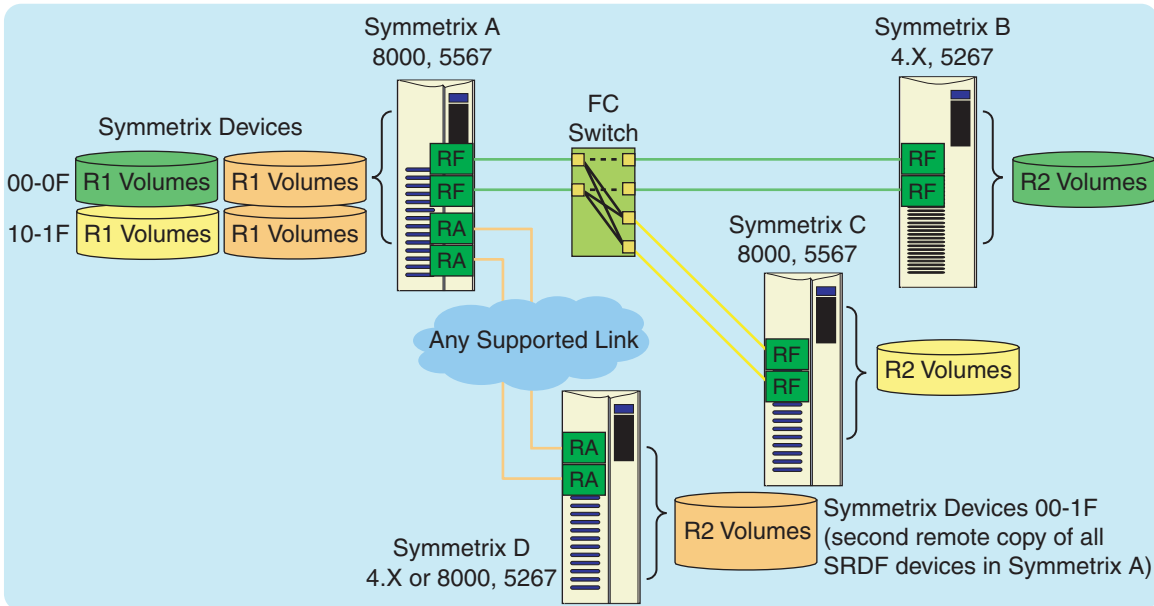


Figure 11. Switched and Concurrent SRDF Configuration Example

There are four logical paths from Symmetrix A to Symmetrix C (two logical paths on each RF director to each RF director in Symmetrix C). When Symmetrix A is communicating with Symmetrix B, there is a single logical path from each RF director to one other RF director. This is a point-to-point connection, the same as was provided with earlier Engenuity levels. Also note that all four Symmetrix systems have primary (source, or R1) devices.

The ability to support point-to-multipoint connectivity is not related to primary (source) or secondary (target) relationships. A separate RDF Group C in Symmetrix A is configured with SRDF/FarPoint™ (RAs) for concurrent RDF to Symmetrix D, using Adaptive Copy – Disk mode.

For concurrent SRDF, the primary SRDF mode is a Synchronous or Semisynchronous mode of Symmetrix A's R1s; however, the secondary mode of Adaptive Copy can be enabled for either or both target R2s. In the example shown in Figure 11, the RA links would be extended via channel extenders over a WAN using Adaptive Copy mode for asynchronous replication to Symmetrix D.

As of Symmetrix Engenuity level 5670, SRDF/A is not yet supported with Concurrent SRDF.

With Engenuity 5567 microcode and the Symmetrix 8000, the same local primary volume can be remotely mirrored in two different locations. The Symmetrix 4.X can be configured with a secondary volume that is one of two remote copies from a Symmetrix 8000 primary volume; however, the Symmetrix 4.X cannot be configured to provide two remote copies of the same primary volume. This is a volume-level feature, but is related to this document within the same context as the TimeFinder functions (described under *SRDF with TimeFinder* on page 37).

Using Concurrent SRDF for Symmetrix 8000 primary devices, the two remote volumes can be configured in any of these ways:

- Both to Fibre Channel RF directors
- One to a Fibre Channel RF and one to an ESCON RA director
- Both to ESCON RA directors (RA directors must be configured for different SRDF groups.)

Also note:

- The availability of native GigE directors on Symmetrix 8000 and DMX allows further intermixing of director types.
- Each remote for the same primary volume must be in a different SRDF device group. If using Fibre Channel SRDF RF or RE (GigE) directors, the RF or RE directors may support both SRDF device groups.
- No two primary devices may be configured to the same secondary device anywhere in the SRDF network.
- Both remote secondary devices configured to the same primary device must operate in the same *journaling* mode (Jrn10 or Jrn11).
- Either remote device can operate in either Adaptive Copy – Write Pending or Adaptive Copy – Disk mode. Both remote volumes use the same maximum skew value when operating in either mode.
- A BCV R1 cannot have more than one remote mirror assigned.

ESCON

SRDF over ESCON uses a Symmetrix RA director, which is basically an EA director configured to run SRDF emulation code.

RA directors employ an ESCON protocol schema, with one RA (RA1) in each connection assuming a role similar to a mainframe channel, and the other (RA2) assuming the role of a mainframe control unit. For this reason, significant protocol overhead is incurred in cases where a primary (source or R1) volume is configured to an RA2 director (bidirectional).

Configuration options using additional RA directors are available to bypass this effect. Connections in this environment may be through direct multimode cable connections between RA directors in Symmetrix systems up to 3 km apart. (Refer to Figure 12 on page 24.) For distance limitations regarding cable types for each cable segment, refer to Table 7 on page 41.

Each ESCON connection requires one pair of fiber-optic strands (*xmit* and *rcv*). RA directors can be used for SRDF through an ESCON director; however, the ESCON director ports must be configured to be static and dedicated. IBM ESCON Manager software may be used to control the ESCON director ports, but will present invalid status upon query operations to SRDF director ports. Because ESCON directors provide their own transmit signals at each port, the effective distance of the overall 3 km link can be doubled. By using ESCON extender/repeater units or the ESCON director XDF feature, these distances can be extended up to 66 km for Campus-mode SRDF.

For SRDF distances beyond 10 km, or connections via channel extenders, FarPoint mode should be used to eliminate distance limitations and minimize performance penalties. (These connection types are discussed under *Metropolitan Area Network SRDF Implementations* on page 25.)

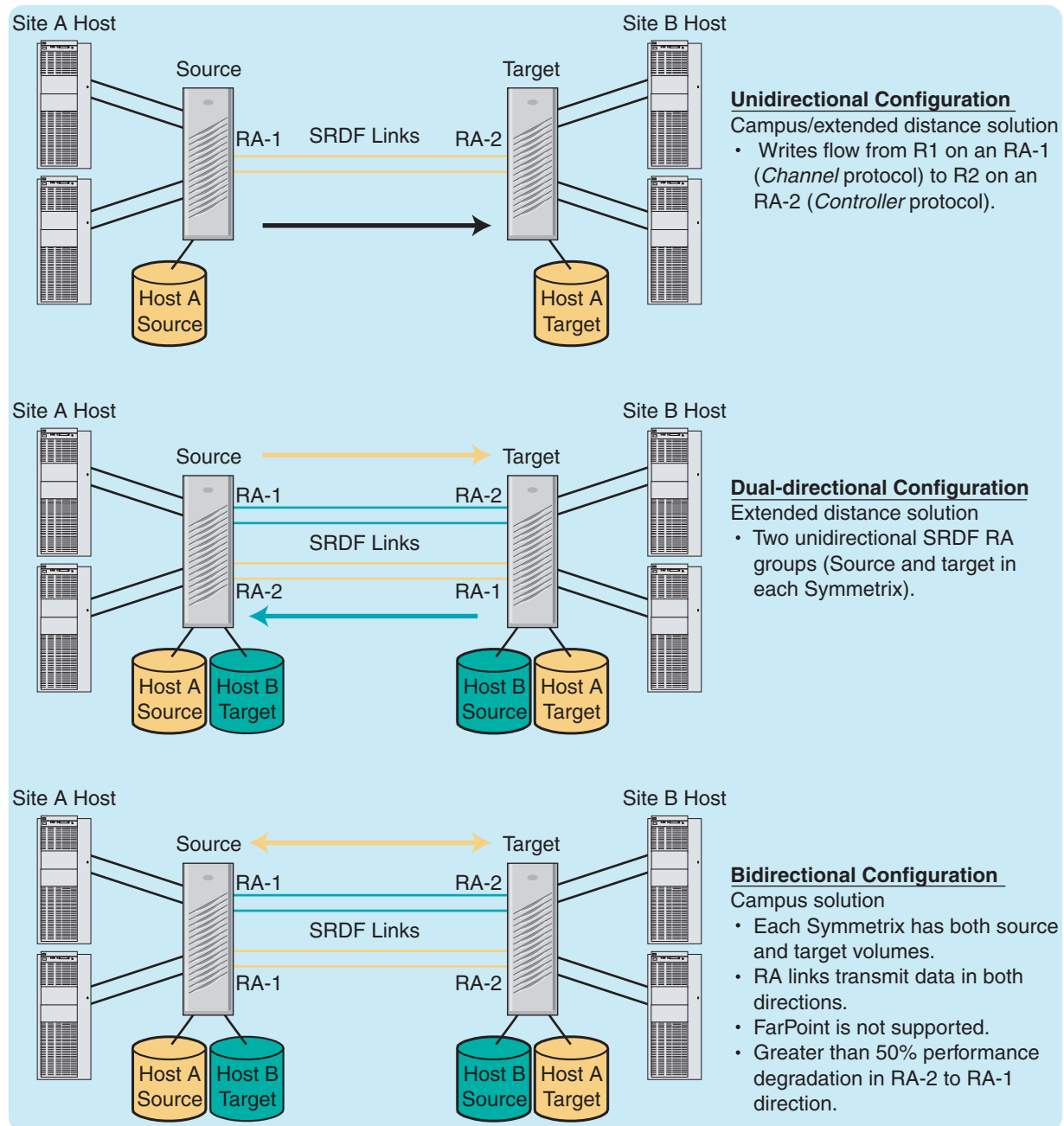


Figure 12. SRDF ESCON Topologies (Point-to-Point)

Detailed information about ESCON with repeaters or ESCON directors providing longer-distance solutions is provided under *ESCON with Repeaters* on page 26.

Metropolitan Area Network SRDF Implementations

The use of SRDF over Metropolitan Area Networks (MANs) is determined by the ability of the customer or carrier to pull/install/provision *dark fiber* cable that allows the customer to use the entire bandwidth available on that fiber.

Table 5. GigE/Fibre Channel/ESCON Recommendations for MAN Implementations

	GigE	Fibre Channel	ESCON
DWDM Connectivity	Direct or through Ethernet switch (no distance restrictions)	Requires Fibre Channel switch (distance determined by BB credits calculation)	Direct (FarPoint)
SONET Connectivity	Packets over SONET (router)	Fibre Channel/SONET converter	ESCON/SONET converter

MANs are useful for:

- Campuses with multiple data centers
- ISPs that have several sites along a fiber-optic network right of way
- XSPs that need to reach multiple customers in the area

This access to the fiber means that the maximum bandwidth is available and that the delay or latency is low and controllable.

Many optically linked configurations are available for the campus/MAN distance (10 km to over 200 km):

- ESCON/FarPoint with repeaters: RA — repeaters — RA
- ESCON/FarPoint via DWDM/WDM: RA — (D)WDM — (D)WDM — RA
- Switched Fibre Channel/DWDM: RF — FC switch — DWDM-DWDM — FC switch — RF
- SRDF/GigE via DWDM: RE — DWDM — DWDM — RE
- SRDF/GigE over SONET: RE — router — SONET ring — router — RE
- Switched Fibre Channel over SONET: RF — FC switch — FC/SONET device — SONET ring — FC/SONET device — FC switch — RF

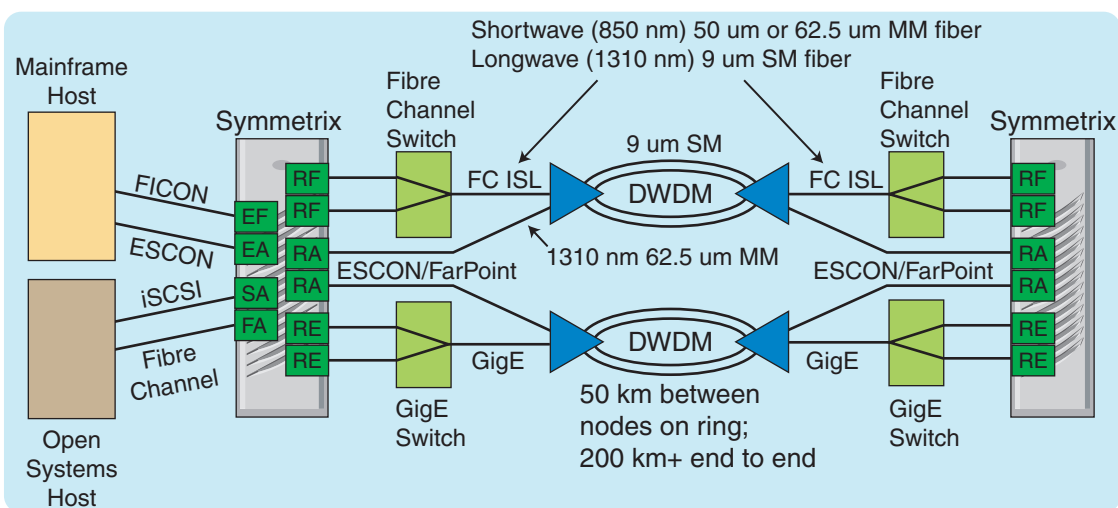


Figure 13. SRDF over Fibre Channel Using DWDM Technology

ESCON with Repeaters

At greater than 3 km, ESCON directors (dynamic switches providing point-to-point connections) can be used to extend multimode distance to 6 km. Beyond 6 km, converters/repeaters are required to convert the multimode to single-mode fiber. When this approach is taken, there is usually a one-to-two relationship between the ESCON channels carrying the SRDF traffic and the fiber strands required between stations. The exception is repeaters that multiplex multiple ESCON channels into one physical pair of fiber strands, transmit (xmit) and receive (rcv).

An example of multiplexing four ESCON channels over one single-mode channel is the INRANGE DMIF card, an option for the CD-9000 ESCON director/extender. Figure 14 provides an example using McDATA 9191 converters/repeaters.

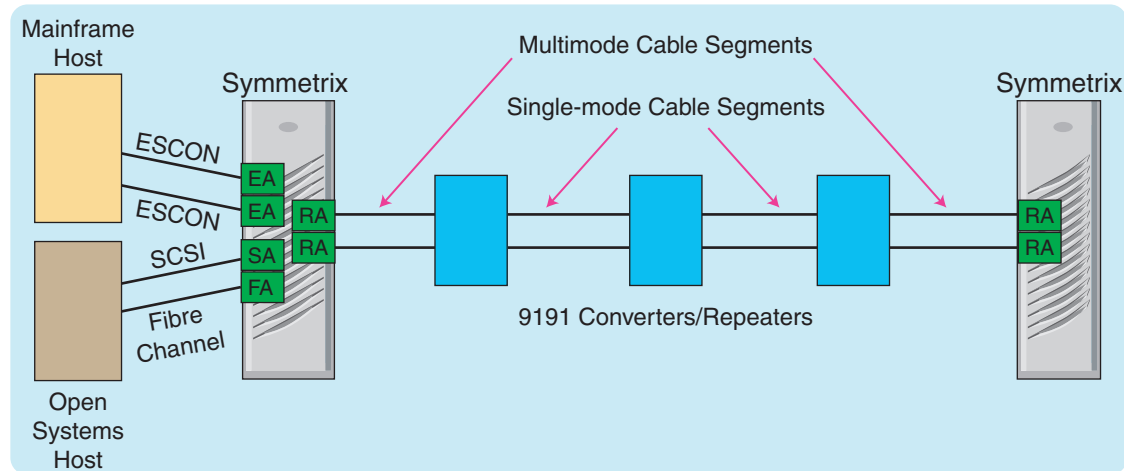


Figure 14. ESCON with Repeaters

Distance capabilities are constantly changing as technology improves. Review the *EMC Support Matrix* (<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>) for the latest information. Also refer to Table 7 on page 41 for distances supported between each unit.

EMC FarPoint is qualified for an ESCON link. FarPoint supports direct connect for TPF operating systems using repeaters/converters, Wave Division Multiplexing (WDM), and Dense Wave Division Multiplexing (DWDM). Throughput and response time improve over ESCON using FarPoint; the greater the distance, the greater the benefit. The most significant benefits begin after 15 km.

FarPoint operation is described under *FarPoint* on page 34.

DWDM

Wavelength Division Multiplexing (WDM) is a process in which multiple different or multiple individual channels of data are carried at different wavelengths over one pair of fiber links. Dense WDM (DWDM) refers to the capability to carry 32 or more data channels on one fiber. This contrasts to conventional fiber optic systems in which just one channel is carried over a fiber pair.

For EMC customers, DWDM enables transfer of multiple SRDF channels and server channels over one pair of fiber links along with traditional network traffic. This is especially important in locations where fiber links are at a premium. For example, a customer may be leasing fiber, so the more traffic they can run over a single link, the more cost-effective the solution. With today's technology, the capacity of a single pair of fiber strands is virtually unlimited; the limitation comes from the DWDM itself. The input traffic per channel is limited by the required optical-to-electrical transfers for switching and channel protection.

Point-to-point DWDM configurations were the first to appear on the market. More recently, ring and meshed topologies emerged to provide greater flexibility. DWDM technology can tie two or more metro-area data centers together into one virtual data center.

Figure 15 shows the basic concept of DWDM. Optical channels such as Gigabit Ethernet, Fibre Channel, and ESCON are converted from optical signals to electrical signals. Each electrical signal is then assigned to a specific wavelength of light, between approximately 1500 and 1600 nm. The process is reversed on the target side. Since no error detection or switching is involved, the process takes microseconds to complete, adding little delay to the transfer of data. Data integrity, error detection, and error correction are left to the end devices (such as the HBA, E_Port, SRDF RA director, or NIC).

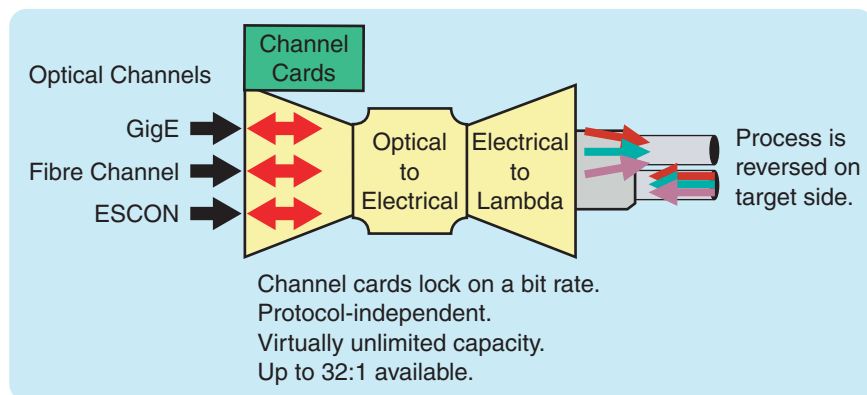


Figure 15. Basic Elements of DWDM

ESCON with (D)WDM Options

Mainframe ESCON channels or SRDF ESCON/FarPoint RA directors can directly connect to WDM or DWDM unit ports. With direct RA to DWDM or WDM connections, an attenuation device may be required to match receive signal strength between RA and WDM or DWDM port connections. Refer to the appropriate Symmetrix product documentation and the DWDM device manufacturer's documentation for permissible limits and the possible need for attenuation.

Damage can result if high-powered lasers (desirable for long range) are connected to devices not designed for such light intensities.

Using WDM or DWDM, many ESCON SRDF channels can be multiplexed over one pair of fiber-optic strands, and distances can be greatly extended. Many DWDMs support 4:1 multiplexing of ESCON onto a single wavelength. Refer to the *EMC Support Matrix* (<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>) regarding supported WDM and DWDM vendors equipment, and Table 7 on page 41 for supported distances between different WDM or DWDM units.

Mainframe and open systems traffic can coexist on a single DWDM loop.

Selection Process: SRDF/ESCON

Point-to-point ESCON operates at distances up to 66 km with repeaters and converters; one fiber pair for one-to-four channels. Physical placement of the repeaters may be impractical when attempting to achieve maximum distance due to cabling constraints or lack of suitable facilities to accommodate the repeater.

The distance between a Symmetrix RA and a (D)WDM port can be up to 3 km without repeaters, or up to 66 km when repeaters are used. Distances between (D)WDM units can be over 200 km. This can be beneficial when the cost of multiple pairs of fiber is prohibitive (in a metro area, for example).

Fibre Channel with DWDM Options

SRDF over Fibre Channel does not currently support direct connections between RF directors using WDM or DWDM unit port connections, due to performance limitations and the relatively variable latencies of such links over long distances. DWDM units, however, are supported for SRDF traffic over ISL connections using Fibre Channel switches.

For supported DWDM unit vendors, refer to the *EMC Support Matrix* (<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>). Refer to *Planning Performance Planning BB_Credits and I/O Size* on page 39 for performance planning information.

Fibre Channel switches use their ISLs to provide the additional buffer-to-buffer credits required to effectively use the Fibre Channel bandwidth over long-distance SRDF connections. Switches also use ISLs to send traffic, consolidated from many different parts, from one switch to another. More information on Fibre Channel switches and topology can be found in the *EMC Networked Storage Topology Guide* (<http://powerlink.emc.com>, **Support, Document Library, Solutions Guides**).

EMC recommends multiple SAN configurations, to eliminate a single point of failure at the SAN level. (Application of an incorrect zoning configuration to a single SAN could possibly cause outage of all SRDF links.)

Latency increases regardless of technology, so applications using long-distance links always consider latency impact.

Selection Process: SRDF/Fibre Channel and/or DWDM

Fibre Channel is valid for distances up to 35 km for single-mode (9 μ m) fiber, specifically qualified switches, sufficient light budget, acceptable latency, appropriate repeaters, etc. All distances are based on typical fiber attenuation over distance from switch port to switch port.

DWDM is valid up to over 200 km, depending on DWDM equipment and optical amplifiers. Connecting a Symmetrix RF director port to a Connectrix Fibre Channel switch port using single-mode technology supports up to 10 km for each RF-to-Connectrix port connection. Each Connectrix single-mode connection to a DWDM port can be up to 35 km. Based on these figures, these connections could provide a maximum distance of up to 120 km. Refer to *Planning Performance Planning BB_Credits and I/O Size* on page 39 for calculation of buffer-to-buffer credits. Refer to the appropriate Symmetrix product documentation and the DWDM device manufacturer's documentation for permissible limits and the possible need for attenuation.

Distance capabilities are constantly changing as technology improves. Each SRDF-based remote replication solution has different capabilities. For the latest information, please check the *EMC Support Matrix* (<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>).

All quoted distances are subject to change. For the latest information, contact your EMC representative directly.

Refer to the *EMC Networked Storage Topology Guide* (<http://powerlink.emc.com>, **Support, Document Library, Solutions Guides**) for the latest specifications and other important information.

GigE with DWDM Options

SRDF over GigE supports direct connections between RE directors using WDM or DWDM unit port connections. IP routers/switches are required only to provide improved performance for distances beyond metropolitan deployments.

Wide Area Network SRDF Implementations

With wide area networks (WANs), physical location or regulatory barriers can limit customer access to the network. This is manifested by very high costs, one or few carriers, and limited bandwidth. Limited network access can also be caused by crossing geographic or political borders.

WAN distances range from 10 km up to transoceanic or transcontinental distances. Typically, a carrier offers ATM, T3/E3, T1/E1, IP, or SONET connections. In some locations, these are the only available services, and use WAN technology even for short distances.

Table 6. GigE/Fibre Channel/ESCON Recommendations for WAN Implementations

GigE	Fibre Channel	ESCON
No bridging needed for IP over distance	FCIP or iFCP bridge or channel extender required for IP connectivity	ESCON/IP channel extender required for IP connectivity

Symmetrix connection to these WANs currently requires one or more GigE, Fibre Channel, or ESCON connections. A Symmetrix GigE director would connect into a router or switch for native GigE support. Fibre Channel or ESCON interfaces would connect into channel extenders that convert those protocols into a WAN protocol.

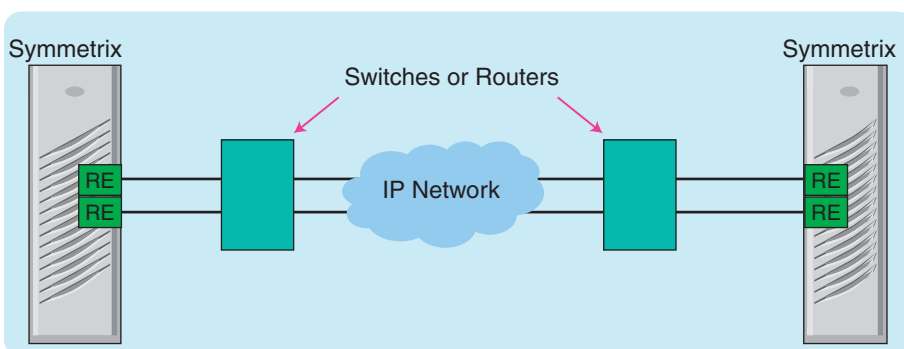


Figure 16. General Concept of SRDF WAN Connectivity

Duplicating the network elements, including the network interface units (as shown in Figure 16), eliminates single points of failure. The concept of eliminating single points of failure should be considered when referring to the WAN connectivity diagrams shown in the following pages of this document.

WAN Communications Options

This section provides an overview of WAN communication options, including:

- T1/T3, E1/E3
- Synchronous Optical Networks (SONET/SDH)
- ATM-OC-3
- IP

T1/T3, E1/E3

T1/T3/E1/E3 are all implementations of Time Division Multiplexing (TDM), introduced by the telecommunications industry decades ago as the first Digital Service (DS) for wide area networking. DS-1 or T1 uses TDM to give each channel a slot on the link.

A DS-1 consists of 24 separate 64 Kb/s slots for a total throughput of 1.54 Mb/s. T1 networks feature low latency to support voice and data, albeit at a very low throughput. DS-3 or T3 multiplexes 28 DS-1 channels for a total throughput of 45 Mb/s.

These networks were designed for minimum latency in order to deliver voice and data over the same network. Outside of the United States, E3 service is available with the same latency characteristics (with a throughput of 34 Mb/s).

DS-3 (T3) links can be supported with SONET technology today by the telecommunication companies. This reduces the hard requirement for a redundant second T3 link. SONET rings are self-healing; if there is a break in the SONET ring in one direction, the traffic is routed in the other direction, reestablishing the link in milliseconds.

SRDF over T1/T3, E1/E3

This SRDF extended-distance solution uses leased T1, E1, T3, or E3 data lines provisioned from the telecommunications provider. A network interface unit (ESCON multimode-to-network interface converter) is required. Different vendor equipment and model types provide a varied number of SRDF multimode ESCON ports and network link interface ports. (Refer to vendor documentation specific to each model type.) For a list of supported vendors' equipment, refer to the *EMC Support Matrix* (<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>).

With these network interface units, FarPoint is always enabled in the Symmetrix system.

These WAN circuits are full duplex; therefore, full link bandwidth is available in both directions. A single WAN link of this type can service Symmetrix SRDF traffic in a dual-directional Symmetrix configuration. A dual-directional configuration exists when all primary volumes (source, R1) are configured to RA1 directors, and all secondary volumes (target, R2) are configured to RA2 directors. Both RA1 and RA2 directors are located in each Symmetrix system at opposite sides of the SRDF link.

A bidirectional SRDF configuration (where primary and secondary devices are configured to the same RA1 or RA2 director) is not allowed in these environments. Any T1/T3/E1/E3 extended-distance configuration requires a clear channel network link. The network interface units require a dedicated circuit that cannot be shared through TDM techniques.

Figure 17 shows a dual-directional configuration.

Single network elements represent a single point of failure and are not recommended, but are used to simplify the diagrams in this document.

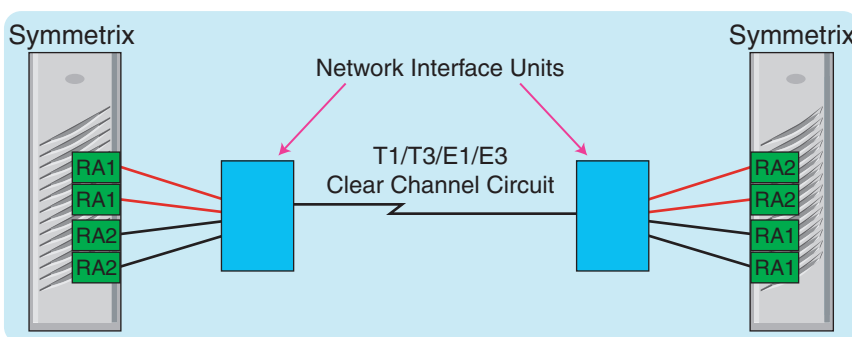


Figure 17. SRDF Dual-Directional Configuration Using T1/T3/E1/E3

Synchronous Optical Networks (SONET/SDH)

As the telecommunication carriers migrated to optical backbones, they developed and deployed rings of fiber and created a standard method of connecting to these rings. In Europe, the standard is Synchronous Digital Hierarchy (SDH), and in the United States it is Synchronous Optical Networks (SONET); for our purposes here, they are treated as the same service.

An SDH/SONET ring is a dual-redundant ring with electronics that will heal or reroute traffic within 50 m/s. This is possible because only one direction of the ring is used, with the other direction kept as a spare (resulting in a ring sparing ratio of 1:1). These rings have grown in capability such that they can now carry dozens of connection circuits over very long distances by interconnecting rings. This mapping or provisioning of the capacity can take many months, as a path is charted across the rings from the customer sites.

Carriers have a large investment in the capital equipment, people, and operations that run SDH/SONET networks to deliver a 99.999 percent level of availability.

EMC GigE ports can connect directly to SDH/SONET equipment that provides the layer two IP switching function.

Switched Fibre Channel and ESCON can be bridged over SONET. For supported Fibre Channel and ESCON devices over SONET, refer to the *EMC Support Matrix* (<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>).

ATM-OC-3

ATM (Asynchronous Transfer Mode) is used for corporate LAN backbones, as well as WANs. SRDF can connect to either of these infrastructures. EMC's partners support multiple OC-3 interfaces, each of which supports up to 155 Mb/s of bandwidth. These OC-3 links can connect to larger ATM switches (OC-12 for example), leveraging campus ATM backbones. Today, a permanent virtual circuit (PVC) with either Constant Bit Rate (CBR) or Variable Bit Rate (VBR) is supported.

ATM is a network protocol that transmits in the form of 53-byte units called *cells*. Each cell consists of a 5-byte header and a 48-byte payload. The term *asynchronous* in this context refers to the fact that cells from any one particular source need not be periodically spaced within the overall cell stream. In other words, users are not assigned a set position in a recurring frame as is common in circuit switching. ATM multiplexes logical channels within a physical channel through very high-speed switching hardware. These high-speed switches reduce latency to the point where network overhead is not an issue.

ATM is a connection-oriented technology, which means that a connection must be established between two stations before data can be transferred between them. An ATM connection specifies the transmission path, allowing the cells to self-route through an ATM network.

ATM runs over both SONET and SDH. While electrical transports are available, optical is the most common transport and the physical interface supported today by the channel extenders. SONET is generally used in the United States, and SDH is the preferred transport outside of the United States. Both SONET and SDH allow the optical component (fiber) to be parceled out in Optical Carrier (OC) capacity. This starts at OC-1 (51.84 Mb/s) and continues through OC-192 (9,952 Mb/s). Sub-OC-1 circuits are available from carriers today.

ATM includes an Adaptation Layer (AAL), which supports many kinds of services with different traffic characteristics. This includes the distinction between Constant Bit Rate (CBR) and Variable Bit Rate (VBR). VBR delivers a minimum bit rate with upside flexibility.

ATM is generally priced city to city, as opposed to DS3 (T3/E3), which is priced per mile. You may see a cost advantage with ATM over long distances. The challenge is usually the last mile, getting the SONET ring to the customer's destination site from the ATM service.

SRDF over ATM Overview

SRDF over ATM uses a network interface unit (ESCON or Fibre Channel multimode-to-network interface converter) very similar to the T1/T3/E1/E3 connection described earlier, but the network interface unit connects to an ATM network. All rules regarding FarPoint, dual-directional, and b-directional configurations described under *SRDF over T1/T3, E1/E3* apply.

Figure 18 describes one side of the SRDF-over-ATM connection. SRDF/Fibre Channel over ATM does not have the bidirectional limitations of ESCON/FarPoint, so dual-directional configuration is not required.

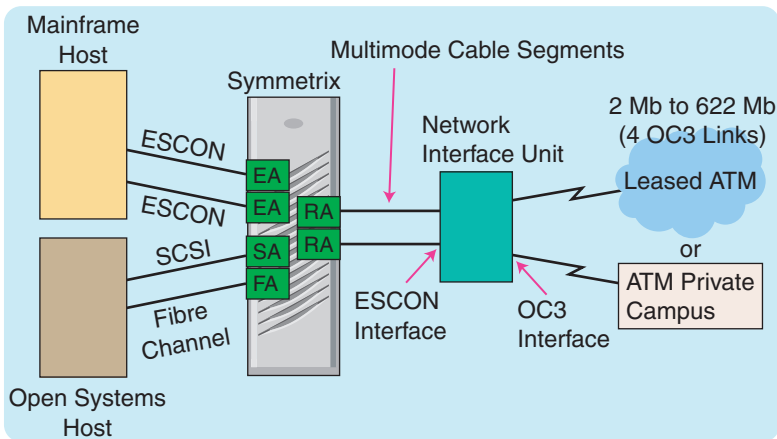


Figure 18. SRDF ATM Connectivity

IP

Internet Protocol (IP) can be used to communicate across any set of interconnected networks, and works equally well for LAN and WAN communications. IP is supported by every major system vendor, network vendor, and communications provider in the world. For these reasons, IP is the world's most popular networking protocol.

IP and TCP/IP generally refer to a group of protocols working together to accomplish three major tasks: generating datagrams, routing them across interconnected networks, and ensuring their delivery.

At its core, IP is a connectionless protocol that generates packets of data commonly referred to as *datagrams*. Datagrams are given addresses and routed through networks by utilizing routing tables that are referenced at each hop along the network. TCP (Transmission Control Protocol) manages the end-to-end delivery. TCP ensures delivery and provides a level of traffic control for datagrams entering the network.

SRDF can utilize any IP network. However, private *intranets* are highly recommended over the use of the public Internet, due to the available levels of quality of service (QoS) and security. A customer can lease a circuit capable of transporting IP traffic with adequate QoS from most major telecommunications companies or Internet Service Providers (ISPs). IP traffic can run over such data networks as T1/E1, T3/E3, SONET, ATM, Frame Relay, and Wavelength Services. Many telecommunications companies also offer Ethernet services over the MAN, which expands the appeal of IP-based solutions. This service provides what is for all practical purposes a door-to-door IP-based Ethernet network between the customer locations.

SRDF over IP

This section covers information that is relevant to all SRDF-over-IP deployments, whether it be native IP or channel extension technology bridging Fibre Channel or ESCON into IP networks.

SRDF supports IP-based networks using a channel extender, which converts SRDF frames to IP packets and back again. This is similar to extended-distance solutions that utilize non-IP-based transport, such as ATM or clear-channel circuits. Symmetrix 8000 and DMX series support SRDF over IP directly using the native GigE directors, eliminating need for external channel extenders.

Both ESCON and Fibre Channel I/O interfaces are supported for the Symmetrix RAs for SRDF over IP.

The channel extender vendor handles the IP encapsulation, bandwidth throttling, data compression, packet sequencing, packet tracking, and buffering to ensure that the allotted bandwidth is fully utilized and that the Symmetrix system is able to transmit data as efficiently as possible.

Refer to *SRDF with Native GigE* on page 16 for more information.

For a list of supported vendor equipment, refer to *EMC Support Matrix*: <http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>.

Professional Services offerings for these implementations can come from EMC or the channel extender vendor. All management and control software remains operational, and all SRDF modes are supported.

IP-based networks can sometimes be more unpredictable than dedicated non-IP-based circuits; therefore, all SRDF-over-IP implementations require network qualification through EMC TSG to determine the suitability of the technology to the business problem and to analyze the proposed network to assure that it is adequate for the task. This assessment is not optional; without it, the sale will not be approved.

Analysis of the network prior to the SRDF-over-IP implementation is handled by both EMC and the channel extender vendor (if using network interface units for connectivity). EMC and the channel extender vendor will both provide technical guidance.

A real-time disaster recovery solution utilizing SRDF normally means Synchronous mode. Due to the potential for network performance to be unpredictable, EMC recommends SRDF over IP as a business continuance and data replication solution in SRDF/A or Adaptive Copy mode, preferably utilizing TimeFinder. However, synchronous SRDF over IP is supported where network latency is low enough to support host applications. Semisynchronous mode is not currently supported for SRDF over IP.

While the first three of the following choices are strongly encouraged, all of these modes of operation may be used:

- SRDF/Asynchronous, which can efficiently employ over IP and maintain data consistency over long distance, with no host application impact.
- Differential resynchronization from a TimeFinder business continuance volume (BCV R1), using TimeFinder differential-split techniques. (Refer to *SRDF with TimeFinder* on page 37.)
- Delayed synchronization using a multihop configuration and TimeFinder. (Refer to *SRDF with TimeFinder* on page 37.)
- Synchronous mode on networks where a high quality of service can be assured and latency due to distance can be supported.
- Adaptive Copy, in which data is sent asynchronously. This provides much better long-distance performance; however, the entire logical volume must be moved before the data is valid because there is no synchronous update at the secondary side. Adaptive Copy is used primarily for data migrations.

Factors Affecting Throughput

- **Link Bandwidth** — Factors impacting link bandwidth requirements include SRDF data transfer requirements and SRDF communication requirements. Typically, Fibre Channel and Gigabit Ethernet links require a minimum bandwidth of 10 Mb/s per RDF link, and ESCON links require a minimum of 2 Mb/s per RDF link.

EMC TSG is recommended throughout the sales cycle (including pre-sales), and is necessary throughout the implementation phases. End-to-end assessment is provided by TSG to ensure that the IP network can support the expected level of SRDF traffic.

- **Link Latency** — Link latency impacts throughput in any IP link. The effective throughput of a link can be calculated for a link if the roundtrip delay and the TCP buffer size are known.

Effective throughput is equal to the TCP buffer size divided by the round-trip delay. For example, a single TCP connection with 40 ms round-trip delay using a 1 MB TCP buffer would have a maximum effective throughput of 25.6 MB/s (1024 bytes/40 ms). Increased throughput can be achieved by scaling the number of TCP connections.

A typical configuration using two Symmetrix Gige ports through a switched network will have four TCP connections.

Load Balancing

SRDF uses all available ports associated with an RDF group to transmit and receive data. Data transfer is load balanced equally across the ports. RDF group mappings to ports are configured in the `IMPL.bin` file when RDF is configured, and should include at least two ports for redundancy. All RDF ports associated with the same RDF group should have equivalent characteristics in terms of amount of bandwidth, network delay, and packet loss.

WAN Optimization

This section provides additional WAN considerations.

Bandwidth by WAN Link

EMC supports T1/E1, T3/E3, IP, SONET, ATM, Frame Relay, Wavelength Services, and other circuits for long-distance network links. Each of these links has different bandwidths and cost structures. For a summary of these characteristics, refer to *Bandwidth by WAN Link* on page 42. For SRDF/Fibre Channel and native Gige, ensure that the minimum bandwidth per SRDF link is at least 10 Mb/s to prevent link problems.

Compression

Data compression options are available when ESCON and Fibre Channel extenders are used for T1/E1, T3/E3, IP, SONET, ATM, Frame Relay, Wavelength Services, and other circuits. On Symmetrix DMX systems, data compression is also supported on native Gige directors.

For models and links with compression support, refer to the *EMC Support Matrix*,

<http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>.

The compression benefit varies with the type of data being replicated. Many existing SRDF customers find a typical compression rate of data that has not been previously compressed by a host to be from 2:1 to as high as 15:1. If the data is 100 percent compressible (2:1), one T3 link can be used to support 90 Mb/s of write activity. Actual performance will vary with distance, the application's propensity to pipelining, and the compressibility of the data.

FarPoint

FarPoint is an SRDF feature used with all ESCON extended-distance solutions (and ESCON campus solutions with links greater than 12 to 15 km) to optimize the performance of the SRDF links. With FarPoint, a single remote adapter can serially transmit more than one write I/O over the SRDF link with up to one outstanding I/O per logical volume in Synchronous mode (up to eight writes per volume in Adaptive Copy mode). This method, called *pipelining*, enables the SRDF communication link to be more fully utilized.

FarPoint may not be used with bi-directional ESCON configurations, where source and target volumes are required at each side of the same SRDF link.

Pipelining is not a native attribute of ESCON, so it had to be introduced into the SRDF/ESCON protocol. Using a buffer-to-buffer credit scheme, pipelining is a characteristic native to the Fibre Channel protocol and naturally available to SRDF over Fibre Channel. FarPoint improves bandwidth use for mainframe TPF environments, at any cable segment length, due to the small block size. FarPoint buffer setting (maximum amount of data per RA allowed on the link) defaults to 200,000 bytes per link. For long-distance or high-latency and high-bandwidth FarPoint links, EMC Customer Support can increase the FarPoint Buffer setting to maximize throughput.

SRDF QoS

Throttling controls within Symmetrix Enginuity can affect SRDF performance for copy tasks: resyncs, adaptive copy, and BCV/R1 remote copies using SRDF/AR. (By default, throttling is disabled.) The SRDF QoS setting adds delay to servicing of R2 invalid tracks by the DAs, in effect throttling the frequency of placing copy tasks on the SRDF copy queue. There are white papers on SPEED that provide detail on tradeoffs between front-end and back-end (including SRDF) resource utilization and the impact of the SRDF and BCV QoS settings.

There is also a fixed setting in Enginuity for the number of copy tasks per SRDF Group to limit the DA utilization for placing work on the SRDF queue. The fixed value is 40 tasks (tracks) per RDF Group. This can limit SRDF performance on exceptionally high-latency links. In exceptional cases, EMC Support can monitor the SRDF queue depth to determine if the SRDF links are being throttled by the 40-task limit, and change the value. Since it increases the DA workload, this could affect front-end performance and cache utilization.

SRDF/A Considerations

SRDF/A runs as an application above the SRDF link directors, using linked lists and cache directly for SRDF I/O operations. SRDF/A is the only SRDF-based application that does not use the normal SRDF queue (high priority for host writes and low priority for copy tasks). The SRDF directors use the SRDF/A linked lists directly for transferring data from cache slots to the SRDF links. This means that the earlier comments about SRDF QoS and 40-copy task limits do not apply to SRDF/A link performance.

SRDF/A groups host-write updates into 30-second (default setting) Delta Sets that include multiple cache slots for many volumes. There is no limitation within an SRDF/A cycle based on the number of writes per volume or number of copy tasks. If there are any invalid tracks accrued in an SRDF/A Delta Set (as can occur during initiating of SRDF/A, after suspending SRDF/A, or after link outages), SRDF/A might flood the SRDF links with copy tasks. The only limit for copy tasks within SRDF/A is 30,000 tracks, so be careful. If you have built up many invalid tracks, use Adaptive Copy mode to decrease the workload before activating SRDF/A.

Since it is critical to properly size link bandwidth and cache for SRDF/A application, engage your local SPEED Guru to use the SYMMERGE tool for sizing SRDF/A. It is also helpful to run in Adaptive Copy – Write Pending mode for a period of time prior to implementing SRDF/A. This will give you a practical demonstration of the impact on cache due to specific SRDF link configuration and bandwidth before activating SRDF/A.

WAN Delays and Performance Impact

This section provides an overview of the I/O delay introduced by extended-distance mirroring and associated technologies.

Protocol Conversion Impact

Any process of converting SRDF data frames from a Symmetrix GigE, Fibre, or ESCON format to be placed onto any type of circuit for transport between two remote sites introduces latency into the SRDF connection. The amount of latency will vary depending on the SRDF protocol and the bridging equipment that is used at the two sites to convert the data from the default Symmetrix format and back again at each site.

Distance Impact

The impact of distance increases at a rate of approximately 1 ms for each 200 km (125 miles) of the link. For SRDF traffic that begins as GigE or ESCON, the distance considered for calculating latency is one round trip. For SRDF traffic that begins as Fibre Channel, two round trips are needed to ship a data frame, so four times the actual distance

must be considered. For example, for one SRDF write operation, data centers that are 200 km apart will add 4 ms to overall latency.

Total Impact

By considering SRDF, the channel extenders/converters, and distance, you can estimate the response time per I/O as viewed by the application. Refer to Figure 19.

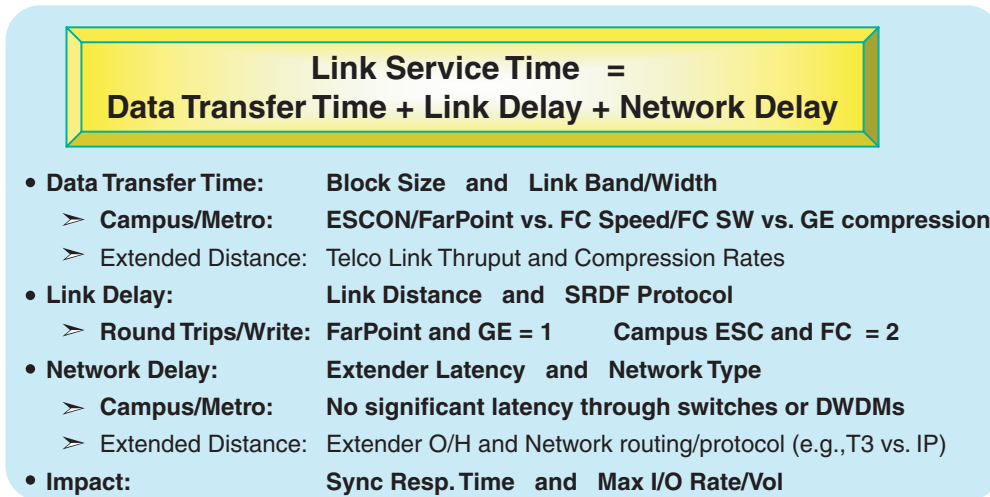


Figure 19. Link Service Time

Recommendations

There are number of factors to consider in selecting the network technology for an extended-distance solution. The first is the business requirement for the application. If zero data loss is a hard requirement, a synchronous implementation or multihop is required to do the job. Response time will be dictated by distance (described under *Distance Impact* on page 36) and throughput by available bandwidth (described under *Bandwidth by WAN Link* on page 42). Both must be considered for a successful implementation.

In any synchronous implementation, consider the following guidelines during the planning process:

- Bandwidth to support peak write activity is required.
- Larger I/O block sizes are better for response time and link efficiency.
- Positioning data across a greater number of Symmetrix logical volumes improves performance, especially by striping the log file of a database across multiple logical volumes.

Implementing a synchronous data mirroring solution over extended distance requires detailed planning and consideration. EMC has the knowledge and experience to recommend, plan, and implement a comprehensive data mirroring solution to meet your business problem.

An asynchronous data mirroring solution brings related but different challenges to the problem. Again, EMC's experience can be applied to shorten your time to deployment and increase your level of satisfaction. Please contact your EMC representative, who can call on significant resources to bring a proven process to your most demanding challenges.

T1/T3/E1/E3

T1/T3/E1/E3 provide finite bandwidth. The number of links employed must be specified correctly the first time; otherwise, an implementation can be useless until new link capacity is obtained. Multiple links between the same location can be used, but these links are costly. These types of links are generally available within short notice from

the local telecommunications providers. For temporary SRDF solutions, such as using SRDF to move data center locations, these links are often used.

DS-3/OC-3

DS-3 or OC-3 links over ATM SONET networks are typically less expensive, and usually allow a higher bandwidth if required. The challenge with these types of networks is typically the amount of time needed to obtain a connection, and getting the connection to the customer site from the existing SONET ring.

IP

Private intranetworks are preferred over the use of the public Internet for the transfer of SRDF over IP. Due to the lack of quality-of-service guaranty available on the Internet, it is not a choice for SRDF. EMC TSG is recommended throughout the sales cycle (including pre-sales), and is necessary throughout the implementation phases. End-to-end assessment is provided by TSG to ensure that the IP network can support the expected level of SRDF traffic.

SRDF with TimeFinder

The Symmetrix TimeFinder feature uses one or more software-controllable, dynamically assignable mirror volumes called business continuance volumes (BCVs). TimeFinder BCVs can be locally mirrored or remotely mirrored via SRDF (but not both locally and remotely mirrored simultaneously).

If a TimeFinder BCV is remotely mirrored (a BCV R1 volume), the logical remotely mirrored SRDF connection for the BCV mirror is suspended while the BCV is established as a mirror to any other standard device in the Symmetrix system. When the BCV/standard device mirrored relationship is split through software commands, the user can choose to leave the BCV remote mirror connection split or to reestablish the BCV remote mirror SRDF connection automatically, thus resynchronizing the BCV remote mirror. Figure 20 provides an example of establishing/splitting a BCV R1 to/from an existing SRDF device.

Using TimeFinder BCV R1 volumes to remotely mirror BCV volumes is often referred to as *differential resynchronization*. This buffering technique is advisable when using high-latency communications links, such as very long T1/E1, T3/E3, ATM links, or any IP link.

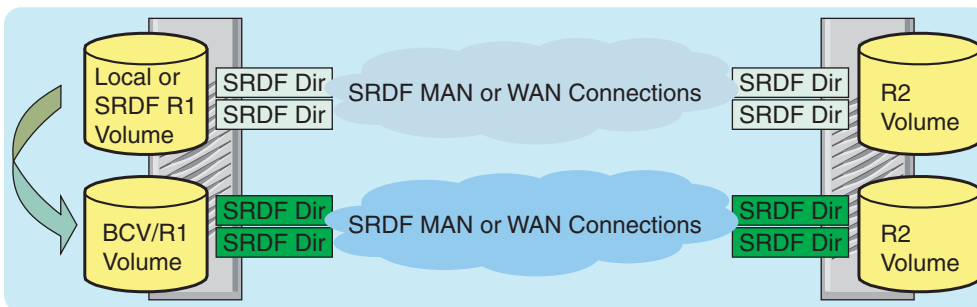


Figure 20. General Concept of Differential Resynchronization

An SRDF/AR multihop configuration, using two or more Symmetrix systems, may be desirable. A multihop configuration may be used in any supported MAN or WAN connection, but is especially effective when true disaster recovery (first hop, using direct-connect or very low latency links enabling SRDF Synchronous mode operations) and differential resynchronization (second hop) are desired. Refer to Figure 21.

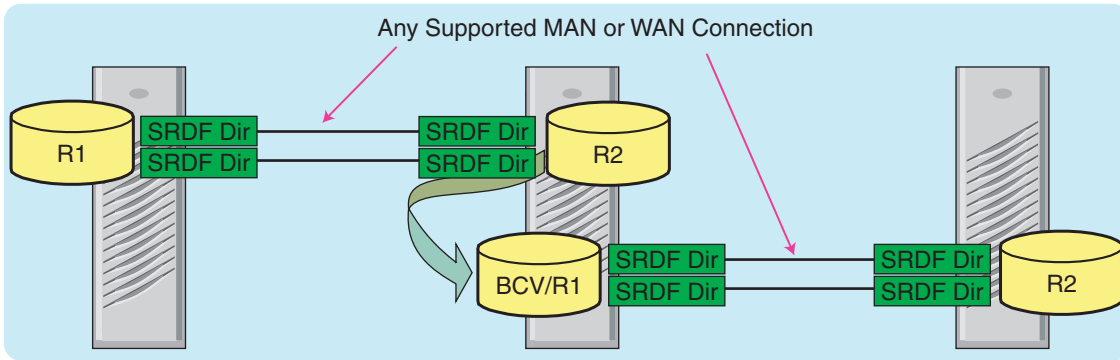


Figure 21. SRDF/AR Multihop Configuration

Appendix A Planning Performance Planning BB_Credits and I/O Size

Every Fibre Channel device contains a communications chip that has one or more internal 2 KB buffers. The number of these buffers is referred to as *buffer-to-buffer credits*, or *BB_Credits*. The number of buffers at the receiving end of the link determines the amount of data that can be loaded and transmitted down the fiber link to the other end before transmission must stop and the data transmission is acknowledged to the sender.

The more BB_Credits in the receiving system, the greater the link use. For example, when transmitting a 2 KB frame down a link 200 km long, only 2 km of the link is used at any one time. This is similar to a 4 km long train on a 200 km track; only two percent of the track is used at any one instant. Placing more trains on the track, going in the same direction, increases track use. Throughput on long links can quickly degrade if not enough frames are on the link. The longer the link, the more frames must be sent down the link to prevent this degradation. Fibre Channel switches are often recommended for long-distance transmission because the E_Ports (switch-to-switch ports) typically have a larger number of BB_Credits than individual Fibre Channel devices.

Calculating BB_Credits

For a standard fiber 1 Gb/s (equivalent to 100 MB/s for these calculations) Fibre Channel link, buffer-to-buffer credit calculation depends on the length of the link. Length, in this context, is the total length of the network connection, including the distance of the connection between each Fibre Channel switch and each Symmetrix system.

The approximate calculation is as follows:

$$\text{BB_Credits} = (2 * \text{length, in meters, of the total link distance}) / 4311 + 1$$

For example, the BB_Credits needed for a 50 km, 1 Gb/s (100 MB/s) link would be:

$$(2 * 50,000) / 4311 + 1 = 24 \text{ BB_Credits}$$

Be sure to round up the result to the nearest integer value.

In the example above, 24 BB_Credits provide the maximum throughput for the Fibre Channel link. With the maximum effective SRDF throughput at between 50 and 55 MB/s, half of the entire link throughput is utilized. In other words, 50 percent to 55 percent of the ideal BB_Credit value is needed for SRDF links, so the ideal numbers can be divided by 2. Further, a user desiring to put 10 MB/s down the link needs only 10 percent of the BB_Credits ($24/10 = 2.4$, rounded up to 3). This is not an exact calculation, but can be considered a guideline. Always round up!

Other Performance Considerations

The nominal 1 Gb/s (100 MB/s) throughput is seldom reached, due to overhead within various elements of the system. One major factor is the time taken setting up each I/O to resolve the address for the I/O and the time taken to stage and destage the I/O from the I/O system.

Along with buffer-to-buffer credits, the other major performance factor is I/O size, which in turn impacts setup time. I/Os being updated and sent down the link need time to resolve World Wide Names (WWNs), and time to load the data from electrical signal into light, along with buffer transfers, and so on. These or similar issues affect every form of networking.

The address resolution time is approximately constant. The time required to get data in to and out of the link depends on the data size. (This discussion ignores the travel time in the link.) In practice, the link is more active and has more data throughput with larger I/O sizes. The constant address resolution time becomes significant with smaller I/O sizes. However, if the number of I/Os is the goal of the SRDF link, small I/O sizes may be the best way to meet the objective.

These calculations are difficult because local conditions impact results. However, because these effects take time away from the link transporting data, I/O size must be considered.

Appendix B DWDM Considerations

The description of each d(x) connection in Figure 22 is as follows:

- d1: DWDM signal over dark fiber medium. These connections use 9 μm fiber-optic cable.
- d2 and d3: Local ISLs between switches and DWDM input ports. These connections may be single-mode or multimode, depending on DWDM and switch interface hardware, and based on local distance requirements. The connections may also be direct local Symmetrix ESCON RA connections to the DWDM input port (multimode).
- d4 and d5: Local RF director (or server) connections to the fabric.

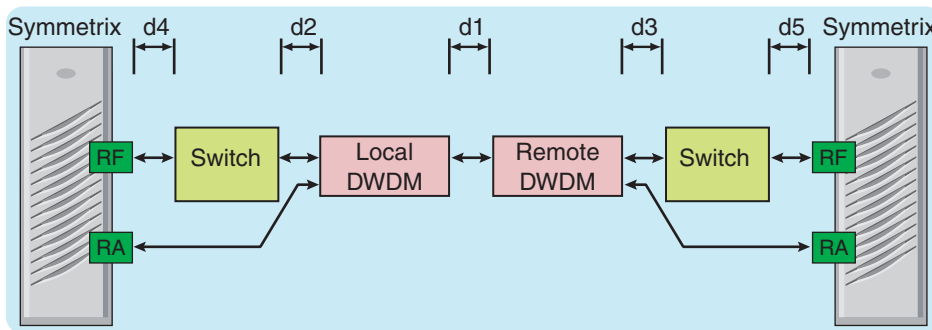


Figure 22. Basic Point-to-Point (Two-Site) Configuration

EMC has qualified this solution to 200 km for SRDF over ESCON, SRDF over Fibre Channel, and Fibre Channel open systems host-to-remote storage extension. For Fibre Channel, this maximum distance is the ISL distance between any pair of Fibre Channel switches exchanging data over DWDM. For SRDF over ESCON, this is defined by the distance between two Symmetrix systems exchanging data over SRDF.

Amplifiers and/or regeneration stations may be deployed within D1 depending on factors that include distance and attenuation. No other devices are needed. Since Fibre Channel or ESCON can be sent natively over DWDM, no conversion to WAN or SONET protocols is needed.

Check the *EMC Support Matrix*, <http://www.emc.com/horizontal/interoperability/matrices/EMCSupportMatrix.pdf>, for possible updates to the supported distance.

Configuration Envelope

The following information provides general guidelines for the use of DWDM systems:

- DWDM may be used for ESCON RDF distance extension, with direct connection of RA to DWDM input ports.
- DWDM may be used for ISL extension of Fibre Channel switched fabrics. (Fabric topology guidelines are provided per Fibre Channel switch documentation.)
- Direct connections from a host HBA or Symmetrix RF/ FA to a DWDM port are not currently supported.

As a general approach, two distances are measured. The shorter one is the maximum distance supported at the site:

- Maximum supported distance per Fibre Channel switch port BB_Credit guidelines. (This calculation is not required for direct ESCON RA-to-DWDM connections.) Refer to *Planning Performance Planning BB_Credits and I/O Size* on page 39 for a BB_Credit overview and calculation examples.
- Maximum allowable distance based on optical power measurements of the site:
 - These measurements should be approved by DWDM, Fibre Channel switch, and optical fiber service provider(s), and conform to the dB max/min and link budget specifications for each unit in the network.
 - Refer to the appropriate product manual for each unit in the network to obtain the specifications.

Appendix C Cable Specifications

Table 7 provides network cable specifications and supported distances.

Table 7. Cable Specifications

Primary SRDF Links	Network Supported		Nominal Distance
SRDF/ESCON	Direct fiber, multimode:	62.5/125 μ m cable	3 km/cable segment
		50/125 μ m cable	2 km/cable segment
	Fiber repeaters/converters (e.g., McDATA 9191 to McDATA 9191 using 9 μ m cable) 3 converters/repeaters maximum allowed		30 km/cable segment
	Other fiber repeaters/converters (using 9 μ m cable) 3 converters/repeaters maximum allowed		20 km/cable segment ^a
	DWDM, WDM (MAN)		200 km ^{b,c,d}
	LAN / WAN - T1/E1, T3/E3, ATM, IP		Unlimited ^d
SRDF/GigE or SRDF/Fibre Channel	Direct fiber, multimode:	50/125 μ m cable	500 m/cable segment @ 1 Gb/s; 250 m/cable segment @ 2 Gb/s Fibre Channel
		62.5/125 μ m cable	300 m/cable segment @ 1 Gb/s; 150 m/cable segment @ 2 Gb/s Fibre Channel
	SRDF direct fiber, single-mode (using 9 μ m cable)		10 km/cable segment
	Fibre Channel switch to Fibre Channel switch		Up to 35 km total ^c
	DWDM (MAN)		200 km ^{b,c,d}
	LAN or WAN		Varies

- a. Typical best-case distance specifications are quoted; refer to specific vendor's equipment for current information.
- b. Limited by vendor's DWDM laser technology and the type of cable for the Symmetrix system-to-DWDM cable segment.
- c. Refer to the *EMC Support Matrix* and the *EMC Networked Storage Topology Guide* for the latest supported distances.
- d. Use of SRDF Synchronous mode is limited by the application's ability to tolerate delay introduced by distance. Buffering techniques, such as SRDF/A, SRDF Adaptive Copy mode, and TimeFinder BCVs, are available.

A cable segment is a physical cable connecting one node to another.

Some vendors place very powerful lasers in their systems to improve signal strength. Other vendors have receivers that can be damaged or even destroyed by this intense light. Light attenuators may be needed between equipment, based on the connection distance involved. Please check input and output ranges carefully before operational testing.

Appendix D Bandwidth by WAN Link

Table 8 provides bandwidth ratings for the various WAN links. Performance varies depending on many factors, including I/O size, configuration, and media.

Note that the availability of links and the “last mile” cost can have a significant impact on total bandwidth costs, and can vary substantially by region.

Table 8. Bandwidth by WAN Link

WAN Link	Rated Bandwidth	Maximum Bandwidth	Comments
T1	1.5 Mb/s	0.15 MB/s	Can inverse multiplex multiple links to act like one.
T3	45 Mb/s	4.5 MB/s	
E1	2 Mb/s	0.2 MB/s	International link.
E3	34 Mb/s	3.4 MB/s	International link.
ATM-OC3	155 Mb/s	15.5 MB/s	ATM can be a LAN backbone owned by the customer or a WAN link leased from a telecommunications provider.
SRDF Director Links			
GigE	1024 Mb/s	Depends on block size: Symmetrix 8000: 4-40 MB/s DMX: 4-50 MB/s	For a single link, SRDF can use approximately half of the rated bandwidth of GigE. Future releases of microcode and hardware will increase the throughput.
Fibre Channel	1024 Mb/s or 2048 Mb/s	Depends on block size: Symmetrix 4.8: 4-28 MB/s Symmetrix 8000: 4-45 MB/s DMX: 4-64 MB/s	For a single link, SRDF can utilize approximately half of the rated bandwidth of Fibre Channel. Future releases of microcode, CPUs, and Fibre Channel chipsets will increase the throughput.
ESCON	200 Mb/s	14 MB/s (depending on block size and Symmetrix model).	While the IBM rated speed of ESCON is 17 MB/s, 14 MB/s is used for SRDF planning purposes.

Glossary

ATM

Asynchronous Transfer Mode, a high-speed, connection-oriented switching technology that can transmit voice, video, and data traffic simultaneously through fixed-length packets called *cells*. ATM is used as a protocol for LAN and WAN traffic, as well as a transport protocol for IP packets. ATM is generally associated with SONET, which provides the optical link layer.

Buffer-to-Buffer Credits (BB_Credits)

The number of internal 2 KB buffers on a communications chip in a Fibre Channel device. More credits for longer distance enables more efficient use of the available link capacity.

Change Tracker

A tool available to EMC SEs to aid in the estimation of bandwidth required in an SRDF configuration. Change Tracker allows a user to monitor the update activity on Symmetrix devices, and is especially useful for sizing SRDF in a multihop configuration.

Change Tracker consists of two programs: a collector program that gathers the update activity statistics, and a reporter program that analyzes the data and formats it into useful reports.

The collector program is run first. The collector runs as a started task and, through input parameters, is told the devices for which to collect statistics. It then writes the data to a dataset. At specified intervals, the collector recognizes which tracks of the specified devices changed, and saves that information for later use by the reporter.

Using the data created by the collector, the reporter presents the data in a meaningful format. Reports can be generated showing the track changes on a Symmetrix system level, a volume level, or on a dataset level over a period of time. Multihop uses TimeFinder BCVs as the source, and only changed tracks are sent over the link from the BCV, making this kind of information extremely useful in sizing network bandwidth for this configuration.

DA

Disk Adapter. Generally the term *DA* applies to the disk director on all Symmetrix models except the DMX800. The disk director and its disk adapter provide the interface between cache and the disk devices.

In the DMX800, DA functionality is provided by a multifunction front-end/back-end (FEBE) board. For the purpose of this white paper, the term *DA* applies to the cache-to-disk interface in any Symmetrix model.

Dark Fiber/Lit Fiber

Fiber-optic cable that is inactive (dark) until the customer lights it up with new traffic. When leasing dark fiber, the customer has full use of the bandwidth on that fiber. In a lit (currently used) fiber service, a wavelength or specific protocol such as Gigabit Ethernet has been provided to the customer's building or data center. It is already lit up with other traffic since it is a shared fiber. Note that a band in a DWDM fiber could be considered dark if it is not yet used.

Dense Wavelength Division Multiplexing (DWDM)

Dense Wavelength Division Multiplexing (DWDM) is a process in which multiple different or multiple individual channels of data are carried at different wavelengths over one pair of fiber links. DWDM assigns one wavelength of light (λ) to each data stream applied. These wavelengths are then multiplexed through a single fiber pair. The process is protocol independent. The channel module locks in on the bit rate assigned. Distance is limited by the power of the laser, typically 80 km or less. Ratios of 32:1 protected channels are available for enterprises, and 128:1 for carrier-class systems.

Director

Channel directors in the Symmetrix system provide (through adapters) the interfaces between the host channels and data storage. SRDF directors are channel directors (Gigabit Ethernet, Fibre Channel, or ESCON) that are configured for SRDF.

E1

Also known as CEPT1, the 2.048 Mb/s rate used by European CEPT carriers to transmit 30 64 Kb/s digital channels for voice or data calls, plus a 64 Kb/s signaling channel and a 64 Kb/s channel for framing and maintenance. E1 has similar latency characteristics to T1. Refer to T1.

E3

Also known as CEPT3, the 34.368 Mb/s rate used by European CEPT carriers to transmit 16 CEPT1s plus overhead. E3 has similar latency characteristics to T3. Refer to T3.

Enginuity

The operating environment for Symmetrix 8000 series and newer systems that provides high-speed, highly available storage management functionality. The term is equivalent to *microcode* in older Symmetrix systems.

ESCON

An IBM mainframe serial-I/O channel path, which allows attachment of one or more control units to an ESA/390 channel subsystem by using optical fiber links. Best case throughput is 17 MB/s. This forms the basis of the original transport layer for SRDF between Symmetrix systems and still works very well today.

FA

Symmetrix Fibre Channel director. When this director is configured for SRDF, it becomes an RF.

Fibre Channel

Open systems high-performance serial-I/O channel path, with data rates up to 200 MB/s. Fibre Channel transports SCSI commands and data in serial frames, which can be routed in a switched environment.

Fibre Channel combines the performance, hardware-based functionality, and reliability of I/O channels with the distance and routing benefits of serialized network protocols. This forms the basis of the second-generation transport layer for SRDF.

Gb/s

Gigabits per second.

Gigabit Ethernet (GigE)

Ethernet framing format operating at 1024 Mb/s, primarily over fiber. It is a full-duplex implementation, using a variable-length payload of 64-byte to 1514-byte packets. Used primarily as a LAN backbone.

IP

Internet Protocol, designed to provide addressing and routing at a level capable of being routed over multiple transports, enabling the creation of internets. Transports are rapidly consolidating to Ethernet for the LAN, and SONET and dark fiber for the WAN.

Internet

Spelled with a lowercase “i,” a collection of networks interconnected by a set of routers that allow them to function as a single, large virtual network.

Spelled with an uppercase “I,” the largest internet in the world, consisting of large national backbone nets and a variety of regional and local campus networks all over the world. The Internet uses the Internet Protocol suite.

ISL

Interswitch link, the link between two Fibre Channel switches in a fabric.

Mb/s

Megabits per second.

MPCD

Multiprotocol Channel Director, a two-port or four-port Symmetrix director that can be configured for GigE, iSCSI, or FICON. Refer to *Multiprotocol Channel Director (MPCD) on Symmetrix DMX Series* on page 12.

MTU

Maximum Transmission Unit.

Multimode Fibre (MM)

Fibre Channel cable with a glass diameter of either 62.5 μm or 50 μm . MM is less expensive than single-mode (SM) cable, but has less range because the larger diameter allows more reflections off the sides of the glass, producing a fuzzy optical signal over long distances. Single-mode cable is much smaller in diameter and there is less reflection, enabling an acceptable signal to travel farther. Multimode fiber works well up to 500 meters.

Packets over SONET (PoS)

Places the IP layer directly above the SONET layer, and while offering quality of service, eliminates the overhead of using the ATM protocol as a transport between the SONET and IP packet.

PVC

Permanent Virtual Circuit, or virtual channel connection (ATM), that is established by administrative means, much like a leased or dedicated real circuit.

RA

ESCON remote adapter. Refer to *ESCON Director (RA)* on page 13.

RE

Gigabit Ethernet remote adapter. Refer to *Gigabit Ethernet Director (RE)* on *Symmetrix 8000* on page 13.

RF

Fibre Channel remote adapter. Refer to *Fibre Channel Director (RF)* on page 13.

Single-Mode Fibre (SM)

Fibre Channel cable with a glass diameter of 9 μm . The smaller glass diameter (compared to MM) results in much less light reflection off the sides of the glass and, therefore, fewer wave fronts in the signal. This increases the effective distance an acceptable optical signal can travel.

Single-mode fibre connections between Symmetrix systems can be up to 10 km if single-mode ports on the Symmetrix system are used. Long runs between Fibre Channel switches are typically done with single-mode fiber.

SONET

Synchronous Optical Network Transport, a physical layer technology designed to provide a universal transmission and multiplexing scheme, with transmission rates in the multiple-Gb/s range, and a sophisticated operations and management system. SONET is the transport layer between the network protocol and the physical fiber that provides the framing and add/drop multiplexing function. Throughput ranges from OC-1 at 51.84 Mb/s to OC-256 at 13 Gb/s. OC-192 is currently being deployed for long-haul traffic within carrier networks, connecting data centers and local offices.

T1

Point-to-point digital communications circuit (DS1) provided by North American carriers for voice and data transmission (1.544 Mb/s). T1 has similar latency characteristics to E1. Refer to E1.

T3

Point-to-point digital communications circuit (DS3) provided by carriers for voice and data transmission (44.5 Mb/s in U.S. or 34 Mb/s in Europe-E3); can be divided into 24 separate 64 Kb channels. T3 has similar latency characteristics to E3. Refer to E3.

TCP

Transmission Control Protocol.