Backup and Recovery in a SAN

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For the most up-to-date information, always consult the EMC Support Matrix (ESM), available through E-Lab Interoperability Navigator (ELN), at: http://elabnavigator.EMC.com, under the PDFs and Guides tab.
Under the **PDFs and Guides** tab resides a collection of printable resources for reference or download. All of the matrices, including the ESM (which does not include most software), are subsets of the E-Lab Interoperability Navigator database. Included under this tab are:

- The **EMC Support Matrix**, a complete guide to interoperable, and supportable, configurations.
- Subset matrices for specific storage families, server families, operating systems or software products.
- Host connectivity guides for complete, authoritative information on how to configure hosts effectively for various storage environments.

Under the **PDFs and Guides** tab, consult the **Internet Protocol** pdf under the "Miscellaneous" heading for EMC's policies and requirements for the **EMC Support Matrix**.

Related documents include:

- The following documents, including this one, are available through the E-Lab Interoperability Navigator, **Topology Resource Center** tab, at [http://elabnavigator.EMC.com](http://elabnavigator.EMC.com).

These documents are also available at the following location:


- **Building Secure SANs TechBook**
- **Extended Distance Technologies TechBook**
- **Fibre Channel over Ethernet (FCoE): Data Center Bridging (DCB) Concepts and Protocols TechBook**
- **Fibre Channel over Ethernet (FCoE): Data Center Bridging (DCB) Case Studies TechBook**
- **Fibre Channel SAN Topologies TechBook**
- **iSCSI SAN Topologies TechBook**
- **Networked Storage Concepts and Protocols TechBook**
- **Networking for Storage Virtualization and RecoverPoint TechBook**
- **WAN Optimization Controller Technologies TechBook**
- **EMC Connectrix SAN Products Data Reference Manual**
- **Legacy SAN Technologies Reference Manual**
- **Non-EMC SAN Products Data Reference Manual**

- **EMC Support Matrix**, available through E-Lab Interoperability Navigator at [http://elabnavigator.EMC.com > PDFs and Guides](http://elabnavigator.EMC.com > PDFs and Guides)
Backup and Recovery in a SAN TechBook

Preface

- RSA security solutions documentation, which can be found at http://RSA.com > Content Library

All of the following documentation and release notes can be found at EMC Online Support at https://support.emc.com.

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- Host Connectivity Guides
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For Cisco and Brocade documentation, refer to the vendor’s website.

- http://cisco.com
- http://brocade.com

Authors of this TechBook

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**Note:** A note presents information that is important, but not hazard-related.

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- Names of interface elements (such as names of windows, dialog boxes, buttons, fields, and menus)
- Names of resources, attributes, pools, Boolean expressions, buttons, DQL statements, keywords, clauses, environment variables, functions, utilities
- URLs, pathnames, filenames, directory names, computer names, filenames, links, groups, service keys, file systems, notifications

**Bold**  
Used in running (nonprocedural) text for:

- Names of commands, daemons, options, programs, processes, services, applications, utilities, kernels, notifications, system calls, man pages

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This chapter provides the following information on traditional backup and recovery architectures.

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Overview of backups

This section provides basic information on backup and recovery.

Terminology

The following terminology is used throughout this section.

- **Back up** — Create a copy of data.
- **Archive** — Move data with low usage patterns to a slower media for historical or other purpose.
- **Restore** — Copy a file or group of files from a backup to the primary storage location.
- **Recover** — Rebuild a system or data center from backups.

Why perform backups?

Backups are needed as an insurance policy against loss of data, which can occur because of:

- Hardware failures
- Human error
- Application failures
- Security breaches, such as hackers or viruses

High-availability storage arrays have reduced the need to recover data because of hardware failures. Hardware availability features can protect data from loss due to hardware failures; however, these availability features cannot protect against the other factors that can result in loss of data.

Backups are sometimes used as an archive; for instance, government regulations require that certain financial data must be kept for a specific number of years. In this context, a backup also becomes an archive.
Backup architectures

Refer to the appropriate sections for more information on these backup architectures:

Traditional backup architectures are discussed in his chapter:
- “Direct-attached backups” on page 16
- “LAN-based backups” on page 18

SAN backup topologies are discussed in Chapter 2, “SAN-based Backup and Recovery”:
- “LAN-free backups” on page 24
- “Serverless backups” on page 29
- “NAS backups” on page 45

Disk and tape backup and recovery technologies are discussed in Chapter 3, “Disk and Tape Backup and Recovery.”
Direct-attached backups

Many organizations started with a simple backup infrastructure called direct-attached. This topology is also sometimes referred to as host-based or server-tethered backup. Each backup client has dedicated tape devices. Backups are performed directly from a backup client’s disk to a backup client’s tape devices.

**Figure 1** Data flow for direct-attached backups

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**Advantages**

The key advantage of direct-attached backups is speed. The tape devices can operate at the speed of the channels. Direct-attached backups optimize backup and restore speed, since the tape devices are close to the data source and dedicated to the host.

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**Disadvantages**

Direct-attached backups impact the host and the application, since backups consume host I/O bandwidth, memory, and CPU resources.

Direct-attached backups are generally better suited for smaller environments. Growth rates in servers and data can cause direct-attached backups to become costly and difficult to manage and operate. Organizations with large growth may experience some or all of the following issues with direct-attached backup infrastructures:

- Large numbers of tape devices might be underutilized.
- A wide variety of backup media might be in use.
Operators could find it difficult to manage tape. Tape devices might be scattered between floors, buildings, or entire metropolitan areas.

Each server might have unique (and possibly locally created) backup processes and tools, which can complicate backup management and operation.

It might be difficult to determine if everything is being backed up properly.

Dispersed backups, multiple media types, diverse tools, and operational complexity can challenge the task of business continuance recovery.

Migration paths

Organizations that have outgrown direct-attached backup infrastructures have several migration paths, described in these sections:

- “LAN-based backups” on page 18
- “LAN-free backups” on page 24

Improvement options

The following can also improve backup speed and efficiency:

- Utilize EMC® TimeFinder® to reduce production impact by making a snapshot of the production disk that will be backed up
- Implement faster devices, including disk and disk libraries
- Improve disk and tape pathing
LAN-based backups

LAN backup infrastructures can be configured similar to the schematic illustrated in Figure 2.

The metadata server is the central control point for all backups. This is where the metadata (also known as tape catalog or backup index) and backup policies reside. Tape control servers manage and control backup devices, and are controlled by the metadata server. (A metadata server can also be a tape control server.) The primary use of LAN backup topologies is to centralize and pool tape resources.

Backup process overview

The backup process is as follows:

1. The metadata server invokes backup client processes on the backup client.
2. The tape control server places tapes into the tape drives.
3. The backup client determines which files require backup.
4. The backup client reads the backup data from disk and writes the backup data to the LAN.
5. The tape control server reads the backup data from the LAN and writes the backup data to the tape.
6. The backup client and the tape control servers send metadata information to the metadata server, including what was backed up and which tapes the backups used.
7. The metadata server stores the metadata on disk.

Advantages

The key advantages of LAN-based backups compared to direct-attached backups are:

- Reduced costs — Pooling tape resources improves tape device utilization and reduces the number of tape drives required, which also results in fewer host bus adapters.

Some small servers may require backups; because of tape drive cost or limited card slot availability, however, it might not be practical to dedicate a tape drive to one of these systems. LAN backups can address these issues.

- Improved management and operability — Centralized backups reduce management complexity; there are fewer resources to manage, and they are all in one place.

Centralizing tape resources into tape control servers improves the productivity of the operations staff, especially when backup clients are scattered across floors of a building, campuses, or cities. Operability can be improved further by utilizing automated, robotic tape libraries.

Disadvantages

A LAN-based infrastructure introduces some disadvantages to the backup process:

- Backups impact the host and the application.
- A LAN-based backup adds two additional data movement steps.
Traditional Backup and Recovery

- Backups consume host I/O bandwidth, memory, LAN, and CPU resources.
- There could be network issues.
- A LAN-based backup might require dedicated media servers.
- There could be restore and cloning issues.

**Additional data movement steps**
LAN backups require two additional data movement steps to put the backup data on tape, as illustrated in Figure 3.

![LAN Backup Flowchart]

1. Client reads from disk
2. Client writes to LAN
3. Server reads from LAN
4. Server writes to tape

**Figure 3** LAN backup: Additional steps

Additional CPU and memory resources are required on the backup client (compared to directly connected tape devices) to comply with network protocols, format the data, and transmit the data over the network. Note that restore processing in a LAN environment is identical except that the data flows in the opposite direction.

**Resource consumption**
Like direct-attached backups, LAN backups consume CPU, I/O bandwidth, and memory. Since the final destination of the backup data resides elsewhere on the LAN, additional CPU is required on a tape control server. LAN bandwidth is also required.
Network issues
LAN backups will generally not perform as well as direct-attached backups. Additional data movement steps, network protocol overhead, and network bandwidth limits reduce the speed of backups. If the network segment is not dedicated to backups, the backup performance can be erratic, since it is vulnerable to such other network activity as large FTPs, video, audio, and email.

Even the fastest available network connections can be overwhelmed by a few disk connections. Backup disk I/O consists of intense read activity. Modern cached disk arrays, like the EMC® Symmetrix® system, process I/O as fast as the channels will allow. Cache arrays with two Ultra SCSI or Fibre Channel connections are capable of exceeding the theoretical and practical rates of even the faster networking technologies. A single logical disk per path can impact the network for lengthy bursts, and multiple logical disks can saturate the network for long periods.

Environments that back up many logical disks to many tape libraries will constrain even the fastest network technologies. Adding additional LAN bandwidth may not always be technically feasible, since there are often limits on how many high-speed NICs (network interface cards) a server can support.

LAN backups can increase management and troubleshooting complexity. Performing backups through firewalls can be a challenge. Troubleshooting may require engagement with operations personnel,
system administrators, storage administrators, and network administrators to resolve a problem.

**Possible requirement for dedicated tape control servers**
LAN-based backups can require dedicated tape control servers to drive the tape devices and to act as a tape central control point. Many larger organizations implement metadata servers with no tape devices, along with dedicated tape control servers for the tape libraries. Some tape device maintenance (especially SCSI) can require the server to be taken out of service. If there are multiple tape robots connected to dedicated tape control servers and the metadata server is kept separate, restores and other backups can continue while maintenance is performed on the tape device. Dedicated tape servers are not always a technical requirement, but they are quite often an operational requirement.

**Migration paths**
Organizations that have outgrown direct-attached backup infrastructures have several migration paths, including the following, described later in this document:

- “LAN-free backups” on page 24

**Improvement options**
The following can also improve backup speed and efficiency:

- Utilize TimeFinder BCVs to reduce production impact
- Implement faster devices, including disk and disk libraries
- Improve disk and tape pathing
This chapter provides the following information on SAN-based backup and recovery, including case studies.

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LAN-free backups

LAN-free backups, as shown in Figure 5, utilize SAN (Storage Area Network) technology in conjunction with backup software that supports tape pooling. The high-speed and extended distance capabilities of Fibre Channel are used for the backup data movement path. Metadata is still moved over the LAN to the backup metadata server. This traffic is typically light and insignificant in relation to the large amounts of data moved during a backup. In a LAN-free architecture, the metadata server is also the control point for the robotic mechanism of the tape library.

Backup process overview

The backup process is as follows:

Note: The order of steps 2, 3, and 4 may vary depending on the backup tool that is utilized.

1. The metadata server invokes backup client processes on the backup client.

2. If tape pooling is used, the metadata server assigns tape devices to the backup client.
3. The metadata server instructs the tape robot to load tapes into the assigned drives.

4. The backup client determines which files require backup.

5. The backup client reads the backup data from disk through the SAN and writes backup data to the tape device through the SAN.

6. The backup client sends metadata information to the metadata server, including what was backed up and what tapes the backups used.

7. The metadata server stores the metadata on disk.

In theory, LAN-free backups can be implemented without tape pooling capabilities. This would provide the benefits of Fibre Channel performance and distance. This approach would essentially be a direct-attached backup at extended distance and would not address the tape utilization and management issues associated with direct-attached backups.

Organizations that are evolving from a direct-attached backup topology to LAN-free backup topology can gain additional benefits from tape pooling. Organizations that are evolving to LAN-free backups from a LAN backup topology are already conceptually performing tape pooling functions. To implement LAN-free backups without tape pooling would potentially require an increase in the number of tape devices. The remainder of this section assumes that backup software with tape pooling capabilities is part of the solution.

**Advantages**

An SAN-enabled backup infrastructure introduces these advantages to the backup process:

- Fibre Channel performance, reliability, and distance
- Fewer processes and less overhead
- No need to use the LAN to move backup data
- Elimination or reduction of dedicated media servers
- Improved backup and restore performance

**Fibre Channel performance, reliability, and distance**

Fiber is designed for data movement and storage functions. This makes Fibre Channel an ideal channel for moving backup data.
The performance capabilities of Fibre Channel allow the backup application to move the backup data at the speeds required for modern backup windows. Switched fabric provides the capability to connect multiple backup clients to the tape libraries, and is key to providing tape pooling. The distance capabilities of Fibre Channel allow the solution to maintain a centralized architecture. SAN-enabled backups provide centralization and tape pooling while operating at direct-attached backup speeds.

**Fewer processes and less overhead**

Figure 6 shows the process flow for SAN backups. Two steps are required to copy the data to the backup media. (LAN backups require four steps.) The reduction in data movement steps reduces CPU and memory resource requirements for backup. Since restore processing follows the same steps (except that the data flows in the opposite direction), restores will perform faster with fewer resources as well.

![Process flow for SAN backups](image)

**No need to use the LAN**

By removing the network bottleneck, the SAN allows the tape libraries to operate to full performance. Elimination of network traffic will also free CPU and memory, since the data does not need formatting for network transfer and networking protocols do not have to be managed by the system for backup traffic.

Additionally, overall system performance improves because of the reduction of backup traffic on the LAN.
Elimination or reduction of dedicated media servers
SAN reduces or eliminates dedicated media servers. CPU consumption for backup processes is directly related to the number of data movement steps. Since a LAN-free backup requires two fewer steps to move backup data, there are less CPU resources required. This CPU savings for LAN-free backups is on the media server. Organizations evolving from LAN backups to LAN-free might have the option to downsize or eliminate dedicated media servers because of the CPU reductions.

Improved backup and restore performance
Backup and restore performance is improved because of the following factors:

- Number of processing steps is reduced.
- Backup traffic is moved to higher bandwidth and higher reliability fiber connections.
- Network protocol overhead is eliminated.

These factors also improve overall system performance. EMC PowerPath® will also help balance and manage disk path contention caused by backup load.
Disadvantages

LAN-free backups impact the host and the application. LAN-free backups also consume host I/O bandwidth, memory, and CPU resources.

Migration paths

Organizations that have exceeded the capabilities of LAN-free backups have several migration paths, including the following, described further in this chapter:

◆ “Serverless backups” on page 29 — An emerging enhancement to LAN-free backups is the serverless backup concept. Serverless backup utilizes the third-party copy capability of the Fibre Channel standard to move the backup data over the SAN straight from disk to tape under the control of the backup application.

Improvement options

The following can also improve backup speed and efficiency:

◆ Faster devices
◆ Improved pathing
◆ Utilization of TimeFinder BCVs
Serverless backups

Serverless backups, as shown in Figure 8, use SAN resources to move backup data from disk to tape. These backups are called serverless because the application server does not have to utilize host resources to perform the movement of backup data. Serverless backups are the next evolutionary step in LAN-free backup.

**Note:** Serverless backups are sometime referred to as server-free backups.

![Figure 8 Serverless backup](image)

**Theory of operation**

Serverless backups use the *third-party copy* function (also called *extended copy*) of the Fibre Channel standard. Third-party copy allows a device to copy data between points on the SAN. A device performing third-party copy can be thought of as a copy engine.

Currently, Cisco is supporting serverless backup in its switches with a SSM module. Cisco refers to this feature as NASB. The copy task is initiated and controlled by a host application that instructs the copy engine to copy a specific number of blocks from the source device to the target device.
EMC NetWorker® offers support for Windows and VERITAS offers support for Solaris. The copy engine then copies the data, block by block, until complete. The copy engine performs all of these copies inside the SAN and outside of the host.

With serverless backups, the backup application determines which blocks on disk require a backup. The backup application then instructs the copy engine to copy these disk blocks to the tape device.

Backup process overview

A typical backup process follows these steps:

Note: The order of steps 2, 3, and 5 may vary depending on the backup tool that is utilized.

1. The metadata server invokes backup client processes on the backup client.
2. If tape pooling is used, the metadata server assigns tape devices to the backup client.
3. The metadata server instructs the tape robot to load tapes into the assigned drives.
4. The metadata server notifies the backup client which tape drives it may use.
5. The backup client determines which files require backup.
6. The backup client instructs the copy engine to copy data, block by block, from the storage directly through the SAN to the tape drive.
7. When the backup is complete, the backup client sends metadata information to the metadata server.
8. The metadata server stores the metadata on disk.

Advantages

Serverless backups offer the following advantages over server-based backups:

- Fibre Channel performance, reliability, and distance — Fibre is designed for data movement and storage functions. This makes Fibre Channel an ideal channel for moving backup data.
- No use of host resources to move backup data — Since the backup data is moved outboard from the host CPU, memory and I/O bandwidth resources are not consumed. This substantially reduces the impact on the application by removing resource contention points. Large organizations can realize a significant CPU savings during the backup window.

- Reduced application impact.

- No use of the LAN to move backup data — By removing the network bottleneck, the SAN allows tape libraries to operate to full performance. The elimination of network traffic will also free CPU and memory, since the data does not have to format for network transfer, and networking protocols do not require management by the system for backup traffic.

- Improved backup and restored performance — Backup performance is improved primarily because of reduced host-contention points. This serverless architecture is also designed to keep the tape devices streaming so that they operate at maximum performance.

Performance is improved because:

- Processing steps are reduced.
- Backup traffic is moved to higher bandwidth and higher-reliability fiber connections.
- Network protocol overhead is eliminated.

These factors also improve overall system performance. PowerPath also helps balance and manage disk path contention caused by backup load.

**Disadvantages**

Since serverless backups move data over the production SAN, there is a potential to cause an indirect impact on applications if the SAN has heavy I/O activity. Some implementations of serverless backup operate at the logical disk level, as opposed to the file level.
Backup over long distances using FCIP and routers

Using FCIP and routers allows backups over long distances within a SAN environment. It also allows longer distance vaulting for security, remote copy, real estate, etc. Tape acceleration techniques help ensure acceptable performance.

Figure 9 shows a typical SAN on both the right side and on the left. The routers link the two SANs together using FCIP. The SANs behave as if they are a SAN ISL, making the two SANs appear as one large SAN, thus extending the distance over which backups can occur.

Figure 9  Backup over long distances

Theory of operation

Long distance backup utilizes SAN (storage area network) technology in conjunction FCIP using traditional backup software. The high-speed and extended distance capabilities of Fibre Channel and FCIP are used for the backup data movement path. Metadata is still moved over the LAN to the backup metadata server. This traffic is typically light and insignificant in relation to the large amounts of data moved during a backup. The metadata server is also the control point for the robotic mechanism of the tape library.
Advantages

An SAN-enabled backup infrastructure introduces these advantages to the backup process:

- Fibre Channel performance, reliability, and distance.
- Fewer processes and less overhead.
- Use of inexpensive dedicated LAN to move backup data to more remote locations.
- Elimination or reduction of dedicated media servers.
- Improved backup and restore performance.
FCIP tape acceleration with EMC Connectrix MDS switches

Tape devices store and retrieve data sequentially. Normally, accesses to tape drives have only one outstanding SCSI write operation at any given time. This single command nature of tape writes impacts backup and archive performance because each SCSI write operation does not complete until the host receives a good status response from the tape drive.

The FCIP tape acceleration feature, introduced in MDS SAN-OS Release 2.0(1b), solves this problem. It improves tape backup and archive operations by allowing faster data streaming from the host to the tape over the WAN link.

With tape acceleration, the backup server issues write operations to a remote tape drive.

Figure 10 illustrates FCIP link tape acceleration.
The local EMC Connectrix® MDS switch acts as a proxy for the remote tape drive by quickly returning a Transfer Ready (Write Accelerator) signal to the host. This enables the host to more quickly begin sending the data.

After receiving all the data, the local Connectrix MDS switch responds to signal the successful completion of the SCSI write operation (Tape Accelerator). This response allows the host to start the next SCSI write operation.

This proxy method of operation results in more data being sent over the FCIP tunnel in the same time period compared to same operation with no proxying. This proxying method also improves the utilization of WAN links.

At the other end of the FCIP tunnel, another Connectrix MDS switch buffers the command and data it has received. The remote Connectrix MDS switch then acts as a backup server to the tape drive by listening to a Transfer Ready from the tape drive before forwarding the data.

The Connectrix MDS SAN-OS provides reliable data delivery to the remote tape drives using TCP/IP over the WAN. Write data integrity is maintained by allowing the Write Filemarks operation to complete end-to-end without proxying. The Write Filemarks operation signals the synchronization of the buffer data with the tape library data. While tape media errors are returned to backup servers for error handling, tape busy errors are retried automatically by the Connectrix MDS SAN-OS software.

For more information, refer to the MDS 9000 Family Fabric Manager Configuration Guide, available at EMC Online Support.

Notes

Note the following:

- The tape acceleration feature is disabled by default and must be enabled on both sides of the FCIP link. If it is only enabled on one side of the FCIP tunnel, the tunnel is not initialized.

- FCIP tape acceleration does not work if the FCIP port is part of a Port Channel or if there are multiple paths with equal weight between the initiator and the target port. Such a configuration might cause either SCSI discovery failure or broken write or read operations.
SAN-based Backup and Recovery

- When tape acceleration is enabled in an FCIP interface, a FICON VSAN cannot be enabled in that interface. Likewise, if a FCIP interface is up in a FICON VSAN, write acceleration cannot be enabled on that interface.
- Enabling the tape acceleration feature automatically enables the write acceleration feature.
- Enabling tape acceleration for an FCIP tunnel re-initializes the tunnel.
- The flow control buffer size specifies the maximum amount of write data that a Connectrix MDS switch buffers for an FCIP tunnel before it stops the tape acceleration proxying process. The default buffer size is 256 KB and the maximum buffer size is 32 MB.

Enabling FCIP tape acceleration on Connectrix MDS switches

To enable FCIP tape acceleration using Fabric Manager:

1. From Fabric Manager, choose ISLs > FCIP from the Physical Attributes pane.
   The FCIP profiles and links display in the Information pane.
2. From Device Manager, choose IP > FCIP.
   The FCIP dialog box displays.
3. Click the Tunnels tab.
   The FCIP link information displays.
4. Click the Create Row icon in Fabric Manager or the Create button in Device Manager.
   The FCIP Tunnels dialog box displays.
5. Set the profile ID in the ProfileID field and the tunnel ID in the TunnelID field.
6. Set the RemoteIPAddress and RemoteTCPPort fields for the peer IP address you are configuring.
7. Check the Write Accelerator and TapeAccelerator checkbox.
8. Optionally, set the other fields in this dialog box and click Create to create this FCIP link.
FC-Write acceleration on Cisco MDS 9000 Family SSM

This section contains the following information:
- “Cisco MDS 9000 Family SSM” on page 37
- “Cisco I/O Accelerator (IOA)” on page 39

Cisco MDS 9000 Family SSM

The Cisco MDS 9000 Family Storage Services Module (SSM) provides the intelligent service of identifying the SCSI I/O flow for a given initiator-target pair. This information is used to provide the FC-Write acceleration (FC-WA) feature and the feature to gather advanced I/O statistics for a given initiator-target pair. The FC-WA feature decreases the latency of an I/O over long distances. The advanced I/O statistics collected can be used to evaluate storage performance for the initiator-target pair.

The improved performance results from a coordinated effort performed by the Storage Services Module local to the initiator and the Storage Services Module local to the target. The initiator Storage Services Module, bearing the host-connected intelligent port (HI-port), allows the initiator to send the data to be written well before the write command has been processed by the remote target and an SCSI Transfer Ready message has had the time to travel back to start the data transfer in the traditional way.

The exchange of information between the HI-port and the disk-connected intelligent port (DI-port) allows the transfer to begin earlier than in a traditional transfer. The procedure makes use of a set of buffers for temporarily storing the data as near to the DI-port as possible. The information between the HI-port and DI-port is piggy-backed on the SCSI command and the SCSI Transfer Ready command, so there are no additional FC-WA-specific frames traveling on the SAN. Data integrity is maintained by the fact that the original message that states the correct execution disk side of the write operation (SCSI Status Good) is transferred from the disk to the host.
Figure 11 shows the effect of latency in the communication channel to the time taken to complete the I/O operation during a SCSI write operation. The time added to the net execution time of the operation is at least four times the trip delay between the host and the disk because of the transfer of the command, the Transfer Ready message, the data, and the status.

Figure 12 on page 39 shows how FC-WA allows the data to be sent on the line without waiting for the disk Transfer Ready message to be transferred all the way back to the host. To preserve data integrity, the status message is not emulated. Depending on the timing, the latency added by the communication time may be as low as two times the trip delays, transfer of the command, and transfer of status. Therefore the expected distance between the host and the disk can now be increased by up to 50 percent.
Cisco I/O Accelerator (IOA)

The Cisco MDS 9000 Family I/O Accelerator (IOA) feature provides Small Computer System Interface (SCSI) acceleration in a storage area network (SAN) where the sites are interconnected over long distances using Fibre Channel or Fibre Channel over IP (FCIP) Inter-Switch Links (ISLs). Figure 13 on page 40 shows an example of an IOA topology.
Figure 13  IOA topology

Benefits include:

- Unified acceleration service

IOA provides both SCSI write acceleration and tape acceleration features as a unified fabric service. These services were provided in previous releases in the form of Fibre Channel write acceleration for remote replication over Fibre Channel links and FCIP write acceleration and tape acceleration over FCIP links. Fibre Channel write acceleration was offered on the Storage Services Module (SSM) and FCIP write acceleration and tape acceleration were offered on the IP storage services modules. IOA offers both the write acceleration and tape acceleration services on the Cisco MDS MSM-18/4 module, SSN-16 module, and 9222i switch as a fabric service. This eliminates the need to buy separate hardware to obtain Fibre Channel write acceleration and FCIP write acceleration and tape acceleration.
- **Topology independent**
  IOA can be deployed anywhere in the fabric without rewiring the hardware or reconfiguring the fabric. There are no restrictions on where the hosts and targets are connected to. Both the Fibre Channel and FCIP write acceleration is supported only on PortChannels but do not support multiple equal-cost links. FCIP tape acceleration is not supported on PortChannels. IOA eliminates these topological restrictions.

- **Transport agnostic**
  IOA is completely transport-agnostic and is supported on both Fibre Channel and FCIP ISLs between two sites.

- **High availability and resiliency**
  IOA equally supports both PortChannels and equal-cost multiple path (ECMP) links across two data centers. This allows you to seamlessly add ISLs across the two data centers for capacity building or redundancy. IOA is completely resilient against ISL failures. IOA uses a Lightweight Reliable Transport Protocol (LRTP) to guard against any ISL failures as long as there is an alternate path available across the two data centers. Remote replication and tape backup applications are completely unaffected by these failures.

- **Improved tape acceleration performance**
  IOA tape acceleration provides higher throughput numbers than the FCIP tape acceleration, which is limited by a single Gigabit Ethernet throughput.

- **Load balancing**
  IOA uses clustering technology to provide automatic load balancing and redundancy for traffic flows across multiple IOA service engines that can be configured for the IOA service. When an IOA service engine fails, the affected traffic flows are automatically redirected to the available IOA service engines to resume acceleration.
FastWrite acceleration and tape pipelining

To optimize performance of backups over FCIP links, consider using FastWrite and tape pipelining.

**Note:** These features are supported only in Fabric OS 5.2.x and higher.

FastWrite and tape pipelining provide accelerated speeds to FCIP tunnels in some configurations:

- FastWrite accelerates the SCSI write I/Os over FCIP.
- Tape pipelining accelerates SCSI write I/Os to sequential devices (such as tape drives) over FCIP, reducing the number of roundtrip times needed to complete the I/O over the IP network and accelerating the process.

**Note:** You must enable FastWrite in order to use tape pipelining.

- Both sides of an FCIP tunnel must have matching configurations for these features to work.

FastWrite, and tape pipelining features do not require any predefined configurations. This makes it possible to enable these features by adding optional parameters such as `-c`, `-f`, or `-t` when you create FCIP tunnels. Refer to the *Fabric OS Administrators Guide* for further information.

**Brocade 7800 and EMC EDL over IP case study**

In Figure 14 on page 43, a configuration was built with Brocade 7800 and IP network emulating up to 40,000 kilometers distance (EMC EDL 4200 local devices and remote and EMC NetWorker). FastWrite and tape pipelining were turned on for the remote configuration.

In Step 1, the backups are written to the local EMC EDL 4200 device.

In Step 2, the backup is cloned to the remote location which consists of a remote EDL 4200 connected to a remote Brocade 7800. FastWrite and tape pipelining are turned on in both the local and remote Brocade 7800s.
In Figure 14, a configuration was built using EMC Celerra®, Brocade 7800, and an IP network emulating up to 40,000 kilometers distance, EMC EDL 4200 devices locally and remote, and EMC NetWorker. FastWrite and tape pipelining were turned on for the remote configuration.

In Step 1, the backups are written to the local EMC EDL 4200 device by Celerra under NetWorker NDMP control.

In Step 2, the backup is cloned by Celerra under NDMP control to the remote location, which consists of a remote EDL DL710 connected to remote Brocade 7800. FastWrite and tape pipelining are turned on in both the local and remote Brocade 7800s.
Figure 15  Brocade tape acceleration — NDMP remote backup

Note: EDL has IP replication between the EDLs, but this solution uses Celerra NDMP over IP.

Results

Performance is based on the block size, but the improvement with tape pipelining is up to 80%.
NAS backups

The Celerra Network Attached Storage (NAS) device provides supports multiple backup options:

- Local and remote backup
- Network backups
- Network Data Management Protocol (NDMP) backups

Local and remote backup

Local backup uses tape devices that are directly connected to the Celerra.

Remote backup transfers the backup data to another server that contains a tape device. The backup data may be transmitted over the network or it may be transferred through direct server-to-server connection.

NDMP backup

The Network Data Management Protocol (NDMP) is an open standard communication protocol that is specifically designed for backup of network attached storage devices. NDMP enables centralized backup management and minimizes network traffic.

A key feature of NDMP is that it separates the flow of data from the management of the data. This allows third-party backup tools to interface with Celerra and maintain centralized control. NDMP backups can be performed locally (NDMP V1) with tape devices connected directly to the Celerra or remotely (NDMP V2) to another location. Both of these options are managed by the third-party backup tool.
Figure 16 on page 46 shows an example of NDMP.

For more information on Celerra backups can be found in various Celerra documents available at EMC Online Support.

For more information on NDMP backups on an EMC VNX™ series system, refer to the EMC VNX Series Configuring NDMP Backups on VNX document, available at EMC Online Support.
This chapter provides the following information on backup and recovery.

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Backup and recovery

This section briefly describes the following:

- “Tape-based backup” on page 48
- “Disk-based backup” on page 48
- “Deduplication” on page 49

Tape-based backup

Traditional tape-based backup systems can be slowed by the mechanical nature of tape.

Consider the following:

Tape Speed = Tape Transfer Rate + Mechanical Motion

where mechanical motion consists of the following factors:

- Robot mount / dismount time
- Load-to-ready times, find the start of the tape
- Rewind times

Disk-based backup

Disk arrays can be faster than tape for both backups and restores. Advantages include:

- Potentially faster transfer speeds
- No mount, rewind, load-to-ready issues
- Not vulnerable to streaming issues

A potential disadvantage of backup to disk is that it may require changes to existing backup processes and operations.

For more information concerning backup to disk, refer to the EMC VNX Series Configuring NDMP Backups on VNX document, available at EMC Online Support.
Deduplication

Data deduplication is a method of reducing storage needs by eliminating redundant data. Only one unique instance of the data is actually retained on storage media, such as disk or tape. Redundant data is replaced with a pointer to the unique data copy.

Deduplication occurs across the files. Any redundant data across the files (not only within the file as in case of compression) is stored only once.

The deduplication process searches all files that have redundant chunks of data and saves only the unique blocks in the disk, adding a pointer whenever a block is repeated. As a result, the disk capacity required to store the files is reduced. Figure 17 shows an example of the data deduplication process.

**Figure 17  Data deduplication process**

Data deduplication enables organizations to reduce back-end capacity requirements by minimizing the amount of redundant data that is ultimately written to disk backup targets. The actual data reduction can vary significantly from organization to organization or from application to application depending on a number of factors, the most important being the rate at which data is changing, the frequency of backup and archive events, and how long that data is retained online.

Benefits include:

- Lower storage space requirements, hence reducing disk expenditure and power and cooling requirements.
- Longer disk retention periods.
- Reduction in the amount of data to be sent over distance.
EMC has the following deduplication options:

- **Avamar®**
  This is a deduplication backup software that identifies redundant data at the source, thereby reducing the amount of data sent over the fabric.

- **Data Domain® Deduplication appliance**
  This is the storage which dedupes the data before storing, hence reducing the disk space.

- **NetWorker**
  This backup application provides deduplication with integration of Avamar.

For more information, refer to the *Backup and Recovery: Accelerating Efficiency and Driving Down IT Costs Using Data Depulication* White Paper, available at [EMC Online Support](https://www.emc.com).
Data archiving is the process of moving data that is no longer actively used to a separate data storage device for long-term retention.

Data archives consist of older data that is still important and necessary for future references, as well as data that must be retained for regulatory compliance. Archives are indexed and have search capabilities so that files, and parts of files, can be easily located and retrieved.

Generally, the data to be archived is moved to slow and less expensive storage, mainly to tape. The tape can be moved out of the library and stored in external offsite storage that is considered safe from the possibility of disasters. The archive is the primary copy of the data. All other copies of the data are deleted. Only one copy is stored as archive.

Archive to tape can be done directly from the disk storage, such as Virtual Tape Library. The EMC Disk Library (EDL) has an export-to-tape feature that transfers the data from the disk to tape without using the server for the backup and archiving to tape. When the tape is directly connected to the EDL, it frees the network of the traffic associated with the archiving process.
Backup media

This section includes the following information on backup media:

- “Tape libraries” on page 52
- “Editing the Solaris configuration file: st.conf” on page 52
- “HBAs” on page 53
- “Tape drives” on page 54

Tape libraries

A tape library consists of tape storage facilities, a robotic tape selection mechanism (sometimes referred to as a picker), and tape devices.

Tape libraries connect to the SAN with two types of connections: the data path and the robotic control path. The data path is the mechanism that moves data between the server and the tape device(s). The robotic control path controls the robotic mechanisms.

The robotic control (picker) path connects to the SAN with an embedded bridge or blade located in the tape library. Depending on the tape library and customer preferences, the drive data path can connect through the blade, or directly to the SAN. Some newer libraries do not use a blade for the picker. In this case, one drive is configured to be the control LUN-based drive, and the picked control path is a LUN under the drive. There are no significant technical advantages or disadvantages to either connection.

The key benefit from a SAN backup comes from the ability to connect the tape devices to the SAN.

Editing the Solaris configuration file: st.conf

Note: Valid only for Solaris 8 and below non-Leadville-based Solaris configurations.

If tape devices are addressed (through a blade, bridge or control drive) they can use target IDs and LUNs greater than zero. The driver configuration file /kernel/drv/st.conf must be modified to include the correct definitions for each target ID and LUN. The Solaris driver treats all entries in all target drivers (such as sd and st)
as one continuous assignment per instance of the HBA. Therefore, be sure that `st.conf` does not contain target numbers already specified in `sd.conf`. Different HBAs behave in slightly different ways, so consult your HBA vendor to see if these changes are needed.

Solaris provides host application access to the tape through:

```
/dev/rmt/0, /dev/rmt/1,...x
```

Therefore, `/drv/rmt/<x>` addresses must be used for the tape access.

**Note:** The numbering in `/dev/rmt` should be sequential, starting with 0.

**Note:** Changes to `st.conf` do not take effect until the host is rebooted with the reconfigure option (`reboot -- -r`).

---

**CAUTION**

Deleting internal drive entries from `/kernel/drv/st.conf` makes your host unbootable.

---

**HBAs**

Persistent binding is recommended. Persistent binding keeps the LUNs and tape numbers consistent since there is a slight chance that they could change during a system event. Consult your HBA vendor for details.

**Windows**

Requires no additional settings. You must install a tape driver when working with a tape drive.

**Sun Solaris**

*(Fibre Channel tape support)*

You may need to change two files:

- `sd.conf` — Configuration file used for disks; outlines the specific devices that can be used, and enables binding.

- `st.conf` — Configuration file used for tapes; all tape drives must be listed in this file, and binding can be enabled.
Tape drives

All new generation tape drives support FC-SW and FC-AL. Some drives may default to loop. EMC recommends setting your switch or drive to FC-SW. Some devices have two ports; EMC supports the use of only one port at a time.

Each Fibre Channel tape drive is configured with a static, unique World Wide Name (WWN) assigned by the manufacturer. You can use this WWN during the fabric zoning process to allow servers access to tape devices.

The most popular drive technology is LTO, which is currently at generation 5. There are variants of half-height and full-height LTO 4 and LTO 5 tape drives.

- LTO 5 has the capability of 8 G FC interface and can store 1.5 TB of native data and 3 TB in compressed form.
- LTO 4 and LTO 5 tape drives also provide target-based encryption of the data-at-rest with the use of Key manager for storing and managing the encryption keys.

Oracle’s Storagetek tape drives T10000A and T10000B also provide the encryption functionality.
Mirrored fabric backup solution

EMC supports many Fibre Channel tape backup solutions. This section describes the solution that best fulfills the following objectives:

- **Ease of management:**
  - No new zone sets are required; only new tape zones.
  - Traffic patterns/routes are direct and deterministic.

- **Supportability:**
  - No new hardware or configuration is required.
  - Affected resources are easily identified because of consistent placement and routing.

- **Flexibility:**
  - PowerPath allows non-simultaneous use of the same HBAs for both disk and tape.

  **Note:** PowerPath does not provide multipathing or failover solutions for tape.

  - Core/edge fabric topologies allow traffic segregation and localization, so bandwidth requirements can be managed separately.

- **Scalability** — Provides the scalability benefits of the mirrored, core/edge fabric design.

- **Availability:**
  - Core/edge fabrics provide multiple paths from servers to tapes.
  - Mirrored fabrics protect against HBA failures, switch failures, tape failures, fabric failures, and maintenance activities.

- **Maintainability** — Since all servers have access to tapes on both fabrics, either fabric can be placed in a maintenance state without catastrophically interrupting the backup cycle.

- **Maximum return on capital investments:**
  - PowerPath allows hosts to provide additional disk access when backups are not being performed. (Backup customization may be required.)
Disk and Tape Backup and Recovery

- Better utilization of bandwidth, ISLs, and switch ports.

“Solution description” on page 56 describes the solution in detail, and illustrates how each aspect of the backup solution adheres to the project requirements.

Solution description

Since tape drives are supported as single attached devices only, our solution must provide a means to protect our backup resources in the event of a failure in the environment. To accomplish this, EMC recommends that tape drive resources be distributed evenly across both sides of the proposed mirrored fabric environment.

Understanding the importance of backup resources in your business continuance plan, EMC strives to provide the highest level of protection possible, while maximizing the duty cycle of all resources. Each media server or application server (LAN-free backup) in this facility would be configured so that it could access disk and tape storage on both fabrics. This can ensure that any service interruptions or failures on one fabric do not affect the storage (disk/tape) resources attached to the other fabric.

Providing resources that are isolated from the impact of maintenance cycles or failures helps ensure that backup resources are always available when you need them.

The backup software solution should be evaluated for the best way to create media pools of devices that can include tape drives from both fabrics. PowerPath scripting should also be employed to set specific HBAs that share tape and disk into standby mode during backup cycles. Setting a path to standby allows PowerPath to use the HBA in the case of path failure, but would not use it for data traffic during normal conditions.

This procedure can ensure that the HBA is dedicated to tape access during the time of the backup, alleviating contention for bandwidth resources across this link (which could cause backup performance degradation). This procedure is especially useful for hosts that do not have enough available slots for a dedicated tape (backup) HBA. It is also useful for hosts that are already very write-intensive.

Figure 18 on page 57 shows an example of a backup software solution.
Figure 18  Example of backup software solution

Although tape drives can be placed anywhere in the fabric, EMC recommends placing the tape drives at the core of a core/edge fabric. This provides equal (single-hop) access from each of the LAN-free backup servers located at the edge switches. Centralizing the tape storage also helps to prevent any ISL bandwidth congestion that might occur by providing direct routes to the tape storage. This also aids in balancing the backup load across the entire fabric without complex backup scheduling. Backup, restore, and recovery requirements can be maintained simply by adding the required core/edge ISLs needed to handle the peak application and backup bandwidth load.

Dedicated media servers and third-party copy engines (server-free backup) should also be placed at the core of the fabric. Since these servers are dedicated to tape access, placing them at the core ensures that their data will traverse only the internal switch backplane or the core-to-core ISLs. This provides better use of the switch’s internal resources, helping to minimize the required core/edge ISLs.

Utilizing the core-to-core ISLs also provides a means to reduce the contention for ISL resources by segregating the backup traffic from the application traffic. Maintaining the backup objectives for these dedicated media servers and third-party copy engines is managed by adding the proper number of core-to-core ISLs. Because the number of dedicated media servers and third-party copy engines is usually much lower than the number of application servers (backup clients), the fan-out benefits of the core/edge fabric design is not adversely affected. Providing a level of traffic segregation also provides better control over our application server SLAs by minimizing the impact of backup traffic on our application servers and their data routes.
**Figure 19** is a sample of a core/edge fabric with the recommended application server, tape drive, disk storage, and media server placement.

---

**Physical backup device centralization**

Creating a centralized backup location that contains both the trained backup administrators and backup media resources can increase the duty cycles of your backup media, and increase the efficiency of your personnel resources.
Centrally locating the personnel provides the following benefits:

- Faster communication between group members.
- Provides better access and transfer of skills among the members.
- Eliminates the necessity for operators to move between locations for tape processing and troubleshooting.

Summary

While EMC supports many different fabric environments, core/edge mirrored fabric environments offer an efficient, robust design that can fulfill both your application and business continuance requirements.
Tapes and fabrics

This section discusses the following:

- “SCSI tape” on page 60
- “Fibre Channel tape” on page 60
- “Sharing tape and disk on the same HBA” on page 62

For basic information on tape, refer to “Tape libraries” on page 52 and “Tape drives” on page 54.

SCSI tape

SCSI-attached tape storage devices have been, and continue to be, a viable solution in the data storage environment. Whether these devices were legacy hardware, new purchases or advanced SCSI technology, they will also have to communicate with the Fibre Channel portion of the SAN environment. In order to achieve this, they have to be attached directly to SCSI-to-Fibre Channel bridges and through them to the SAN.

Fibre Channel tape

Most native Fibre Channel tape drives available today are FC-SW capable, but there are some early first-generation native FC tape drives that only support Fibre Channel Arbitrated Loop (FC-AL). Consult your tape drive vendor to obtain this information. Public loop devices are arbitrated loop devices that support Fibre Channel fabric login and services. Each Fibre Channel tape drive has one or more NL_Ports (Node Loop Ports), which can be used to connect into either a loop device or fabric device capable of communication with NL_Ports or a loop-to-fabric bridge.

Each Fibre Channel tape drive is configured with a static, unique, World Wide Name (WWN) assigned by the manufacturer. This WWN can be used during the fabric zoning process to allow servers access to the tape devices.

Supported Fibre Channel tape drives

E-Lab Navigator lists the currently supported FC-AL and FC-SW tape drives.
Connecting Fibre Channel tape drives into a fabric

Some fabric switches, routers, and bridges support both the FC-AL protocol and the Fibre Channel Point-to-Point protocol. Point-to-Point is required for SAN appliances that support switched fabric communication. A physical port on such an appliance is referred to as an FL_Port (Fabric Loop Port). FL_Ports may either automatically negotiate the method of communication with a connected N_Port or NL_Port device on initialization, or the user may be required to manually set the port type in the device’s configuration file prior to connecting the devices together. In order to connect with SAN devices that do not support FC-AL (Connectrix ED-1032, for example) a loop-to-switch bridge can be used.

Configuration details

The supported switches all provide the same functionality when configuring Fibre Channel tape drives. Prior to starting the configuration, make sure that the Fibre Channel ports on the tape drives are enabled and that the tape drives are on line:

- **Tape drive connection to switch** — Each port on these switches is capable of auto-negotiating and auto-initializing the port for loop or switch communication. Auto-configuration occurs immediately after the tape devices are connected to the switch port. At the completion of the auto-configuration phase (almost instantaneously), the port should appear as an FL_Port in the name server list on the switch. No additional software or licensing is required for this functionality.

  **Note:** Do not configure these ports as QuickLoop or Fabric Assist ports. The QuickLoop or Fabric Assist mechanisms are not required for public loop device support and are not supported by EMC.

  When the negotiation and initialization is complete, you will also be able to view the tape drive’s WWPN in the switch’s name server list.

- **Server connection to switch** — Each server connected to the switch that will communicate with the FC-AL tape drive should be configured as a Fibre Channel switch fabric device. When the server is connected to the switch it will automatically run through the port negotiation and initialization procedures, but the resultant port configuration will appear as a fabric-capable N_Port in the switch’s name server list. When the negotiation and initialization is complete, you should be able to view the server’s HBA WWPN in the switch’s name server list.
Disk and Tape Backup and Recovery

**Note:** E-Lab Navigator identifies the latest drivers and firmware associated with these HBAs.

- **Zoning** — The switch’s Web browser configuration tool will allow you to zone the unique WWPN of the tape drive with the WWPN of the server’s HBA.

  “Sharing tape and disk on the same HBA,” next, describes the considerations on sharing the same HBA for both disk and tape.

- **Server-to-tape communication** — Translation of FC-AL protocols associated with the tape drive from/to FC-SW associated with the server’s HBA are all handled automatically, internal to the switch. No special settings on the switches are necessary to allow translation and communication.

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**Sharing tape and disk on the same HBA**

While EMC supports simultaneous tape and disk access over the same HBA, some access scenarios impact the feasibility of such a solution. E-Lab Navigator contains specific details about your configuration.

When disk and tape share the same HBA, the HBA must support four I/O activities:

- Production disk reads to support your applications
- Production disk writes to support your applications
- Disk reads to feed the backup operation
- Tape writes to support the backup operation

In heavy I/O environments, these four activities combined can result in I/O path and device contention.

I/O path contention occurs when more than one application is trying to access the same I/O path at the same time. Both operations must arbitrate for control of the path, and one must wait while the other is using the path. All technologies also have their own path bandwidth limits, which must be shared between the operations.

Device contention occurs when multiple operations are trying to access the same information at the same time. Again, while one operation is accessing a resource, other resources must wait their turns.
Path and device contention can result in both reduced application performance and reduced tape backup performance.

Tape devices are sequential media that expect data to be sent in large continuous blocks. This continuous flow of data (called streaming) keeps the tape media progressing at its fastest speed. If streaming is interrupted due to congestion, the drive must stop and back up to the end of the last block transferred before it can accept new data. Stopping and repositioning takes time because of the effort required to gradually slow down the tape drive in an orderly fashion. (Rapid deceleration could damage the media; by stretching the tape, for example.)

Backing up to the last block endpoint and stopping again also involves a change of direction, acceleration and deceleration, a stop, a re-tension, and a position check. Some tape devices (depending on the drive) may also require that the tape be kept at a specific tension level. In this situation, if a data transfer stops, the drive must stop, and back up to the end, after which the tape will move forward and backwards slowly until the data transfer starts again. This method (often called shoe shining) is used to maintain the proper tension on the tape.

Another way that congestion can interfere with your backup is its effect on data compression. Most modern tape devices also have built-in hardware compression. The data is written to a buffer in the tape device, compressed, and then written to the physical media. Part of the compression mechanism involves using standard algorithms; however, part of the compression mechanism also combines the contents of the tape buffer into mega blocks to reduce inter-record gaps on the tape device.

Heavy congestion can also cause tape compression rates to drop, as the drives are unable to use completely full buffers when they create the mega blocks. Since the data is not optimally compressed, more write operations are required to get the data to the tape media. More write operations results in degradation of backup performance. This could also result in more tape cartridges being required and subsequent elongated recovery times because there are now more tape cartridges to recover.

If your backup environment is in a congestion situation, the congestion can be partially addressed by placing disk and tape on separate HBAs. The potential benefits of separate tape and disk HBAs (in congestion situations) include reduced production disk path contention and improved tape performance. If the number of
HBAs on the server is limited, you can also employ PowerPath during the backups to manage the load across the adapters. PowerPath provides the ability to set an HBA into *standby* mode, which allows the HBA to be used if there is a failure, but not for disk traffic (while in standby mode). When the backups were complete, you could set the HBA back into an *active* state. Once the HBA was in an active state, PowerPath would rebalance the disk traffic, using this HBA in its load-balancing calculations.

**Limitations**

Moving the Fibre Channel cables associated with the tape or with the server communicating with the tape to a different switch port while I/O is running will result in I/O failures and device lockout. If this occurs, you may be required to either power cycle the tape device or return the Fibre Channel cables to their original ports, and manually release the tape device to return the system to working order. It will then be necessary to restart the backup job.

EMC supports only single-port usage of the STK 9840. Simultaneous use of both ports can result in contention for devices on both server boot and setting of device reservation.