Solution Overview

Fibre Channel over SONET/SDH

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Proliferation of storage traffic due to disaster recovery and business continuity requirements, combined with the high cost associated with downtime or loss of data, justifies the need for storage area network (SAN) extensions over geographically dispersed areas. Enterprises as well as service providers are seeking affordable solutions to interconnect their SAN islands and implement geographically dispersed data recovery solutions. SAN extension solutions help to interconnect customer storage islands which are geographically dispersed and are the key enabler for disaster recovery and business continuance applications.

The most popular protocols for SAN include Fibre Channel, Enterprise Systems Connection (ESCON), and IBM Fiber Connection (FICON). The three primary technologies available to extend theses protocols across the WAN are SAN over dense wavelength-division multiplexing (DWDM), IP, and SONET/SDH.

Service providers have made significant investments in SONET/SDH networks. Hence, storage over SONET/SDH is considered an essential component of a service provider's SAN extension solution. DWDM networks are ideal to transport high-density, high-bandwidth SAN applications across the metro. For transport of SAN over large distances, service providers can use SAN extensions over SONET/SDH, or their current IP/MPLS core to transport SAN over IP (FCIP or iSCSI). Each method has its own merits and drawbacks.

This document provides an introduction to optical and storage product offerings from Cisco Systems®, with a focus on the SL-Series Fibre Channel/FICON over SONET/SDH interface card for the Cisco® ONS 15454 and the Cisco MDS 9000 Family. It then outlines the applications to deliver Fibre Channel/FICON over SONET/SDH solutions for common disaster recovery and business continuity applications.

Cisco Storage and Optical Products

Cisco ONS 15000 Series Optical Product Portfolio

To meet the demands of service provider and enterprise networks, Cisco optical platforms maximize service density and flexibility while delivering unprecedented services on demand with support for multiple data, storage, and traditional networking protocols. The Cisco ONS Family of optical solutions offers maximum service velocity, density, variety, and capacity, building the foundation to accelerate IP and optical networking.

The Cisco optical portfolio includes solutions that are designed to increase service provider profitability while reducing network cost, operating expenses (OpEx), and infrastructure complexity. These innovative solutions include the Cisco ONS 15454 Multiservice Provisioning Platform (MSPP), ONS 15600 MSSP, ONS 15310 MSPP, and ONS 15454 Multiservice Transport Platform (MSTP). Although designed to meet the reliability and usability requirements of service providers, these solutions are also benefiting enterprise companies that use them for private-line optical and Ethernet services. With the Cisco ONS 15454 SL-Series line cards, companies can transparently extend their SAN over SONET/SDH.

Cisco optical products are certified by partners such as IBM for its Geographically Dispersed Parallel Sysplex (GDPS) applications and IBM Peer-to-Peer Remote Copy, EMC for its Symmetrix Remote Data Facility (SRDF) applications, Hitachi Data Systems TrueCopy, and HP/Compaq DRM.

Cisco provides an integrated element management system, Cisco Transport Manager, to provision, manage, and monitor all the multiservice optical platforms at the network's edge, in the metropolitan-area network (MAN or metro), and in the core. Additionally, management for the Cisco ONS 15500 product line and the award-winning Cisco ONS 15454 ML-Series card is based on Cisco IOS® Software. This facilitates integration into existing networks based on Cisco products using CiscoWorks and CiscoView, reducing training and management costs.

Cisco ONS 15454 – The Leading SONET Multiservice Provisioning Platform

Since its introduction defined the multiservice provisioning platform market, the Cisco ONS 15454 has remained the market leader, providing unprecedented multiservice interfaces on demand, including Ethernet, storage, and time-division multiplexing (TDM). The Cisco ONS 15454 efficiently aggregates data, storage, voice, and video services for high-density, highly available transport across metro networks.

The Cisco ONS 15454 continues its evolution with the Cisco ONS 15454 Multiservice *Transport* Platform (MSTP). With integrated DWDM functions, this product provides multirate transponders and muxponders for TDM, data, storage, and video wavelength services; flexible optical add/drop multiplexers (OADMs); advanced amplifiers for transmission from tens to hundreds of kilometers; and network intelligence through software enhancements for point-and-click setup. In addition, it has automated optical power management and wavelength additions, and A–Z wavelength provisioning.

Cisco further expands upon the market-leading capabilities of the Cisco ONS 15454 MSPP with the SL-Series storage over SONET/SDH interface card.

Cisco ONS 15454 SL-Series Card

The Cisco ONS 15454 SL-Series card (part number 15454-FC-MR-4) is a single-slot card with four client ports, each supporting 1.0625- or 2.125-Gbps Fibre Channel/FICON. It uses pluggable gigabit interface converter (GBIC) optical modules for the client interfaces, enabling greater user flexibility and an option to invest as companies generate the revenue to support it. The payload from a client interface is mapped directly to SONET/SDH payload via transparent generic framing procedure (GFP-T) encapsulation. This payload is then cross-connected to the system's optical trunk interfaces (up to OC-192) for transport, along with other services, to other network elements.

The card fills the Fibre Channel over wavelength and Fibre Channel over storage gaps in the transport category of the solution space. Not only does this allow Cisco to provide 100-percent coverage of the Fibre Channel transport space, but it also provides end-to-end coverage of data center and enterprise storage networking solutions over the metropolitan, regional, and wide-area network.

The SL-Series interface card plugs into the existing Cisco ONS 15454 chassis and is managed through the existing management system. Its introduction does not pose a major investment in capital expenditures (CapEx) or OpEx, but rather, an evolutionary extension of services. For the service provider, this creates an opportunity to further capture market and revenues from their existing and often extensive Cisco ONS 15454 installations. For the enterprise, this equals access to new storage over SONET/SDH services, enabling them to deploy needed SAN extensions and meet their business-continuance objectives.

Cisco ONS 15454 SL-Series Card Highlights

Following the tradition of the Cisco ONS 14545 MSPP supporting TDM, Ethernet, and now storage, the Cisco ONS 15454 SL-Series leads the industry in bit rate and density for Fibre Channel over storage:

- It supports 1-Gbps and also 2-Gbps Fibre Channel with low-latency GFP-T mapping, allowing customers to grow beyond 1-Gbps Fibre Channel.

- It supports industry-leading Fibre Channel density over protected SONET/SDH transport network in a single network element: 16 line-rate Fibre Channel on a single shelf over fully protected transport network such as 4-fiber bidirectional line switched ring (BLSR) OC-192, or dual 2-fiber BLSR/unidirectional-path switched ring (UPSR) OC-192.

The Cisco ONS 15454 SL-Series integrates into existing Cisco ONS 15454 MSPP installations, protecting customer investment and increasing their return:

- Lowers OpEx and CapEx by using existing infrastructure and management tools
- Increases the service offering capabilities
- Does not require upgrade of costly components of the Cisco ONS 15454 MSPP, such as the switch matrix of the network element

The Cisco ONS 15454 SL-Series card with CTC SONET/SDH supports the following modes:

- Line rate mode – This mode is backward-compatible with the Release 4.6 line rate mode.
- Enhanced mode – This mode supports subrate, distance extension, and other enhancements to support storage extension.

Line rate support is as follows:

- 1-Gbps Fibre Channel/FICON is mapped into the following:
  - SONET CCAT: STS24c, STS48c
  - SONET VCAT: STS3c-8v, STS1c-24v
  - SDH CCAT: VC4-8c, VC4-16c
  - SDH VCAT: VC4-8v
- 2-Gbps Fibre Channel/FICON is mapped into the following:
  - SONET CCAT: STS48c
  - SONET VCAT: STS3c-16v, STS1c-48v
  - SDH CCAT: VC4-16c
  - SDH VCAT: VC4-16v

Enhanced card mode support is as follows:

- 1-Gbps Fibre Channel/FICON is mapped into the following:
  - SONET CCAT: STS1c, STS3c, STS6c, STS9c, STS12c, STS18c, STS24c, STS48c
  - SONET VCAT: STS3c-Nv (N is 1 to 6), STS1c-Nv (N is 1 to 24)
  - SDH CCAT: VC4-1c, VC4-2c, VC4-3c, VC4-4c, VC4-6c, VC4-8c, VC4-16c
  - SDH VCAT: VC4-Nv (N is 1 to 8)
- 2-Gbps Fibre Channel/FICON is mapped into the following:
  - SONET CCAT: STS1c, STS3c, STS6c, STS9c, STS12c, STS18c, STS24c, STS36c, STS48c
  - SONET VCAT: STS3c-Nv (N is 1 to 12), STS1c-Nv (N is 1 to 48)
  - SDH CCAT: VC4-1c, VC4-2c, VC4-3c, VC4-4c, VC4-6c, VC4-8c, VC4-12c, VC4-16c
  - SDH VCAT: VC4-16v (N is 1 to 16)

Cisco MDS 9000 Family

The Cisco MDS 9000 Family of storage products lowers the total cost of ownership (TCO) for storage networking by combining an extremely robust and flexible hardware architecture with multiple layers of network and storage intelligence. This powerful combination helps organizations to build highly available, scalable storage networks with comprehensive security and unified management.

Comprehensive Multilayer Storage Networking Products

The Cisco MDS 9000 Family provides a line of products to meet requirements for storage networks of all sizes and architectures. It delivers intelligent network services such as multiprotocol/multitransport integration, virtual SANs (VSANs), network security, advanced traffic management, sophisticated diagnostics, and unified SAN management. In addition, the Cisco MDS 9000 Family provides an open platform for embedding intelligent storage services such as network-based virtualization. With its multilayer approach to network and storage intelligence, the Cisco MDS 9000 Family ushers in a new era in storage networking.

Cisco MDS 9500 Series – Defining the Multilayer Director

The Cisco MDS 9500 Series Multilayer Director elevates the standard for director-class switches. Providing industry-leading availability, scalability, security, and management, the Cisco MDS 9500 Series allows you to deploy high-performance SANs with the lowest TCO. Layering a rich set of intelligent features onto a high-performance switch fabric that supports multiple protocols, the Cisco MDS 9500 Series meets the stringent requirements of large data center storage environments. Available in 6-slot, 9-slot, and 13-slot configurations, the Cisco MDS 9500 Series supports up to 256 1-/2-Gbps autosensing Fibre Channel ports in a single chassis and up to 768 Fibre Channel ports per rack. And with an industry-leading 1.44 terabits per second (Tbps) of system bandwidth, the Cisco MDS 9500 Series is ready for integration of future 10-Gbps modules.

Cisco MDS 9216 – 16-Port Multilayer Fabric Switch

The Cisco MDS 9216 Multilayer Fabric Switch introduces new functions and investment protection to the fabric switch market. Sharing a consistent architecture with the Cisco MDS 9500 Series, the MDS 9216 combines multilayer intelligence with a modular chassis making it the industry's most intelligent and flexible fabric switch. Starting with 16 1-/2-Gbps autosensing Fibre Channel ports, the Cisco MDS 9216's expansion slot allows for the addition of any Cisco MDS 9000 Family module for up to 48 total ports. As the storage network expands further, Cisco MDS 9000 Family modules can be removed from Cisco MDS 9216 multilayer fabric switches and migrated into Cisco MDS 9500 Series multilayer directors, providing smooth migration, common sparing, and outstanding investment protection.

Cisco MDS 9000 Family Highlights

- *Highly available director* – The Cisco MDS 9500 Series combines nondisruptive software upgrades, stateful process restart/failover, and full redundancy of all major components for a new standard in director-class availability; supports 1-/2-/4- and 10-Gbps autosensing Fibre Channel ports in a single chassis and up to 768 Fibre Channel ports in a single rack
- *Highly flexible fabric switch* – The Cisco MDS 9216 supports up to 48 1-/2-Gbps autosensing Fibre Channel ports in a fabric switch configuration – modular design provides a base system consisting of 16 1-/2-Gbps autosensing Fibre Channel ports and can be expanded with a variety of optional Cisco MDS 9000 Family switching modules up to 48 total Fibre Channel ports.
- *Advanced architecture* – The Cisco MDS 9000 Family architecture provides common switching modules that can be migrated to any chassis within the Cisco MDS 9500 Series or the Cisco MDS 9200 Series.
- *Cost-effective design* – The Cisco MDS 9000 Family offers advanced management tools for overall lowest TCO, and introduces VSAN technology for hardware-enforced, isolated environments within a single physical fabric for secure sharing of physical infrastructure, which further decreases TCO.

- *Multiprotocol/multitransport* – The multilayer architecture of the Cisco MDS 9000 Family enables a consistent feature set over a switch fabric that supports multiple protocols and integrates Fibre Channel, iSCSI, and Fibre Channel over IP (FCIP) in one system. Its flexible architecture allows integration of future storage protocols.
- *Intelligent network services* – The Cisco MDS 9000 Family introduces VSAN technology, access control lists (ACLs) for hardware-based intelligent frame processing, and advanced traffic management features such as Fibre Channel Congestion Control (FCC) and fabric-wide quality of service (QoS) to enable migration from SAN islands to enterprisewide storage networks.
- *Open platform for intelligent storage services* – The Cisco MDS 9000 Family provides an open platform for hosting intelligent storage services such as network-based virtualization and replication.
- *Comprehensive network-security framework* – The Cisco MDS 9000 Family supports RADIUS authentication, Simple Network Management Protocol Version 3 (SNMPv3), role-based access control, Secure Shell (SSH) Protocol, Secure File Transfer Protocol (SFTP), Fibre Channel Security Protocol (FC-SP), VSANs, hardware-enforced zoning, and ACLs.
- *Sophisticated diagnostics* – Provides industry-first intelligent diagnostics, protocol, decoding, and network analysis tools, as well as integrated "call home" capability for added reliability, faster problem resolution, and reduced service costs. The Call Home feature in switches provides a notification system for alarms and events.
- *Unified storage management* – The Cisco MDS 9000 Family includes built-in storage management with all features available via command-line interface (CLI) or Cisco Fabric Manager, a centralized management tool that simplifies management of multiple switches and fabrics.
- *Industry's highest-performance Inter-Switch Links (ISLs)* – The Cisco MDS 9000 Family supports up to 16 2-Gbps links in a single PortChannel – links may span any port on any module within a chassis for added scalability and resilience.
- *Flexibility and investment protection* – The Cisco MDS 9000 Family shares common switching modules across all Cisco MDS 9500 Series products as well as the Cisco MDS 9216 Multilayer Fabric Switch.

The Cisco optical and storage products described in this document support an ideal solution for delivering Fibre Channel/FICON over SONET/SDH – a SAN extension solution to support common disaster recovery and business-continuance applications.

Disaster Recovery and Business-Continuity Applications

Disaster recovery and business-continuity plans drive the need for solutions that protect critical business information and provide continuous access to important data in case of disaster. Disaster-recovery applications are intended to replicate data to a remote backup location. The backup site can be located in the same metro area, such as New York and New Jersey, or at transcontinental distances. The more stringent requirements of business continuance emphasize real-time restoration – when disaster occurs, failover is near immediate, providing for faster recovery. Business continuance is put in place to protect business applications at times when downtime is not an option. Common applications for replicating and protecting critical information include synchronous and asynchronous replication and tape backup.

Synchronous Replication

Synchronous replication is used to protect data and applications with stringent availability requirements. Some applications, such as online trading, must be designed and implemented so that no data is lost in case of a disaster. To achieve this, transactions must be written on both the main and backup sites synchronously to keep the databases consistent. When an application writes data to disk, that data is being replicated to the remote site before a write acknowledgment is sent back to the application. The write I/O is acknowledged on the server only when a block of data has been written on both sites. Hence, the latency introduced in the network directly affects the application performance. The latency introduced is a function of the speed of light and the distance between:

```
Latency = 5 Microseconds * (Round-trip distance) * 2
        = 5 * 100 * 2
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= 1 millisecond (ms)
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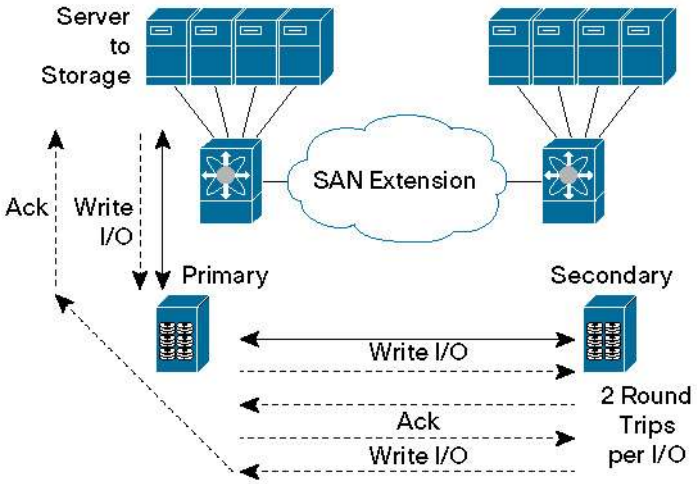
In this example, 1 ms of latency is introduced to replicate the data between sites 50 kilometers (km) apart. Two round trips are required to complete the I/O.

To limit the impact of replication, storage-array vendors are imposing distance limitations for synchronous replication. The distance is typically around 100 km.

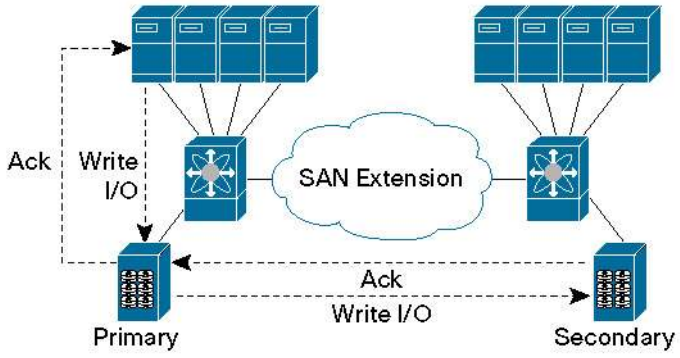
Figure 1
Synchronous Replication



Asynchronous Replication

If a limited amount of business information can be lost in case of disaster, asynchronous replication can be used. Asynchronous replication provides very good protection, but some transactions could be lost in case of disaster. With asynchronous replication, Write I/O is completed once written on the main storage array. The server does not wait until the I/O is completed on the other storage array. There is no distance limitation and typical asynchronous replication applications can span thousands of kilometers or more.

Figure 2
Asynchronous Replication



Requirements of Disaster-Recovery and Business-Continuity Applications

Before designing a WAN, it is important to understand the requirements of each application and how it performs on the network. There are numerous applications available and Table 1 generalizes some of the major applications that demand stringent requirements. The MAN/WAN should be able to provide the requirements that each application demands to obtain maximum efficiency.

Table 1. Application Requirements

Application	Bandwidth	Latency	Comments	Asynchronous or Synchronous
Tape backup	Typically 10 to 15 MB per tape drive. Up to 40 MB per tape drive (Super DLT tapes).	<1–5 ms	Sensitive to delay. Rely on Small Computer System Interface (SCSI) protocol for timeouts and error recovery. Note: Once a session is interrupted, the all-backup session is lost.	Synchronous
Disk mirroring	Varies depending on storage array. Typically maximum 50 MB per storage array.	<1–5 ms for synchronous Asynchronous replication tolerates higher latency (100 ms)	Synchronous applications are very sensitive to delay. Asynchronous are less sensitive to delay.	Synchronous or Asynchronous
File access	OS dependent.		Depends on the OS and application above it.	

* Other requirements include provisioning, error monitoring, and end-to-end management.

An end-to-end Cisco solution uses Cisco platforms as building blocks (which include Cisco ONS 15454, Cisco MDS 9000, and Cisco ONS 15540/15530) to support almost all disaster-recovery and business-continuance applications that are prominent in the market. The following sections highlight some of these applications and the design methodologies to architect a typical Cisco SAN extension solution to support these applications.

Some of these applications supported by Cisco end-to-end solutions include (but are not limited to) tape backup, disk mirroring, and geographic clustering of servers.

Remote Tape-Backup Applications

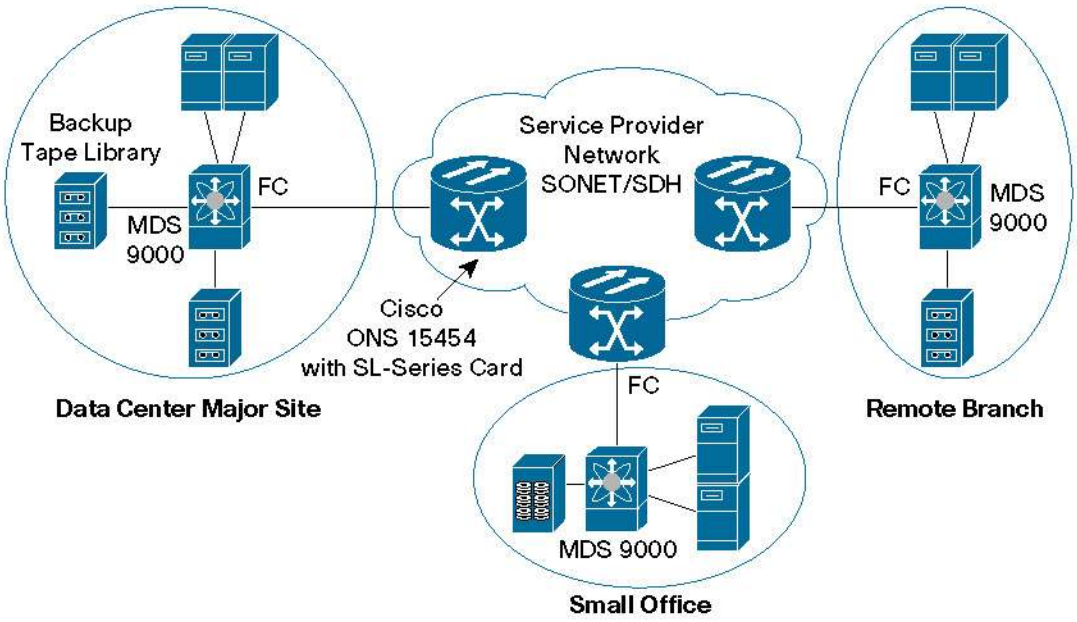
In an enterprise network, certain sites (remote branches or small offices) could have a small SAN that connects a few servers to the storage arrays. Backing up and restoring these servers over the WAN are the fundamental components of disaster-recovery operations. Extending tape backup over a wide area puts stringent requirements for efficient tape-backup and recovery operations. The requirements include no data loss, low latency and jitter, monitoring of the link, and high security.

Slow wide-area links could increase backup time and could make it impossible to complete backup within the allocated time period (or “window”). Distance is not a major limitation for backup to tape applications as long as it is possible to predict delay requirements. For backup to tape to be as efficient as possible, Cisco recommends sustaining a certain speed so that a continuous stream of data is sent to tape. Backup performance has been found to be best when the tape can accept a continuous stream. Backup to tape transfer over the WAN is asymmetrical in nature. Figure 3 shows a Cisco solution to interconnect two remote sites that are being backed up to a main data center. The asymmetrical nature of tape-backup data transfer creates unique challenges when designing SAN extension networks.

Tape “pipelining” technology helps to extend tape drives thousands of kilometers, thus making remote tape backup an essential component of business-continuance and disaster-recovery applications. The efficiency is achieved by implementing buffering and error-recovery mechanisms.

The concept is similar to spoofing – the server and tape controller, even though are separated by a large distance, behave as if they are colocated. The tape pipelining technique relaxes the design constrains of SAN extension technologies.

Figure 3
Tape Backup



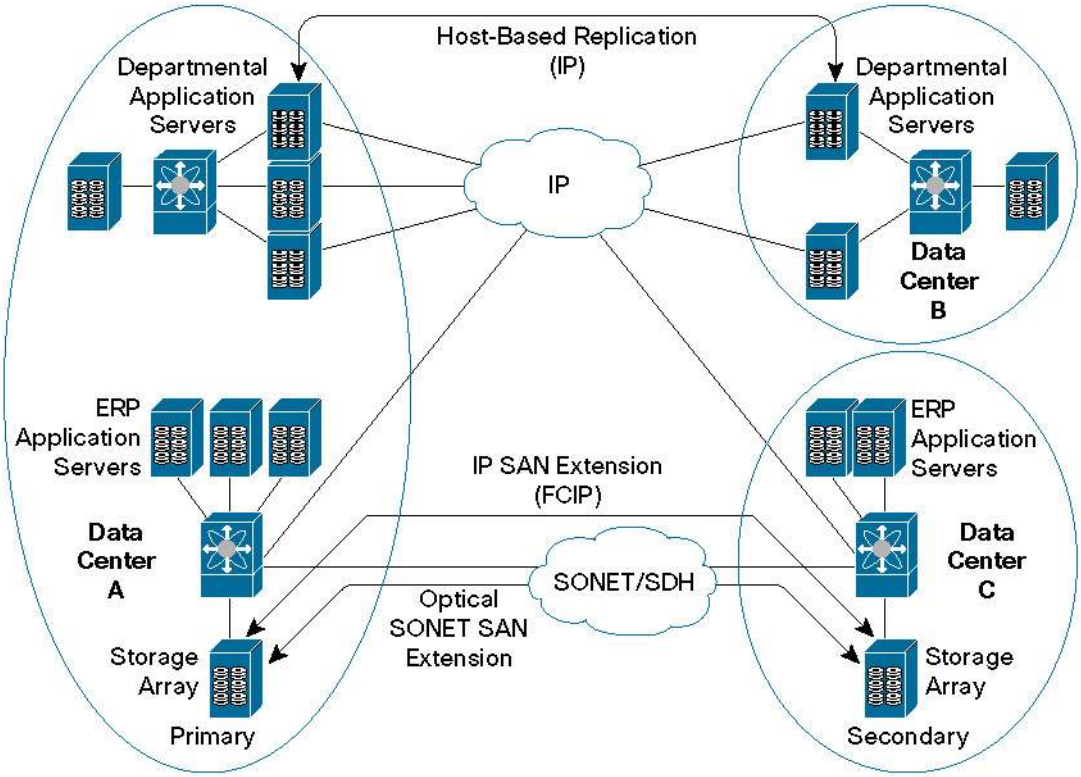
A typical solution includes transport over SONET/SDH, which provides all the necessary QoS requirements required by tape-backup applications. The Cisco solution shown in Figure 3 provides necessary provisioning, management, bandwidth optimization, and performance parameters that are critical to implement tape-backup applications. The Cisco solution can scale as bandwidth requirements increase and still maintain the QoS requirements required to support this application.

Remote Disk Mirroring

Disk mirroring is a technique in which data is written to two different disks at the same time. This process helps to ensure that if the primary disk fails, the failover mechanisms will switch the system instantly to the secondary disk, eliminating or minimizing the loss of data. The Internet demands that data be available 24 hours a day, and failure is not an option. Disk mirroring is frequently used in database applications. Because of disaster-recovery and business-continuance requirements, enterprises are demanding geographically dispersed mirroring techniques, known as remote disk mirroring. A typical remote disk mirroring network architecture using both Fibre Channel and Gigabit Ethernet combined (collapsed network architecture) is shown in Figure 4.

Figure 4

A Collapsed Data Center Network (Disk Mirroring Application) over WAN



Fibre Channel SAN Extension Design – Storage-Based Replication

Cisco SAN extension solutions support storage-array-based replication applications of the most common storage-array vendors. The principles and methods to design the SAN extension network are identical and provide redundancy and fast convergence in case of network failure. Two high-level solution designs are described here. The first design relies on redundant Fibre Channel switches to form a resilient fabric. The second design relies on Cisco MDS 9000 high-availability and redundancy features.

The designs proposed in this section are applicable to replication application from different storage vendors. These applications include SRDF from EMC, HDS Truecopy, Compaq/HP DRM, and IBM PPRC.

EMC Symmetrix Remote Data Facility

The EMC Symmetrix Remote Data Facility (SRDF) is an online, host-independent, mirrored data solution that duplicates production-site data on physically separate target Symmetrix systems. This SRDF SAN solution dramatically lowers the risks associated with all major tasks that impact business continuance: disaster recovery, backups and scheduled maintenance, data center migration and consolidation, and testing.

Hitachi Data Systems TrueCopy

HDS TrueCopy provides a storage-based hardware solution for disaster recovery that enables fast and accurate system recovery. Once TrueCopy operations are established, duplicate copies of data are automatically maintained for backup and disaster-recovery purposes. During normal TrueCopy operations, the primary volumes remain online to all hosts and continue to process both read and write I/O operations. In the event of

a disaster or system failure, the secondary copy of data can be rapidly invoked to allow recovery with a very high level of data integrity. TrueCopy can also be used for data duplication and migration tasks.

Compaq/HP DRM

A single DRM provides a disaster-tolerant storage solution through the use of hardware redundancy and data replication between two sites separated by some distance. Multiple heterogeneous servers can be connected to one or more shared storage subsystems. A basic DRM configuration consists of two sites, an *initiator* and a *target*. The initiator site carries out primary data processing. The target site is used for data replication. As data processing occurs at the initiator site, the data is replicated or mirrored to the target site. If a single component at either site fails, DRM will fail over to a redundant component at the same site to allow continued operation. For example, if one of the dual-redundant Fibre Channel links between the sites were to fail, DRM would fail over to the other link. If a significant failure (disaster) occurs at the initiator site, data processing can be resumed at the target site, where the data is intact. This process is called *site failover*. When the cause of the initiator site failover has been resolved, data processing can be moved back to the initiator site in a process called *site failback.*

DRM uses the peer-to-peer remote copy function of the HSG80 controller to achieve data replication. HSG80 controller pairs at the initiator site are connected to their partner HSG80 controller pairs at the target site. This process is completely host independent.

IBM Peer-to-Peer Remote Copy

Peer-to-Peer Remote Copy (PPRC) is an Enterprise Storage Server (ESS) function that allows the shadowing of application system data from one site (usually called the application site) to a second site (called the recovery site). The logical volumes that hold the data in the ESS at the application site are called primary volumes, and the corresponding logical volumes that hold the mirrored data at the recovery site are called secondary volumes. The connection between the primary and the secondary ESSs is done using ESCON links.

Architecture and Network Design

Disaster recovery applications require a network architecture that is resilient and that introduces minimum latency (at least for synchronous replication). SONET/SDH networks can be used to transport storage within the metro and for longer distances. SONET/SDH networks are built with 50-ms convergence time. Ring topologies help ensure an alternate path is always possible in case of a fiber cut. Figure 5 illustrates architecture with dual Fibre Channel switches connected to the same Cisco ONS 15454 SONET/SDH platform.

Figure 5

Network Architecture for EMC SRDF Applications

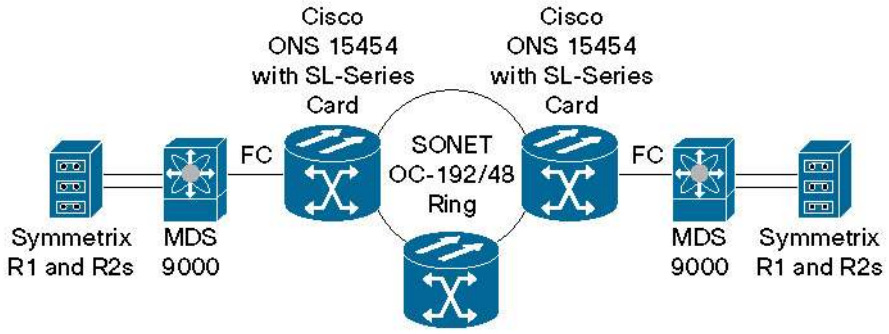


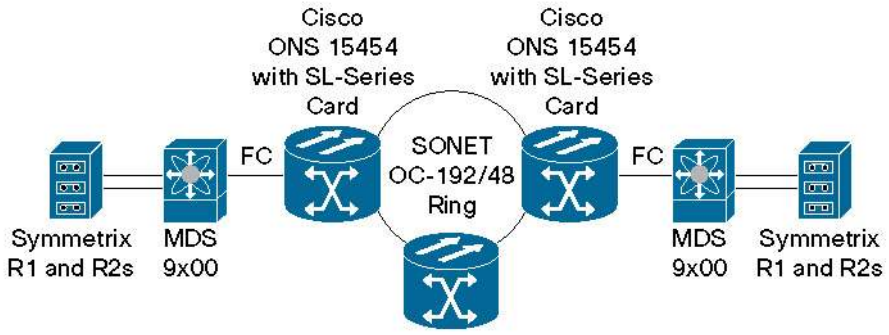
Figure 6 shows two EMC Symmetrix storage arrays connected through the SAN extension system. Two Fibre Channel ports are connected on each Symmetrix device so that a dual Fibre Channel path is accomplished between the Symmetrix devices. On the Cisco ONS 15454, the SL-

Series card provides Fibre Channel connectivity to the Cisco MDS 9000 Fibre Channel switches. A SONET/SDH circuit is being provisioned between the two SONET end nodes. If 1-Gbps Fibre Channel wire rate is required, then a STS-24 circuit is provided. The circuit is fully protected.

An alternative solution would be to use only one Cisco MDS Fibre Channel Switch and connect both RDF ports to that switch. Resiliency is provided at the platform level with dual power supply and supervisor.

Figure 6

Network Architecture for SRDF Applications (No Redundancy)



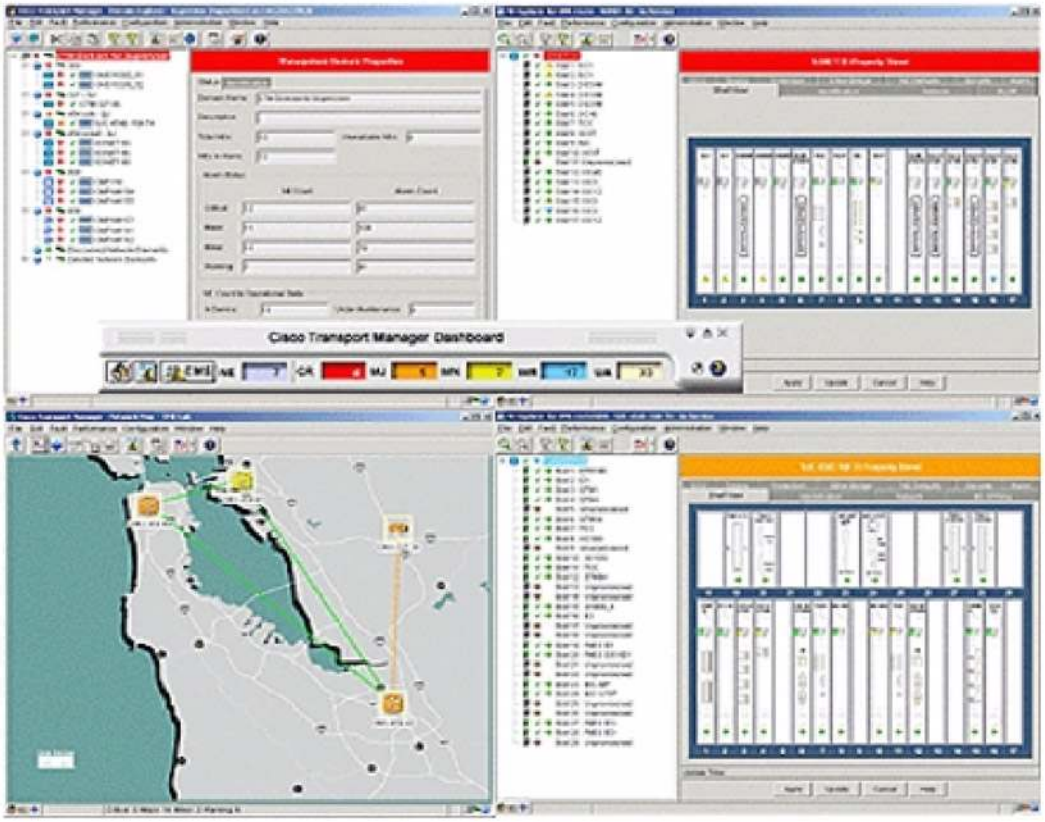
It is interesting to note that both R1 and R2 volumes are being created on both sides, that is, traffic is generated in both directions. In this scenario, information is being created on both sides on R1s and is being replicated to the other location (R2s). This is a common situation as enterprises share the load for business applications between the two sites.

Storage Network Management

As storage network environments continue to grow, the need for comprehensive management services of the storage network environment becomes more apparent. There are several features and services offered with the Cisco ONS 15454 optical platform and Cisco MDS 9000 Family of products that support such applications.

Cisco Transport Manager, the single, integrated, optical, element management system for Cisco ONS 15000 optical systems, simplifies management and accelerates deployment of Cisco ONS 15454s. Cisco Transport Manager provides advanced capabilities in the functional management areas of configuration, fault, performance, and security for Cisco optical network elements, subnetworks, and networks. With inherent support for SONET, SDH, DWDM, Fibre Channel/FICON, and Ethernet, along with open interfaces to operations support systems (OSSs) and a proven record of reliability and scalability, Cisco Transport Manager delivers the full power over the wide range of advanced Cisco optical systems to today's network operators. A typical Cisco Transport Manager view is shown in Figure 7.

Figure 7
Cisco Transport Manager GUI



The Cisco Fabric Manager, which consists of an element and fabric manager, offers diverse management capabilities for the Cisco MDS 9000 Family. The element manager allows network administrators to configure the switch and to track statistics and events. The Cisco fabric manager provides the capability to manage the fabric as a collection or network of devices. The fabric manager application is built upon a topology representation of the fabric. Once the fabric manager is invoked, a topology discovery process begins. Using information polled from a seed Cisco MDS 9000 Family switch including *NameServer* registrations and Fibre Channel-GS-3 *Fabric Configuration Server* information, the fabric manager can recreate a fabric topology and represent it for the user in a customizable map. The Cisco MDS 9000 Family of switches comes with a series of fabric-oriented management tools and facilities that can be used to discover and monitor the entire connected fabric. These tools are Fibre Channel ping and traceroute, SCSI target discovery, support for all generic services of Fibre Channel-GS-3, and Fibre Channel span. Using the Cisco Fabric Analyzer, users can capture Fibre Channel control traffic from a switch and decode it without having to disrupt any connectivity, and without having to be local to the point of analysis.

Summary

Enterprise businesses want to protect information and have 24-hour access to critical application services, requirements that for some are mandated by law. Cisco optical solutions allow these customers to select the transport service – whether IP/Ethernet, SONET/SDH, or WDM – that best meets their recovery time and point objectives for business continuity. Whether the enterprise self-manages its metro or WAN, or outsources it network needs to a service provider, Cisco offers a full portfolio of solutions.

The Cisco ONS 15454, together with a variety of interface cards, delivers a single, integrated platform that supports a broad range of data and other services over a high-density, high-capacity optical network. With this platform, the service provider or the enterprise can offer scalable Ethernet, SONET/SDH, or wavelength services in ways that address the customer's storage interconnection needs, regardless of the distances involved. By deploying these Cisco optical network solutions, service providers and enterprises can address a variety of disaster recovery and business continuity needs, ranging from archiving e-mail to data mirroring with zero information loss.

For More Information

For more information about SAN extension and Cisco storage and optical solutions, refer to the following:

- EMC Symmetrix DMX series: http://www.emc.com/products/systems/DMX_series.jsp
- Data sheet – Cisco SL-Series for the Cisco ONS 15454: http://www.cisco.com/en/US/products/hw/optical/ps2006/products_data_sheet09186a00801b97a7.html
- Cisco MDS 9000 Family: http://www.cisco.com/en/US/products/hw/ps4159/ps4358/index.html

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