



Solution Overview

Efficient Transport of Storage and Ethernet Across Hybrid DWDM and SONET/SDH Networks

Introduction

Proliferation of storage traffic due to disaster recovery and business continuance requirements, combined with the high cost associated with downtime or loss of data, justifies the need for interconnecting geographically dispersed data centers. At the same time, mission-critical applications such as e-business and customer relationship management, and emerging applications such as streaming media, are impacting all parts of the transport infrastructure – access, metropolitan-area network (MAN), and WAN. This document describes an innovative solution to efficiently transport Gigabit Ethernet and storage area network (SAN) protocols from multiple dense wavelength-division (DWDM) access rings across the core SONET/SDH network. It explains how the Cisco® ONS 15454 2.5-Gbps Data Muxponder Card can aggregate SAN services – Fibre Channel, Fiber Connectivity (FICON), Enterprise Systems Connection (ESCON), and Gigabit Ethernet – into the DWDM access ring for transport over the core SONET/SDH infrastructure.

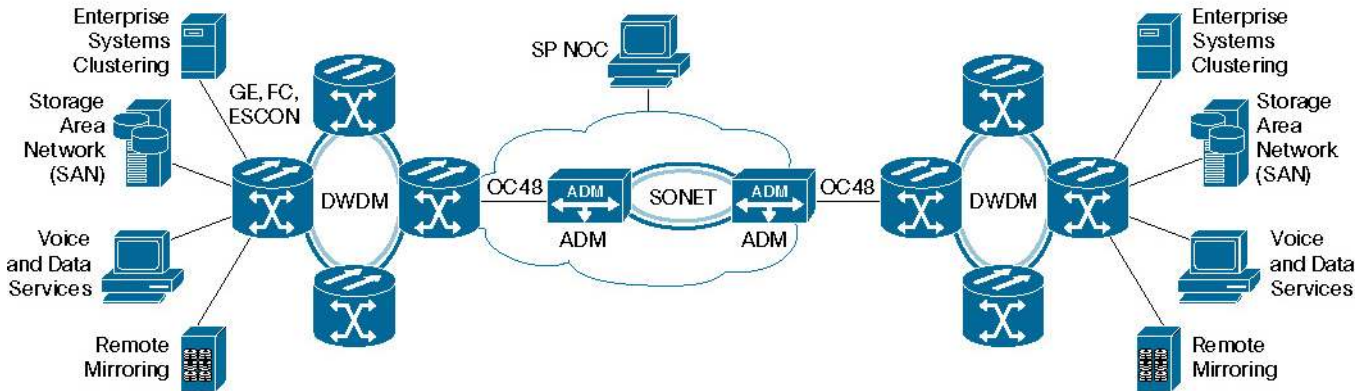
Business Benefits

Enterprises need affordable solutions to interconnect geographically dispersed data centers, an emerging market that offers new opportunities for service providers. Using Cisco solutions, service providers, as well as enterprise customers, can expand their portfolio by delivering profitable SAN extension services over their existing optical (SONET/SDH, DWDM) or IP infrastructure.

Service providers have a substantial investment in existing SONET/SDH networks. They can extract additional value by supporting data services (Gigabit Ethernet, SANs, etc.) across this infrastructure or, alternatively, across Multiprotocol Label Switching (MPLS)-based IP networks. DWDM is an ideal MAN technology because it provides high bandwidth, density, low latency, and transparent transport for data and storage protocols.

Service providers build access rings to collect traffic from multiple customers. In most cases, especially for disaster recovery applications, traffic flowing from different access rings is transported across the service provider's core SONET/SDH network. With the Cisco 2.5-Gbps Data Muxponder Card, service providers can deploy a hybrid DWDM-SONET/SDH infrastructure because the card aggregates Fibre Channel, FICON, ESCON, and Gigabit Ethernet services into a 2.5-Gbps signal for transport over a DWDM access network. The signal can then terminate on a SONET/SDH core network, allowing the service provider to use the core network for the transport of data services (see Figure 1).

Figure 1
DWDM Access Ring Feeding SONET Core Network



Cisco Solution

Integrating the capabilities of the Cisco ONS 15454 Multiservice Transport Platform (MSTP) with the Cisco ONS 15454 Multiservice Provisioning Platform (MSPP) eliminates the need to maintain physically distinct networks because a converged optical network provides the bandwidth and guaranteed service for voice, video, and data, including storage and traffic.

There are two options for deploying a converged optical network. It can be based on a multiservice platform that incorporates a number of technologies, including reconfigurable optical add/drop multiplexer (ROADM), tunable optics, transponders, and muxponders. This is an ideal choice if the network needs to support a variety of time-division multiplexing (TDM) and data/storage services. The second option, which allows for IP and DWDM integration, is to use pluggable DWDM optics in client devices that support data and storage services. The solution described here highlights the advantages of installing the Cisco 2.5-Gbps Data Muxponder Card in the Cisco ONS 15454 MSTP, and this combination offers a model for building a converged optical network.

Solution Overview

The Cisco ONS 15454 MSTP provides capital and operational efficiencies because it addresses the increasing demand for multiple services, greater transport capacity, networking flexibility, multiple distance options, and management simplicity in a single platform. This next-generation multiservice platform also provides optical transparency for supporting a variety of services by integrating wavelength, SONET/SDH transport, and switching capabilities.

The 2.5-Gbps Data Muxponder Card aggregates Gigabit Ethernet, Fibre Channel, FICON, and ESCON services over a 2.5-Gbps ITU-compliant wavelength. The card has eight client interfaces that are electronically multiplexed and converted to a single-line DWDM interface, without accessing the Cisco ONS 15454's cross-connect fabric. In addition to providing transparent data transport services on the Cisco ONS 15454 MSTP for SAN extension in metro and WAN environments, the 2.5-Gbps Data Muxponder Card can also be used to interconnect primary and secondary data centers for disaster recovery and business continuance.

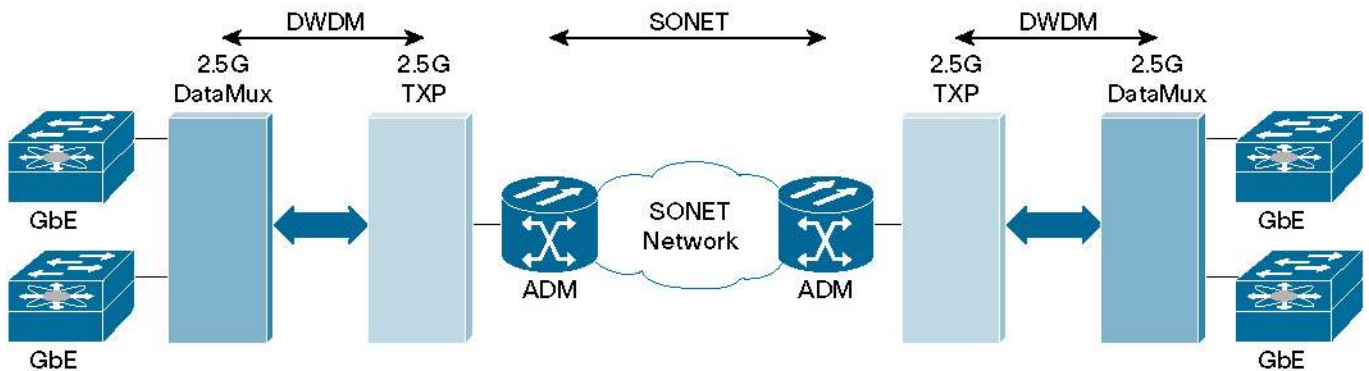
The 2.5-Gbps Data Muxponder card's applications include:

- Business continuance – Synchronous (real-time) or asynchronous (non-real-time) data mirroring between primary and backup data centers for disaster recovery
- Remote storage service connectivity – Remote storage subsystem access, tape backup for offsite data storage
- Data center interconnect – High density, low latency, and high bandwidth needed for data center interconnection

Note: The 2.5-Gbps Data Muxponder Card trunk aggregated signal is a pure OC-48 signal built on two STS-24c structures. This allows for easy transport of the signal across a DWDM or SONET/SDH network.

The 2.5-Gbps Data Muxponder Card aggregates different data services for transport over an OC-48/STM-16 wavelength. The wavelength terminates on the Cisco 2.5-Gbps Multirate Transponder Card that interfaces to an OC-48/STM-16 port on a SONET/SDH ADM. The OC-48/STM-16 signal is carried across the SONET/SDH core to a 2.5-Gbps Multirate Transponder Card (2.5G TXP) at the remote end, which feeds the signal to the DWDM network. The wavelength then terminates on a 2.5-Gbps Data Muxponder Card (2.5G Data Mux), which demultiplexes the data services to their original data format. Such a hybrid infrastructure uses the capabilities and benefits of the DWDM access network and the SONET/SDH core for transport of data services over a large geographic area (see Figure 2). This solution takes advantage of SONET/SDH networks, which are readily accessible and are the primary optical backbone for many service providers. Fibre Channel traffic can easily coexist with TDM and Ethernet traffic over the SONET/SDH core, with bandwidth assigned per application requirements.

Figure 2
Solution Schematic Diagram



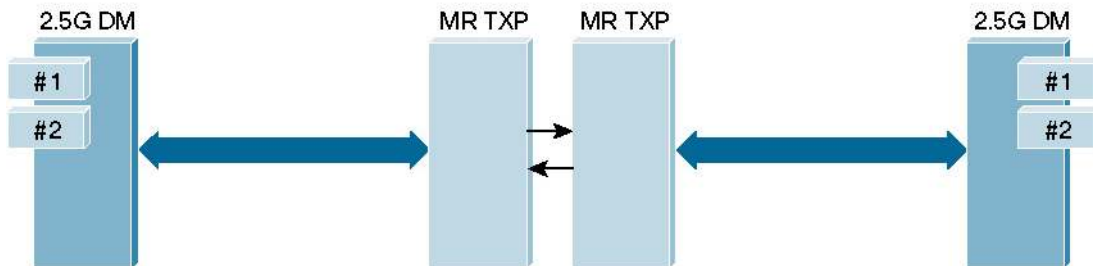
A mandatory condition for supporting the above application is the SONET/SDH network's capability to manage STS-24c/VC4-8c concatenation format. In the case of Fibre Channel, the protocol's buffer credit mechanism assumes a key role in the end-to-end transport of the Fibre Channel signal. It is essential to evaluate the maximum distance that can be supported by Fibre Channel switches and the 2.5-Gbps Data Muxponder Card.

Regeneration of 2.5-Gbps Muxponder Cards Using 2.5-Gbps Transponder Cards

The 2.5-Gbps Multirate Transponder Card's trunk aggregated signal is a pure OC-48/STM-16 signal built with two STS-24c or VC4-8c structures that enable the signal to be transported across a hybrid DWDM-SONET/SDH network. A direct benefit of this mapping is that the Multirate Transponder Card (MR TXP) regenerates the Data Muxponder Card's (2.5G DM) signal, as shown in Figure 3.

Figure 3

Regeneration of 2.5-Gbps Muxponder Signals Using Cisco Multirate Transponder Cards

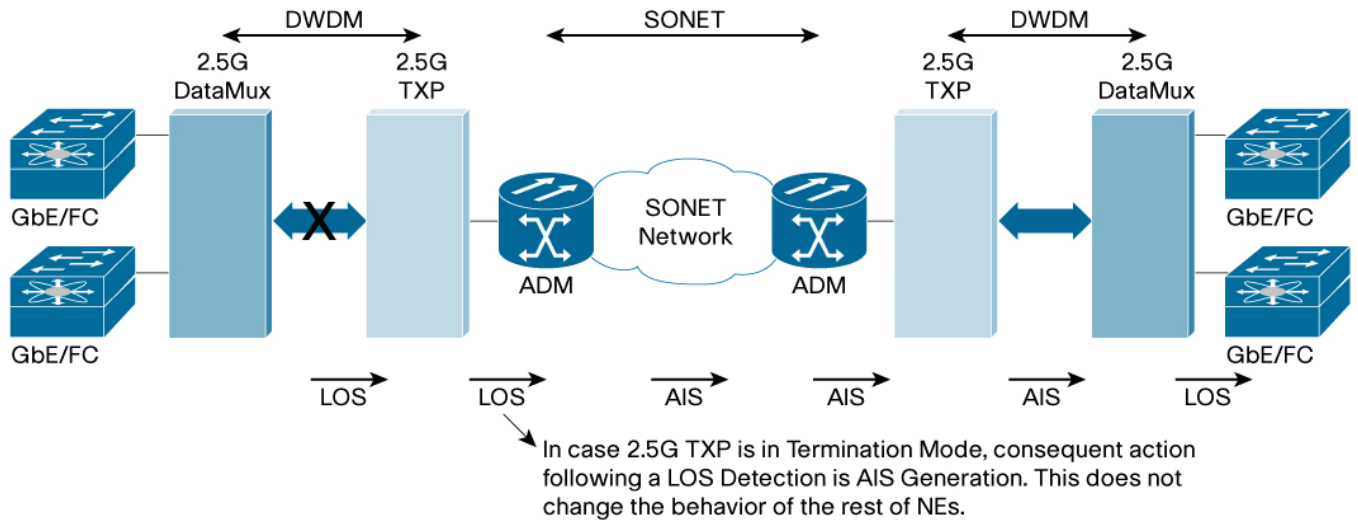


Isolating Fault in Case of a Failure

The hybrid network is capable of detecting and responding to DWDM or SONET/SDH failures and fiber cuts. The 2.5-Gbps Data Muxponder Card features a list of remote signaling capabilities to activate a well-defined set of behaviors in response to near-end events. In case of a failure on the client side, the client signal propagates a Loss of Signal (LOS) message. This propagation uses the GFP-T client management frame as specified in Table 6-4 G.7041 (ITU-T specifications). For unprotected application, in case of trunk LOS, Loss of Frame (LOF), or Alarm Indication Signal (AIS), the client interface squelches or NOS. When NOS is forced, the unrecognized 10B neutral disparity codeword, either 001111 0001 (RD-) or 110000 1110 (RD+), is generated, depending on beginning running disparity. The following scenario provides more details in the event of DWDM and SONET/SDH network failure.

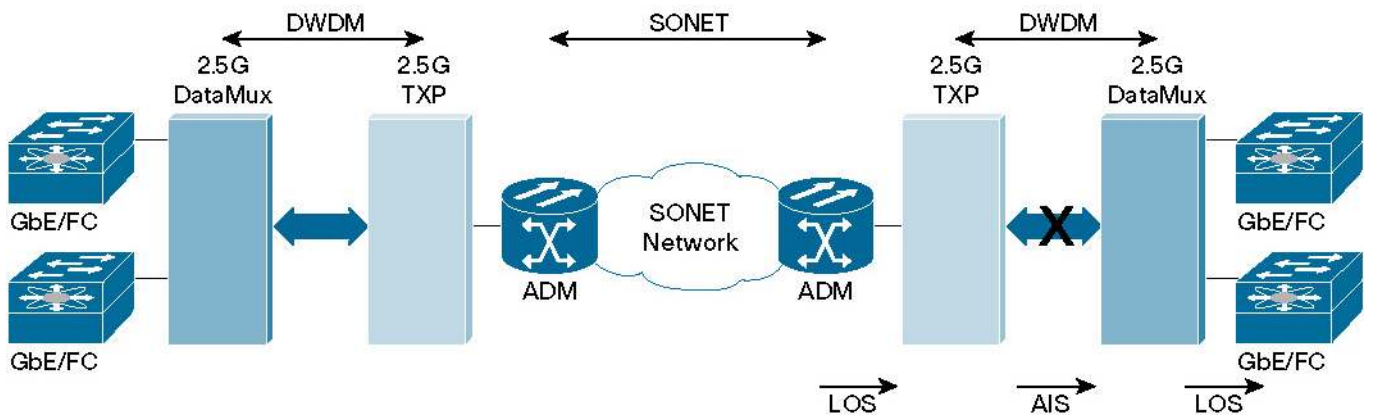
- **CASE A – DWDM Failure (fiber cut):** In this case an LOS is received by the 2.5-Gbps Multirate Transponder Card that, as a consequence, will generate on the client port AIS (in case of Termination Mode) or will squelch the client (in case of Transparent Mode). The ADM will propagate an AIS across the SONET/SDH network toward the client of the 2.5-Gbps Multirate Transponder Card. The 2.5-Gbps Multirate Transponder Card will generate an AIS down to the DWDM line; the remote 2.5-Gbps Data Muxponder Card will squelch the clients after receiving the AIS. Figure 4 depicts the failure condition.

Figure 4
Failure Analysis on the DWDM Side



- CASE B – LOS between DWDM and SONET/SDH link: In this case a LOS is received by the 2.5-Gbps Multirate Transponder Card's client port that, as a consequence, will generate an AIS on the trunk port (in the case of Termination Mode) or will squelch the trunk port (in case of Transparent Mode). The remote 2.5-Gbps Data Muxponder Card will squelch the clients after receiving the AIS or the LOS.

Figure 5
Failure Analysis on the SONET Side



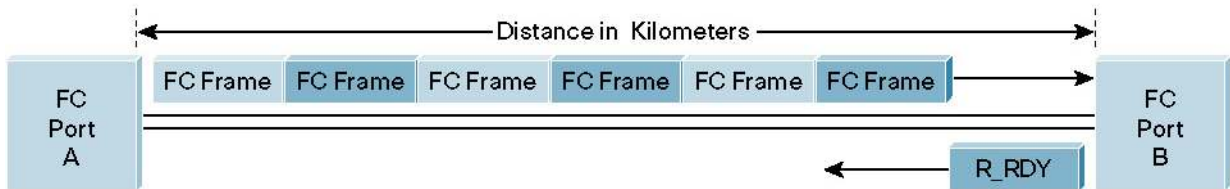
Distance Extension for Storage Applications

Fibre Channel uses the buffer-to-buffer mechanism for hardware-based flow control between Fibre Channel ports. Fibre Channel ports use these buffers, or memory, to store frames as they arrive for delivery to the upper-layer protocol. Fibre Channel ports establish buffer-to-buffer credits, which equal the number of frames the receiver can accept before sending an R_RDY message to the sender. (R-RDY is a frame-acknowledgement mechanism provided by the Fibre Channel standard.)

The Fibre Channel protocol uses flow control to avoid frame loss. The transmitting node waits for an R_RDY for every frame it sends. At no time can the number of outstanding frames exceed the buffer capacity of the receiving node (see Figure 6). As distances increase so does the time it takes the transmitting node to receive an R_RDY due to signal propagation delays. For this reason, full utilization of the available bandwidth is not possible beyond the distance supported by the buffer credit limitation. The standard practice for a 1-Gbps Fibre Channel link is to allow 1 buffer credit for each 2 kilometers (km) of distance. The Cisco 2.5-Gbps Data Muxponder Card supports 804 credits, enabling a 1-Gbps Fibre Channel signal to extend about 1600 km.

One method for overcoming the buffer credit limitation is spoofing, or buffer credit management at the optical node. The 2.5-Gbps Data Muxponder Card uses this technique to transport Fibre Channel over extended distances. The card spoofs the R_RDY signals for every frame that the Fibre Channel node transmits, and the R_RDY messages are sent at a rate consistent with the provisioned bandwidth.

Figure 6
Role of Fibre Channel Buffer Credits



The 2.5-Gbps Data Muxponder Card can spoof the buffer-to-buffer client credit by using a proprietary exchange of memory information between the two 2.5-Gbps data muxponder cards, thus allowing client equipment to run at full rate across hundreds of kilometers. The end systems interoperate transparently with the spoofed solution. The frames involved in error monitoring and flow control are terminated for reporting and flow controlling functions. The R_RDY messages are terminated locally and are not part of flow control and so do not use WAN bandwidth. The IDLE frames are terminated locally and regenerated at the far end, which also saves bandwidth.

Note: The 2.5-Gbps Data Muxponder Card supports up to 804 buffer credits.

Cisco ONS 15454 2.5-Gbps Multirate Data Muxponder Card

A single 2.5-Gbps Data Muxponder Card multiplexes up to two Gigabit Ethernet/Fibre Channel/FICON signals, eight ESCON services, or a single 2-Gbps Fibre Channel/FICON service. The interface to the client is through a variety of Small Form-Factor Pluggable (SFP) optics modules. The modules facilitate a wide service mix, including Gigabit Ethernet, 1- or 2-Gbps Fibre Channel or FICON, different fiber types (single-mode and multimode), wavelengths (850 and 1310 nanometers), and fiber reach (for intra-office, intermediate, and short-haul applications). The SFP optics modules are equipped with LC connectors to enable high-density placement on the card, and up to 12 cards can be deployed in the Cisco ONS 15454 platform.

The DWDM line interface provides one long-reach, ITU-compliant, 100-GHz spaced optical interface. The DWDM output line interface is tunable across four adjacent wavelengths, allowing deployment of 32-channel DWDM networks using only eight separate cards. Each wavelength can operate in a protected or unprotected mode. The protected mode includes a second DWDM line output/input for optical line protection. With necessary amplification and dispersion compensation, the 2.5-Gbps Data Muxponder Card (Figure 7) is capable of optical reaches exceeding 500 km.

The card supports many carrier-class features and advanced capabilities, including service flexibility, wavelength tuning, flexible, protection mechanism, management, SAN extension beyond the metro, and performance monitoring.

Figure 7

Cisco ONS 15454 2.5-Gbps Data Muxponder Card



Technical Details for the Cisco 2.5-Gbps Data Muxponder Card

The 2.5-Gbps Data Muxponder Card aggregates data signals mapping using the GFP-T G.7041 encapsulation method over an OC-48/STM-16 signal. There is a well-defined mapping scheme using STS-24c/VC4-8c building blocks. The port-by-port mapping is as follows (Figure 8):

- Port 1 accepts 2-Gbps Fibre Channel/FICON, 1-Gbps Fibre Channel/FICON, 1-Gigabit Ethernet, or ESCON signals.
- Port 2 accepts 1-Gbps Fibre Channel/FICON, 1-Gigabit Ethernet, or ESCON signals.
- Ports 1 to 8 accept ESCON signals.

Figure 8

Data Mapping over SONET/SDH Mechanism

Client Signal	Port	SONET Mapping
2G FC/FICON	1	STS-48c
GE/FC/FICON	1	STS-24c (sts 1-24)
GE/FC/FICON	2	STS-24c (sts 25-48)
ESCON	1-4	STS-24c (sts 1-24)
ESCON	5-8	STS-24c (sts 25-48)

Note: The 2.5-Gbps Data Muxponder Card supports the mapping of the card's client ports to the creation of STS24c/VC4-8c and STS48c/VC4-16c circuits for interoperability with the SL Card and other data muxponder cards.

Conclusion

Customers want to assure access to and protection of business-critical information. The Cisco ONS 15454 2.5-Gbps Data Muxponder Card allows service providers to offer customers a very flexible solution for efficiently transporting SAN and Gigabit Ethernet services over high-bandwidth, high-capacity DWDM access rings and also take advantage of the reach of the SONET/SDH core network. The 2.5-Gbps Data Muxponder Card can also be used by enterprise customers to interconnect data centers for high-density transport of Ethernet and storage protocols.

For More Information

For more information about the Cisco ONS 15454 MSTP and MSPP and other network management products, please visit:

<http://www.cisco.com/en/US/products/sw/opticsw/ps2204/index.html>

<http://www.cisco.com/en/US/products/hw/optical/ps2006/ps5320/index.html>

<http://www.cisco.com/en/US/products/hw/optical/ps2006/ps2010/index.html>

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