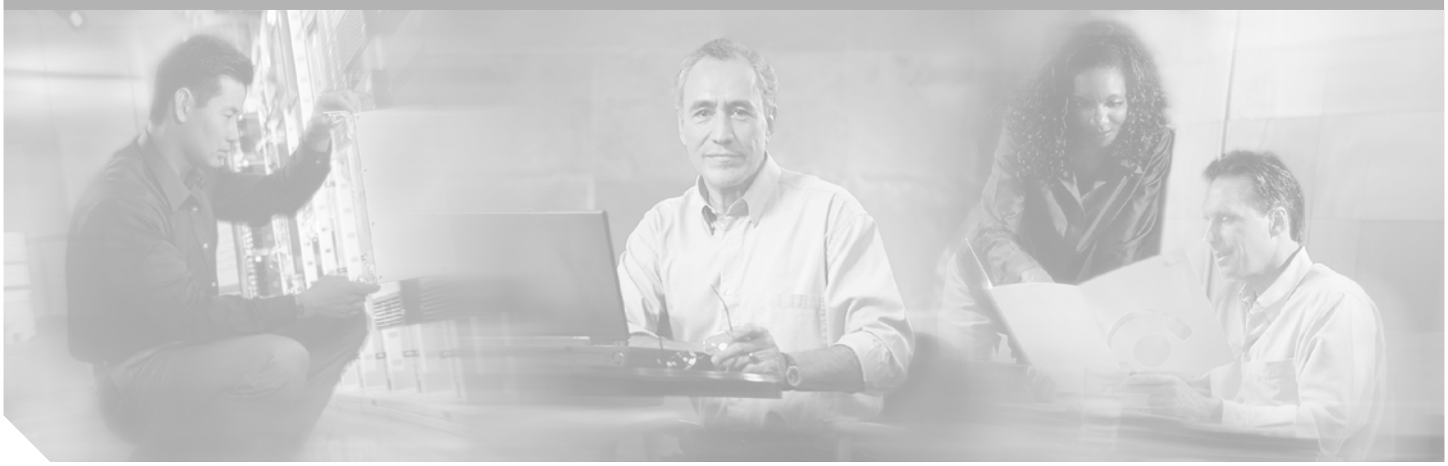

Cisco ONS 15530 Planning Guide

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CONTENTS

Preface

This preface describes the purpose, intended audience, organization, and conventions for the *Cisco ONS 15530 Planning Guide.*

The information contained in this document pertains to the entire range of hardware components and software features supported on the Cisco ONS 15530 platform. As new hardware and Cisco IOS software releases are made available for the Cisco ONS 15530 platform, verification of compatibility becomes extremely important. To ensure that your hardware is supported by your release of Cisco IOS software, see the “New and Changed Information” section in the *Cisco ONS 15530 Configuration Guide* for your software release. Also refer to the “Hardware Supported” section and “Feature Set” section of the latest release notes for the Cisco ONS 15530.

Purpose

This guide serves as a planning tool for implementing DWDM transport networks using the Cisco ONS 15530 Optical Aggregation and Transport platform. This guide addresses important considerations and provides guidelines for planning an optical network. These include an understanding of the Cisco ONS 15530 basic system design, supported topologies and protection schemes, engineering rules and restrictions, and optical power budget calculations. Typical example networks are described, along with their associated chassis configurations.

Audience

This guide is intended for system designers, engineers, and others responsible for designing networks based on DWDM transport using the Cisco ONS 15530.

Note The design guidelines in this document are based on the best currently available knowledge about the functionality and operation of the Cisco ONS 15530. The information in this document is subject to change without notice.

Organization

The chapters of this guide are as follows:

Chapter	Title	Description
Chapter 1	System Overview	Describes the Cisco ONS 15530 chassis, components, and system architecture
Chapter 2	Protection Schemes and Network Topologies	Describes the supported network topologies and fault protection schemes
Chapter 3	Shelf Configuration Rules	Provides the rules for physical configuration of the Cisco ONS 15530
Chapter 4	Optical Loss Budgets	Provides metrics for calculating optical link loss budgets in Cisco ONS 15530 based networks
Chapter 5	Amplified Network Planning	Discusses the amplification and attenuation features supported by the Cisco ONS 15530.
Chapter 6	Example Shelf Configurations and Topologies	Provides examples of shelf configurations for the protection options and common topologies
Appendix A	IBM Storage Protocol Support	Provides design information for applications that use IBM storage protocols

Related Documentation

This guide is part of a documentation set that supports the Cisco ONS 15530. The other documents in the set are as follows:

- *Regulatory Compliance and Safety Information for the Cisco ONS 15500 Series*
- *Cisco ONS 15530 Hardware Installation Guide*
- *Cisco ONS 15530 Cleaning Procedures for Fiber Optic Connections*
- *Cisco ONS 15530 Optical Turn-up and Test Guide*
- *Cisco ONS 15530 Configuration Guide and Command Reference*
- *Quick Reference for the Cisco ONS 15530 TL1 Commands*
- *Cisco ONS 15530 System Alarms and Error Messages*
- *Cisco ONS 15530 Troubleshooting Guide*
- *Network Management for the Cisco ONS 15530*
- *Cisco ONS 15530 MIB Quick Reference*
- *Cisco ONS 15530 Software Upgrade Guide*

Obtaining Documentation

Cisco documentation and additional literature are available on Cisco.com. Cisco also provides several ways to obtain technical assistance and other technical resources. These sections explain how to obtain technical information from Cisco Systems.

Cisco.com

You can access the most current Cisco documentation at this URL:

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- Report security vulnerabilities in Cisco products.
- Obtain assistance with security incidents that involve Cisco products.
- Register to receive security information from Cisco.

A current list of security advisories and notices for Cisco products is available at this URL:

http://www.cisco.com/go/psirt

If you prefer to see advisories and notices as they are updated in real time, you can access a Product Security Incident Response Team Really Simple Syndication (PSIRT RSS) feed from this URL:

http://www.cisco.com/en/US/products/products_psirt_rss_feed.html

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Cisco is committed to delivering secure products. We test our products internally before we release them, and we strive to correct all vulnerabilities quickly. If you think that you might have identified a vulnerability in a Cisco product, contact PSIRT:

- Emergencies—security-alert@cisco.com
- Nonemergencies—psirt@cisco.com

Tip We encourage you to use Pretty Good Privacy (PGP) or a compatible product to encrypt any sensitive information that you send to Cisco. PSIRT can work from encrypted information that is compatible with PGP versions 2.*x* through 8.*x*.

Never use a revoked or an expired encryption key. The correct public key to use in your correspondence with PSIRT is the one that has the most recent creation date in this public key server list:

http://pgp.mit.edu:11371/pks/lookup?search=psirt%40cisco.com&op=index&exact=on

In an emergency, you can also reach PSIRT by telephone:

- 1 877 228-7302
- 1 408 525-6532

Obtaining Technical Assistance

For all customers, partners, resellers, and distributors who hold valid Cisco service contracts, Cisco Technical Support provides 24-hour-a-day, award-winning technical assistance. The Cisco Technical Support Website on Cisco.com features extensive online support resources. In addition, Cisco Technical Assistance Center (TAC) engineers provide telephone support. If you do not hold a valid Cisco service contract, contact your reseller.

Cisco Technical Support Website

The Cisco Technical Support Website provides online documents and tools for troubleshooting and resolving technical issues with Cisco products and technologies. The website is available 24 hours a day, 365 days a year, at this URL:

http://www.cisco.com/techsupport

Access to all tools on the Cisco Technical Support Website requires a Cisco.com user ID and password. If you have a valid service contract but do not have a user ID or password, you can register at this URL:

http://tools.cisco.com/RPF/register/register.do

Note Use the Cisco Product Identification (CPI) tool to locate your product serial number before submitting a web or phone request for service. You can access the CPI tool from the Cisco Technical Support Website by clicking the **Tools & Resources** link under Documentation & Tools. Choose **Cisco Product Identification Tool** from the Alphabetical Index drop-down list, or click the **Cisco Product Identification Tool** link under Alerts & RMAs. The CPI tool offers three search options: by product ID or model name; by tree view; or for certain products, by copying and pasting **show** command output. Search results show an illustration of your product with the serial number label location highlighted. Locate the serial number label on your product and record the information before placing a service call.

Submitting a Service Request

Using the online TAC Service Request Tool is the fastest way to open S3 and S4 service requests. (S3 and S4 service requests are those in which your network is minimally impaired or for which you require product information.) After you describe your situation, the TAC Service Request Tool provides recommended solutions. If your issue is not resolved using the recommended resources, your service request is assigned to a Cisco TAC engineer. The TAC Service Request Tool is located at this URL:

http://www.cisco.com/techsupport/servicerequest

For S1 or S2 service requests or if you do not have Internet access, contact the Cisco TAC by telephone. (S1 or S2 service requests are those in which your production network is down or severely degraded.) Cisco TAC engineers are assigned immediately to S1 and S2 service requests to help keep your business operations running smoothly.

To open a service request by telephone, use one of the following numbers:

Asia-Pacific: +61 2 8446 7411 (Australia: 1 800 805 227)
EMEA: +32 2 704 55 55
USA: 1 800 553-2447

For a complete list of Cisco TAC contacts, go to this URL:

http://www.cisco.com/techsupport/contacts

Definitions of Service Request Severity

To ensure that all service requests are reported in a standard format, Cisco has established severity definitions.

Severity 1 (S1)—Your network is "down," or there is a critical impact to your business operations. You and Cisco will commit all necessary resources around the clock to resolve the situation.

Severity 2 (S2)—Operation of an existing network is severely degraded, or significant aspects of your business operation are negatively affected by inadequate performance of Cisco products. You and Cisco will commit full-time resources during normal business hours to resolve the situation.

Severity 3 (S3)—Operational performance of your network is impaired, but most business operations remain functional. You and Cisco will commit resources during normal business hours to restore service to satisfactory levels.

Severity 4 (S4)—You require information or assistance with Cisco product capabilities, installation, or configuration. There is little or no effect on your business operations.

Obtaining Additional Publications and Information

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- Cisco Marketplace provides a variety of Cisco books, reference guides, and logo merchandise. Visit Cisco Marketplace, the company store, at this URL:

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- *Cisco Press* publishes a wide range of general networking, training and certification titles. Both new and experienced users will benefit from these publications. For current Cisco Press titles and other information, go to Cisco Press at this URL:

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- *Packet* magazine is the Cisco Systems technical user magazine for maximizing Internet and networking investments. Each quarter, Packet delivers coverage of the latest industry trends, technology breakthroughs, and Cisco products and solutions, as well as network deployment and troubleshooting tips, configuration examples, customer case studies, certification and training information, and links to scores of in-depth online resources. You can access Packet magazine at this URL:

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- *iQ Magazine* is the quarterly publication from Cisco Systems designed to help growing companies learn how they can use technology to increase revenue, streamline their business, and expand services. The publication identifies the challenges facing these companies and the technologies to help solve them, using real-world case studies and business strategies to help readers make sound technology investment decisions. You can access iQ Magazine at this URL:

  http://www.cisco.com/go/iqmagazine

- *Internet Protocol Journal* is a quarterly journal published by Cisco Systems for engineering professionals involved in designing, developing, and operating public and private internets and intranets. You can access the Internet Protocol Journal at this URL:

  http://www.cisco.com/ipj

- World-class networking training is available from Cisco. You can view current offerings at this URL:

  http://www.cisco.com/en/US/learning/index.html

CHAPTER 1

System Overview

The Cisco ONS 15530 is an optical transport platform that employs DWDM (dense wavelength division multiplexing) technology. With the Cisco ONS 15530, users can take advantage of the availability of dark fiber to build a common infrastructure that supports data networking and storage networking.

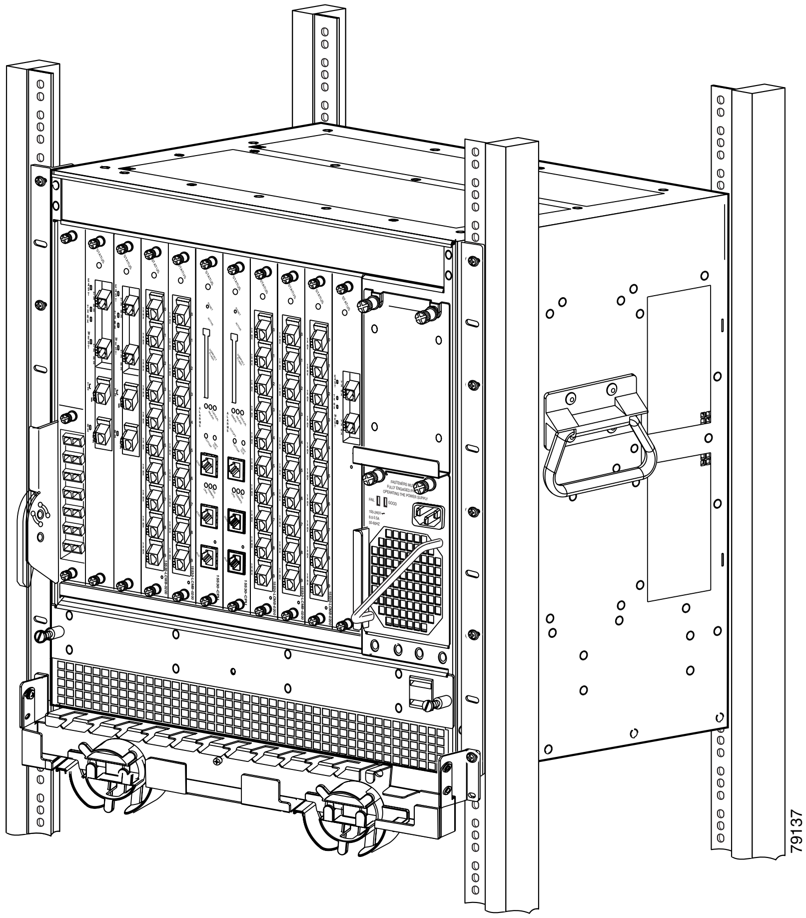
This chapter contains the following major sections:

Chassis Description

The Cisco ONS 15530 uses an 11-slot modular vertical chassis (see Figure 1-1). As you face the chassis, the leftmost slot (slot 0) holds up to two OADM (optical add/drop multiplexer/demultiplexer) modules. Slots 1 to 4 and 7 to 10 hold the line cards. Slots 5 and 6 hold the CPU switch modules. Air inlet, fan tray, and cable management are located beneath the modular slots. The system has an electrical backplane for system control and signal cross connection via the switch fabric.

The system receives power from two +12 volt redundant power supplies. Both 120V AC and –48V DC power supply options are supported.

Figure 1-1 Cisco ONS 15530 Shelf Layout



Chassis Configurations

There are two versions of the Cisco ONS 15530 chassis, each with different air flow and other mechanical design characteristics. The NEBS (Network Equipment Building System) version of the Cisco ONS 15530 chassis is designed for the North American and other markets. The mechanical design characteristics include the following:

- Handles located on the top of the chassis
- Air flow through the chassis from front to back

The other chassis is designed for ETSI (European Telecommunications Standards Institute), a standards organization for the European Union. The mechanical design characteristics include the following:

- Handles located on the sides of the chassis.
- Air flow through the chassis from bottom to top and equipped with baffles that bring the air from the front to the back.

For detailed specifications information on the Cisco ONS 15530 chassis, refer to the *Cisco ONS 15530 Hardware Installation Guide*.

System Functional Overview

The Cisco ONS 15530 connects to client equipment, to the DWDM trunk (transport network), to other Cisco ONS 15530 shelves, and to other DWDM equipment, such as the Cisco ONS 15540 ESP and Cisco ONS 15540 ESPx. Simply described, the Cisco ONS 15530 takes a client signal and converts it to an ITU-T G.692 compliant wavelength, then either optically multiplexes it with the other client signals for transmission over an optical fiber link or sends it through an uplink connection to a Cisco ONS 15540 ESP or Cisco ONS 15540 ESPx.

The Cisco ONS 15530 supports 1+1 path protection using both hardware mechanisms and software based on the APS (Automatic Protection Switching) standard. In a single shelf configuration, a Cisco ONS 15530 node can support up to four channels with facility (fiber) protection or with line card protection, or eight unprotected channels. In a multiple shelf configuration, a node can support up to 32 channels. The Cisco ONS 15530 can be deployed in point-to-point, hubbed ring, and mesh topologies.

The Cisco ONS 15530 is a duplex system with both light emitters and light detectors. For example, the client side interfaces both transmit and receive light. The same is true of the DWDM interface. Also, the OADM modules both multiplex the transmit signal and demultiplex the receive signal.

The Cisco ONS 15530 supports the following two types of transmission modes:

- Transparent mode using the transponder line cards
- Switched mode using the switch fabric on the CPU switch modules to cross connect the ESCON aggregation cards, 4-port 1-Gbps/2-Gbps FC aggregation card, or 8-port FC/GE aggregation line cards and 2.5-Gbps ITU trunk cards, 10-Gbps ITU tunable and non tunable trunk cards, or 10-Gbps uplink cards.

Figure 1-2 illustrates the principal functions involved in transparent transmission of the signal between the client and trunk networks using the transponder line card. Optical cross connections from the front panel of the transponder line card take the signal to the OADM module.

Figure 1-2 Simplified Data Flow Architecture For a Transponder Line Card

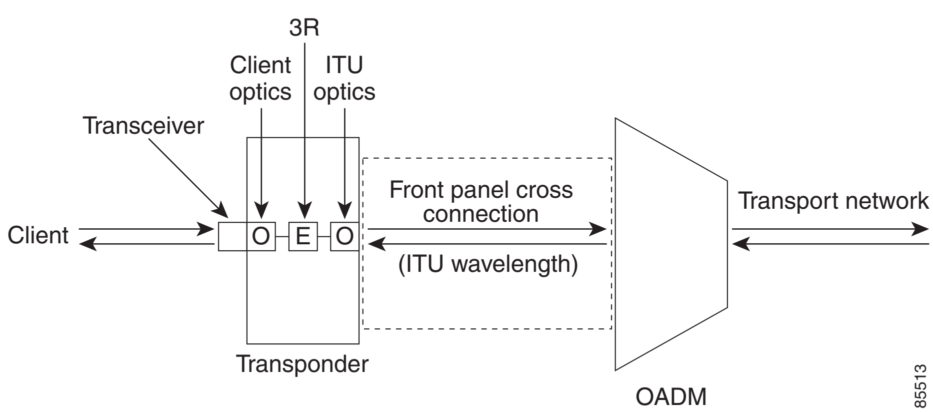
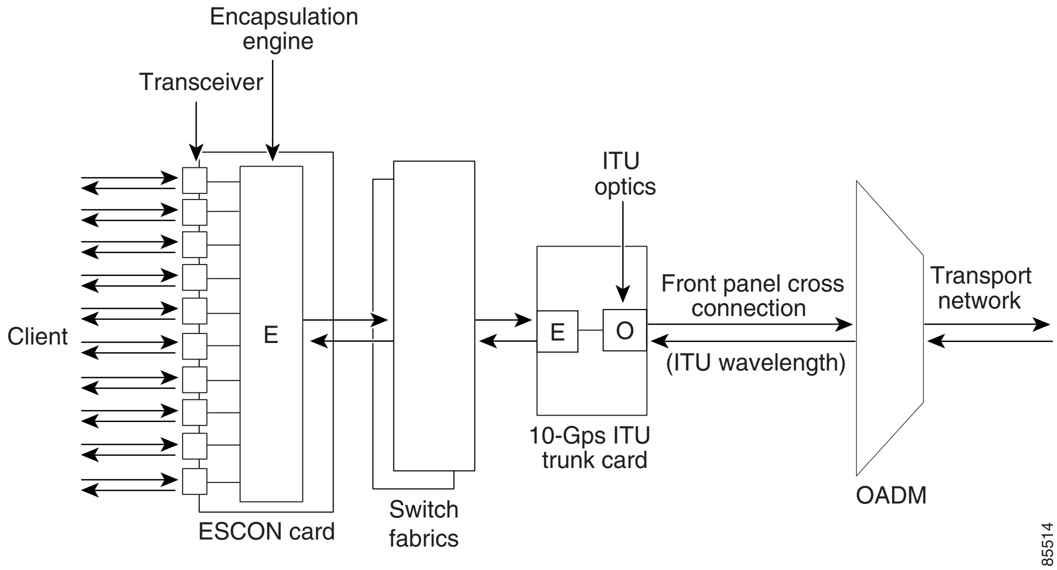


Figure 1-3 illustrates the principal functions involved in transmission of the signal between the client and trunk networks using the ESCON aggregation card and the 10-Gbps ITU trunk card. Electrical cross connections from the backplane side of the ESCON aggregation card take the signal through the switch fabrics on the CPU switch modules to the 10-Gbps ITU trunk card. Optical cross connections from the front panel of the 10-Gbps ITU trunk card take the signal to the OADM module.

Figure 1-3 Simplified Data Flow Architecture For an ESCON Aggregation Card and a 10-Gbps ITU Trunk Card



System Components

The Cisco ONS 15530 has a modular architecture that provides the flexibility to expand the system as the network grows. The Cisco ONS 15530 components are described in the following sections.

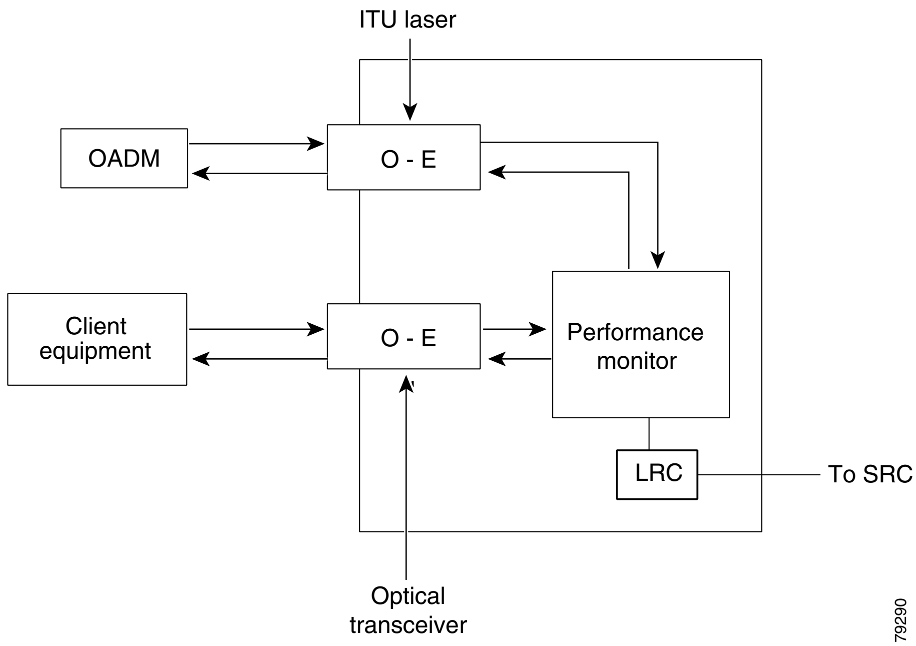
Transponder Line Cards

The Cisco ONS 15530 supports two types of transponder line cards: SM (single-mode) and MM (multimode). You can install the transponder line cards in any line card slot in the shelf (slots 1 to 4 and 7 to 10).

In the transponder line card, the client signal is regenerated, retimed, and retransmitted on an ITU-compliant wavelength. The ITU laser on each transponder line card is capable of generating one of two wavelengths on the trunk side. Thus, there are 16 different transponder line cards (for channels 1–2, 3–4,..., 31–32) to support the 32 channels; each module is available in SM and MM versions. The wavelength generated is configurable from the CLI (command-line interface).

Figure 1-4 shows the architecture of the transponder line card.

Figure 1-4 Transponder Line Card Architecture



A safety protocol, LSC (laser safety control), shuts the transmit laser down on the trunk side when a fiber break or removed connector is detected. The transponder line cards are hot pluggable, permitting in-service upgrades and replacement.

Client Side Interfaces

The client interfaces on the SM transponder line cards and MM transponder line cards are protocol transparent and bit-rate transparent, and accept either single-mode or multimode client signals on the 1310-nm wavelength through SC connectors. The multimode transponder supports 62.5 µm MM, 50 µm MM, and 9 or 10 µm SM fiber; the single-mode transponder supports 50 µm MM fiber and 9 or 10 µm SM fiber.

The transponder interfaces support encapsulation of client signals in either 3R (reshape, retime, retransmit) enhanced mode, which allows some client protocol monitoring (such as code violations and data errors) or regular 3R mode, where the transponder is transparent to the client data stream. In either case, the content of the client data stream remains unmodified. Configurable failure and degrade thresholds for monitored protocols are also supported.

Table 1-1 shows the common client signal protocol encapsulations supported on the SM transponder line cards and MM transponders modules.

Table 1-1 Common Protocol Encapsulations Supported on SM Transponder Line Cards and MM Transponder Line Cards

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
Gigabit Ethernet (1250 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	Yes	No	Yes	No	Yes
	MM 62.5/125 µm	Yes	No	No	No	—
Fast Ethernet (125 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	No
	MM 50/125 µm	Yes	No	Yes	Yes	No
	MM 62.5/125 µm	Yes	No	No	Yes	No
SONET STS-3/ SDH STM-1 (OC-3) (155 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	Yes
	MM 50/125 µm	Yes	No	Yes	Yes	Yes
	MM 62.5/125 µm	Yes	No	No	Yes	Yes
SONET STS-12/SDH STM-4 (OC-12) (622 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	Yes
	MM 50/125 µm	Yes	No	Yes	Yes	Yes
	MM 62.5/125 µm	Yes	No	No	Yes	Yes
SONET STS-48/ SDH STM-16 (OC-48) (2488 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	Yes	No	Yes	No	Yes
	MM 62.5/125 µm	Yes	No	No	No	—
ATM 155 (OC-3) (155 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	Yes
	MM 50/125 µm	Yes	No	Yes	Yes	Yes
	MM 62.5/125 µm	Yes	No	No	Yes	Yes
Fiber Channel (1062 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	Yes	No	Yes	No	Yes
	MM 62.5/125 µm	Yes	No	No	No	—
Fiber Channel (2125 Mbps)	SM 9 o r10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	Yes	No	Yes	No	Yes
	MM 62.5/125 µm	Yes	No	No	No	—
FDDI (125 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	No
	MM 50/125 µm	Yes	No	Yes	Yes	No
	MM 62.5/125 µm	Yes	No	No	Yes	No

Table 1-2 shows the IBM storage protocols on the SM transponder line cards and MM transponders modules.

Table 1-2 IBM Storage Protocols Supported on Single-Mode and Multimode Transponders

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
ESCON (200 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	Yes
	MM 50/125 µm	Yes	No	No	Yes	Yes
	MM 62.5/125 µm	Yes	No	No	Yes	Yes
FICON (1062 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	Yes	No	Yes[1]	No	Yes
	MM 62.5/125 µm	Yes	No	Yes[1]	No	Yes
FICON (2125 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	Yes	No	Yes[2]	No	Yes
	MM 62.5/125 µm	Yes	No	Yes[1]	No	Yes
Coupling Facility, ISC-3 compatibility mode (1062 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	Yes	No	Yes[1]	No	Yes
	MM 62.5/125 µm	No	No	—	—	—
Coupling Facility, ISC-3 peer mode (2125 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	No	No	—	—	—
	MM 62.5/125 µm	No	No	—	—	—
Coupling Facility, ISC-3 peer mode (1062 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	Yes
	MM 50/125 µm	No	No	—	—	—
	MM 62.5/125 µm	No	No	—	—	—
Sysplex Timer (ETR and CLO) (8 Mbps[3])	SM 9 or 10/125 µm	No	No	—	—	—
	MM 50/125 µm	Yes	No	No	Yes	No
	MM 62.5/125 µm	Yes	No	No	Yes	No

1. These protocols require the use of a special mode-conditioning patch cable (available from IBM) at each end of the connection.
2. These protocols require the use of a special mode-conditioning patch cable (available from IBM) at each end of the connection.
3. Sysplex Timer is the only protocol supported at a clock rate less than 16 Mbps.

Table 1-3 shows some other common protocols that are supported on the SM transponder line cards and MM transponders modules without protocol monitoring.

Table 1-3 Other Client Signal Encapsulations Supported on Single-Mode and Multimode Transponders

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
DS3 (45 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	No
	MM 50/125 µm	Yes	No	Yes	Yes	No
	MM 62.5/125 µm	Yes	No	No	Yes	No
OC-1 (51.52 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	Yes	No
	MM 50/125 µm	Yes	No	Yes	Yes	No
	MM 62.5/125 µm	Yes	No	No	Yes	No
OC-24 (933.12 Mbps)	SM 9 or 10/125 µm	Yes	No	Yes	No	No
	MM 50/125 µm	Yes	No	Yes	No	No
	MM 62.5/125 µm	Yes	No	No	No	No

Additional discrete rates are also supported in regular 3R mode. For SM transponder line cards, these rates fall between 16 Mbps and 2.5 Gbps; for MM transponder line cards, the rates are between 16 Mbps and 622 Mbps.

The system supports OFC (open fiber control) for Fibre Channel and ISC encapsulations. Alternatively, FLC (forward laser control) can be enabled to shut down the laser on the client or trunk side if a Loss of Light is detected on the other side.

The transponder line cards support autonegotiation for Gigabit Ethernet traffic.

Note The Cisco ONS 15530 transponder line cards do not support autonegotiation for 2-Gbps Fibre Channel. The transponder line cards only recognize the configured clock rate or protocol encapsulation.

For detailed information about client interface configuration, refer to the *Cisco ONS 15530 Configuration Guide*.

Protocol Monitoring

The transponder line cards can monitor protocol and signal performance. When monitoring is enabled, the system maintains statistics that are used to determine the quality of the signal.

The following protocols can be monitored:

- ESCON (Enterprise Systems Connection)
- FC (Fibre Channel) (1 Gbps and 2 Gbps)
- FICON (Fiber Connection) (1 Gbps and 2 Gbps)
- GE (Gigabit Ethernet)
- ISC-3 links compatibility mode
- ISC-3 links peer mode (1-Gbps and 2-Gbps)
- SDH (Synchronous Digital Hierarchy) (STM-1, STM-4, STM-16)
- SONET (OC-3, OC-12, OC-48)

For GE, FC, and FICON traffic, the Cisco ONS 15530 monitors the following conditions:

- CVRD (code violation running disparity) error counts
- Loss of Sync
- Loss of Lock
- Loss of Light

For SONET errors, the Cisco ONS 15530 monitors the SONET section overhead only, not the SONET line overhead. Specifically, the system monitors the B1 byte and the framing bytes. The system detects the following defect conditions:

- Loss of Light
- Loss of Lock (when the clock cannot be recovered from the received data stream)
- Severely errored frame
- Loss of Frame

For SONET performance, the system monitors the B1 byte, which is used to compute the four SONET section layer performance monitor parameters:

- SEFS-S (second severely errored framing seconds)
- CV-S (section code violations)
- ES-S (section errored seconds)
- SES-S (section severely errored seconds)

For ISC-3 traffic, the system monitors the following conditions:

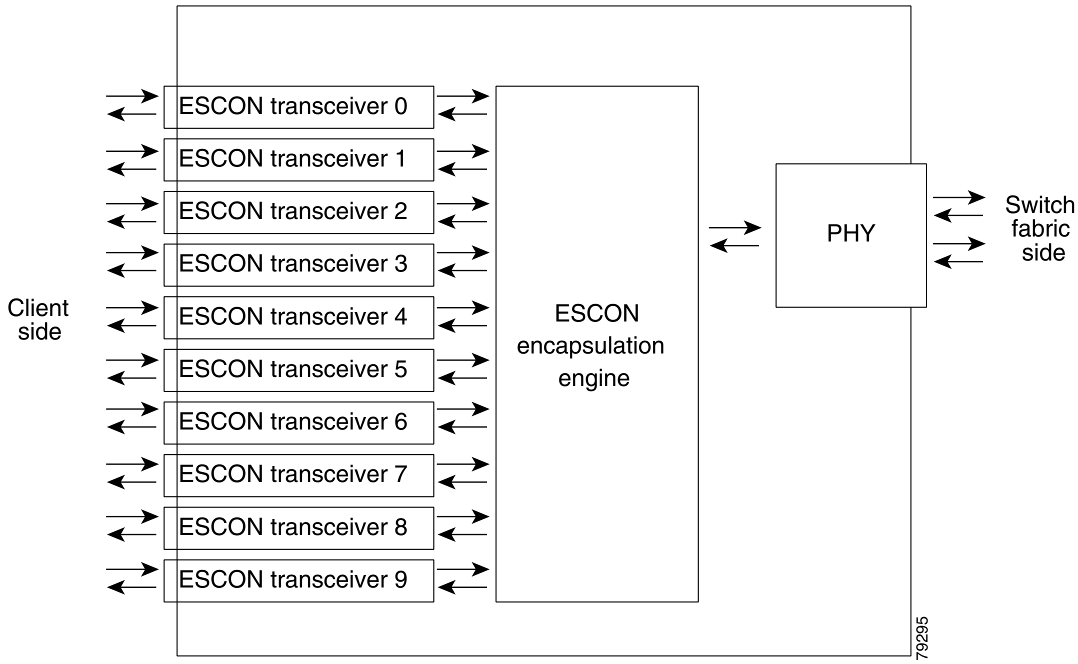
- CVRD error counts
- Loss of CDR (clock data recovery) Lock
- Loss of Light

ESCON Aggregation Cards

The Cisco ONS 15530 supports a line card specifically for ESCON traffic. The ESCON aggregation card accepts up to 10 SFP (small form-factor pluggable) optics for client traffic. The ESCON aggregation card converts the client signals from optical form to electrical and then aggregates them into a single signal. This aggregated signal passes through the backplane and the switch fabric on the active CPU switch module to a 2.5-Gbps ITU trunk card, 10-Gbps ITU tunable or non tunable trunk card, or a 10-Gbps uplink card (see Figure 1-3). The cross connection between the two cards through the backplane and switch fabrics is configured using the CLI. The ESCON aggregation card has redundant connections over the backplane to the switch fabrics on the active and standby CPU switch modules.

Figure 1-5 shows the architecture of the ESCON aggregation card.

Figure 1-5 ESCON Aggregation Card Architecture



The ESCON aggregation card uses pluggable transceivers with MT-RJ connectors for the client signals. The Cisco ONS 15530 supports up to six ESCON aggregation cards for a total of 60 ESCON signals.

Table 1-4 lists features for the SFP optics supported by the ESCON aggregation cards.

Table 1-4 ESCON Aggregation Card SFP Optics Features

Part Number	Description	Fiber Type	Wavelength	Connector Type
15500-XVRA-01A2	Fixed rate	MM 50/125 µm MM 62.5/125 µm	1310 nm	MT-RJ
15500-XVRA-10A1	Low-band variable rate 16 Mbps to 200 Mbps	MM 50/125 µm MM 62.5/125 µm	1310 nm	LC
15500-XVRA-10B1	Low-band variable rate 16 Mbps to 200 Mbps	SM 9/125 µm	1310 nm	LC

Note The Cisco IOS software only supports Cisco-certified SFP optics on the ESCON aggregation card.

4-Port 1-Gbps/2-Gbps FC Aggregation Cards

The Cisco ONS 15530 supports a line card specifically for 1-Gbps and 2-Gbps FC (Fibre Channel), FICON (Fibre Connection), and ISC (InterSystem Channel) links traffic. The 4-port 1-Gbps/2-Gbps FC aggregation card has the following features:

- Accepts up to four single-mode or multimode SFP (small form-factor pluggable) optics for client traffic. Each SFP optic supports 1-Gbps or 2 Gbps FC, FICON, or ISC traffic, depending on how the interface is configured in the CLI.
- Does not restriction how you can populated the card with SFPs. For example, you can mix a single-mode SFP optics with a multimode SFP optics in the same aggregated signal.
- Converts up to four client signals from optical form to electrical and transmits them over up to four 2.5-Gbps electric signals. These signals pass through the backplane and the switch fabric on the active CPU switch module to a 2.5-Gbps ITU trunk card, a 10-Gbps ITU trunk card, or a 10-Gbps uplink card. The cross connections between the two cards through the backplane and switch fabrics are configured using the CLI.
- Allows different traffic types on the same card and on the same aggregated signal.
- Allows two 1-Gbps protocol client signals to be aggregated on one 2.5-Gbps signal sent over the switch fabric. Only one 2-Gbps protocol client signal can be sent over a 2.5-Gbps signal over the switch fabric.
- Has redundant connections over the backplane to the switch fabrics on the active and standby CPU switch modules.
- Is compatible with the 8-port FC/GE aggregation card signals. Any 1-Gbps FC, FICON, or ISC signal can be transmitted between a 4-port 1-Gbps/2-Gbps FC aggregation card and an 8-port FC/GE aggregation card.

Note The 8-port FC/GE aggregation card does not support 1-Gbps ISC peer mode.

- Provides buffer credit functionality for Fibre Channel.

Figure 1-6 shows the architecture of the 4-port 1-Gbps/2-Gbps FC aggregation card.

Figure 1-6 4-Port 1-Gbps/2-Gbps FC Aggregation Card Architecture

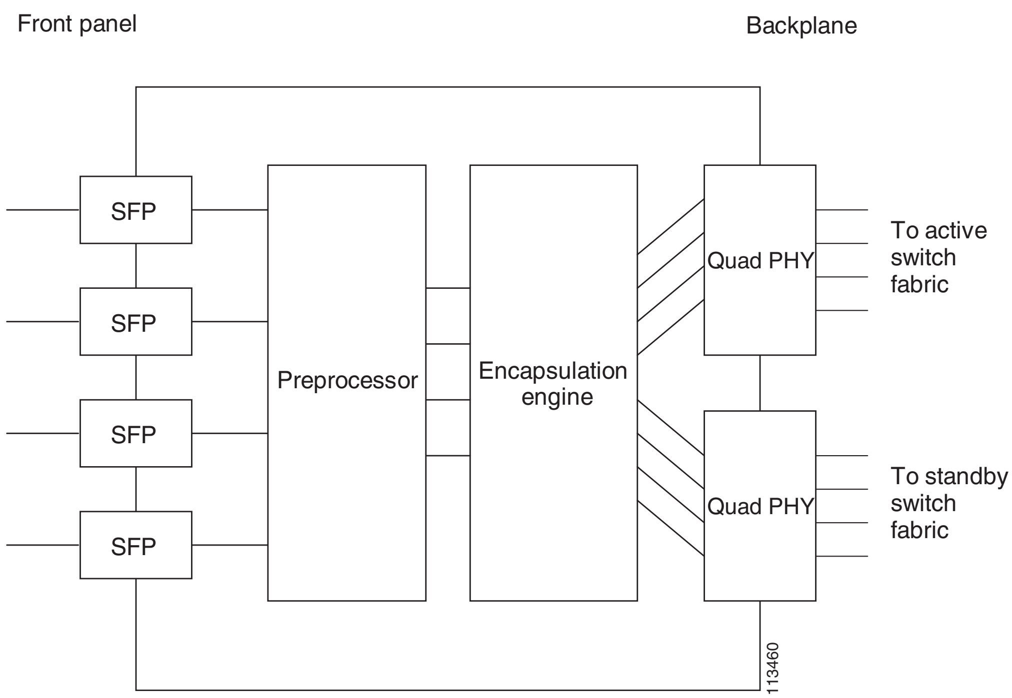


Table 1-5 lists features for the SFP optics supported by the 4-port 1-Gbps/2-Gbps FC aggregation cards.

Table 1-5 4-Port 1-Gbps/2-Gbps FC Aggregation Card SFP Optics Features

Part Number	Protocols or Clock Rate Range Supported	Fiber Type	Wavelength	Connector Type
15500-XVRA-02C1	Fibre Channel (1 Gbps)[1], FICON (1 Gbps)	MM 50/125 µm MM 62.5/125 µm	850 nm	LC
15500-SFP-GEFC-SX	Fibre Channel (1 Gbps and 2 Gbps)[2], Gigabit Ethernet	MM 50/125 µm MM 62.5/125 µm	850 nm	LC
15500-XVRA-03B1	Fibre Channel (1 Gbps)[3], FICON (1 Gbps), ISC links compatibility mode (1 Gbps)	SM 9/125 µm	1310 nm	LC
15500-XVRA-03B2	Fibre Channel (1 Gbps[4] and 2 Gbps[5])	SM 9/125 µm	1310 nm	LC
15500-XVRA-11B1	Mid-band variable rate 200 Mbps to 1.25 Gbps	SM 9/125 µm	1310 nm	LC
15500-XVRA-12B1	High-band variable rate 1.062 Gbps to 2.488 Gbps	SM 9/125 µm	1310 nm	LC

Table 1-5 4-Port 1-Gbps/2-Gbps FC Aggregation Card SFP Optics Features (continued)

Part Number	Protocols or Clock Rate Range Supported	Fiber Type	Wavelength	Connector Type
15454E-SFP-GEFC-S	Fibre Channel (1-Gbps and 2-Gbps)	MM 50/125 µm MM 62.5/125 µm	850 nm	LC
15454-SFP-GEFC-SX	Fibre Channel (1-Gbps and 2-Gbps)	MM 50/125 µm MM 62.5/125 µm	850 nm	LC

1. FC-0-100-M5-SN-S and FC-0-100-M6-SN-S standards
2. FC-0-200-M5-SN-S and FC-0-200-M6-SN-S standards
3. FC-0-100-SM-LC-S standard
4. FC-0-100-SM-LC-S standard
5. FC-0-200-SM-LC-S standard

Note The Cisco IOS software only supports Cisco-certified SFP optics on the 4-port 1-Gbps/2-Gbps FC aggregation card.

The Cisco ONS 15530 supports up to five 4-port 1-Gbps/2-Gbps FC aggregation cards for a total of 20 1-Gbps client signals.

Protocol Monitoring

For FC and FICON traffic, the system monitors the following conditions on the 4-port 1-Gbps/2-Gbps FC aggregation card:

- 8B/10B CVRD error counts
- Tx/Rx frame counts
- Tx/Rx byte counts
- Tx/Rx CRC errors
- Link failures
- Sequence protocol errors
- Invalid transmission words
- 5-minute input/output rates
- Loss of Sync
- Loss of Light

For ISC traffic, the system monitors the following conditions on the 4-port 1-Gbps/2-Gbps FC aggregation card:

- 8B/10B CVRD error counts
- Loss of Light

Support for FC Port Types

The 4-port 1-Gbps/2-Gbps FC aggregation card supports the following FC port types, with or without the buffer credit distance extension feature enabled:

- B_port—bridge port
- E_port—expansion port
- F_port—fabric port
- N_port—node port
- TE_port—trunking E_port (Cisco MDS 9000 Family systems only)

Note All of the above port topologies, except for TE_port, are point-to-point in the FC specifications.

Examples of valid topologies where you can place a Cisco ONS 15530 shelf, which has an 4-port 1-Gbps/2-Gbps FC aggregation card, in the middle to extend distance include the following:

- E_Port <--> E_Port
- F_Port <--> N_Port
- N_Port <--> N_Port
- B_Port <--> B_Port
- TE_Port <--> TE_Port

The arbitrated loop topology is not supported by the 4-port 1-Gbps/2-Gbps FC aggregation card. The arbitrated loop port types not supported include:

- NL_port—node loop port
- FL_port—fabric loop port
- EL_port—extension loop port

Note Any combination of these arbitrated port types are not supported.

8-Port FC/GE Aggregation Cards

The Cisco ONS 15530 supports a line card specifically for FC (Fibre Channel), FICON (Fibre Connection), GE (Gigabit Ethernet), ISC-1 (InterSystem Channel) links compatibility mode, and 1-Gbps ISC-3 peer mode traffic. The 8-port Fibre Channel/Gigabit Ethernet aggregation card accepts up to eight SFP (small form-factor pluggable) optics for client traffic. Each SFP optic supports FC, FICON, GE, or ISC, depending on how the interface is configured in the CLI.

The 8-port FC/GE aggregation card converts client signals from two adjacent port pairs (0–1, 2–3, 4–5, or 6–7) from optical form to electrical and then aggregates them into four 2.5-Gbps signals. These aggregated signals pass through the backplane and the switch fabric on the active CPU switch module to a 2.5-Gbps ITU trunk card, a 10-Gbps ITU trunk card, or a 10-Gbps uplink card. The cross connections between the two cards through the backplane and switch fabrics is configured using the CLI. The 8-port FC/GE aggregation card has redundant connections over the backplane to the switch fabrics on the active and standby CPU switch modules.

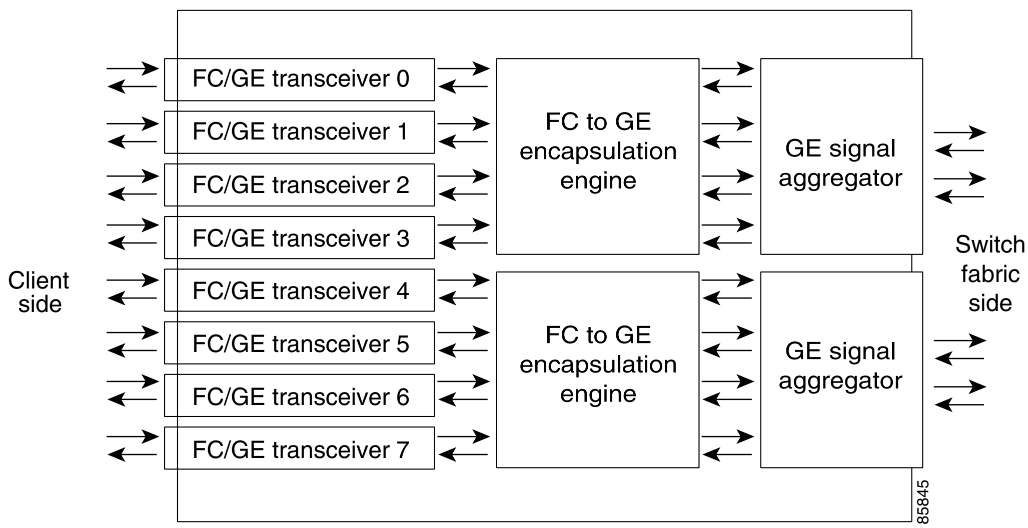
The 8-port FC/GE aggregation card provides buffer credit functionality for Fibre Channel traffic and end-to-end autonegotiation for Gigabit Ethernet traffic.

Note The 8-port FC/GE aggregation card supports end-to-end passthrough of the autonegotiation parameters only for hardware versions earlier than 8.0 updated with functional image A.2-30 or later, or hardware version 8.0, or later, updated with functional image B.2-30 or later. For information on updating functional images, refer to the *Cisco 15530 Software Upgrade Guide*.

Note We strongly recommend configuring port pairs as FC only or GE only. Mixing FC and GE in a port pair increases the FC signal latency between nodes.

Figure 1-7 shows the architecture of the 8-port FC/GE aggregation card.

Figure 1-7 8-port FC/GE Aggregation Card Architecture



The 8-port FC/GE aggregation card uses single-mode and multimode SFP optics for the client signals. There are no restrictions on populating the line card with SFPs. For example, you can mix a single-mode SFP optic with a multimode SFP optic in the same port pair. Table 1-6 lists features for the SFP optics supported by the 8-port FC/GE aggregation cards.

Table 1-6 8-Port FC/GE Aggregation Card SFP Optics Features

Part Number	Protocols or Clock Rate Range Supported	Fiber Type	Wavelength	Connector Type
15500-XVRA-02C1	Gigabit Ethernet[1], Fibre Channel (1 Gbps)[2], FICON (1 Gbps), ISC-3 links compatibility and peer mode (1 Gbps)	MM 50/125 µm MM 62.5/125 µm	850 nm	LC
15500-XVRA-03B1	Gigabit Ethernet[3], Fibre Channel (1 Gbps)[4], FICON (1 Gbps), ISC-3 links compatibility and peer mode (1 Gbps)	SM 9/125 µm	1310 nm	LC

Table 1-6 8-Port FC/GE Aggregation Card SFP Optics Features (continued)

Part Number	Protocols or Clock Rate Range Supported	Fiber Type	Wavelength	Connector Type
15500-XVRA-11B1	Mid-band variable rate 200 Mbps to 1.25 Gbps	SM 9/125 µm	1310 nm	LC
15500-XVRA-12B1	High-band variable rate 1.062 Gbps to 2.488 Gbps	SM 9/125 µm	1310 nm	LC

1. 1000BASE-SX
2. FC-0-100-M5-SN-S and FC-0-100-M6-SN-S standards
3. 1000BASE-LX
4. FC-0-100-SM-LC-S standard

Note The Cisco IOS software only supports Cisco-certified SFP optics on the 8-port FC/GE aggregation card.

Note The MTU (maximum transmission unit) size for GE on the 8-port FC/GE aggregation card is 10232 bytes.

The Cisco ONS 15530 supports up to four 8-port FC/GE aggregation cards for a total of 32 client signals.

Protocol Monitoring

For GE traffic, the Cisco ONS 15530 monitors the following conditions on the 8-port FC/GE aggregation card:

- CVRD error counts
- Tx/Rx frame counts
- Tx/Rx byte counts
- Tx/Rx CRC errors
- Giant packet counts
- Runt packet counts
- 5 minute input/output rates

For FC and FICON traffic, the system monitors the following conditions on the 8-port FC/GE aggregation card:

- 8B/10B CVRD error counts
- Tx/Rx frame counts
- Tx/Rx byte counts
- Tx/Rx CRC errors
- Link failures
- Sequence protocol errors
- Invalid transmission words

- 5 minute input/output rates
- Loss of Sync
- Loss of Light

For ISC-3 links traffic, the system monitors the following conditions on the 8-port FC/GE aggregation card:

- 8B/10B CVRD error counts
- Loss of Light

Support for FC Port Types

The 8-port FC/GE aggregation card supports the following FC port types, with or without the buffer credit distance extension feature enabled:

- B_port—bridge port
- E_port—expansion port
- F_port—fabric port
- N_port—node port
- TE_port—trunking E_port (Cisco MDS 9000 Family systems only)

Note All of the above port topologies, except for TE_port, are point-to-point in the FC specifications.

Examples of valid topologies where you can place a Cisco ONS 15530 shelf, which has an 8-port FC/GE aggregation card, in the middle to extend distance include the following:

- E_Port <--> E_Port
- F_Port <--> N_Port
- N_Port <--> N_Port
- B_Port <--> B_Port
- TE_Port <--> TE_Port

The arbitrated loop topology is not supported by the 8-port FC/GE aggregation card. The arbitrated loop port types not supported include:

- NL_port—node loop port
- FL_port—fabric loop port
- EL_port—extension loop port

Note Any combination of these arbitrated port types are not supported.

8-Port Multi-Service Muxponders

The 8-port multi-service muxponder accepts up to eight SFPs for client traffic. The eight client signals are mapped into the right size STS-n payloads and multiplexed into a 2.5-Gbps ITU signal. The ITU signal is then multiplexed onto the trunk by an OADM.

Note The 8-port multi-service muxponder does not use the switch fabric, an ITU trunk card, or an 10-Gbps uplink card.

The 8-port multi-service muxponder supports the following protocols:

- Gigabit Ethernet (1.25 Gbps), copper and optical
- Fiber Channel (1.062 Gbps), optical
- FICON (1.062 Gbps), optical
- DVB-ASI (Digital Video Broadcast-Asynchronous Serial Interface) (270 Mbps), copper and optical
- SDI (Serial Digital Interface) (270 Mbps)
- ESCON (200 MHz), optical
- SONET OC-3 (155 Mbps), optical
- SDH STM-1 (155 Mbps), optical
- ITS (Integrated Trading System) (196.608 Mbps), optical
- Fast Ethernet (125 Mbps), copper and optical
- T1 (1.544 Mbps), copper
- E1 (2.048 Mbps), copper

Other features on the 8-port multi-service muxponder include:

- 2.5-Gbps ITU trunk signal that is tunable across two wavelengths
- DCC (Data Communications Channel) for in-band management
- Splitter protection

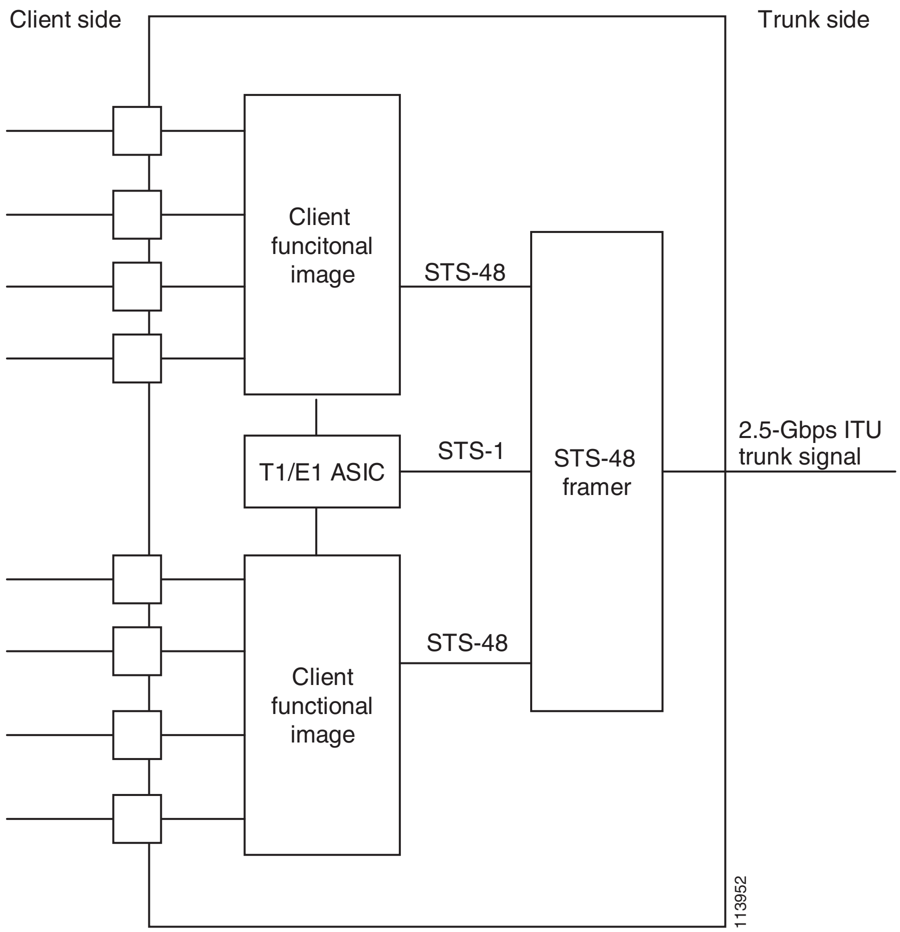
The following features are not supported on the 8-port multi-service muxponder:

- Oversubscription
- Y-cable line card protection
- FICON bridge
- OFC safety protocol

Note Although the 8-port multi-service muxponder uses a SONET-like framing structure to aggregate multiple client data streams, it is not SONET compliant on the optical trunk output. The muxponder ITU compliant optical trunk output must be used in an end-to-end configuration and cannot be connected to a SONET/SDH OADM.

Figure 1-8 shows the architecture of the 8-port multi-service muxponder.

Figure 1-8 8-Port Multi-Service Muxponder Architecture



The 8-port multi-service muxponder uses optical single-mode, optical multimode, and copper SFPs for the client signals. There are no restrictions on populating the line card with SFPs. For example, you can mix a single-mode SFP, a multimode SFP, and a copper SFP in the same muxponder. Table 1-7 lists features for the SFPs supported by the 8-port multi-service muxponders.

Table 1-7 8-port Multi-Service Muxponder SFP Features

Part Number	Protocols Supported	Fiber Type	Wavelength	Connector Type
15500-XVRA-10A2	Low band 8 Mbps to 200 Mbps	MM 50/125 µm MM 62.5/125 µm	1310 nm	LC
15500-XVRA-10B2	Low band 8 Mbps to 200 Mbps	SM 9/125 µm	1310 nm	LC
15500-XVRA-11A2	Mid-band 200 Mbps to 622 Mbps	MM 62.5/125 µm	1310 nm	LC
15500-XVRA-11B2	Mid-band 200 Mbps to 1.25 Gbps	SM 9/125 µm	1310 nm	LC

Table 1-7 8-port Multi-Service Muxponder SFP Features (continued)

Part Number	Protocols Supported	Fiber Type	Wavelength	Connector Type
15500-XVRA-12B1	High-band 1.062 Gbps to 2.488 Gbps	SM 9/125 µm	1310 nm	LC
15500-XVRA-08D1	T1 1.544 Mbps	Copper T1	–	RJ-45
15500-XVRA-09D1	E1 2.044 Mbps	Copper E1	–	RJ-45
15500-XVRA-10E1	SDI and DVB-ASI Video	Copper Digital Video	–	Mini SMB Coax
15500-XVRA-11D1	GE 1.25 Gbps, FE 1.25 Mbps	Copper GE/FE	–	RJ-45

Note The Cisco IOS software only supports Cisco-certified SFP optics on the 8-port multi-service muxponder.

The Cisco ONS 15530 supports up to four 8-port multi-service muxponders for a total of 32 client signals in a protected configuration and up to eight 8-port multi-service muxponders for a total of 64 client signals in an unprotected configuration.

Protocol Monitoring

The 8-port multi-service muxponder only monitors 8B/10B CVRD errors for GE (optical only), FC, FICON, ESCON, ITS, and ASI traffic.

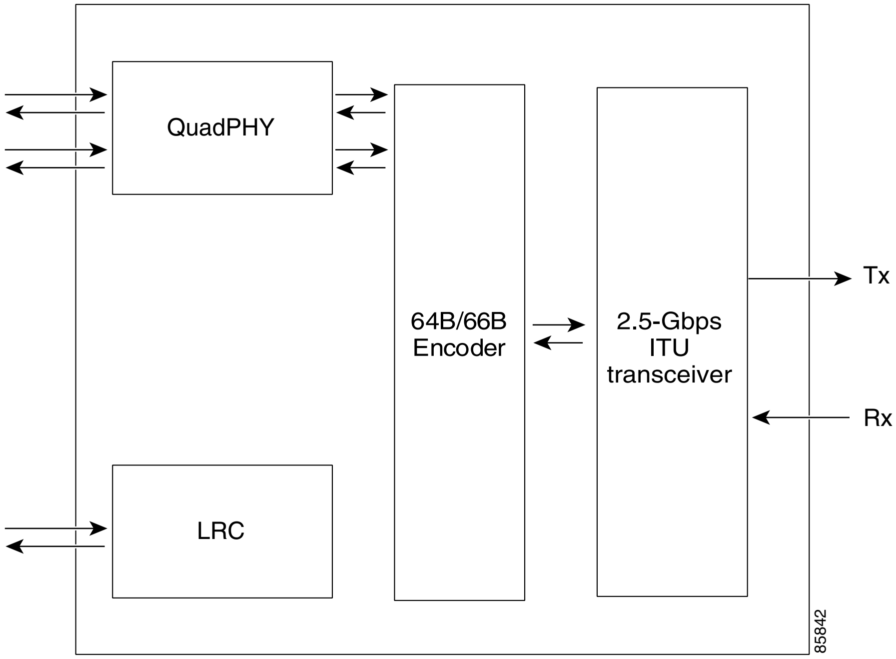
2.5-Gbps ITU Trunk Cards

The 2.5-Gbps ITU trunk card sends and receives the ITU grid wavelength signal to and from an OADM module. This card accepts a 2.5-Gbps (3.125-Gbps line rate) electrical signal from an ESCON aggregation card, an 8-port FC/GE aggregation card, or a 4-port FC aggregation card, which is converted to the ITU grid wavelength, or channel. The 2.5-Gbps ITU trunk card has redundant interfaces to the backplane, connecting to the switch fabrics on the active and standby CPU switch modules. You can turn the ITU laser to one of two channel frequencies. There are 16 different 2.5-Gbps ITU trunk cards (for channels 1–2, 3–4,..., 31–32) to support the 32 channels.

Note When designing your network, consider designs with 10-Gbps ITU tunable and non tunable trunk cards as well as designs with 2.5-Gbps ITU trunk cards. The type of ITU trunk card used affects the design parameters, such as dispersion compensation, amplification, and available wavelengths.

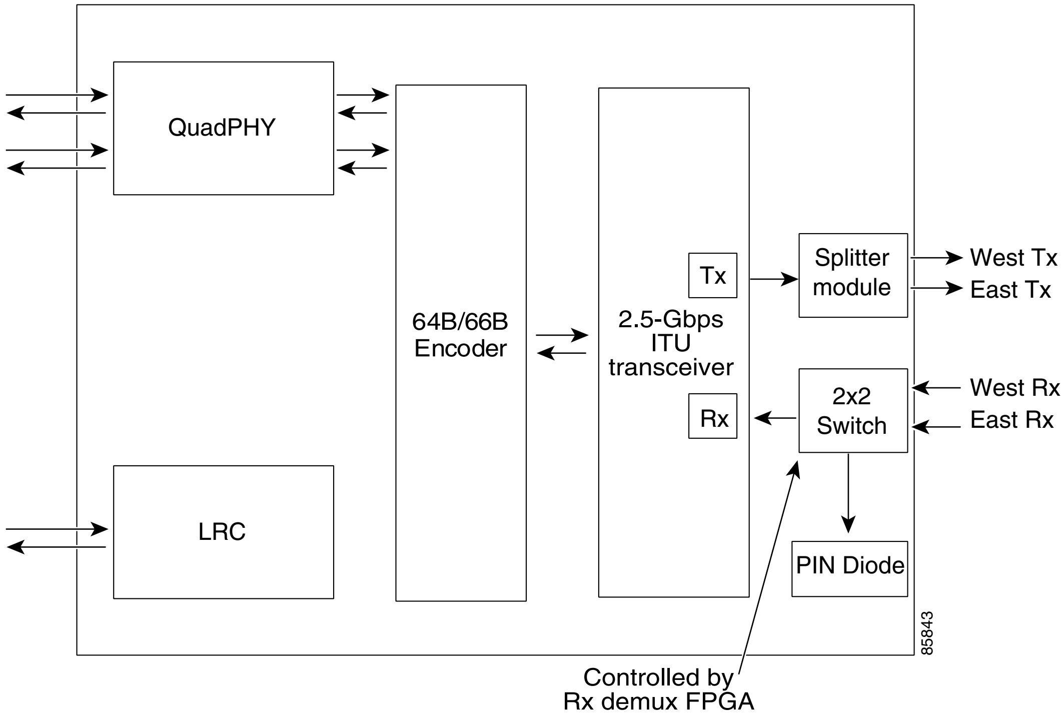
The 2.5-Gbps ITU trunk card has two versions: nonsplitter and splitter. The nonsplitter version has only one pair of optical connectors on the front panel, which connects to either the east or the west OADM module, and can be used for unprotected, line card protected, or switch fabric protected applications (see Figure 1-9).

Figure 1-9 Nonsplitter 2.5-Gbps ITU Trunk Card Architecture



The splitter version of the 2.5-Gbps ITU trunk card has two pairs of optical connectors on the front panel, which connect to the east and west OADM modules, and is designed for splitter protected applications (see Figure 1-10).

Figure 1-10 Splitter 2.5-Gbps ITU Trunk Card Architecture



The Cisco ONS 15530 supports up to four 2.5-Gbps ITU trunk cards for a total of four channels.

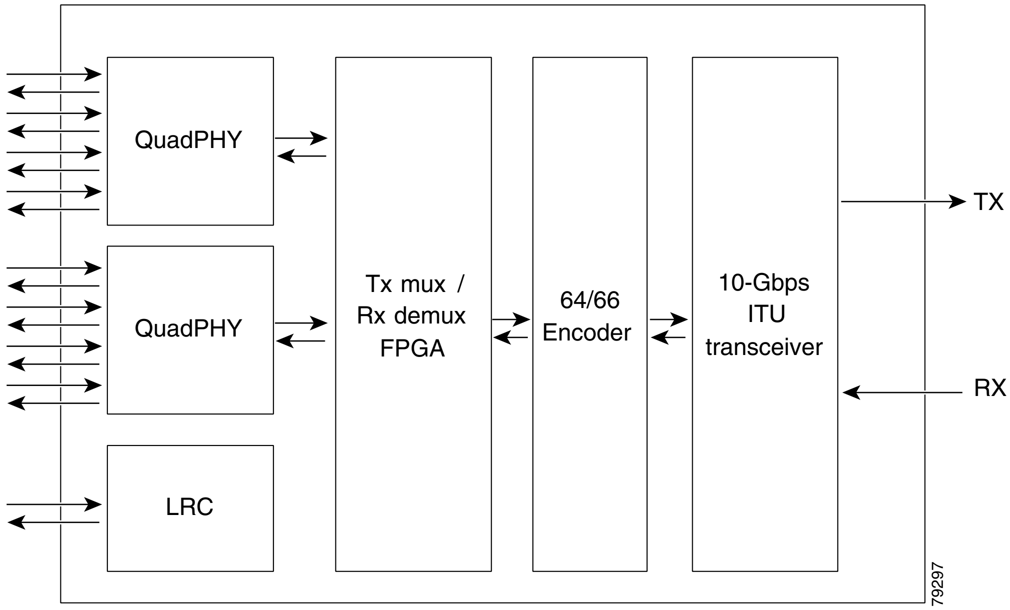
10-Gbps ITU Trunk Cards

The 10-Gbps ITU trunk card sends and receives the ITU grid wavelength signal to and from an OADM module. This card accepts up to four 2.5-Gbps (3.125-Gbps line rate) electrical signals from the ESCON aggregation cards, 8-port FC/GE aggregation cards, or a 4-port FC aggregation card, and combines them into one 10-Gbps signal, which is converted to the ITU grid wavelength, or channel. The 10-Gbps ITU trunk card has four separate redundant interfaces to the backplane, each connecting to the switch fabrics on the active and standby CPU switch modules.

Note When designing your network, consider designs with 10-Gbps ITU trunk cards as well as designs with 2.5-Gbps ITU trunk cards. The type of ITU trunk card used affects the design parameters, such as dispersion compensation, amplification, and available wavelengths.

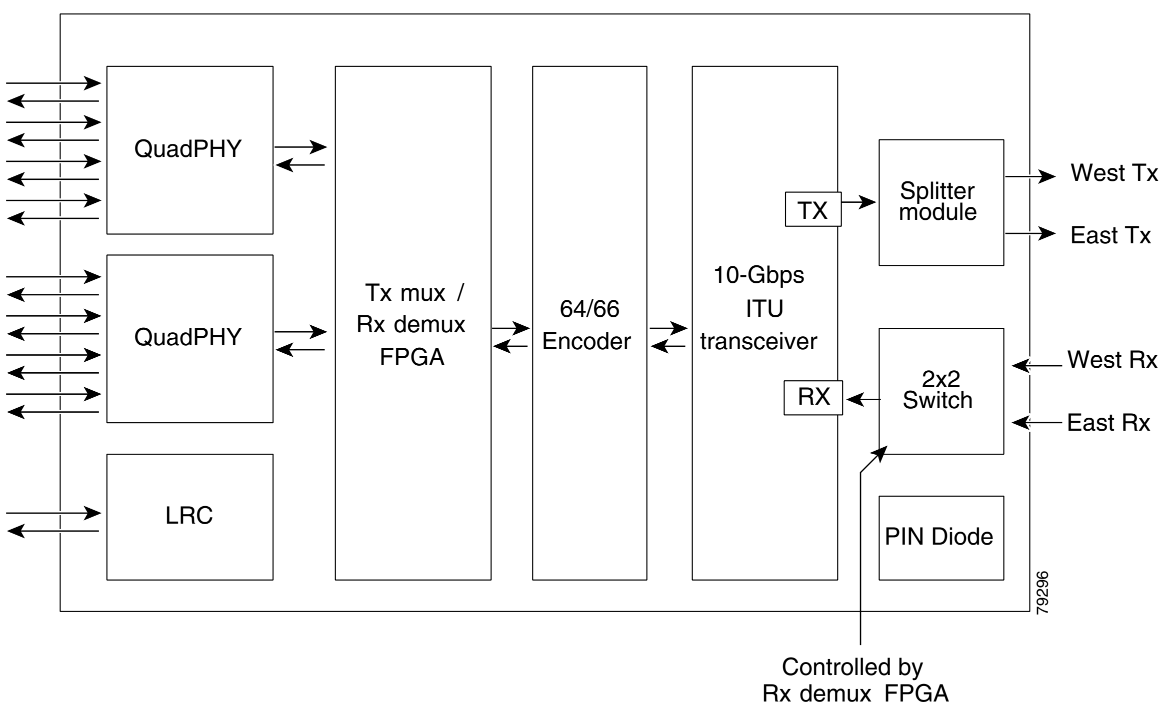
The 10-Gbps ITU trunk card has two version: nonsplitter and splitter. The nonsplitter version has only one pair of optical connectors on the front panel, which connects to either the east or the west OADM module, and can be used for unprotected, line card protected, or switch fabric protected applications (see Figure 1-11).

Figure 1-11 Nonsplitter 10-Gbps ITU Trunk Card Architecture



The splitter version of the 10-Gbps ITU trunk card has two pairs of optical connectors on the front panel, which connect to the east and west OADM modules, and is designed for splitter protected applications (see Figure 1-12).

Figure 1-12 Splitter 10-Gbps ITU Trunk Card Architecture



The Cisco ONS 15530 supports up to four 10-Gbps ITU trunk cards for a total of four channels.

10-Gbps ITU Tunable Trunk Cards

The 10-Gbps ITU tunable trunk card sends and receives the ITU grid wavelength signal to and from an OADM module. This card accepts up to four 2.5-Gbps (3.125-Gbps line rate) electrical signals from the ESCON aggregation cards, 8-port FC/GE aggregation cards, or a 4-port FC aggregation card, and combines them into one 10-Gbps signal, which is converted to the ITU grid wavelength, or channel. The 10-Gbps ITU tunable trunk card has four separate redundant interfaces to the backplane, each connecting to the switch fabrics on the active and standby CPU switch modules.

The 10-Gbps tunable trunk card is equipped with tunable lasers, and can be tuned to four different channels belonging to one band. Table 1-8 shows the tunable frequencies and the corresponding wavelengths. You must use the **show optical wavelength mapping** command to obtain this mapping.

Table 1-8 Tunable Frequencies and Wavelengths

Channel	Frequency (THz)	Wavelength (nm)
0	191.9	1562.23
1	192.	1560.61
2	192.2	1559.79
3	192.3	1558.98
4	192.4	1558.17
5	192.6	1556.55
6	192.7	1555.75
7	192.8	1554.94
8	192.9	1554.13
9	193.1	1552.52
10	193.2	1551.72
11	193.3	1550.92
12	193.4	1550.12
13	193.6	1548.51
14	193.7	1547.72
15	193.8	1546.92
16	193.9	1546.12
17	194.1	1544.53
18	194.2	1543.73
19	194.3	1542.94
20	194.4	1542.14
21	194.6	1540.56
22	194.7	1539.77
23	194.8	1538.98
24	194.9	1538.19
25	195.1	1536.61
26	195.2	1535.82

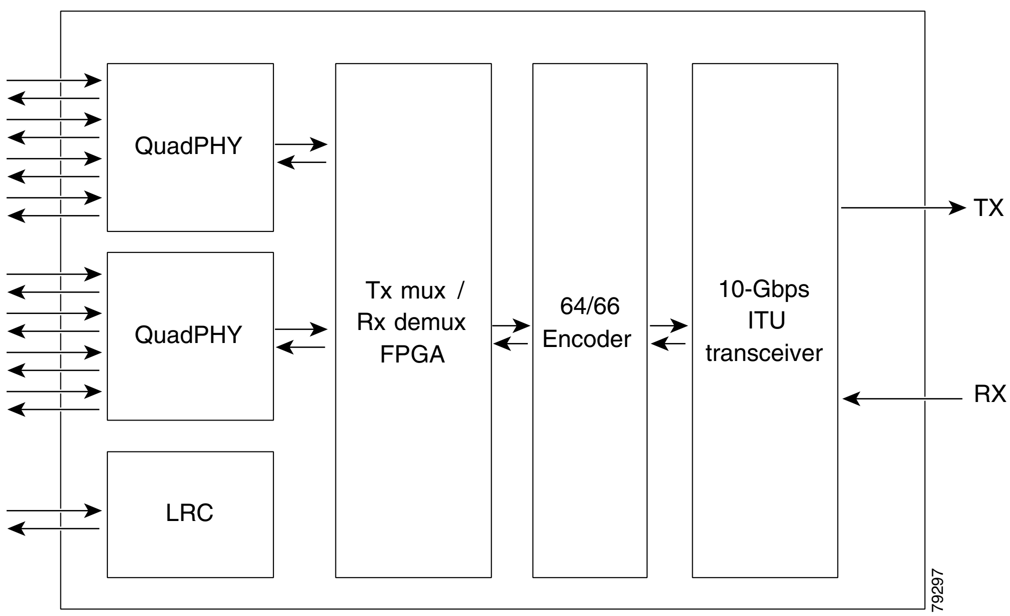
Table 1-8 Tunable Frequencies and Wavelengths (continued)

Channel	Frequency (THz)	Wavelength (nm)
27	195.3	1535.04
28	195.4	1534.25
29	195.6	1532.68
30	195.7	1531.90
31	195.8	1531.12
32	195.9	1530.33

Note When designing your network, consider designs with 10-Gbps ITU tunable trunk cards as well as designs with 2.5-Gbps ITU trunk cards. The type of ITU trunk card used affects the design parameters, such as dispersion compensation, amplification, and available wavelengths.

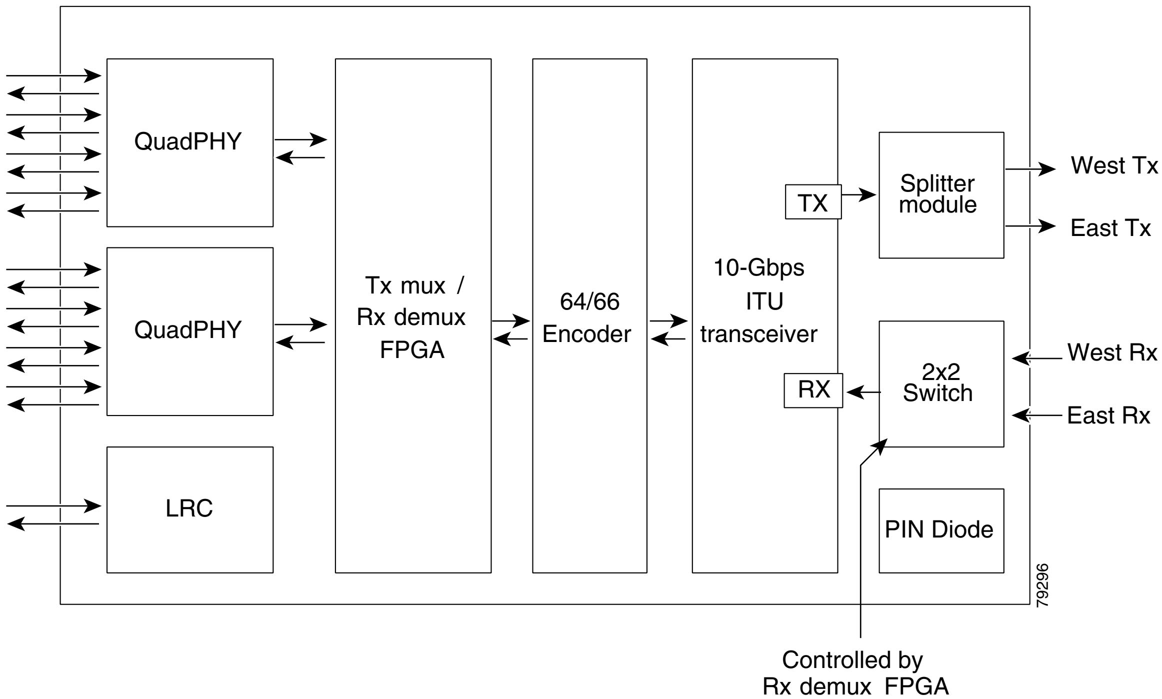
The 10-Gbps ITU tunable trunk card has two version: nonsplitter and splitter. The nonsplitter version has only one pair of optical connectors on the front panel, which connects to either the east or the west OADM module, and can be used for unprotected, line card protected, or switch fabric protected applications (see Figure 1-11).

Figure 1-13 Nonsplitter 10-Gbps ITU Tunable Trunk Card Architecture



The splitter version of the 10-Gbps ITU tunable trunk card has two pairs of optical connectors on the front panel, which connect to the east and west OADM modules and is designed for splitter protected applications (see Figure 1-12).

Figure 1-14 Splitter 10-Gbps ITU Tunable Trunk Card Architecture



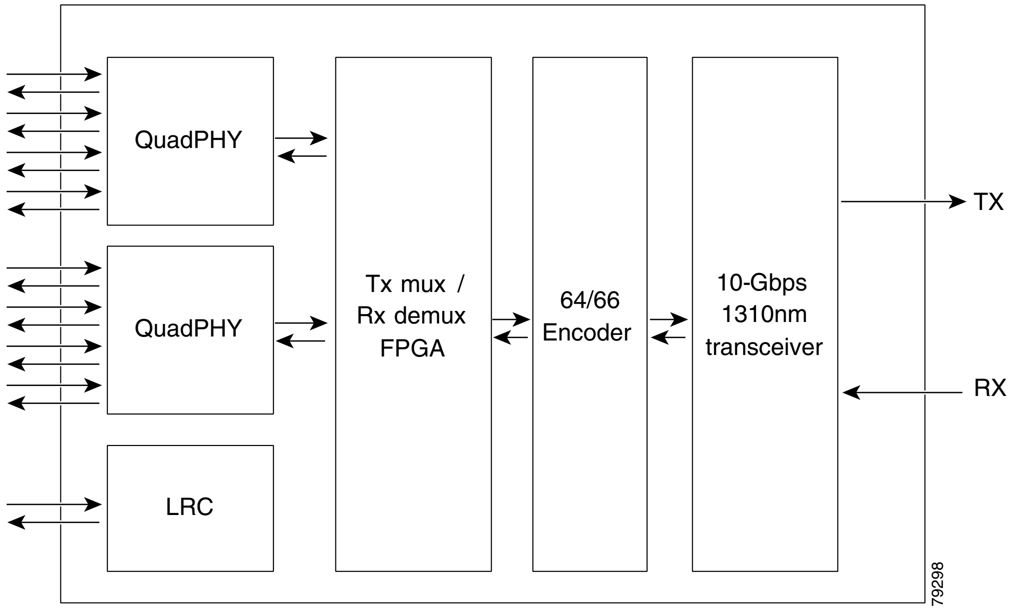
The Cisco ONS 15530 supports up to four 10-Gbps ITU tunable trunk cards for a total of 4 channels.

10-Gbps Uplink Cards

The 10-Gbps uplink card sends and receives a 10-Gbps 1310-nm signal to and from a 10-Gbps uplink card on another Cisco ONS 15530, or to and from a 10-GE transponder module on a Cisco ONS 15540 ESP or Cisco ONS 15540 ESPx. This card accepts up to four (3.125-Gbps line rate) electrical signals from ESCON aggregation cards, 8-port FC/GE aggregation cards, or a 4-port FC aggregation card, and combines them into one 10-Gbps signal (see Figure 1-15).

The 10-Gbps uplink card has four separate redundant interfaces to the backplane. Each interface connects to the switch fabrics on the active and standby CPU switch modules.

Figure 1-15 10-Gbps Uplink Card Architecture



The 10-Gbps uplink card has only one pair of optical connectors on the front panel and can be used for unprotected or line card protected applications. For splitter protected configurations, use the 10-Gbps ITU trunk card.

The Cisco ONS 15530 supports up to four 10-Gbps uplink cards for a total of four channels.

OSC Modules

The Cisco ONS 15530 supports the OSC on a separate module installed in a carrier motherboard. The carrier motherboard accepts up to two OSC modules. Implemented as a 33rd wavelength (channel 0), the OSC is a per-fiber duplex management channel for communicating between Cisco ONS 15530, Cisco ONS 15540 ESP, and Cisco ONS 15540 ESPx systems. The OSC allows control and management traffic to be carried without the necessity of a separate Ethernet connection to each Cisco ONS 15530, Cisco ONS 15540 ESP, and Cisco ONS 15540 ESPx in the network.

The OSC is established over a point-to-point connection and is always terminated on a neighboring node. By contrast, data channels may or may not be terminated on a given node, depending on whether the channels are express (pass-through) or add/drop.

The OSC carries the following types of information:

- CDP (Cisco Discovery Protocol) packets—Used to discover neighboring devices
- IP packets—Used for SNMP and Telnet sessions between nodes
- OSCP (OSC Protocol)—Used to determine whether the OSC link is up
- APS protocol packets—Used for controlling signal path switching

Note A Cisco ONS 15530 system without the OSC and the in-band message channel is not known to other systems in the network and cannot be managed by any NMS. Without the OSC and the in-band message channel, a Cisco ONS 15530 system must be managed individually by separate Ethernet or serial connections. Thus, it is important when adding a node to an existing network of Cisco ONS 15530 systems that the added node have appropriate OSC or the in-band message channel support.

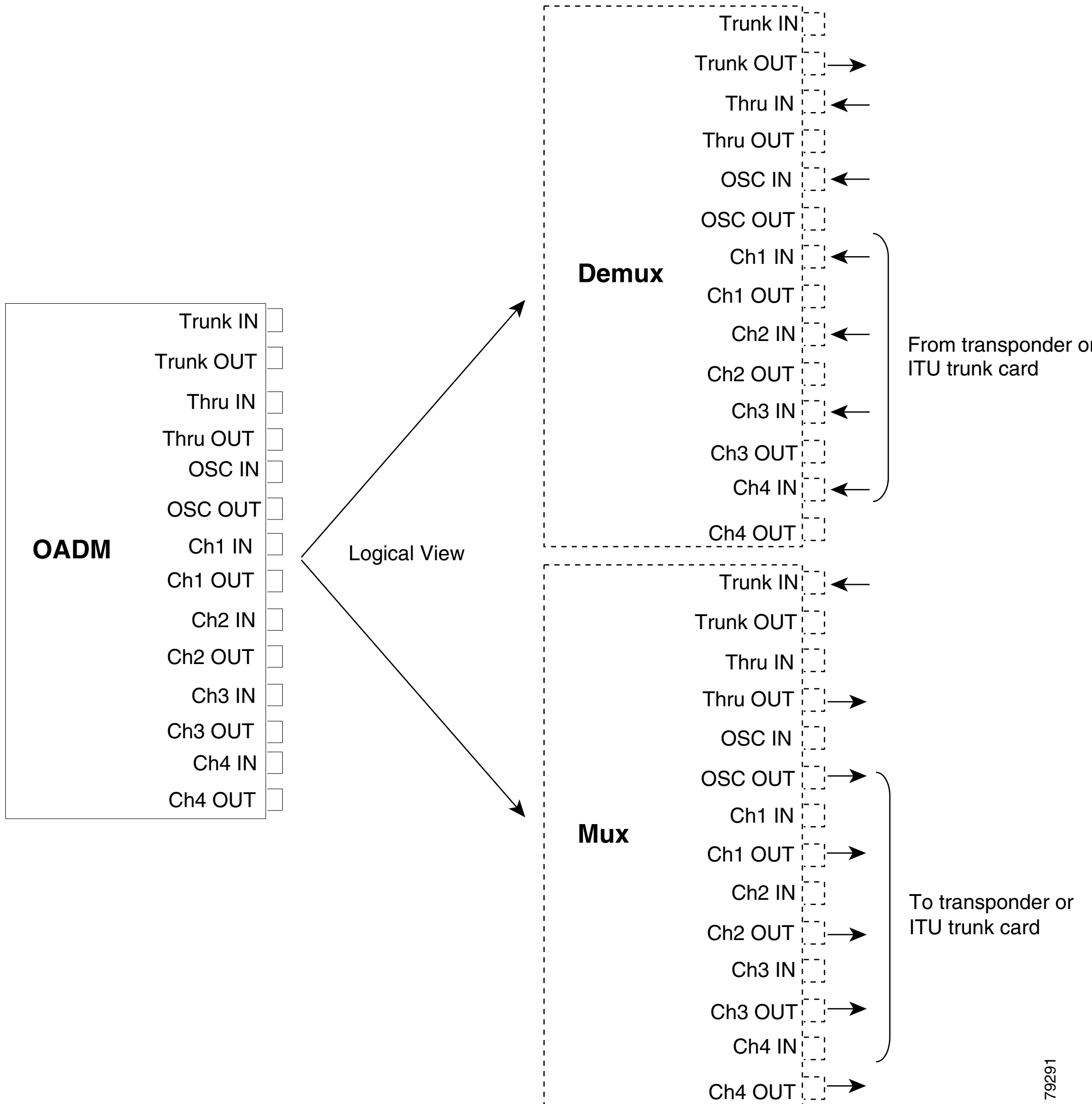
OADM Modules

The OADM (optical add/drop multiplexer/demultiplexer) modules are passive devices that optically multiplex and demultiplex a specific band of 16 ITU wavelengths. The OADM modules supported by the Cisco ONS 15530 each add and drop a band of channels at a node and pass the other bands through. To support the 32-channel spectrum, there are eight different 4-channel OADM modules, each supporting a different band of channels.

In the transmit direction, the OADM modules multiplex signals transmitted by the line cards over optical cross connections and provide the interfaces to connect the multiplexed signal to the DWDM trunk side. In the receive direction, the OADM modules demultiplex the signals from the trunk side before passing them over optical cross connections to the line cards.

Figure 1-16 shows the physical layout of the OADM module for the channels in band A (1–4) along with a logical view of its multiplexing and demultiplexing functions. Optical signals received from the line card, the Thru IN connector, and the OSC IN connector are multiplexed and sent through the Trunk OUT connector. The optical signal received from the Trunk IN connector is demultiplexed and the OSC signal is sent to the OSC OUT connector; the dropped channels are sent to the line card; and the passed channels are sent to the Thru OUT connector.

Figure 1-16 OADM Module Architecture



OADM Modules and Channel Bands

Each OADM module supports a range of channels called a *band*. A band contains 4 channels.

Table 1-9 lists the OADM modules that support each channel band. All cards are available with or without OSC support. For correspondence between channel numbers and wavelengths on the ITU grid, refer to the *Cisco ONS 15530 Hardware Installation Guide*. See Table 1-8 for more information on the tunable frequencies and the corresponding wavelengths.

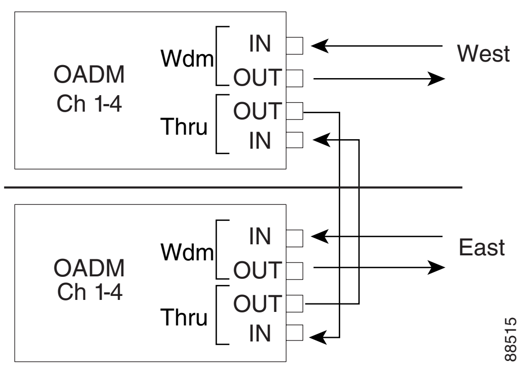
Table 1-9 OADM Modules and Supported Channel Bands

Cisco ONS 15530 Channels	OADM Module
1–4	Band A
5–8	Band B
9–12	Band C
13–16	Band D
17–20	Band E
21–24	Band F
25–28	Band G
29–32	Band H

OADM Module Configurations

In ring configurations, channels that are not supported by a node are passed through that node and sent out on the ring. Figure 1-17 shows an example of how two OADM modules might be cabled in a protected ring configuration.

Figure 1-17 OADM Modules in a Protected Ring Configuration

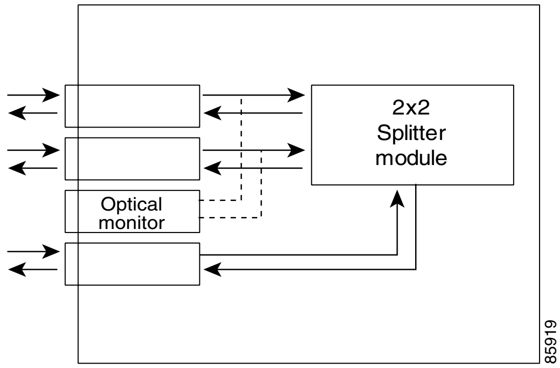


PSMs

The PSM (protection switch module) provides trunk fiber protection for Cisco ONS 15530 systems configured in point-to-point topologies. The PSM sends the signal from an OADM module, an ITU trunk card, or a transponder line card to both the west and east directions. It receives both the west and east signals and selects one to send to the OADM module, ITU trunk card, or transponder line card. Both nodes in the network topology must have the same shelf configuration.When a trunk fiber cut occurs on the active path, the PSM switches the received signal to the standby path. Since the PSM occupies one of the OADM subslots in the shelf, it protects a maximum of four channels and the OSC in a single shelf configuration (see Figure 1-18).

The PSM also has a optical monitor port for testing the west and east receive signals. This port samples one percent of the receive signals that can be monitored with an optical power meter.

Figure 1-18 PSM Architecture



CPU Switch Modules

The Cisco ONS 15530 includes two CPU switch modules for redundancy. Each CPU switch module consists of a number of subsystems, including a CPU, a system clock, Ethernet switch for communicating between CPU switch modules and with the LRC (line card redundancy controller) on the OADM modules, line cards, and carrier motherboards, and the SRC (switch redundancy controller). The active CPU switch module controls the node, and all cards in the system make use of the system clock and synchronization signals from the active CPU switch module.

The CPU switch module is equipped with a console port, a Fast Ethernet interface for Telnet access and network management, and an auxiliary port. There is one slot for a compact Flash disk.

On the CPU switch module front panel are LEDs that display the status of critical, major, and minor signals, as well as the status of alarm cutoff and history conditions.

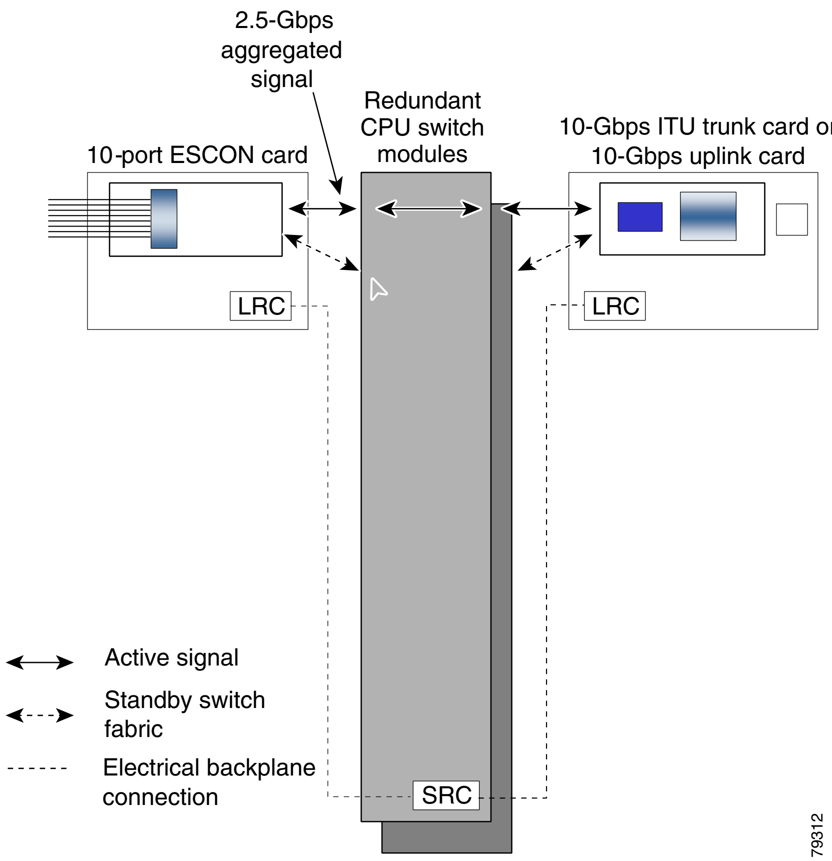
The CPU switch modules run Cisco IOS software and support the following features:

- Automatic configuration at startup
- Automatic discovery of network neighbors
- Online self-diagnostics and tests
- Power-on diagnostics and tests
- Arbitration of CPU switch module status (active/standby) and switchover in case of failure without loss of connections
- Automatic synchronization of startup and running configurations
- In-service software upgrades
- Per-channel APS (Automatic Protection Switching) in linear and ring topologies using redundant subsystems that monitor link integrity and signal quality
- Trunk fiber based DWDM signal protection using APS in point-to-point topologies
- System configuration and management through the CLI and SNMP
- Optical power monitoring on the trunk side, digital monitoring on the client side, and per-channel transponder in-service and out-of-service loopback (client and trunk sides)
- Optional out-of-band management of other Cisco ONS 15530, Cisco ONS 15540 ESP, and Cisco ONS 15540 ESPx systems on the network through the OSC (optical supervisory channel)
- Optional inband management of other Cisco ONS 15530 systems in the network through the in-band message channel

Switch Fabric

The Cisco ONS 15530 CPU switch module has a 32-port by 32-port, nonblocking switch fabric, which can carry up to 3.125 Gbps of traffic per port (for data traffic and the remainder for control traffic). The switch fabric connects signals from client side line cards, such as the ESCON aggregation card, to ITU side line cards, such as the 10-Gbps ITU trunk card (see Figure 1-19). When a shelf is configured for CPU switch module redundancy, the redundant switch fabric increases system availability by protecting against switch fabric failures.

Figure 1-19 Redundant Switch Fabrics



> **Note** Transponder line cards contain both client and ITU optics and do not interface with the switch fabric.

CPU Switch Module Redundancy and Online Insertion and Removal

When the Cisco ONS 15530 is powered up, the two CPU switch modules engage in an arbitration process to determine which will be the active and which will be the standby. Previous power state information is stored in the CPU non-volatile random access memory (NVRAM). The CPU that was previously active reassumes the active role. During operation, the two CPU switch modules remain synchronized (application states, running and startup configurations, system images). The operational status of each CPU switch module is monitored by the CPU switch module redundancy controller of the other CPU switch module through the backplane Ethernet. In the event of a failure or removal of an active CPU switch module, the standby CPU switch module immediately takes over and assumes the active role. Once the problem on the faulty card has been resolved, it can be manually restored to the active function.

In addition to providing protection against hardware or software failure, the redundant CPU switch module arrangement also permits installing a new Cisco IOS system image without system downtime. For more information about CPU switch module redundancy operation, as well as other software features, refer to the *Cisco ONS 15530 Configuration Guide*.

Security Features

The Cisco ONS 15530 supports the following Cisco IOS software security features:

- AAA (authentication, authorization, and accounting)
- Kerberos
- RADIUS
- TACACS+
- SSH (Secure Shell)
- Traffic filters and firewalls
- Passwords and privileges

For detailed information about the security features supported on the Cisco ONS 15530, refer to the *Cisco IOS Security Configuration Guide*.

System and Network Management

The Cisco ONS 15530 is fully manageable through any of the following four mechanisms: the in-band message channel, the OSC, SONET SDCC, and a direct Ethernet connection to the NME (network management Ethernet) on the CPU switch module. While all shelves will be equipped with at least one CPU switch module, provisioning the OSC is optional. The in-band message channel is only available on the 2.5-Gbps ITU trunk cards, 10-Gbps ITU tunable and non tunable trunk cards, and 10-Gbps uplink cards. DCC is only available on the 8-port multi-service muxponder.

All four mechanisms can be deployed within a single network. Each mechanism is associated with an interface that can be assigned an IP address. Management information will be routed between these interfaces.

Different levels of availability exist for each of these management mechanisms. High availability for the direct NME connection can be achieved with redundant CPU switch modules. The OSC becomes highly available when it is provisioned on both the working and protection trunk fibers. The availability of a particular in-band message channel or DCC will mirror the availability of the ITU wavelength with which it is associated.

In-Band Message Channel

The in-band message channel establishes a method for providing in-band, per-wavelength OAM&P (operations, administration, management, and provisioning) functions.

The in-band OAM&P messages carry the following types of information:

- Internodal management traffic.
- APS (Automatic Protection Switching) protocol messages.
- Subport identifiers for signal aggregation.
- Signal defect indications used by the system to identify line, segment, or path failures in the network topology and to take appropriate recovery responses to such failures. These indications include the following:
  - BDI-E (end-to-end backward defect indication)
  - FDI-E (end-to-end forward defect indication)
  - BDI-H (hop-to-hop backward defect indication)
  - FDI-H (hop-to-hop forward defect indication)
- CRC (cyclic redundancy check) computations.

In-Band Message Channel Consideration

The following considerations apply for the in-band message channel:

- The in-band message channel is carried along with the aggregated data signals and does not require extra equipment or a slot in the shelf.
- The in-band message channel is only supported on the 2.5-Gbps ITU trunk cards, 10-Gbps ITU tunable and non tunable trunk cards, and 10-Gbps uplink cards. If a shelf only has transponder line cards, the in-band message channel is not available.
- The in-band message channel must be enabled on both nodes that support the wavelength.

DCC

DCC establishes a method for providing in-band, per-wavelength OAM&P (operations, administration, management, and provisioning) functions on the 8-port multi-service muxponder.

The in-band OAM&P messages carry the following types of information:

- Internodal management traffic.
- APS (Automatic Protection Switching) protocol messages.

DCC Consideration

The following considerations apply for the DCC:

- The DCC is carried along with aggregated data signals and does not require extra equipment or a slot in the shelf.
- The data rate is slower than the in-band message channel supported on the 2.5-Gbps ITU trunk card, the 10-Gbps ITU trunk card, and the 10-Gbps uplink card. This causes the 8-port multi-service muxponder to initialize slower than those cards.
- The DCC must be configured on both 8-port multi-service muxponders that support the wavelength.

OSC

The OSC is an out-of-band method for providing OAM&P functions on a 33rd wavelength. The OSC supports a message channel that functions like the DCC for management and provisioning. Messages transit the network hop-by-hop, and they can be forwarded or routed according to established routing protocols. The OSC can be used to carry traffic to a network management system, or to carry other internodal management traffic such as link management, fiber failure isolation, performance monitoring, alarms, and APS protocol messages.

OSC Considerations

The following considerations apply for the OSC:

- OSC requires a carrier motherboard, which occupies a slot in the shelf, and one or two OSC modules.
- When a node supports OSC, the neighboring nodes in the topology must also support OSC.
- To manage the network topology, every node must support OSC.

NME

The NME is a 10/100 Ethernet port on the CPU switch module. You can connect this port to a router and configure the interface to route messages using established routing protocols. The NME can be used to carry traffic to a network management system.

Note The NME provides little in the way of topology management or fault isolation. We recommend using the in-band message channel, OSC, or both to manage and troubleshoot your network topology.

NME Considerations

The following considerations apply to the NME:

- To remotely manage nodes in the network topology using the NME, each system must be accessible through an IP network.
- The NME port is present on every CPU switch module and does not require extra equipment or a slot in the shelf.

Comparison of In-Band Message Channel, SONET, and OSC

Table 1-10 compares the features provided by the in-band message channel, SONET SDCC, and OSC.

Table 1-10 Comparison of the In-Band Message Channel, SONET, and OSC

Feature	OSC	In-Band Message Channel	SONET [1]
Management reach	Per fiber section	Per wavelength	Per wavelength
Fault isolation and topology discovery	Hop-by-hop fiber (physical topology)	End-to-end wavelength (logical topology)	End-to-end wavelength (logical topology)
Payload	Separate out-of-band channel	10-GE, Fibre Channel, FICON, GE, ESCON	SONET (OC-n)

Table 1-10 Comparison of the In-Band Message Channel, SONET, and OSC (continued)

Feature	OSC	In-Band Message Channel	SONET [1]
Management channel	Per fibre via a 33rd wavelength (channel 0)	Per wavelength via a message byte	Per wavelength via section DCC
Performance monitoring	OSC protocol	8B/10B(GE), 64/66B (10-GE), HEC[2], frame FCS	Section BIP[3]

1. SONET based management is not supported on the Cisco ONS 15530 and is included for comparison with the in-band message channel only.
2. HEC = Header Error Control
3. BIP = bit interleaved parity

For the most comprehensive set of monitoring and management capabilities, use the in-band message channel, SONET DCC, and OSC on your network. The in-band message channel and SONET DCC provide fault isolation and monitoring at the wavelength level, and OSC provides that functionality for the fiber.

CHAPTER 2

Protection Schemes and Network Topologies

This chapter describes how protection is implemented on the Cisco ONS 15530. It also describes the supported network topologies and how protection works in these topologies. This chapter contains the following major sections:

About Protection Against Fiber and System Failures

The design of the Cisco ONS 15530 provides the following levels of 1+1 protection:

- Facility protection provides protection against failures because of fiber cuts or unacceptable signal degradation on the trunk side.
- Client based line card protection provides protection against failures on the fiber, the line cards, (which contain the light emitting and light detecting devices), the 3R (reshape, retime, retransmit) electronics, and the client equipment.
- Y-cable based line card protection provides protection against failures both on the fiber, and in the line cards (which contain the light emitting and light detecting devices), and the 3R electronics.
- Switch fabric based line card protection provides protection against channel signal failures in switch fabric cross connections, ITU and uplink cards, and the fiber.
- Trunk fiber based protection provides protection against trunk fiber cuts.

Splitter Based Facility Protection

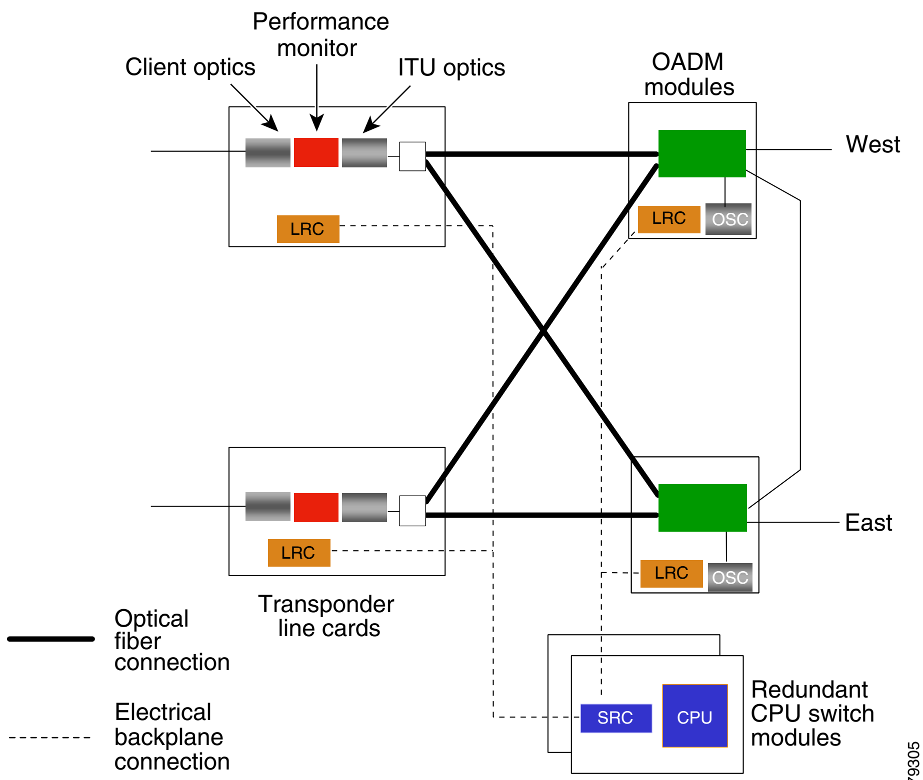
To survive a fiber failure, fiber optic networks are designed with both working and protection fibers. In the event of a fiber cut or other facility failure, working traffic is switched to the protection fiber. The Cisco ONS 15530 supports such facility protection using a *splitter* scheme (see Figure 2-1) to send the output of the DWDM transmitter on two trunk side interfaces.

Transponder line cards, 8-port multi-service muxponders, 2.5-Gbps ITU trunk cards, 10-Gbps ITU tunable and non tunable trunk cards, and 10-Gbps ITU trunk cards support splitter protection.

Transponder Line Cards

With splitter protection, a passive optical splitter module on the transponder line card duplicates the ITU signal. The front panel of each splitter transponder line card has connectors for two fiber pairs for cabling to the two OADM modules. One fiber pair serves as the active connection, while the other pair serves as the standby. The signal is transmitted on both connections, but in the receive direction, an optical switch selects one signal to be the active one. If a failure is detected on the active receive signal, a switchover to the standby receiver signal occurs under control of the LRC (line card redundancy controller). Assume, for example, that if the active signal in Figure 2-1 is on the east interface, a failure of the signal on that fiber would result in a switchover, and the signal on the west interface would be selected for the receive signal. You can configure preferred working and protection interfaces in the software for the system to use for the active and standby signals, as the signal quality allows.

Figure 2-1 Splitter Protection with Transponder Line Cards



A switchover is triggered in hardware by a loss of light on the receive signal. Switchovers for signal degrade or signal failure are configurable in the software.

Splitter Protection Considerations When Using Transponder Line Cards

The following considerations apply when using splitter protection with transponder line cards:

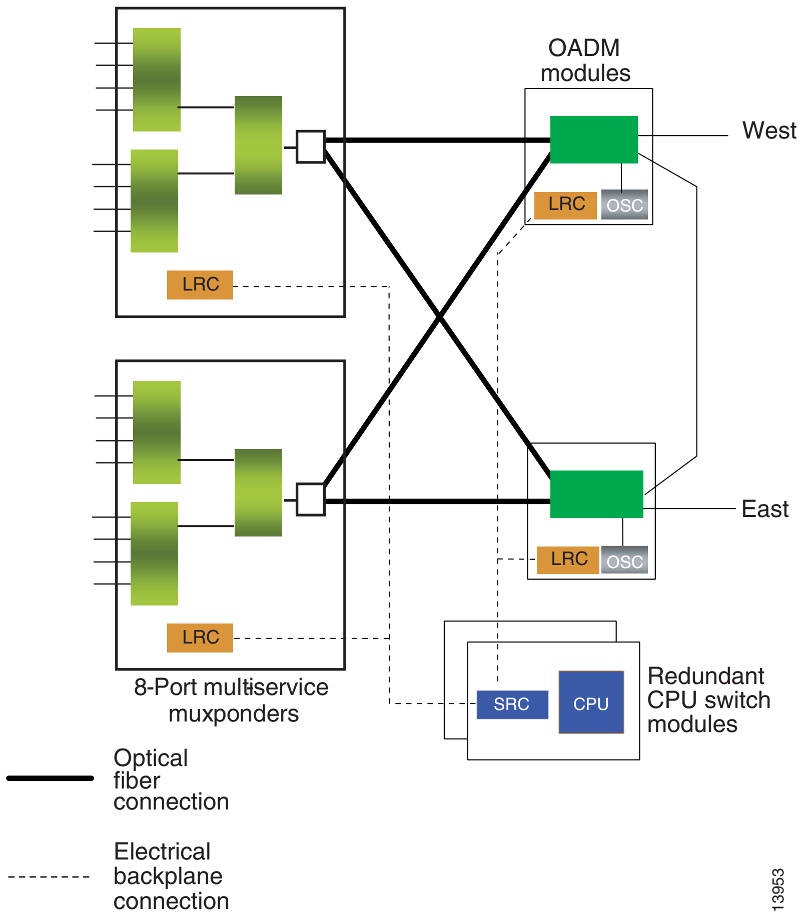
- Because the signal splitter module on splitter transponder line cards introduces 3.55 dB of loss in the transmit direction, we recommend using nonsplitter transponder line cards for configurations where splitter protection is not required.
- The APS software that supports splitter protection can be configured as revertive or nonrevertive. Unless a switchover request from the CLI (command-line interface) is in effect, the system uses the working interface for the active signal. After a system-initiated switchover to the protection interface occurs for signal quality reasons, the active traffic can be put back on the previously failed working fiber after the fault has been remedied. The fault can be remedied either automatically (revertive) or through manual intervention (nonrevertive).
- Up to four channels can be splitter protected on a single shelf.

For rules on how to configure the shelf for splitter protection, see Chapter 6, “Example Shelf Configurations and Topologies.” For instructions on configuring the software for splitter protection, refer to the *Cisco ONS 15530 Configuration Guide.*

8-Port Multi-Service Muxponders

With splitter protection, a passive optical splitter module on the 8-port multi-service muxponder duplicates the ITU signal. The front panel of each splitter 8-port multi-service muxponder has connectors for two fiber pairs for cabling to the two OADM modules. One fiber pair serves as the active connection, while the other pair serves as the standby. The signal is transmitted on both connections, but in the receive direction, an optical switch selects one signal to be the active one. If a failure is detected on the active receive signal, a switchover to the standby receiver signal occurs under control of the LRC (line card redundancy controller). Assume, for example, that if the active signal in Figure 2-1 is on the east interface, a failure of the signal on that fiber would result in a switchover, and the signal on the west interface would be selected for the receive signal. You can configure preferred working and protection interfaces in the software for the system to use for the active and standby signals, as the signal quality allows.

Figure 2-2 Splitter Protection with 8-Port Multi-Service Muxponders



A switchover is triggered in hardware by a loss of light on the receive signal.

Splitter Protection Considerations When Using 8-Port Multi-Service Muxponders

The following considerations apply when using splitter protection with transponder line cards:

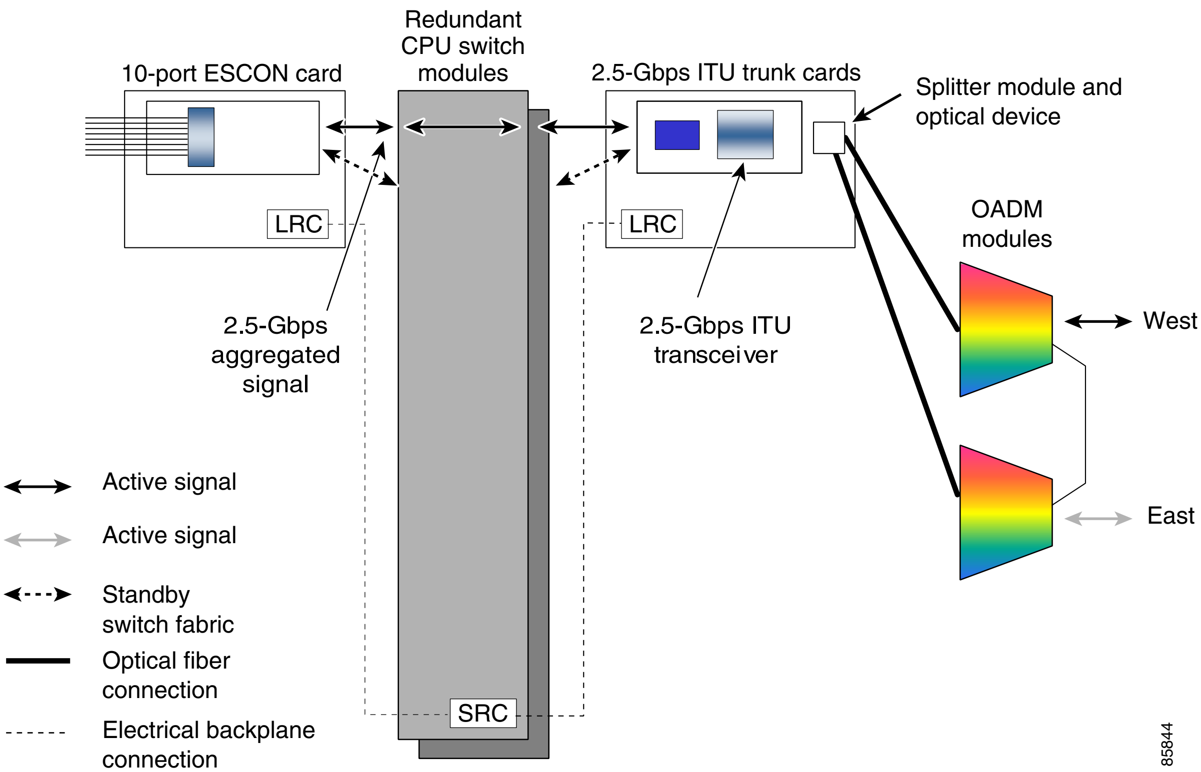
- Because the signal splitter module on splitter 8-port multi-service muxponders introduces 3.55 dB of loss in the transmit direction, we recommend using nonsplitter 8-port multi-service muxponders for configurations where splitter protection is not required.
- The APS software that supports splitter protection can be configured as revertive or nonrevertive. Unless a switchover request from the CLI is in effect, the system uses the working interface for the active signal. After a system-initiated switchover to the protection interface occurs for signal quality reasons, the active traffic can be put back on the previously failed working fiber after the fault has been remedied. The fault can be remedied either automatically (revertive) or through manual intervention (nonrevertive).
- Up to four channels can be splitter protected on a single shelf.

For rules on how to configure the shelf for splitter protection, see Chapter 6, "Example Shelf Configurations and Topologies." For instructions on configuring the software for splitter protection, refer to the *Cisco ONS 15530 Configuration Guide.*

2.5-Gbps ITU Trunk Card

With splitter protection, a passive optical splitter module on the 2.5-Gbps ITU line card duplicates the ITU signal. The front panel of each splitter 2.5-Gbps ITU line card has connectors for two fiber pairs for cabling to the two OADM modules. One fiber pair serves as the active connection, while the other pair serves as the standby. The signal is transmitted on both connections, but in the receive direction, an optical switch selects one signal to be the active one. If a failure is detected on the active receive signal, a switchover to the standby receiver signal occurs under control of the LRC (line card redundancy controller). Assume, for example, that if the active signal in Figure 2-3 is on the east interface, a failure of the signal on that fiber would result in a switchover, and the signal on the west interface would be selected for the receive signal. You can configure preferred working and protection interfaces in the software for the system to use for the active and standby signals, as the signal quality allows.

Figure 2-3 Splitter Protection with 2.5-Gbps ITU Trunk Cards



A switchover is triggered in hardware by a loss of light on the receive signal. Switchovers for signal degrade or signal failure are configurable in the software.

Splitter Protection Considerations When Using 2.5-Gbps ITU Line Cards

The following considerations apply when using splitter protection:

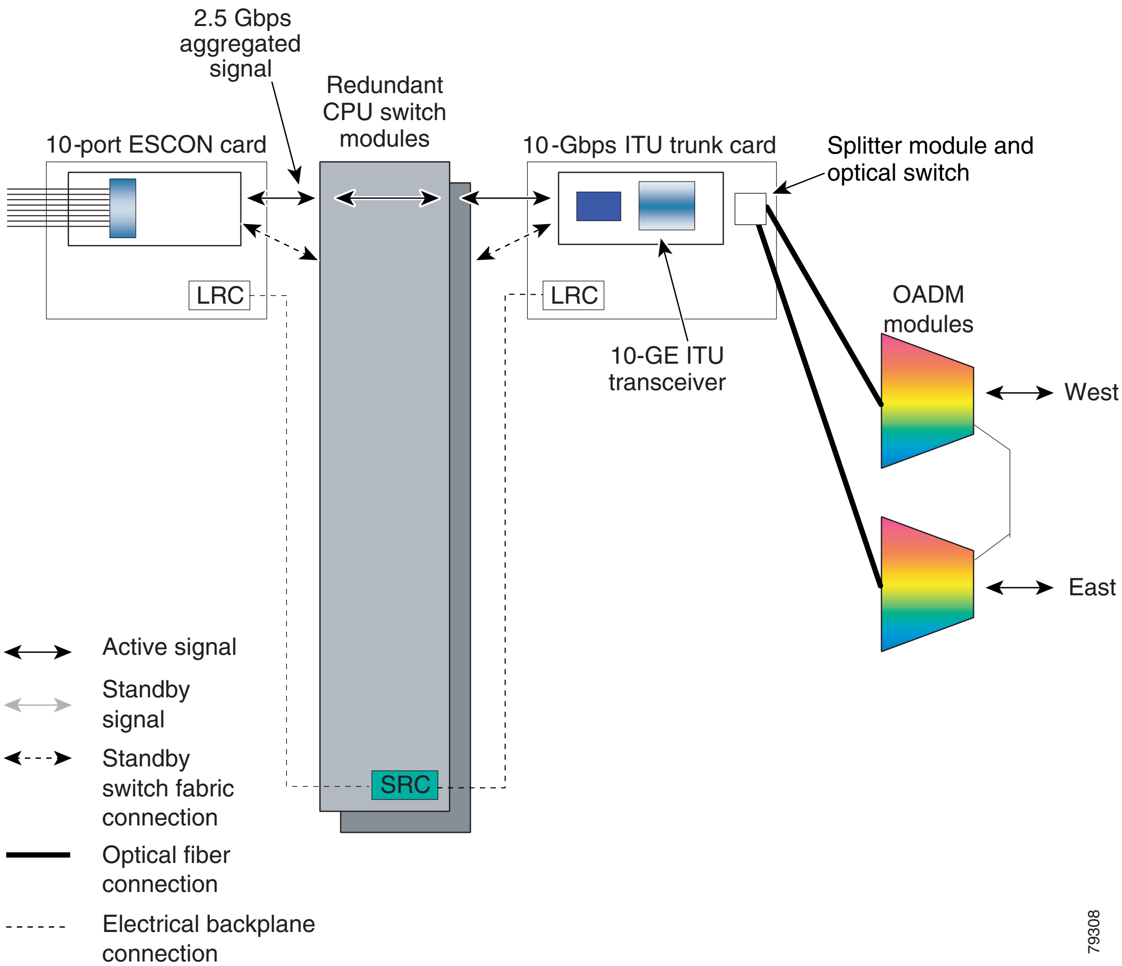
- Because the signal splitter module on splitter 2.5-Gbps ITU line cards introduces 3.55 dB of loss in the transmit direction, we recommend using nonsplitter line cards for configurations where splitter protection is not required.
- The APS software that supports splitter protection can be configured as revertive or nonrevertive. Unless a switchover request from the CLI (command-line interface) is in effect, the system uses the working interface for the active signal. After a system-initiated switchover to the protection interface occurs for signal quality reasons, the active traffic can be put back on the previously failed working fiber after the fault has been remedied. The fault can be remedied either automatically (revertive) or through manual intervention (nonrevertive).
- The OSC and the in-band message channel play a crucial role in splitter based protection by allowing the protection fiber to be monitored for interruption of service.
- Up to four channels can be splitter protected on a single shelf if the OSC is not supported; if the OSC is supported, up to three channels can be splitter protected on a single shelf.

For example of how to configure the shelf for splitter protection, see Chapter 6, "Example Shelf Configurations and Topologies." For instructions on configuring the software for splitter protection, refer to the *Cisco ONS 15530 Configuration Guide.*

10-Gbps ITU Tunable and Non tunable Trunk Card

With splitter protection, a passive optical splitter module on the 10-Gbps ITU line card duplicates the ITU signal. The front panel of each splitter 10-Gbps ITU line card has connectors for two fiber pairs for cabling to the two OADM modules. One fiber pair serves as the active connection, while the other pair serves as the standby. The signal is transmitted on both connections, but in the receive direction, an optical switch selects one signal to be the active one. If a failure is detected on the active receive signal, a switchover to the standby receiver signal occurs under control of the LRC (line card redundancy controller). Assume, for example, that if the active signal in Figure 2-4 is on the east interface, a failure of the signal on that fiber would result in a switchover, and the signal on the west interface would be selected for the receive signal. You can configure preferred working and protection interfaces in the software for the system to use for the active and standby signals, as the signal quality allows.

Figure 2-4 Splitter Protection with 10-Gbps ITU Tunable and Non tunable Trunk Cards



A switchover is triggered in hardware by a loss of light on the receive signal. Switchovers for signal degrade or signal failure are configurable in the software.

Splitter Protection Considerations When Using 10-Gbps ITU Line Cards

The following considerations apply when using splitter protection:

- Because the signal splitter module on splitter 10-Gbps ITU line cards introduces 3.55 dB of loss in the transmit direction, we recommend using nonsplitter line cards for configurations where splitter protection is not required.
- The APS software that supports splitter protection can be configured as revertive or nonrevertive. Unless a switchover request from the CLI (command-line interface) is in effect, the system uses the working interface for the active signal. After a system-initiated switchover to the protection interface occurs for signal quality reasons, the active traffic can be put back on the previously failed working fiber after the fault has been remedied. The fault can be remedied either automatically (revertive) or through manual intervention (nonrevertive).

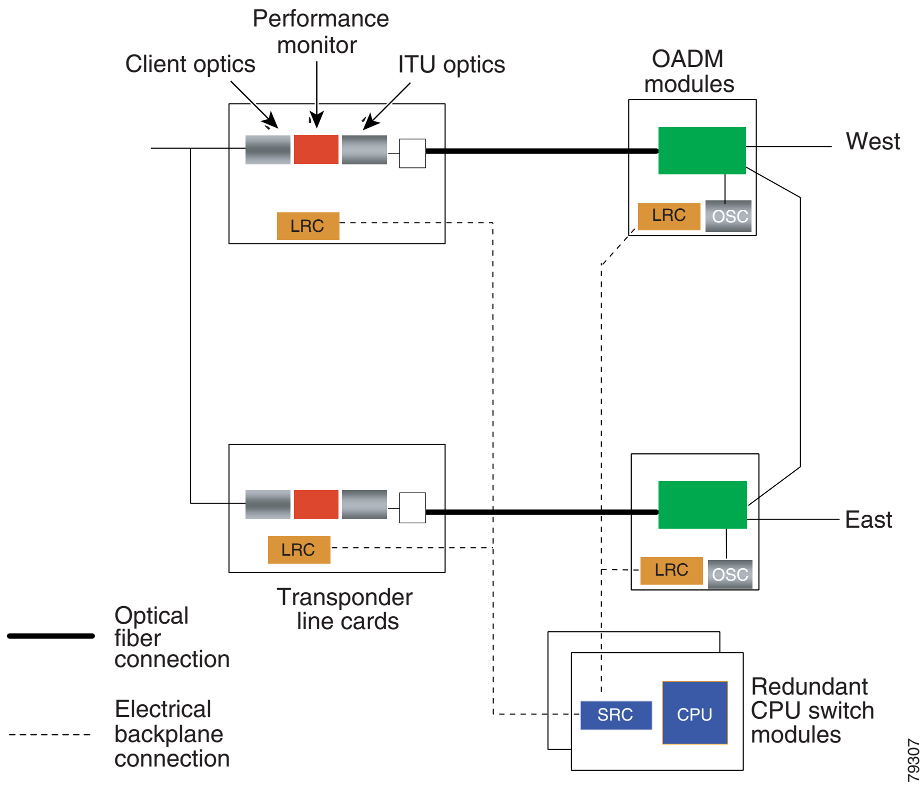
- The OSC and the in-band message channel play a crucial role in splitter based protection by allowing the protection fiber to be monitored for interruption of service.
- Up to four channels can be splitter protected on a single shelf if the OSC is not supported; if the OSC is supported, up to three channels can be splitter protected on a single shelf.

For example of how to configure the shelf for splitter protection, see Chapter 6, "Example Shelf Configurations and Topologies." For instructions on configuring the software for splitter protection, refer to the *Cisco ONS 15530 Configuration Guide.*

Y-Cable Based Line Card Protection

The Cisco ONS 15530 supports line card protection for transponder line cards, 4-port 1-Gbps/2-Gbps FC aggregation cards, and 8-port Fibre Channel/Gigabit Ethernet aggregation cards, using a *Y-cable* scheme. Y-cable protection protects against both facility failures and failure of the line cards. Using an external 2:1 combiner cable (the Y-cable) between the client equipment and the line card interfaces, the client signal is duplicated and sent to two line card interfaces. This arrangement is illustrated in Figure 2-5.

Figure 2-5 Example Y-Cable Protection Scheme Using Transponder Line Cards



In Y-cable protected configurations, one of the line cards functions as the active and the other as the standby. On the active line card, all the lasers and receivers are sending and receiving the client signal. On the standby line card, however, the client side laser is turned off to avoid corrupting the signal transmitted back to the client equipment. The performance monitor on the active line card optically monitors the signal received from the trunk side. If loss of light, signal failure, or signal degrade is detected, and an acceptable standby signal is available, the system switches over to the standby signal. The precise conditions that trigger a switchover based on signal failure or signal degrade are configurable in the alarm threshold software.

Note Y-cable protection is not supported for ESCON aggregation cards and for 8-port multi-service muxponders.

Y-Cable Protection Considerations

The following considerations apply when using Y-cable protection:

- Y-cable protection does not protect against failures of the client equipment. To protect against client failures, protection should be implemented on the client equipment itself.
- Due to their lower optical power loss, we recommend using nonsplitter line cards for configurations with Y-cable protection.
- Because of APS messaging conflicts, you cannot mix Y-cable protection and switch fabric based protection on a 10-Gbps ITU tunable and non tunable trunk card or 10-Gbps uplink card.
- The APS software that supports y-cable protection can be configured as revertive or nonrevertive. After a switchover, the active traffic can be put back on the previously failed working fiber, once the fault has been remedied, either automatically (revertive) or through manual intervention (nonrevertive).
- Y-cable protected configurations allow monitoring of the protection fiber without the OSC.
- Up to four channels can be Y-cable protected on a single shelf when the OSC is not supported; if the OSC is supported, up to three channels can be y-cable protected on a single shelf.

For rules on how to configure the shelf for Y-cable protection, see Chapter 3, "Shelf Configuration Rules." For instructions on configuring the software for y-cable protection, refer to the *Cisco ONS 15530 Configuration Guide.*

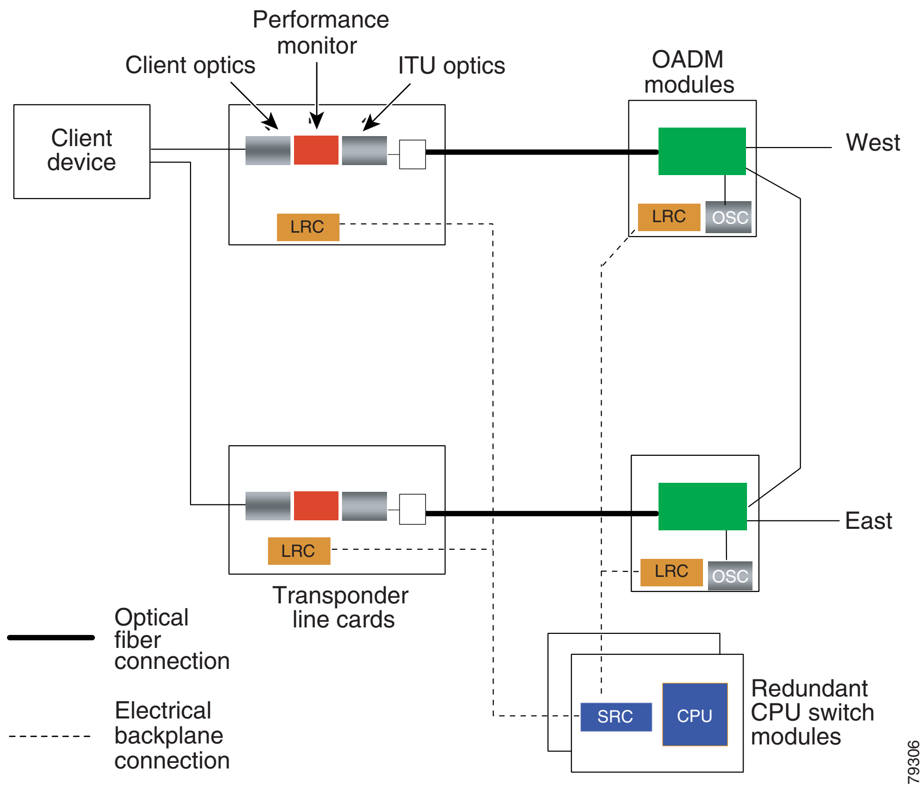
Client Based Line Card Protection

While y-cable protection protects against failures in the transponder line cards and the 8-port Fibre Channel/Gigabit Ethernet aggregation cards or on the fiber, the client still remains vulnerable. For some applications additional protection of the client equipment may be desirable for transponder line card, ESCON aggregation card, and 8-port FC/GE aggregation card applications. The client equipment transmits and receives two separate signals that it monitors. Switchovers are under control of the client rather than the protection mechanisms on the Cisco ONS 15530.

Transponder Line Cards

Figure 2-6 shows the architecture that supports client protection using transponder line cards.

Figure 2-6 Client Based Line Card Protection Scheme for Transponder Line Cards



Considerations for Client Protection with Transponder Line Cards

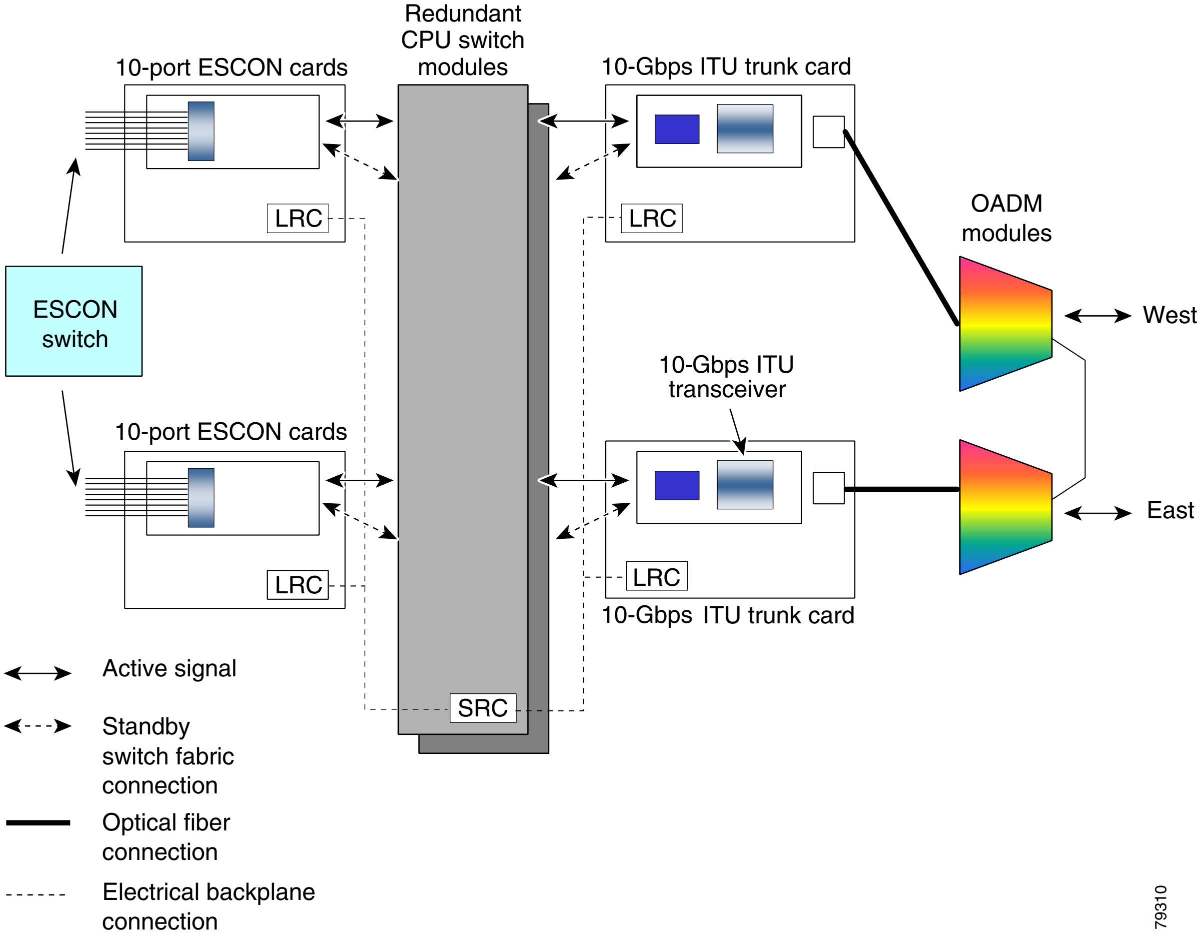
The following considerations apply when using client protection:

- Due to their lower optical loss, we recommend using nonsplitter line cards for configurations with client protection.
- Client protected configurations allow monitoring of the protection fiber without the OSC.
- Using transponder line cards, up to four channels can be client protected on a single shelf when the OSC is not supported; if the OSC is supported, up to three channels can be client protected on a single shelf.

ESCON Aggregation Cards

Figure 2-7 shows an example configuration that supports client protection using ESCON aggregation cards and 10-Gbps ITU trunk cards.

Figure 2-7 Client Based Line Card Protection Scheme for ESCON Aggregation Cards and 10-Gbps ITU Trunk Cards



Considerations for Client Protection With 2.5-Gbps ITU Trunk Cards or 10-Gbps ITU Trunk Cards

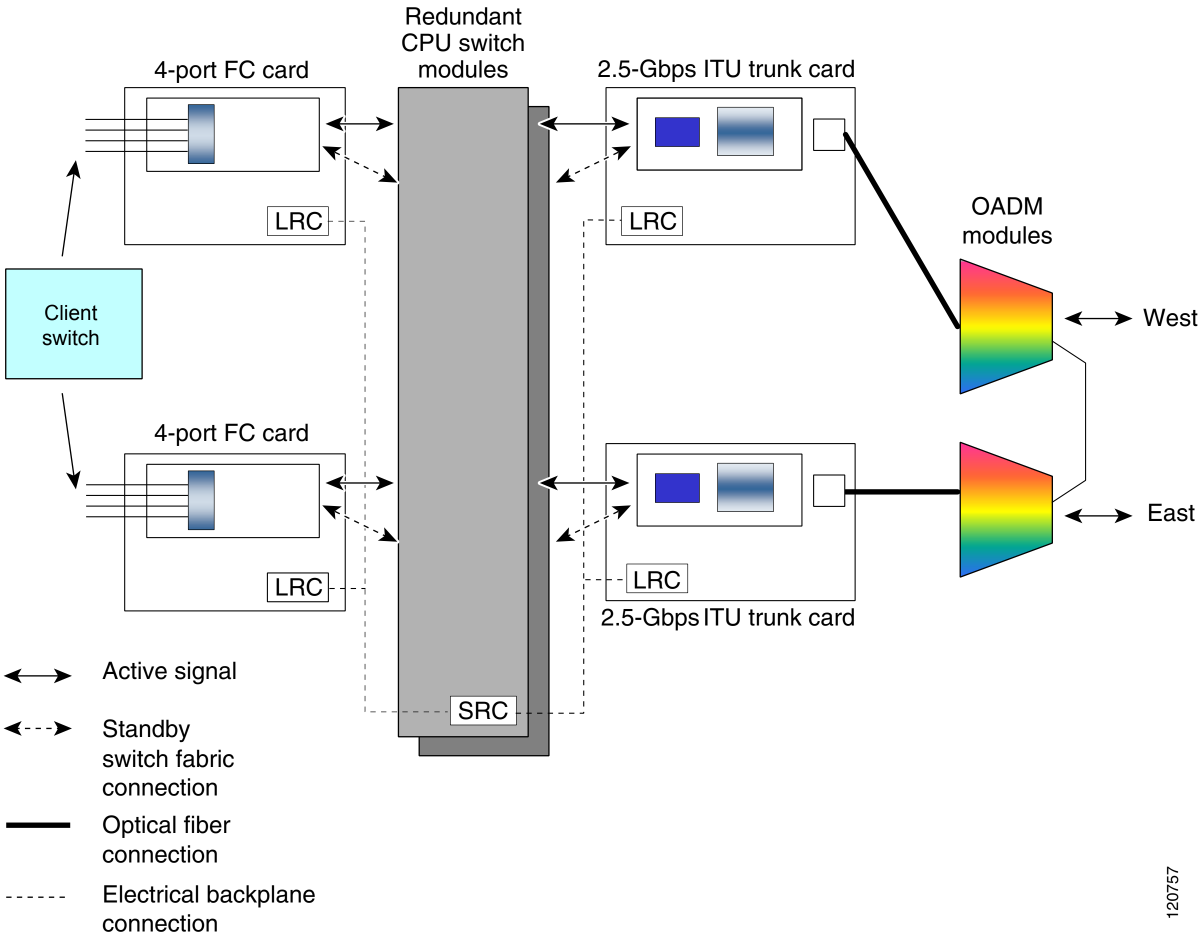
The following considerations apply when using client protection:

- Due to their lower optical loss, we recommend using nonsplitter line cards for configurations with client protection.
- Client protected configurations allow monitoring of the protection fiber without the OSC.
- Up to two channels can be client protected on a single shelf if the OSC is not supported; if the OSC is supported, one channel can be client protected on a single shelf.

4-Port 1-Gbps/2-Gbps FC Aggregation Cards

Figure 2-8 shows an example configuration that supports client protection using 4-port 1-Gbps/2-Gbps FC aggregation cards and 2.5-Gbps ITU trunk cards.

Figure 2-8 Client Based Line Card Protection Scheme for 4-Port 1-Gbps/2-Gbps FC Aggregation Cards and 2.5-Gbps ITU Trunk Cards



Considerations for Client Protection With 2.5-Gbps ITU Trunk Cards or 10-Gbps ITU Trunk Cards

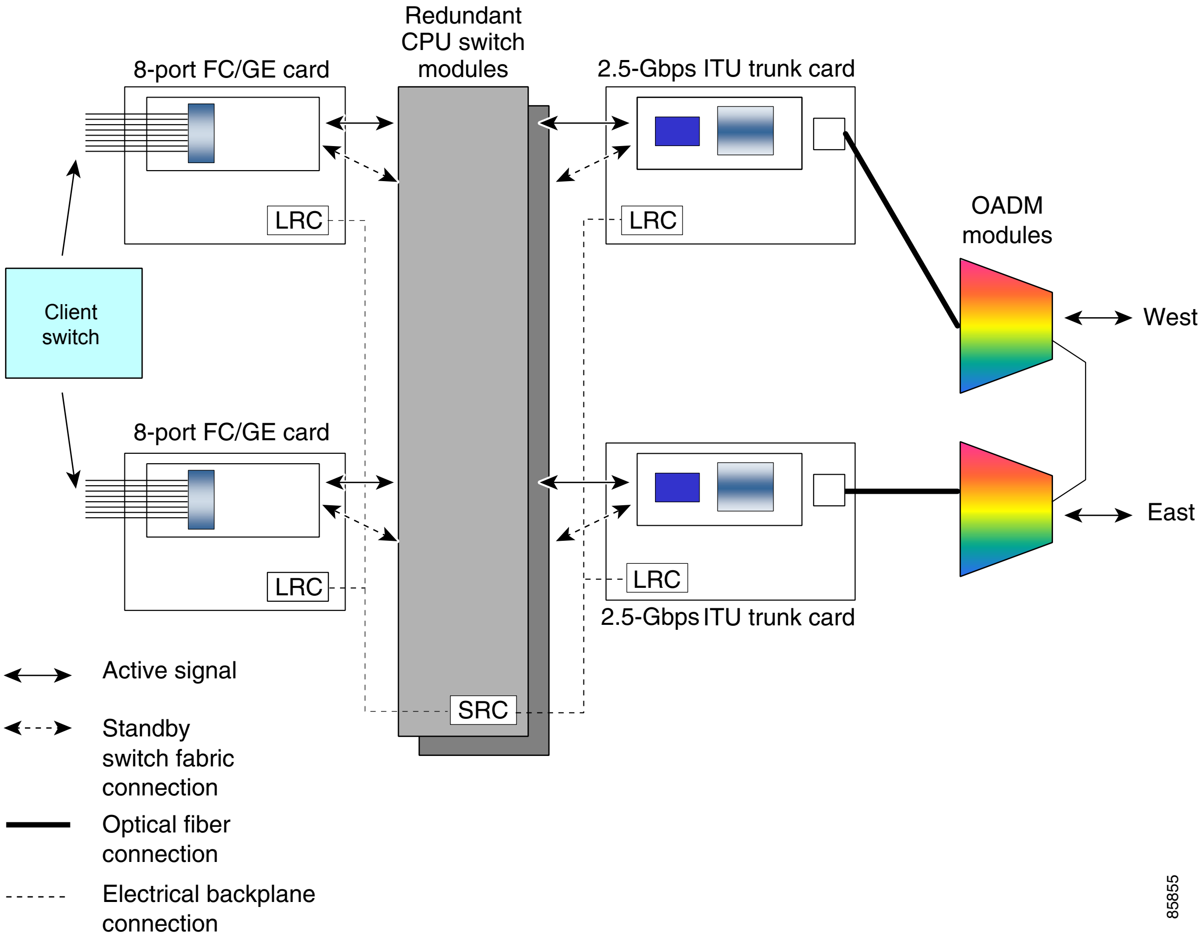
The following considerations apply when using client protection:

- Due to their lower optical loss, we recommend using nonsplitter line cards for configurations with client protection.
- Client protected configurations allow monitoring of the protection fiber without the OSC.
- Up to two channels can be client protected on a single shelf if the OSC is not supported; if the OSC is supported, one channel can be client protected on a single shelf.

8-Port FC/GE Aggregation Cards

Figure 2-9 shows an example configuration that supports client protection using 8-port Fibre Channel/Gigabit Ethernet aggregation cards and 2.5-Gbps ITU trunk cards.

Figure 2-9 Client Based Line Card Protection Scheme for 8-Port FC/GE Aggregation Cards and 2.5-Gbps ITU Trunk Cards



Considerations for Client Protection With 2.5-Gbps ITU Trunk Cards or 10-Gbps ITU Trunk Cards

The following considerations apply when using client protection:

- Due to their lower optical loss, we recommend using nonsplitter line cards for configurations with client protection.
- Client protected configurations allow monitoring of the protection fiber without the OSC.
- Up to two channels can be client protected on a single shelf if the OSC is not supported; if the OSC is supported, one channel can be client protected on a single shelf.

Switch Fabric Based Line Card Protection

The Cisco ONS 15530 provides facility and trunk or uplink card protection based on the switch fabric connecting one aggregation card to two 2.5-Gbps ITU trunk cards, two 10-Gbps ITU tunable or non tunable trunk cards, or two 10-Gbps uplink cards.

With switch fabric protection, when a signal failure occurs on the trunk fiber or on a trunk card or uplink card, the system switches over to the standby signal. In the case of redundant switch fabrics, a failure in the switch fabric itself causes a switchover to the standby switch fabric. The ESCON aggregation card, 4-port 1-Gbps/2-Gbps FC aggregation card, or 8-port FC/GE aggregation card sends two 2.5-Gbps signals through the active switch fabric to two 2.5-Gbps ITU trunk cards or two 10-Gbps ITU tunable or non tunable trunk cards, one in the east direction and one in the west, or two 10-Gbps uplink cards. The aggregation card only receives the 2.5-Gbps signal from the active switch fabric.

Figure 2-10 shows switch fabric based protection with a single switch fabrics.

Figure 2-10 Switch Fabric Based Protection Example With a Single Switch Fabric

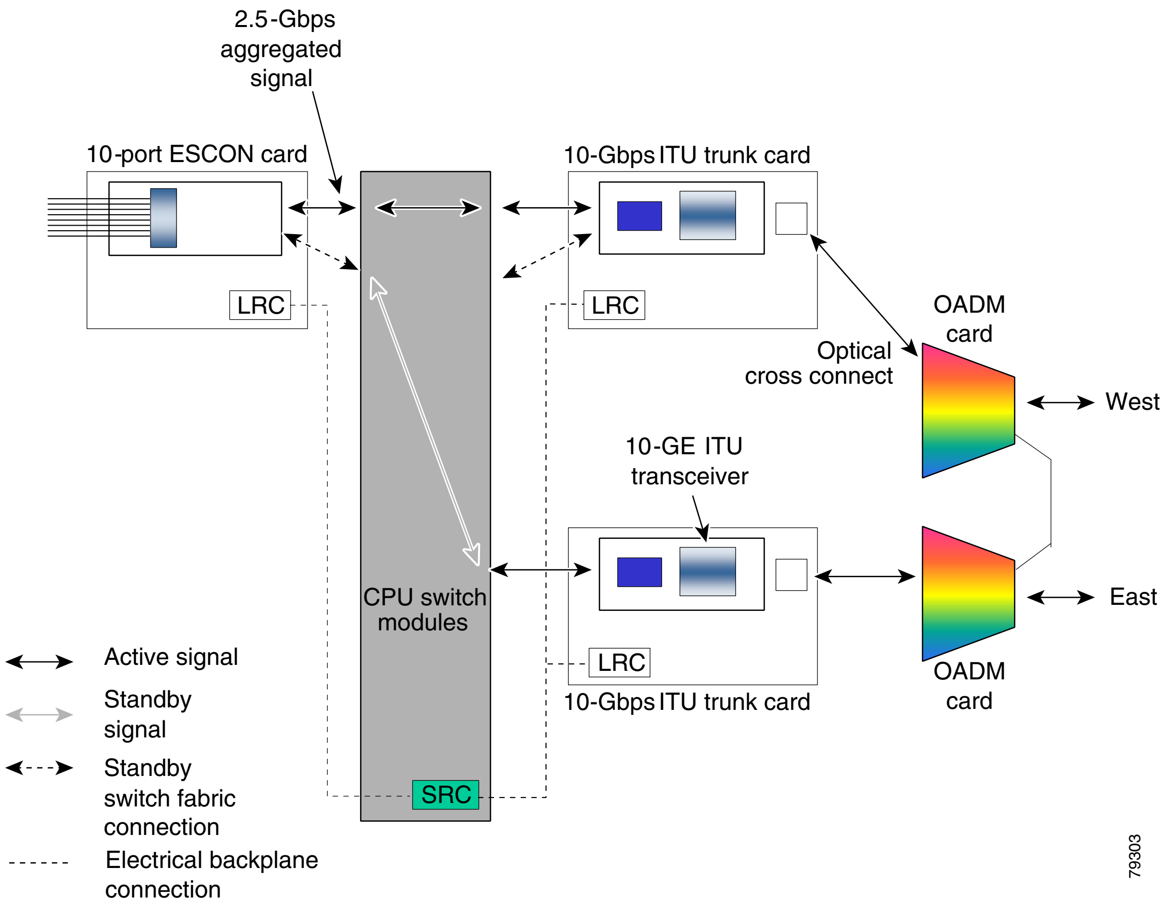
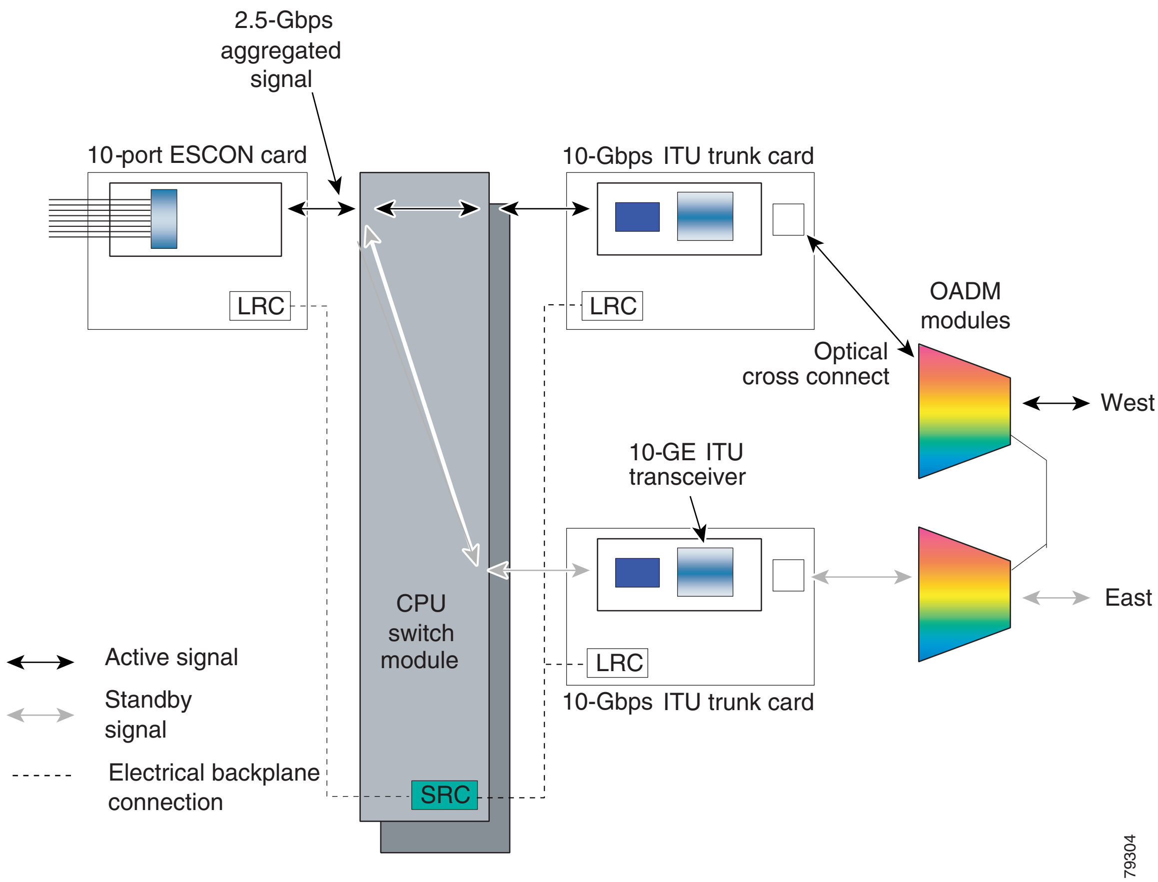


Figure 2-11 shows switch fabric based protection with redundant switch fabrics.

Figure 2-11 Switch Fabric Based Protection Example With Redundant Switch Fabrics



Switch Fabric Based Protection Considerations

The following considerations apply when using switch fabric based protection:

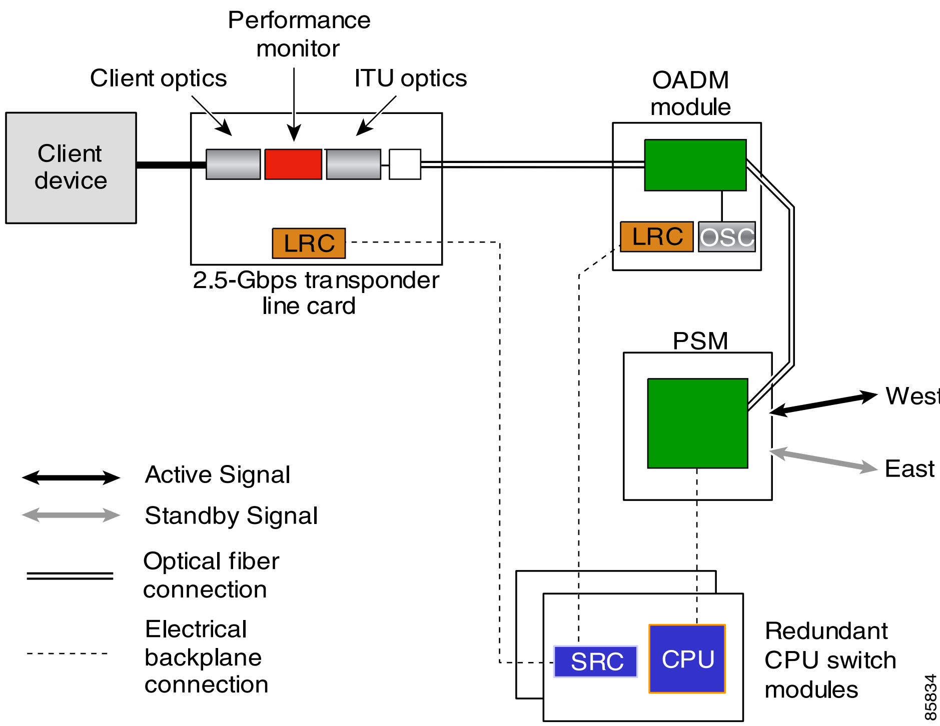
- Switch fabric based protection does not protect against failures of the aggregation cards or the client equipment. To protect against these failures, line card protection should be implemented on the client equipment itself (see the "Client Based Line Card Protection" section on page 2-9).
- Due to their lower optical power loss, we recommend using the nonsplitter 2.5-Gbps ITU trunk cards and 10-Gbps ITU trunk cards for configurations with switch fabric protection.
- Because of APS messaging conflicts, you cannot mix switch fabric based protected signals with y-cable protected signals on a 10-Gbps ITU trunk card.
- The APS software that supports switch fabric protection can be configured as revertive or nonrevertive. After a switchover, the active traffic can be put back on the previously failed working fiber, once the fault has been remedied, either automatically (revertive) or through manual intervention (nonrevertive).
- Switch fabric protected configurations allow monitoring of the protection fiber without the OSC.
- Up to two channels on a single shelf can be protected with switch fabric protection.

Trunk Fiber Based Protection

The PSM (protection switch module) provides trunk fiber based protection on Cisco ONS 15530 systems configured in point-to-point topologies. This type of protection only provides protection against trunk fiber cuts, not specific channel failure as provided by splitter and line card based schemes. However, this protection scheme allows for much simpler shelf configurations in topologies where per channel protection is not required.

Figure 2-12 shows trunk fiber based protection configured with a transponder line card and an OADM module.

Figure 2-12 Trunk Fiber Based Protection With a Transponder Line Card



Trunk Fiber Based Protection Considerations

The following considerations apply when using trunk fiber based protection:

- Trunk fiber based protection does not protect against failures on the shelf itself or the client equipment. To protect against these failures, line card protection should be implemented on the client equipment itself.
- Due to the cumulative effect of the noise from the EDFAs (erbium-doped fiber amplifiers), the PSM cannot support point-to-point topologies with more than two EDFAs on the trunk fiber. For topologies with three or more EDFAs on the trunk fiber, use splitter based protection.
- When EDFAs are present in the topology, the power of the data channels at the PSM receiver must be greater than the cumulative noise of the EDFAs.
- The APS software that supports trunk fiber based protection can be configured as revertive or nonrevertive. After a switchover, the active traffic can be put back on the previously failed working fiber, once the fault has been remedied, either automatically (revertive) or through manual intervention (nonrevertive).

- Use PSMs only in point-to-point topologies.
- On a multiple shelf node, install the PSM on the shelf connected to the trunk fiber.
- Up to four channels on a single shelf can be protected with trunk fiber based protection.

Supported Topologies

The Cisco ONS 15530 can be used in point-to-point and ring topologies. Point-to-point topologies can be either protected and unprotected point-to-point. Ring topologies support add/drop nodes and can be hubbed or meshed. The following sections give a brief overview of these topologies.

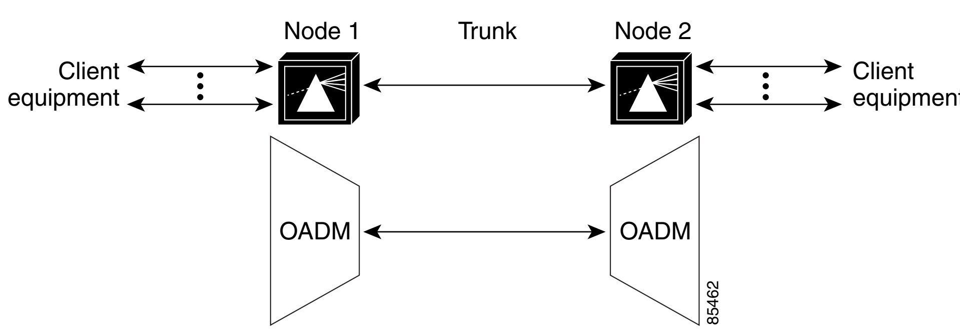
Point-to-Point Topologies

In a pure point-to-point topology all channels terminate on the Cisco ONS 15530 nodes at each end of the trunk. Point-to-point topologies have many common applications, including extending the reach of GE or SONET, and can be configured for unprotected or for protected operation.

Unprotected Point-to-Point Topology

Figure 2-13 shows a point-to-point topology without protection. In this configuration only one optical OADM slot is used in each of the Cisco ONS 15530 nodes. The west or east trunk side interface (OADM module in subslot 0/0 or 0/1) of node 1 connects to the corresponding OADM module on node 2.

Figure 2-13 Unprotected Point-to-Point Topology



For an example configuration of an unprotected point-to-point topology, see Chapter 6, "Example Shelf Configurations and Topologies."

Protected Point-to-Point Topology

Figure 2-14 shows a protected point-to-point topology configured for splitter or line card per channel protection. In either case, there are two trunk side interfaces, west and east, connected by two fiber pairs.

Figure 2-14 Splitter or Line Card Protected Point-to-Point Topology

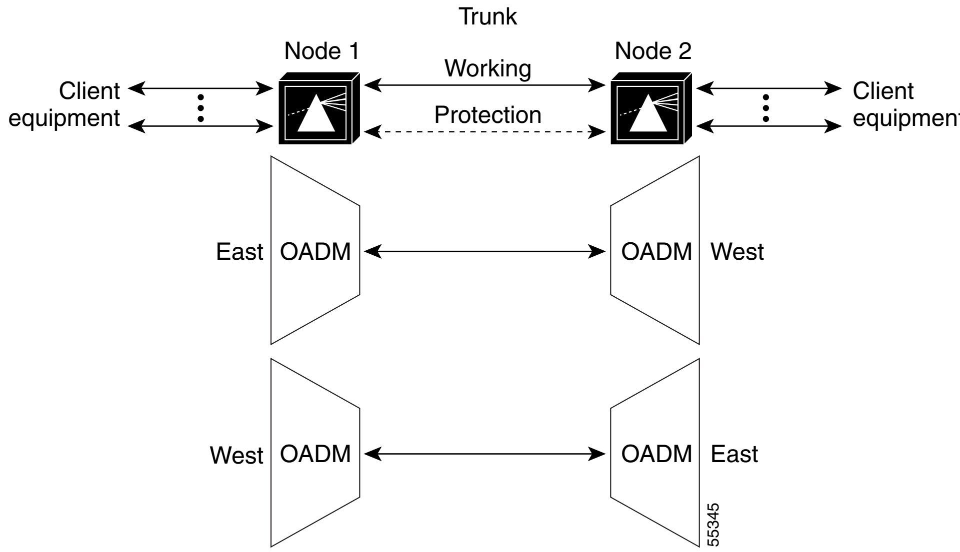
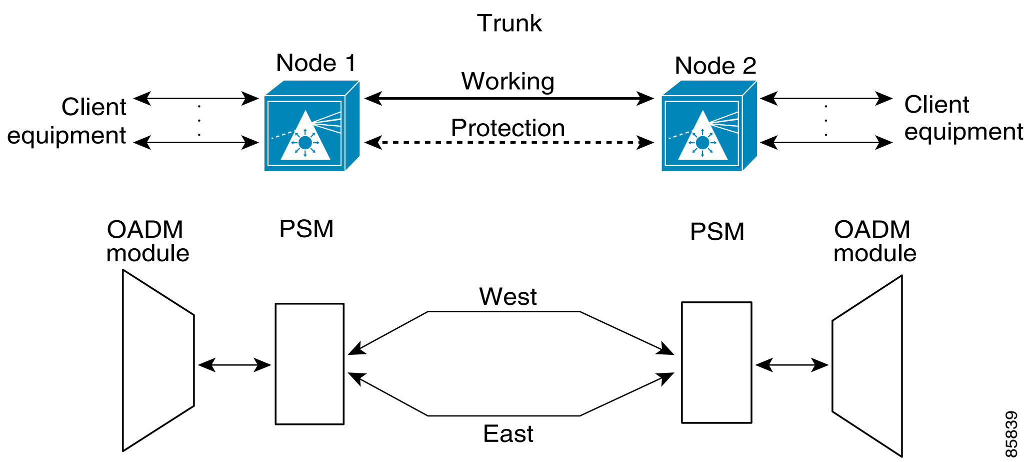


Figure 2-15 shows a protected point-to-point topology configured for trunk fiber protection. There are two trunk side interfaces, west and east, connected by two fiber pairs.

Figure 2-15 Trunk Fiber Protected Point-to-Point Topology



For an example configuration of a protected point-to-point topology, see Chapter 6, "Example Shelf Configurations and Topologies."

Ring Topologies

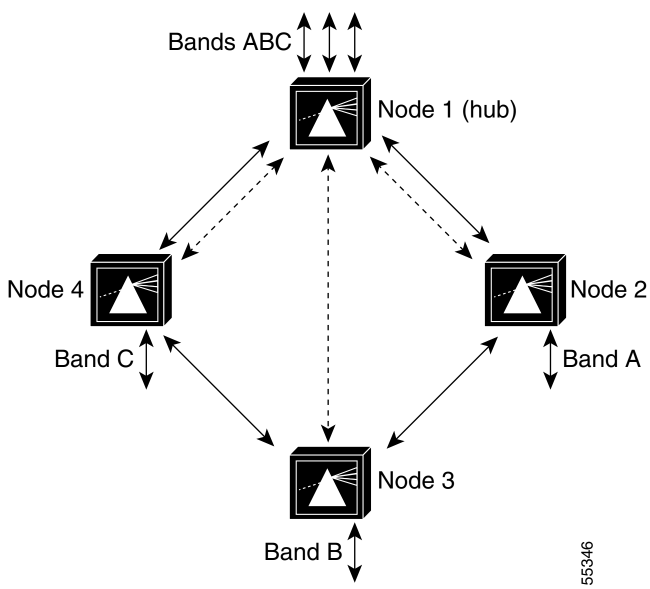
In a ring topology, client equipment is attached to three or more Cisco ONS 15530 systems, which are interconnected in a closed loop. Channels can be dropped and added at one or more nodes on a ring. Rings have many common applications, including providing extended access to SANs (storage area networks) and upgrading existing SONET rings. In the cases where SONET rings are at capacity, the SONET equipment can be moved off the ring and connected to the Cisco ONS 15530 systems. Then the SONET client signals are multiplexed and transported over the DWDM link, thus increasing the capacity of existing fiber.

Hubbed Ring

A hubbed ring is composed of a hub node and two or more add/drop or satellite nodes. All channels on the ring originate and terminate on the hub node, which is either a Cisco ONS 15540 ESP shelf, a Cisco ONS 15540 ESPx shelf, or Cisco ONS 15530 shelves configured in a multiple shelf node. At add/drop nodes certain channels are terminated (dropped and added back) while the channels that are not being dropped (express channels) are passed through optically, without being electrically regenerated.

Channels are dropped and added in bands. Figure 2-16 shows a four-node hubbed ring in which bands ABC terminate on node 1. Nodes 1 and 2 communicate using band A, nodes 1 and 3 communicate using band B, and nodes 1 and 4 communicate using band C.

Figure 2-16 Hubbed Ring Topology Example

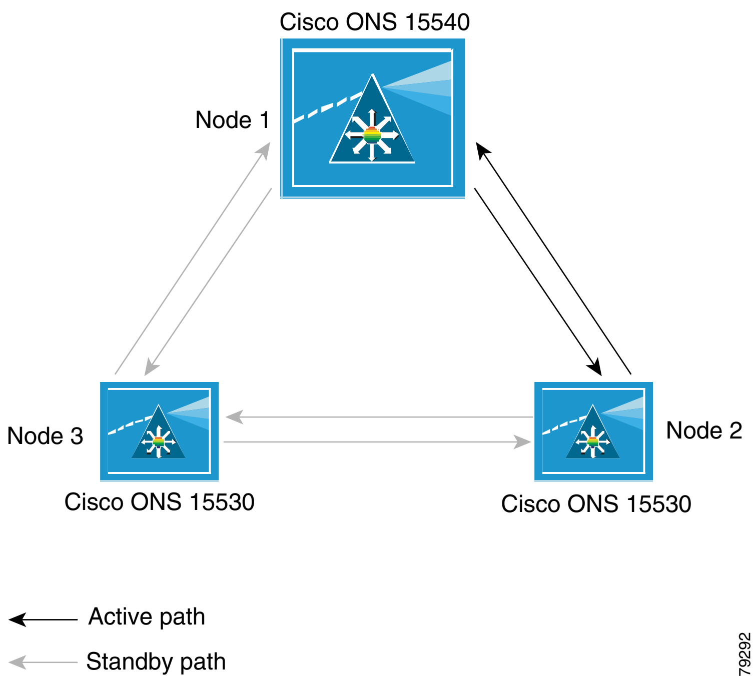


For example configurations of hubbed ring topologies, see Chapter 6, “Example Shelf Configurations and Topologies.”

Meshed Ring

A meshed ring is a physical ring that has the logical characteristics of a mesh. While traffic travels on a physical ring, the logical connections between individual nodes are meshed. An example of this type of configuration, which is sometimes called a *logical mesh*, is shown in Figure 2-17. Nodes 1 and 2 communicate using band A and nodes 1 and 3 communicate using band B.

Figure 2-17 Meshed Ring Topology Example



For example configurations of meshed ring topologies, see Chapter 6, "Example Shelf Configurations and Topologies."

Path Switching in Point-to-Point and Ring Topologies

The Cisco ONS 15530 supports per-channel unidirectional and bidirectional 1+1 path switching. When a signal is protected and the signal fails, or in some cases degrades, on the active path, the system automatically switches from the active network path to the standby network path.

Signal failures can be total loss of light caused by laser failures, by fiber cuts between the Cisco ONS 15530 and the client equipment, or by other equipment failure. Loss of light failures cause switchovers for both splitter protected and y-cable protected signals. Switchovers based on an alarm threshold can also automatically occur when the signal error rate reaches an unacceptable level.

The Cisco ONS 15530 implements path switching using a SONET-compliant APS channel protocol over the OSC (optical supervisory channel) or the in-band management channel on the protection path.

Note Bidirectional path switching operates only on Cisco ONS 15530 networks that have the OSC or the in-band management channel.

Figure 2-18 shows a protected hubbed ring configuration. The configured working path carries the active signal, and the configured protection path carries the standby signal.

Figure 2-18 Active and Standby Path Configuration Example

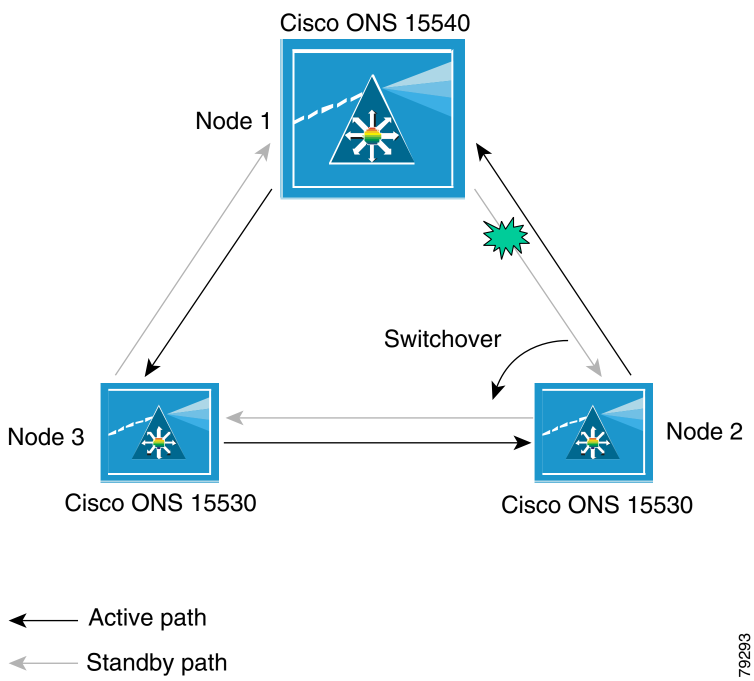


Figure 2-19 shows the behavior of unidirectional path switching when a loss of signal occurs. For the example network, unidirectional path switching operates as follows:

- Node 2 sends the channel signal over both the active and standby paths.
- Node 1 receives both signals and selects the signal on the active path.
- Node 1 detects a loss of signal light on its active path and switches over to the standby path.
- Node 2 does not switch over and continues to use its original active path.

Now the nodes are communicating along different paths.

Figure 2-19 Unidirectional Path Switching Example

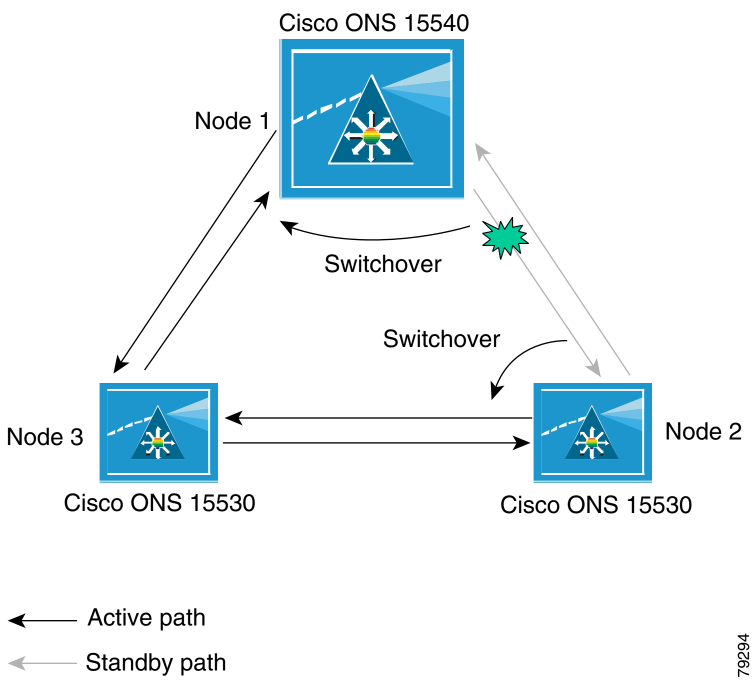
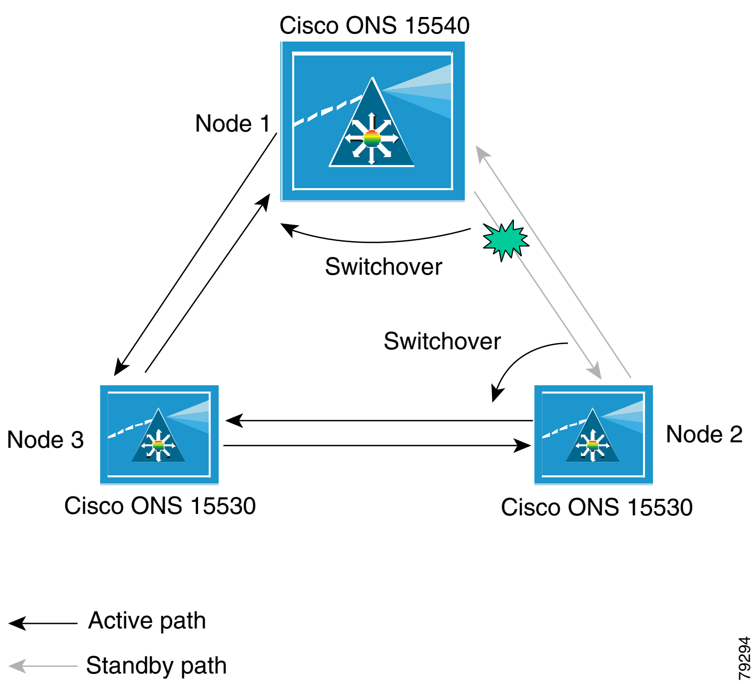


Figure 2-20 shows the behavior of bidirectional path switching when a loss of signal occurs. For the example network, bidirectional path switching operates as follows:

- Node 2 sends the channel signal over both the active and standby paths.
- Node 1 receives both signals and selects the signal on the active path.
- Node 1 detects a loss of signal light on its active path and switches over to the standby path.
- Node 1 sends an APS switchover message to node 2 on the protection path.
- Node 2 switches from the active path to the standby path.

Both node 1 and node 2 communicate on the same path.

Figure 2-20 Bidirectional Path Switching Overview



CHAPTER 3

Shelf Configuration Rules

The design of the Cisco ONS 15530 requires that a set of rules be followed during physical configuration of the shelf. These rules, along with examples, are provided in this chapter. This chapter contains the following major sections:

Note Applying the shelf configuration rules requires an understanding of the Cisco ONS 15530 system components and protection schemes.

Shelf Rules for OADM Modules

This section describes the shelf rules for OADM (optical add/drop multiplexer) modules for different types of protection.

Cabling OADM Modules

The following rules apply when cabling the trunk, thru, and OSC ports on the OADM modules:

- Use fiber optical cables with MU connectors to cable an OADM module to other OADM modules, to OSC modules, to transponder line cards, 2.5-Gbps ITU trunk cards, and to 10-Gbps ITU trunk cards.
- Connect the OSC IN on the OADM module to tx on the OSC module and connect the OSC OUT on the OADM module to rx on the same OSC module. Perform the same process with the redundant OADM module and OSC module.

- Connect west to east, never west to west or east to east, between nodes in a ring.
- Connect Thru OUT to Thru IN between the OADM modules for ring configurations.

For examples of OADM module cabling in a protected ring configuration, see Figure 1-17 on page 1-30.

Rules for Protected Configurations

The rules for OADM modules in protected configurations are as follows:

- You must use two OADM modules that support the same channel band.
- If the OSC is used for APS channel protocol messages, the OADM modules must both support the OSC.

In trunk fiber protected configurations, only one OADM module can be used in single shelf configurations because the PSM (protection switch module) occupies one of the subslots in slot 0.

Shelf Rules for PSMs

For trunk fiber protection to function when the PSM (protection switch module) is connected to an OADM module, the OSC or the in-band message channel (or both) must be available on the shelf. If the OSC is present, the PSM must connect to an OADM module that supports the OSC if it is a multiple shelf node. If the PSM connects to an ITU trunk card, use the in-band message channel as the APS message channel to support trunk fiber protection. If the PSM connects to a transponder line card, use IP for the APS message channel.

Shelf Rules for 2.5-Gbps ITU Trunk Cards

The rules for 2.5-Gbps ITU trunk cards are as follows:

- The 2.5-Gbps ITU trunk cards must support channels in the same 4-channel band supported by the OADM module.
- Two OADM modules are required when configuring splitter protection.

Shelf Rules for Transponder Line Cards

The rules for transponder line cards are as follows:

- When using y-cable protection, ensure that both transponder line cards are the same type (single-mode or multimode) for a given client signal. For example, if client signal A connects by a y-cable to transponders in slot 2 and slot 3, then both of those transponder line cards must either be single-mode or multimode.
- The transponder line cards must support channels in the same 4-channel band supported by the OADM module.

Shelf Rules for 10-Gbps ITU Trunk Cards

The rules for 10-Gbps ITU trunk cards are as follows:

- The 10-Gbps ITU trunk cards must support channels in the same channel band supported by the OADM module.
- Two OADM modules are required when configuring splitter protection.

Shelf Rules for 10-Gbps ITU Tunable Trunk Cards

The rules for 10-Gbps ITU tunable trunk cards are as follows:

- The 10-Gbps ITU trunk cards must support channels in the same channel band supported by the OADM module.
- Two OADM modules are required when configuring splitter protection.

Shelf Rules for 10-Gbps Uplink Cards

The rules for 10-Gbps uplink cards are as follows:

- The 10-Gbps uplink cards must connect to 10-Gbps uplink cards on another Cisco ONS 15530, or to a 10-GE client module on a Cisco ONS 15540 ESP or Cisco ONS 15540 ESPx.
- If the Cisco ONS 15530 shelf has 10-Gbps uplink cards and no 2.5-Gbps transponder line cards, 2.5-Gbps ITU trunk cards, or 10-Gbps ITU trunk cards, no OADM modules or OSC modules are required.

Shelf Rules for OSC Modules

The rules for OSC modules are as follows:

- For unprotected and trunk fiber protected configurations, use one OSC module and one OADM module with OSC support.
- For splitter and line card protected configurations, use two OSC modules and two OADM modules with OSC support.

General Rules for Ring Topologies

The following network rules apply to ring topologies:

- A channel must be present on only two nodes in the ring when using splitter protection.
- All channels added by a node on an east OADM module must be dropped on a west OADM module of one or more other nodes on the ring. All channels added by a node on a west OADM module must be dropped by an east OADM module of one or more other nodes on the ring. This rule may be violated during migration.
- A node cannot add a channel that is already present in the same direction until it has dropped that channel.

CHAPTER 4

Optical Loss Budgets

The optical loss budget is an important aspect in designing networks with the Cisco ONS 15530. The optical loss budget is the ultimate limiting factor in distances between nodes in a topology. This chapter contains the following major sections:

Note The optical specifications described in this chapter are only for the individual components and should not be used to characterize the entire network performance.

Note The information in this chapter applies only to nonamplified network design.

About dB and dBm

Signal power loss or gain is never a fixed amount of power, but a portion of power, such as one-half or one-quarter. To calculate lost power along a signal path using fractional values, you cannot add 1/2 and 1/4 to arrive at a total loss. Instead, you must multiply 1/2 by 1/4. This makes calculations for large networks time-consuming and difficult.

For this reason, the amount of signal loss or gain within a system, or the amount of loss or gain caused by some component in a system, is expressed using the *decibel* (dB). Decibels are logarithmic and can easily be used to calculate total loss or gain just by doing addition. Decibels also scale logarithmically. For example, a signal gain of 3 dB means that the signal doubles in power; a signal loss of 3 dB means that the signal halves in power.

Keep in mind that the decibel expresses a ratio of signal powers. This requires a reference point when expressing loss or gain in dB. For example, the statement “there is a 5 dB drop in power over the connection” is meaningful, but the statement “the signal is 5 dB at the connection” is not meaningful. When you use dB you are not expressing a measure of signal strength, but a measure of signal power loss or gain.

It is important not to confuse decibel and *decibel milliwatt* (dBm). The latter is a measure of signal power in relation to 1 mW. Thus a signal power of 0 dBm is 1 mW, a signal power of 3 dBm is 2 mW, 6 dBm is 4 mW, and so on. Conversely, –3 dBm is 0.5 mW, –6 dBm is 0.25 mW, and so on. Thus the more negative the dBm value, the closer the power level approaches zero.

Overall Optical Loss Budget

An optical signal degrades as it propagates through a network. Components such as OADM modules, fiber, fiber connectors, splitters, and switches introduce attenuation. Ultimately, the maximum allowable distance between the transmitting laser and the receiver is based upon the optical loss budget that remains after subtracting the power losses experienced by the channels as they traverse the components at each node.

Table 4-1 lists the laser transmitter power and receiver sensitivity range for the transponder line cards, ITU trunk card, the OSC (Optical Supervisory Channel) module, and the PSM (protection switch module).

Table 4-1 Trunk Side Transmitter Power and Receiver Ranges

	Transmitter Power (dBm)		**Receiver Sensitivity (dBm)**	
Card or Module Type	**Minimum**	**Maximum**	**Minimum**	**Overload**
Transponder line card	5	10	–28	–8
8-port multi-service muxponder	5	10	–28	–8
2.5-Gbps ITU trunk card	5	10	–28	–8
10-Gbps ITU trunk card	1	6	–22	–8
OSC module	5	10	–19	–1.5
PSM			–31	17[1]

1. The receiver detector only reports up to 0 dBm in the CLI (command-line interface). To measure the actual input power to the receiver, use an optical power meter on the optical monitoring port.

Note Add the proper system-level penalty to the receive power based on your actual network topology characteristics, such as dispersion.

The goal in calculating optical loss is to ensure that the total loss does not exceed the overall optical (or span) budget. The optical budget is determined by subtracting the minimum receiver sensitivity from the minimum laser launch power on the cards. The OSC has an optical budget of 24 dB, which is equal to the minimum OSC receiver sensitivity (–19 dBm) subtracted from the minimum OSC laser launch power (5 dBm) on the OSC module.

Calculating Optical Loss Budgets

Using the optical loss characteristics for the Cisco ONS 15530 components, you can calculate the optical loss between the transmitting laser on one node and the receiver on another node. The general rules for calculating the optical loss budget are as follows:

- The maximum power loss between the nodes cannot exceed the minimum transmit power of the laser minus the minimum sensitivity of the receiver and network-level penalty.

Note Determine the proper network-level penalty to the receive power based on your actual network topology characteristics, such as dispersion.

- The minimum attenuation between the nodes must be greater than the maximum transmitter power of the laser minus the receiver overload value.

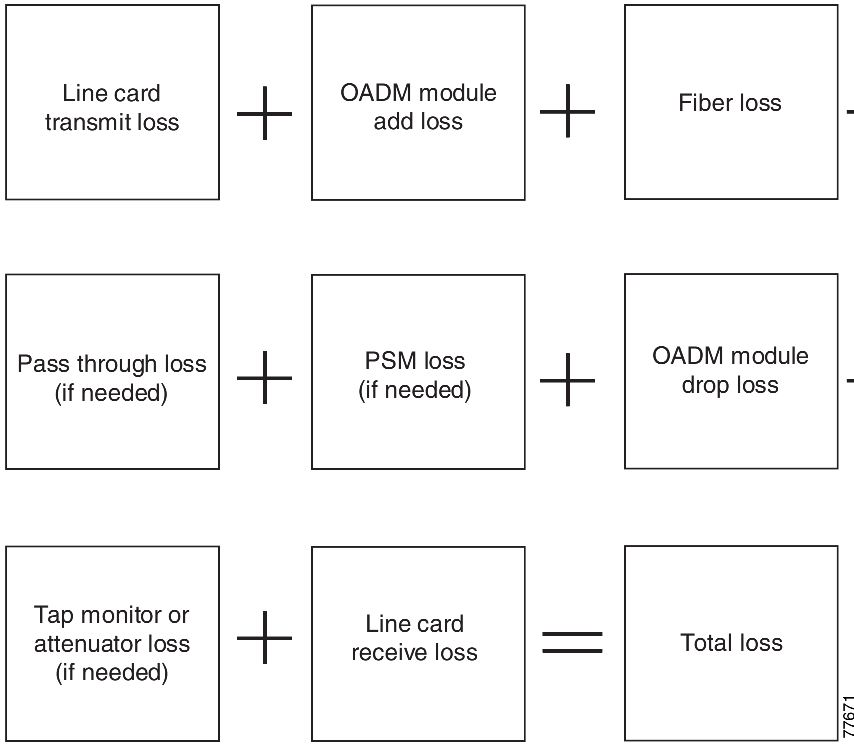
The following example shows how to calculate the optical loss budget for 2.5-Gbps data channels using the values in Table 4-1:

- The power loss between the transmit laser and receiver must not exceed 33 (5 – (–28)) dB or the signal will not be detected accurately.
- At least 18 (10 – (–8)) dB of attenuation between neighboring nodes prevents receiver saturation.

To validate a network design, the optical loss must be calculated for each band of channels. This calculation must be done for both directions if protection is implemented, and for the OSC between each pair of nodes. The optical loss is calculated by summing the losses introduced by each component in the signal path.

At a minimum, any data channel path calculation must include line card transmit loss, channel add loss, fiber loss, channel drop loss, and line card receive loss (see Figure 4-1). In ring topologies, pass-through losses must be considered. Losses due to external devices such as fixed attenuators and monitoring taps also need to be included.

Figure 4-1 Elements of Optical Loss in a Minimal Configuration



For examples of optical loss budget calculations, see the shelf configurations described in Chapter 6, "Example Shelf Configurations and Topologies."

Optical Loss for Transponder Line Cards

In both the receive and transmit directions, splitter transponder line cards attenuate the ITU signal significantly more than the nonsplitter transponder line cards.

Table 4-2 shows the optical loss for the splitter and nonsplitter transponder line cards supported by the Cisco ONS 15530 in the transmit and receive directions.

Table 4-2 Optical Loss for Transponder Line Cards

Protection Type and Direction	Loss (dB)
Splitter Tx	4.05
Splitter Rx	1.35
Nonsplitter Tx	0.5
Nonsplitter Rx	0.5

Optical Loss for 8-Port Multi-Service Muxponders

In both the receive and transmit directions, splitter 8-port multi-service muxponders attenuate the ITU signal significantly more than the nonsplitter transponder line cards.

Table 4-3 shows the optical loss for the splitter and nonsplitter 8-port multi-service muxponders supported by the Cisco ONS 15530 in the transmit and receive directions.

Table 4-3 Optical Loss for 8-Port Multi-Service Muxponders

Protection Type and Direction	Loss (dB)
Splitter Tx	4.05
Splitter Rx	1.35
Nonsplitter Tx	0.5
Nonsplitter Rx	0.5

Optical Loss for 2.5-Gbps ITU Trunk Cards

In both the transmit and receive directions, splitter 2.5-Gbps ITU trunk cards attenuate the ITU signal significantly more than the nonsplitter 2.5-Gbps ITU trunk cards.

Table 4-4 shows the optical loss for the splitter and nonsplitter 2.5-Gbps ITU trunk cards supported by the Cisco ONS 15530 in the transmit and receive directions.

Table 4-4 Optical Loss for 2.5-Gbps ITU Trunk Cards

Protection Type and Direction	Loss (dB)
Splitter Tx	4.05
Splitter Rx	1.35
Nonsplitter Tx	0.5
Nonsplitter Rx	0.5

Optical Loss for 10-Gbps ITU Tunable and Non tunable Trunk Cards

In both the receive and transmit directions, splitter 10-Gbps ITU tunable and non tunable trunk cards attenuate the ITU signal significantly more than the nonsplitter 10-Gbps ITU tunable and non tunable trunk cards.

Table 4-5 shows the optical loss for the splitter and nonsplitter 10-Gbps ITU tunable and non tunable trunk cards supported by the Cisco ONS 15530 in the transmit and receive directions.

Table 4-5 Optical Loss for 10-Gbps ITU Tunable and Non tunable Trunk Cards

Protection Type and Direction	Loss (dB)
Splitter Tx	4.05
Splitter Rx	1.35
Nonsplitter Tx	0.5
Nonsplitter Rx	0.5

Optical Loss for OADM Modules

OADM (optical add/drop multiplexer) modules attenuate the signals as they are multiplexed, demultiplexed, and passed through. The amount of attenuation depends upon the path the optical signal takes through the modules.

Loss for Data Channels

Table 4-6 shows the optical loss for the data channels between the 4-channel OADM modules and the line cards, and between the pass-through add and drop connectors on the OADM modules.

Table 4-6 Optical Loss for Data Channels Through the OADM Modules

Type of OADM Module	Trunk IN to Line Card (Data Drop) in dB[1]	Line Card to Trunk OUT (Data Add) in dB	Trunk IN to Thru OUT (Pass Through) in dB	Thru IN to Trunk OUT (Pass Through) in dB
4-channel with OSC	4.1	4.1	1.5	1.5
4-channel without OSC	4.1	4.1	1	1

1. The insertion loss is the worst case value so care should be taken when calculating minimum loss budget.

Note The insertion losses listed in Table 4-6 are worst case values. Take this into consideration when calculating the minimum loss budget.

Loss for the OSC

Table 4-7 shows the optical loss for the OSC between the OSC module and the OADM modules.

Table 4-7 Optical Loss for the OSC Through the OADM Modules

Type of OADM Module	Trunk IN to OSC Transceiver (dB)	OSC Transceiver to Trunk OUT (dB)
4-channel OADM with OSC	2.8	2.8

Optical Loss for PSMs

The PSM attenuates the trunk signal as it passes between the trunk fiber and the OADM module, ITU trunk card, or transponder line card. Table 4-8 shows the optical loss for the channels passing through a PSM.

Table 4-8 Optical Loss for Channels Passing Through PSMs

Direction	Minimum Loss (dB)	Maximum Loss (dB)
Transmit	2.7	3.7
Receive		1.7

Client Signal Latency on Aggregation Card

The process of aggregating client signals on the ESCON aggregation card and the 8-port FC/GE aggregation card adds latency between the client equipment in the network.

ESCON Aggregation Cards

The ESCON aggregation card adds latency to ESCON traffic. The amount of latency depends on how traffic is configured on the node. Table 4-9 shows the ESCON latency values for different configurations of the ESCON aggregation card.

Table 4-9 Latency for ESCON Aggregation Cards

Traffic Mix in the ITU Wavelength	Latency (in microseconds)
ESCON only	8.5
ESCON and FC	8.5
ESCON and GE	17

4-Port 1-Gbps/2-Gbps FC Aggregation Cards

The 4-port 1-Gbps/2-Gbps FC aggregation card adds latency to FC traffic. The amount of latency depends on how traffic is configured on the node. Table 4-12 shows the FC latency values for different configurations of the 4-port 1-Gbps/2-Gbps FC aggregation card.

Table 4-10 1-Gbps FC and FICON Latency Values for 4-port 1-Gbps/2-Gbps FC Aggregation Cards

	Maximum Added End-to-End Latency[1] (Time and Distance)			
Traffic Mix on Transmitting Node	**No GE**	**1518-Byte GE Packets**	**4470-Byte GE Packets**	**10,232-Byte GE Packets**
One FC/FICON signal only on the 2.5-Gbps aggregated signal carried over a 2.5-Gbps ITU trunk card	12.2 microseconds			
Two FC/FICON signals only on the 2.5-Gbps aggregated signal carried over a 2.5-Gbps ITU trunk card	12.7 microseconds			
One FC/FICON signal only on the 2.5-Gbps aggregated signal carried over a10-Gbps ITU trunk card	11.6 microseconds			
One FC/FICON signal only on the 2.5-Gbps aggregated signal carried over a10-Gbps ITU trunk card		12.8 microseconds	15.2 microseconds	23.9 microseconds
Two FC/FICON signals and GE on the same 2.5-Gbps aggregated signal carried over a 10-Gbps ITU trunk card		13.5 microseconds	16.8 microseconds	26.2 microseconds

1. The latency values are based on configuration of correct transmit buffer sizes as described in the *Cisco ONS 15530 Configuration Guide*.

Table 4-11 2-Gbps FC and FICON Latency Values for 4-port 1-Gbps/2-Gbps FC Aggregation Cards

	Maximum Added End-to-End Latency[1] (Time and Distance)			
Traffic Mix on Transmitting Node	**No GE**	**1518-Byte GE Packets**	**4470-Byte GE Packets**	**10,232-Byte GE Packets**
One FC/FICON signal only on the 2.5-Gbps aggregated signal carried over a 2.5-Gbps ITU trunk card	10.6 microseconds			
One FC/FICON signal only on the 2.5-Gbps aggregated signal carried over a10-Gbps ITU trunk card	9.9 microseconds			
One FC/FICON signal only on the 2.5-Gbps aggregated signal carried over a10-Gbps ITU trunk card		12.1 microseconds	15.4 microseconds	25.1 microseconds

1. The latency values are based on configuration of correct transmit buffer sizes as described in the *Cisco ONS 15530 Configuration Guide*.

8-Port FC/GE Aggregation Cards

The 8-port FC/GE aggregation card adds latency to FC traffic. The amount of latency depends on how traffic is configured on the node. Table 4-12 shows the FC latency values for different configurations of the 8-port FC/GE aggregation card.

Table 4-12 FC and FICON Latency Values for 8-Port FC/GE Aggregation Cards

Traffic Mix on Transmitting Node	Maximum Added End-to-End Latency[1] (Time and Distance)			
	No GE	1518-Byte GE Packets	4470-Byte GE Packets	10,232-Byte GE Packets
FC/FICON only on the 2.5-Gbps aggregated signal carried over a 2.5-Gbps ITU trunk card	18.8 microseconds (3.8 km)			
FC/FICON only on a 2.5-Gbps aggregated signal carried over a 10-Gbps ITU trunk card	19.9 microseconds (4.0 km)			
FC/FICON only on a 2.5-Gbps aggregated signal mixed with GE on the same 10-Gbps ITU trunk card		22.2 microseconds (4.4 km)	24.8 microseconds (5.0 km)	36.3 microseconds (7.3 km)
FC/FICON and GE on the same 2.5-Gbps aggregated signal carried over a 2.5-Gbps ITU trunk card		27.9 microseconds (5.6 km)	47.1 microseconds (9.4 km)	83.6 microseconds (16.7 km)
FC/FICON and GE on the same 2.5-Gbps aggregated signal carried over a 10-Gbps ITU trunk card		39.2 microseconds (7.8 km)	77.1 microseconds (15.4 km)	151.1 microseconds (30.2 km)

1. The latency values are based on configuration of correct transmit buffer sizes as described in the *Cisco ONS 15530 Configuration Guide*.

8-Port Multi-Service Muxponders

The 8-port multi-service muxponder adds latency to client traffic. Table 4-13 shows the client traffic latency values for the 8-port multi-service muxponder.

Table 4-13 Latency Values for 8-Port Multi-Service Muxponders

Protocol	Unidirectional End-to-End Latency for 0 km Fiber	
	Typical Latency (microseconds)	Maximum Latency (microseconds)
ESCON	10	13
Fibre Channel	4	6
GE (optical)	8	10
FE (optical)	16	18
GE (copper)	9	11
FE (copper)	18	20

Table 4-13 Latency Values for 8-Port Multi-Service Muxponders (continued)

Protocol	Unidirectional End-to-End Latency for 0 km Fiber	
	Typical Latency (microseconds)	**Maximum Latency (microseconds)**
SDI	17	20
DVB-ASI	9	11

Fiber Plant Testing

Verifying fiber characteristics to qualify the fiber in the network requires proper testing. This document describes the test requirements but not the actual procedures. After finishing the test measurements, compare the measurements with the specifications from the manufacturer, and determine whether the fiber supports your system requirements or whether changes to the network are necessary.

This test measurement data can also be used to determine whether your network can support higher bandwidth services such as 10 Gigabit Ethernet, and can help determine network requirements for dispersion compensator modules or amplifiers.

The test measurement results must be documented and referred to during acceptance testing of a network.

Fiber optic testing procedures must be performed to measure the following parameters:

- Link loss (attenuation)
- ORL (optical return loss)
- PMD (polarization mode dispersion)
- Chromatic dispersion

Link Loss (Attenuation)

Testing for link loss, or attenuation, verifies whether fiber spans meet loss budget requirements.

Attenuation includes intrinsic fiber loss, losses associated with connectors and splices, and bending losses due to cabling and installation. An OTDR (optical time domain reflector/reflectometer) is used when a comprehensive accounting of these losses is required. The OTDR sends a laser pulse through each fiber; both directions of the fiber are tested at 1310 nm and 1550 nm wavelengths.

OTDRs also provide information about fiber uniformity, splice characteristics, and total link distance. For the most accurate loss test measurements, an LTS (loss test set) that consists of a calibrated optical source and detector is used. However, the LTS does not provide information about the various contributions (including contributions related to splice and fiber) to the total link loss calculation.

A combination of OTDR and LTS tests is needed for accurate documentation of the fiber facilities being tested. In cases where the fiber is very old, testing loss as a function of wavelength (also called spectral attenuation) might be necessary. This is particularly important for qualifying the fiber for multiwavelength operation. Portable chromatic dispersion measurement systems often include an optional spectral attenuation measurement.

ORL

ORL is a measure of the total fraction of light reflected by the system. Splices, reflections created at optical connectors, and components can adversely affect the behavior of laser transmitters, and they all must be kept to a minimum of 24 dB or less. You can use either an OTDR or an LTS equipped with an ORL meter for ORL measurements. However, an ORL meter yields more accurate results.

PMD

PMD has essentially the same effect on the system performance as chromatic dispersion, which causes errors due to the “smearing” of the optical signal. However, PMD has a different origin from chromatic dispersion. PMD occurs when different polarization states propagate through the fiber at slightly different velocities.

PMD is defined as the time-averaged DGD (differential group delay) at the optical signal wavelength. The causes are fiber core eccentricity, ellipticity, and stresses introduced during the manufacturing process. PMD is a problem for higher bit rates (10 GE and above) and can become a limiting factor when designing optical links.

The time-variant nature of dispersion makes it more difficult to compensate for PMD effects than for chromatic dispersion. “Older” (deployed) fiber may have significant PMD—many times higher than the 0.5 ps/Ð km specification seen on most new fiber. Accurate measurements of PMD are very important to guarantee operation at 10 Gbps. Portable PMD measuring instruments have recently become an essential part of a comprehensive suite of tests for new and installed fiber. Because many fibers in a cable are typically measured for PMD, instruments with fast measurement times are highly desirable.

Chromatic Dispersion

Chromatic dispersion testing is performed to verify that measurements meet your dispersion budget.

Chromatic dispersion is the most common form of dispersion found in single-mode fiber. Temporal in nature, chromatic dispersion is related only to the wavelength of the optical signal. For a given fiber type and wavelength, the spectral line width of the transmitter and its bit rate determine the chromatic dispersion tolerance of a system. Dispersion management is of particular concern for high bit rates (10 Gbps) using conventional single-mode fiber. Depending on the design of the 10-Gbps transceiver module, dispersion compensation might be needed to accommodate an upgrade from GE to 10 GE in order to keep the same targeted distances.

Portable chromatic dispersion measurement instruments are essential for testing the chromatic dispersion characteristics of installed fiber.

Fiber Requirements for 10-Gbps Transmission

Do not deploy 10-Gbps wavelengths, or even 2.5-Gbps wavelengths, over G.653 fiber. This type of fiber causes enormous amounts of nonlinear effects.

Amplified Network Planning

The Cisco ONS 15530 topologies might require signal amplification because of the distance between nodes and the optical loss of channels as they pass through nodes in the network. This chapter discusses the amplification and attenuation features supported by the Cisco ONS 15530. This chapter contains the following sections:

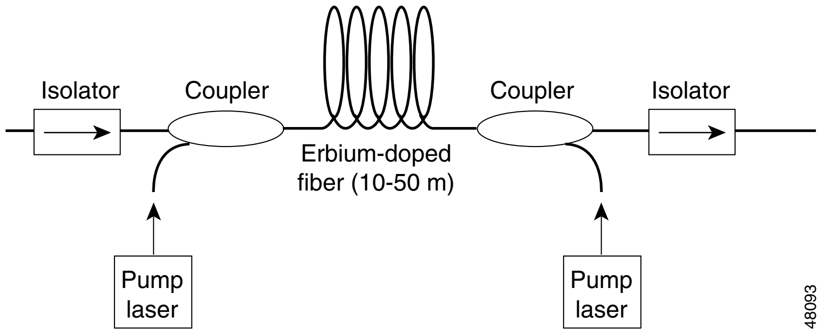
Optical Amplification Overview

Due to attenuation caused by the physical characteristics of the network topology, such as the distance between nodes and the optical loss for channels passing through nodes, there are limits to how far a signal can propagate with integrity before it has to be regenerated. The optical amplifier makes it possible to amplify all the wavelengths at once without any optical-electrical-optical (O-E-O) conversion. Besides being used on optical links, optical amplifiers also can be used to boost signal power after multiplexing (post-amplification), or before demultiplexing (preamplification).

Erbium-Doped Fiber Amplifiers

The EDFA (erbium-doped fiber amplifier) is a key enabling technology that extends the range of DWDM networks. Erbium is a rare-earth element that, when excited, emits light around 1.54 micrometers—the low-loss wavelength for optical fibers used in DWDM. Light at 980 nm or 1480 nm is injected into the fiber using a pump laser. This injected light stimulates the erbium atoms to release their stored energy as additional 1550-nm light. As this process continues down the fiber, the signal on the fiber grows stronger. The spontaneous emissions in the EDFA also add noise to the signal, which is a limiting factor for an EDFA. Figure 5-1 shows a simplified diagram of an EDFA.

Figure 5-1 Erbium-Doped Fiber Amplifier Design



The key performance parameters of optical amplifiers are gain, gain flatness, noise level, and output power. EDFAs are typically capable of gains of 30 dB or more and output power of 17 dBm or more. The target parameters for an EDFA, however, are low noise and flat gain. Gain should be flat because all signals must be amplified uniformly. While the signal gain provided with EDFA technology is inherently wavelength-dependent, it can be corrected with gain flattening filters. Such filters are often built into modern EDFAs.

Low noise is a requirement because noise, along with signal, is amplified. Because this effect is cumulative, and cannot be filtered out, the signal-to-noise ratio is a limiting factor in the number of amplifiers that can be concatenated and, therefore, the end-to-end reach of optical signals. That is because the optical amplifier merely amplifies the signals and does not perform the 3R functions (reshape, retime, retransmit).

Note The Cisco ONS 15530 interoperates with the Cisco ONS 15501 optical solutions amplifier. For information about the Cisco ONS 15501 features, refer to the *Cisco ONS 15501 User Guide*.

About Variable Optical Attenuation

Optical attenuation is often needed to equalize all DWDM channel powers in an amplified ring network. In a ring network, the pass through channels are typically weaker than the added channels. To equalize the channel powers, the added channel powers are attenuated down to the power level of the pass through channels. Power equalization is needed in an amplified network because of the input power limitation of the EDFAs and to simplify network management.

The Cisco ONS 15530 supports two types of variable optical attenuation, per channel and per band. Per channel attenuation equalizes the channel powers on a channel-by-channel basis, while the per band attenuation achieves equalization by attenuating channels on a band-by-band basis.

VOA Modules

Variable optical attenuation on the Cisco ONS 15530 is provided by two types of VOA modules:

- PB-OE (per-band optical equalizer) modules
- WB-VOA (wide-band variable optical attenuator) modules

The VOA modules are half-height modules inserted into a carrier motherboard installed in a Cisco ONS 15530 chassis slot.

PB-OE Modules

The PB-OE module selects and attenuates one or two specific four-channel bands and passes the remaining bands to be attenuated by another PB-OE module, by a WB-VOA module, or not attenuated at all. After the bands are attenuated, they are merged back together and sent out on the trunk fiber. The Cisco ONS 15530 supports eight single band PB-OE modules (one for each four-channel band) and four dual band PB-OE modules (for bands AB, CD, EF, and GE).

Table 5-1 lists the optical specifications for the PB-OE modules.

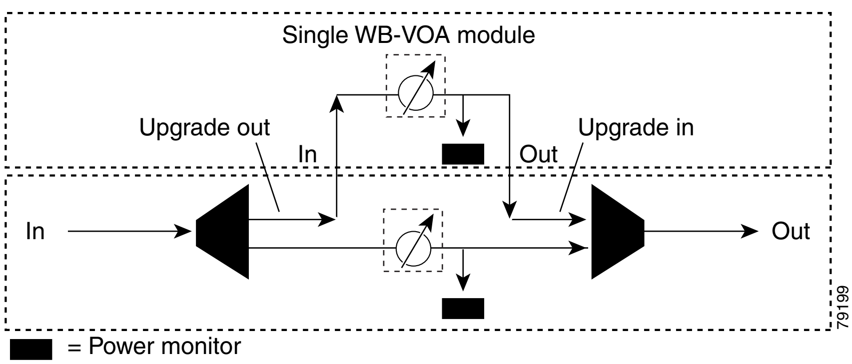
Table 5-1 PB-OE Optical Specifications

Specification	Single Band PB-OE	Dual Band PB-OE
Maximum attenuation	30 dB	30 dB
Minimum attenuation resolution	0.1 dB	0.1 dB
Minimum attenuation	3.4 dB	3.9 dB
Maximum pass through loss	2.6 dB	4.8 dB

A single band PB-OE module accepts an incoming signal containing more than one band. The band are split by an optical band filter into two components. One component is attenuated and the other component can be passed to an another module where it can be attenuated and passed back to the original PB-OE module. The PB-OE module then recombines the two equalized components and sends it out on the trunk fiber.

Figure 5-2 shows a logical view of a single band PB-OE module combined with a single WB-VOA module for pass through band attenuation. You can also combine a PB-OE module with other PB-OE modules in a cascaded fashion.

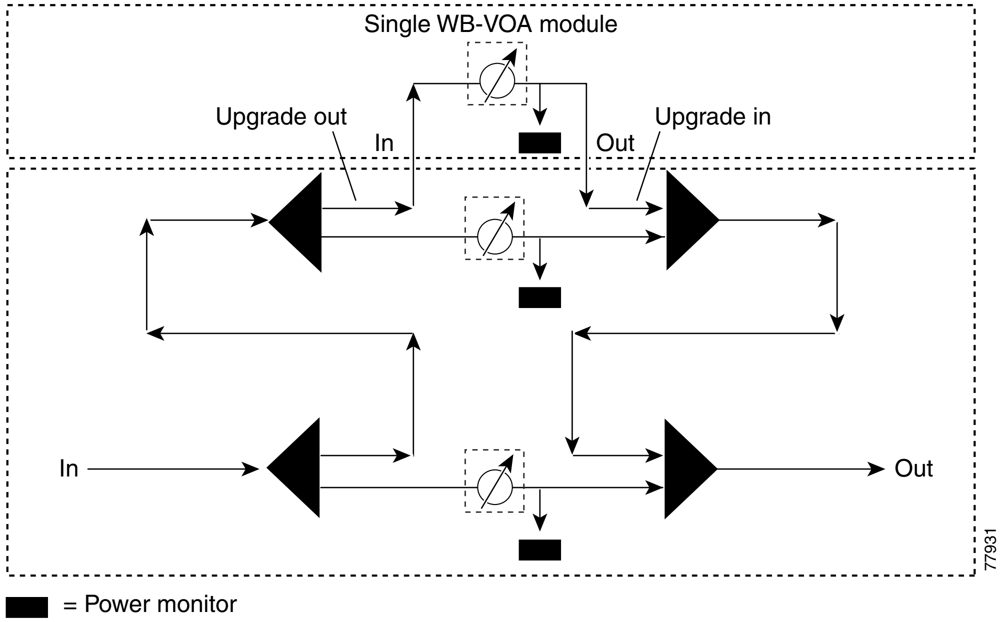
Figure 5-2 Single Band PB-OE Module and Single WB-VOA Module Example



If a band pair has to be attenuated, use a dual band PB-OE module. When more than two add bands are to be attenuated, multiple PB-OE modules and WB-VOA modules can be cascaded. The dual band PB-OE supports band pairs AB, CD, EF, and GH.

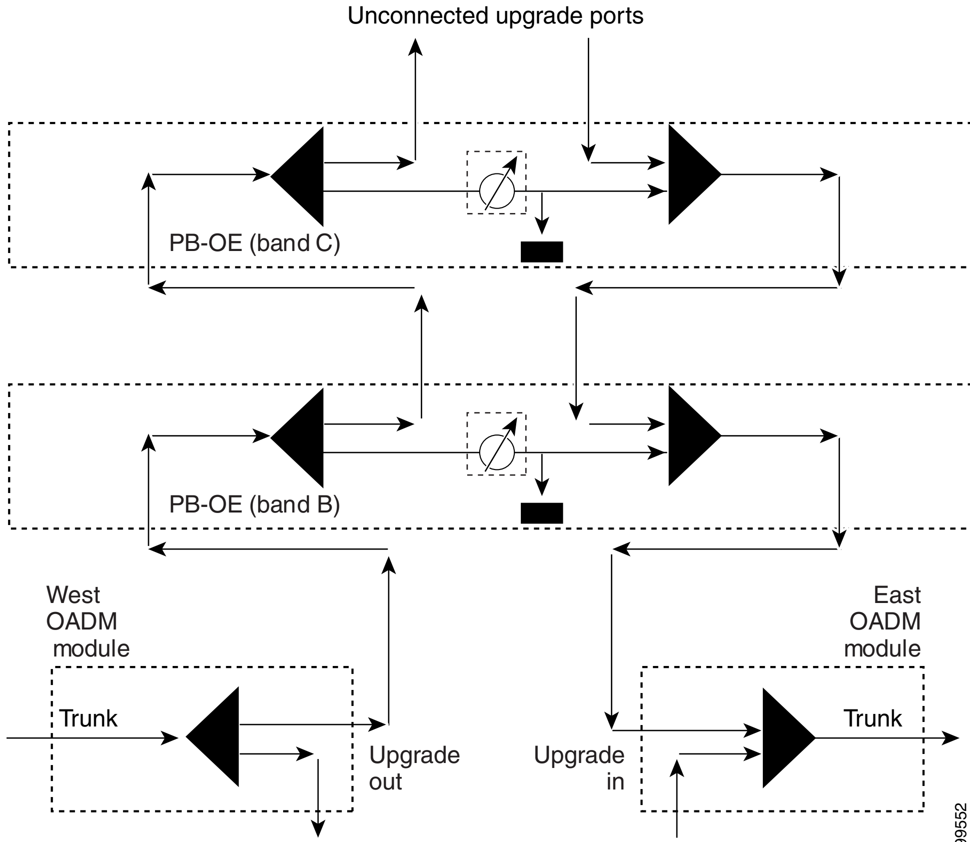
Figure 5-3 shows a logical view of a dual band PB-OE module and single WB-VOA module combination. The single WB-VOA module attenuates the signal passed out from the dual PB-OE module.

Figure 5-3 Dual Band PB-OE Module and Single WB-VOA Module Example



The PB-OE modules can also be use to provide an optical seam that terminates unused bands in a meshed ring topology. Unlike a hubbed ring network, the unused and dark channels in a meshed ring topology are not terminated by any OADM module anywhere in the network. If optical amplifiers are used in a meshed ring network, the EDFA-generated noise corresponding to the unused channels or bands is circulated in the ring and amplified by the EDFAs. If the loss around the ring is less than the gain around the ring, then power oscillations can occur, leading to network instability. An optical seam terminates all unused and dark channels and eliminates potential network instability due to power oscillations. Figure 5-4 shows an example of an optical seam at network site with two pass through bands, band B and band C. The optical seam consists of a band B PB-OE module cascaded with a band C PB-OE module (to allow bands B and C to pass through) and with the attenuation set to a minimum level. The upgrade ports of the band C PB-OE module are unconnected to terminate the unused bands.

Figure 5-4 Optical Seam Example



WB-VOA Modules

The Cisco ONS 15530 supports two types of WB-VOA modules: single and dual. A single WB-VOA module accepts an optical signal and attenuates all frequencies within that signal. The signal can contain a single channel, such as the OSC, a band of channels, or the entire trunk signal.

A dual WB-VOA module consists of two WB-VOA units combined into a single module. Each WB-VOA unit accepts an optical signal and attenuates all frequencies within that signal. The two WB-VOA units function independently of each other. The dual WB-VOA module provides more attenuator ports when space in a shelf is limited.

Table 5-2 lists the optical specifications for the WB-VOA modules.

Table 5-2 WB-VOA Optical Specifications

Specification	Single WB-VOA	Dual WB-VOA
Maximum attenuation	30 dB	30 dB
Minimum attenuation resolution	0.1 dB	0.1 dB
Minimum attenuation	1.7 dB	1.7 dB

You can use WB-VOA modules for the following types of attenuation:

- Per channel—attenuate only a single data channel or the OSC. Place the WB-VOA module between the line card and the OADM.
- Wide band—attenuate all channels on the trunk signal. Use this configuration to avoid saturating the amplifiers.
- Pass through band channels—attenuate the pass through bands by an OADM. Place the WB-VOA on the upgrade, or thru, output port on the OADM.

Amplified Network Planning Considerations

When planning an amplified network topology, you need to consider the following:

- Optical power budget
- OSNR (optical signal-to-noise ratio)
- Chromatic dispersion

Optical Power Budget

Optical power budgets, or link loss budgets, are a critical part of planning an optical network. In general, there are many factors that can result in optical signal loss. The most obvious of these is the distance of the fiber itself. Also, the number of nodes in a network topology is a significant contributor to optical loss.

The key to precise optical power budget calculation is to get an accurate reading on the fiber using an optical time domain reflectometer (OTDR). Using an OTDR, you can obtain the following information about a span:

- Length of the fiber
- Attenuation of the whole link, as well as the attenuation of separate sections of the fiber (if any)
- Attenuation characteristics of the fiber itself
- Locations of connectors, joints, and faults in the cable

The goal in calculating optical loss is to ensure that the total loss does not exceed the span budget. The following are typical values for the main elements in a span:

- Connector splice loss
- Fiber loss
- Fiber aging

It is also important to ensure that the client side or tributary equipment does not overload the local receive laser of the DWDM equipment. This means that the client or tributary equipment must operate within the specifications of the DWDM client interface.

OSNR

Besides the signal itself, optical amplifiers boost the entire input, including noise. The effect is cumulative through the network. The OSNR (optical signal-to-noise ratio) can become so low that a clear signal is not correctly decoded at the receiving end. At this point the signal must be regenerated.

Chromatic Dispersion

Chromatic dispersion occurs because different wavelengths propagate at different speeds.It can result in signal power spread and can reduce receiver sensitivity.

Amplified Network Planning Guidelines

This section describes the guidelines for planning a Cisco ONS 15530 amplified network.

Receive Power Levels

Receiver power levels for individual transponder line cards and ITU trunk cards should be within the power range defined by minimum receiver sensitivity and maximum receiver overload for each card. Depending on network configuration characteristics, such as dispersion and OSNR, apply the proper penalties to the minimum receiver sensitivity.

Optical Component Gain or Loss

Use the statistical gain or loss, determined by mean and variance values, for optical components in the network, such as OADM modules, connectors, and EDFAs. The loss for OADM modules should be based on measured data, and the gain should be based on the gain flatness specification (+/- 0.75 dB) of the Cisco ONS 15501 EDFA. The gain or loss of optical components should be accumulated in a statistical manner, such that the mean and variance of the total gains and losses is the sum of individual means and variances. The maximum gain or loss of an aggregate of optical components is equal to the mean plus three times the standard deviation (sigma), and the minimum gain or loss is equal to the mean minus three times the standard deviation.

EDFA Input Power Limits

The maximum total input power to a Cisco ONS 15501 EDFA is 0 dBm and the minimum total input power is –29 dBm.

OSNR

Use the following equation to compute the OSNR:

$$OSNRout = -10*\log(10^{-OSNRin/10} + 6.33*10^{-6} * 10^{-Pin/10})$$

where OSNRin and Pin are the OSNR and input power, respectively, of the signal at the input of the EDFA, and OSNRout is the OSNR of the signal at the output of the EDFA.

The signal OSNR at the receiver should be higher than the minimum OSNR required for the particular card type and the data bit rate, with the proper penalties for dispersion depending on network configuration.

The above OSNR calculations can be carried out manually to verify the OSNR of individual optical channels. However, we recommend that a network design tool, such as Metro Planner, be used to validate all amplified network designs.

Channel Power Equalization

Amplified networks require that all channel powers be equalized in the network. There are two channel equalization options for Cisco ONS 15530 and Cisco ONS 15540 networks: per-channel and per-band equalization.

In the per-channel option, a WB-VOA module is placed between each transmitting ITU laser and the OADM module. The WB-VOA module attenuation value is set individually so that all channels added at the OADM module are equal in power on the outgoing trunk.

Alternatively, the added channels can be equalized on a per-band basis. The PB-OE modules and WB-VOA modules can be used for this purpose. In this case, the added bands are demultiplexed, separately attenuated, and multiplexed back together by PB-OE modules placed at the OADM module out-going trunk. The pass through bands can also be attenuated by the WB-VOA modules connected to the pass through path of the PB-OE modules.

For more information on the PB-OE modules and WB-VOA modules, see the "PB-OE Modules" section on page 5-3 and the "WB-VOA Modules" section on page 5-5.

Dispersion Limits

Table 5-3 lists the dispersion limits, in the absence of DCUs (dispersion compensation units), of various components on the Cisco ONS 15530 and the Cisco ONS 15540.

Table 5-3 Dispersion Limits

Card Type	Dispersion Limit (ps/nm)
Cisco ONS 15540 SM/MM transponder module	1800
Cisco ONS 15540 extended reach transponder module	3200
Cisco ONS 15540 10-GE transponder module	1000
Cisco ONS 15530 transponder line card	3200
Cisco ONS 15530 2.5-Gbps ITU trunk card	3200
Cisco ONS 15530 10-Gbps ITU trunk card	1000
OSC module	3200

DCUs

DCUs (dispersion control units) can be used in networks that exceed the dispersion limit of the transmitters. There are three types of Cisco ONS 15216 DCUs that are available: –350 ps/nm, –750 ps/nm, and –1150 ps/nm. DCUs should be placed where total power is low, for example, at the input to a preamplifier or just before an OADM module input trunk. DCUs should be placed such that any span of half the dispersion limit or more should be compensated to a value close to zero, and that the residual dispersion at the receiver is within the dispersion limit.

We recommend the use of a network design tool, such as Metro Planner, for the validation of DCUs in amplified network designs for Cisco ONS 15530 and Cisco ONS 15540 networks.

Fiber Nonlinearity

To avoid undesirable nonlinear effects, the maximum allowed channel power in ITU-652 compliant fibers must be limited in the network.

Maximum per-channel power for 10 Gbps channels is 2 dBm when there are at most three post-amplifiers, and 0 dBm when there are at most five post-amplifiers.

Maximum per-channel power for 2.5 Gbps channels is 5 dBm when there are at most five post-amplifiers.

Other types of fibers, such as ZSDF, LEAF and Truewave are not supported by these rules and must be treated separately as special cases.

OSC

The OSC (Optical Supervisory Channel) is a 1562-nm node-to-node communication channel. Because it is within the C-band range, it is also amplified by the Cisco ONS 15501 EDFA. All the rules for data channels, such as receiver power levels, OSNR, optical gains and losses, and dispersion, also apply to the OSC.

CHAPTER 6

Example Shelf Configurations and Topologies

The requirements of a particular topology determine what components must be used and how they are interconnected. This chapter provides examples of shelf configurations and optical power budget calculations specific to each of the main types of protection schemes supported by the Cisco ONS 15530, and examples of supported topologies. This chapter contains the following major sections:

Shelf Configurations

This section describes how to populate a Cisco ONS 15530 shelf for different types of protection configurations.

Unprotected Configurations

This section describes the configuration of the modules and unprotected line cards for unprotected configurations.

Note You can use splitter line cards for unprotected configurations but they have a higher optical loss.

Figure 6-1 shows an example of a Cisco ONS 15530 shelf in an unprotected configuration using nonpsplitter transponder line cards.

Figure 6-1 Unprotected Configuration Using Nonsplitter Transponder Line Cards

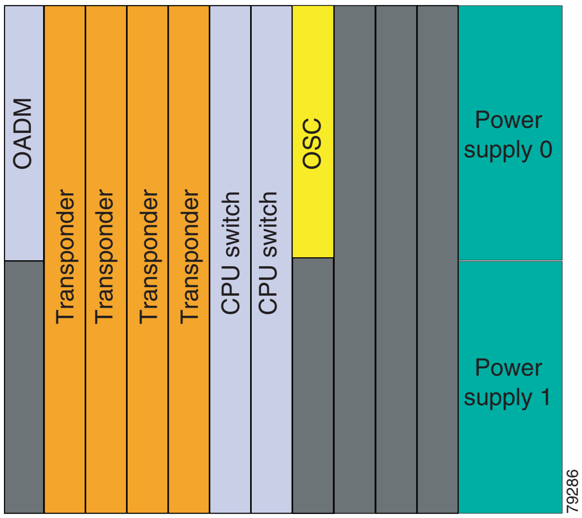


Figure 6-2 shows the optical power budget for an unprotected configuration using nonsplitter transponder line cards.

Figure 6-2 Optical Power Budget for an Unprotected Configuration Using Nonsplitter Transponder Line Cards

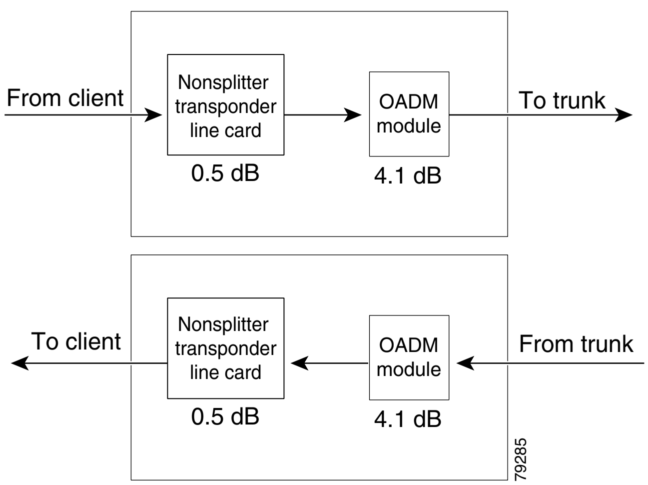


Figure 6-3 shows an example of a Cisco ONS 15530 shelf in an unprotected configuration using ESCON aggregation cards and nonsplitter 2.5-Gbps ITU trunk cards.

Figure 6-3 Unprotected Configuration Using ESCON Aggregation Cards and a 2.5-Gbps ITU Trunk Card

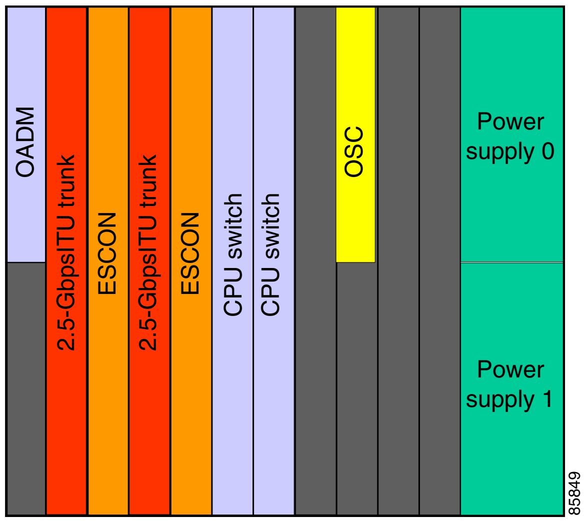


Figure 6-4 shows the optical power budget for an unprotected configuration when using nonsplitter 2.5-Gbps ITU trunk cards.

Figure 6-4 Optical Power Budget for an Unprotected Configuration Using Nonsplitter 2.5-Gbps ITU Trunk Cards

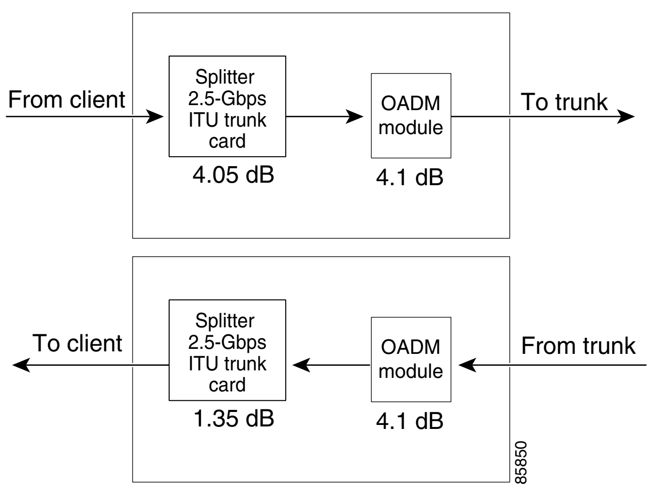


Figure 6-5 shows an example of a Cisco ONS 15530 shelf in an unprotected configuration using 8-port FC/GE aggregation cards and a nonsplitter 10-Gbps ITU trunk card.

Figure 6-5 Unprotected Configuration Using ESCON Aggregation Cards, 8-Port FC/GE Aggregation Card, and 10-Gbps ITU Trunk Cards

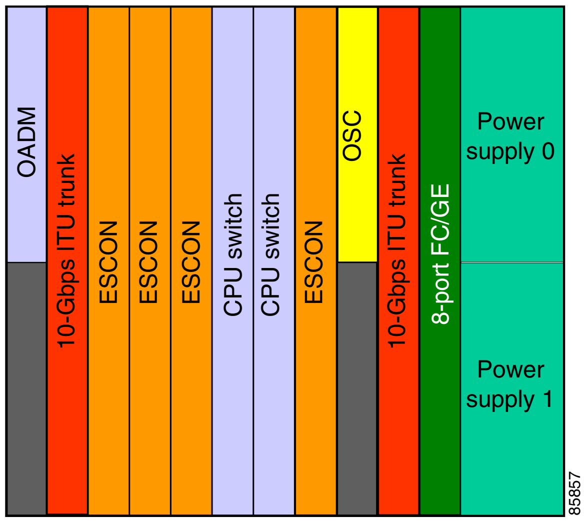


Figure 6-6 shows the optical power budget for an unprotected configuration when using nonsplitter 10-Gbps ITU trunk cards.

Figure 6-6 Optical Power Budget for an Unprotected Configuration Using Nonsplitter 10-Gbps ITU Trunk Cards

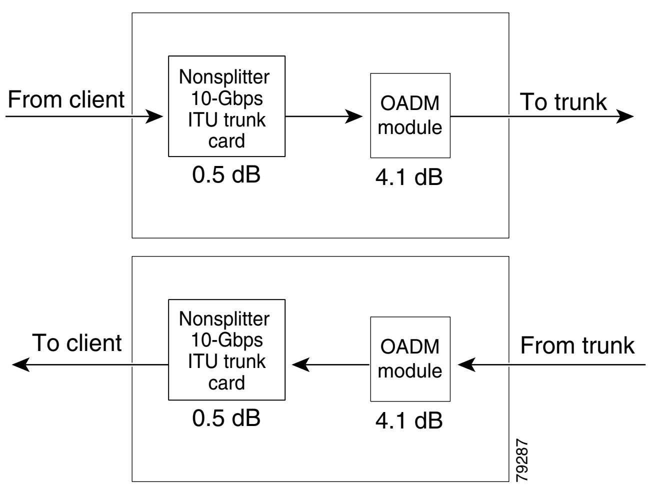


Figure 6-7 shows an example of a Cisco ONS 15530 shelf in an unprotected configuration using ESCON aggregation cards and a 10-Gbps uplink card.

Figure 6-7 Unprotected Configuration Using ESCON Aggregation Cards and a 10-Gbps Uplink Card

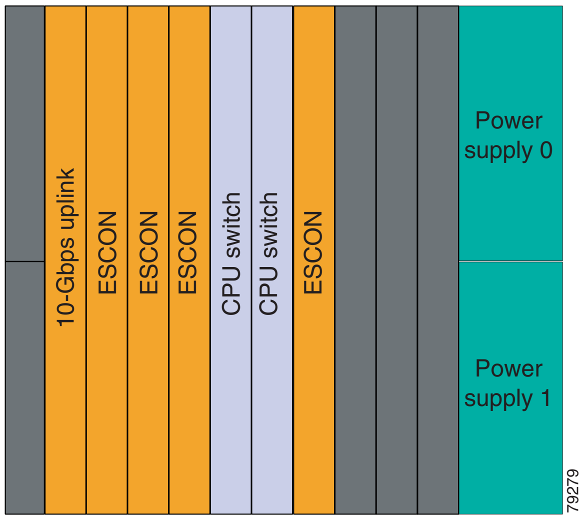


Figure 6-1 shows an example of a Cisco ONS 15530 shelf in an unprotected configuration using nonpsplitter 8-port multi-service muxponders.

Figure 6-8 Unprotected Configuration Using Nonsplitter 8-Port Multi-Service Muxponders

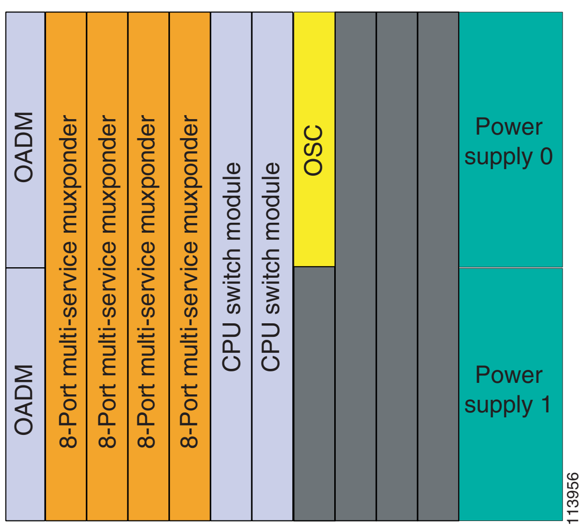
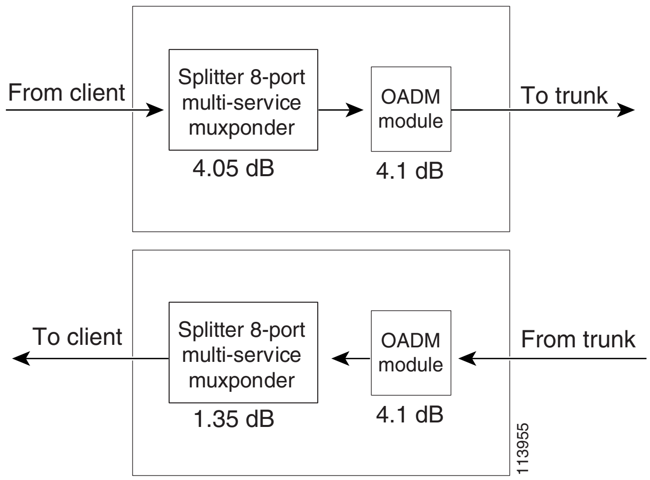


Figure 6-9 shows the optical power budget for an unprotected configuration using nonsplitter 8-port multi-service muxponders.

Figure 6-9 Optical Power Budget for an Unprotected Configuration Using Nonsplitter 8-Port Multi-Service Muxponders



Splitter Protected Configurations

This section describes the configuration of the modules and line cards for splitter protected configurations.

Figure 6-10 shows an example of a Cisco ONS 15530 shelf in a splitter protected configuration using transponder line cards.

Figure 6-10 Splitter Protected Configuration Using Transponder Line Cards

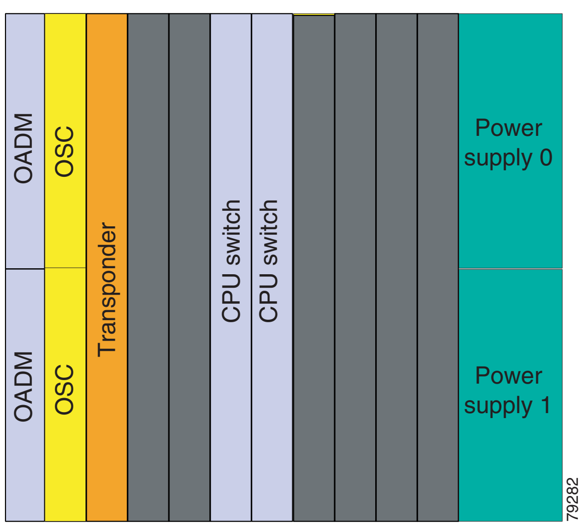


Figure 6-11 shows the optical power budget for a splitter protected configuration.

Figure 6-11 Optical Power Budget for a Splitter Protected Configuration Using Transponder Line Cards

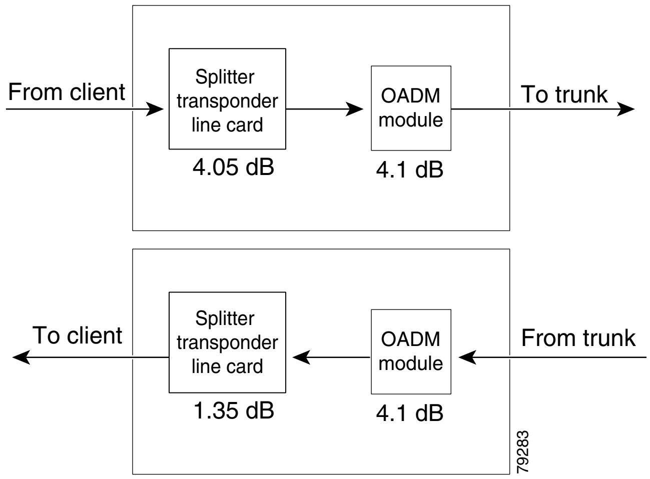


Figure 6-12 shows an example of a Cisco ONS 15530 shelf in a splitter protected configuration using an 8-port FC/GE aggregation cards and 2.5-Gbps ITU trunk cards.

Figure 6-12 Splitter Protected Configuration Using an 8-Port FC/GE Aggregation Card and Splitter 2.5-Gbps ITU Trunk Cards

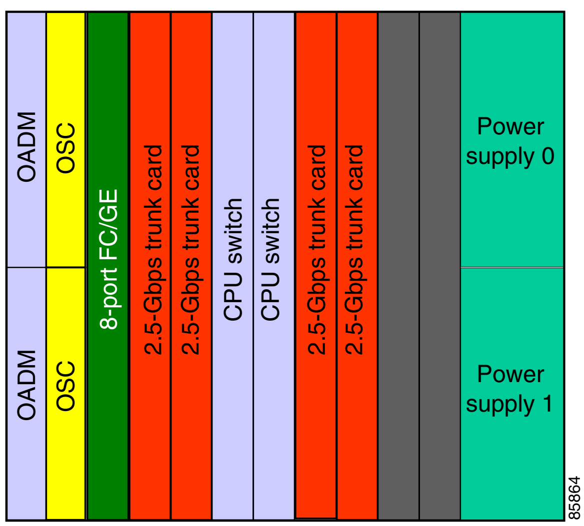


Figure 6-13 shows the optical power budget for a splitter protected configuration.

Figure 6-13 Optical Power Budget for a Splitter Protected Configuration Using Splitter 2.5-Gbps ITU Trunk Cards

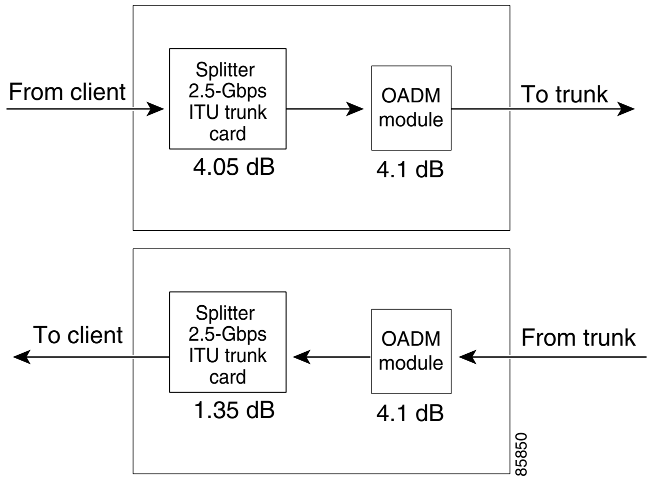


Figure 6-14 shows an example of a Cisco ONS 15530 shelf in a splitter protected configuration using ESCON aggregation cards and 10-Gbps ITU trunk cards.

Figure 6-14 Splitter Protected Configuration Using ESCON Aggregation Cards and 10-Gbps ITU Trunk Cards

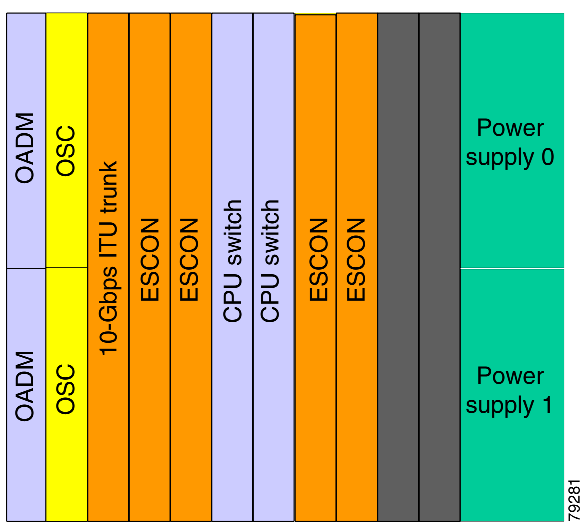


Figure 6-15 shows the optical power budget for a splitter protected configuration.

Figure 6-15 Optical Power Budget for a Splitter Protected Configuration Using 10-Gbps ITU Trunk Cards

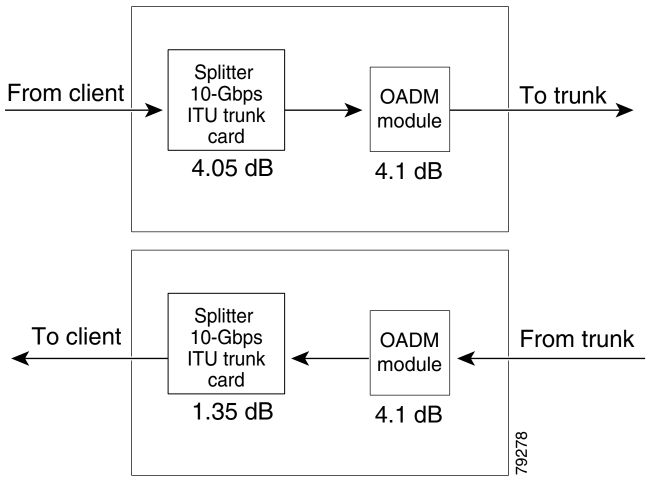


Figure 6-16 shows an example of a Cisco ONS 15530 shelf in a splitter protected configuration using 8-port multi-service muxponders.

Figure 6-16 Splitter Protected Configuration Using 8-Port Multi-Service Muxponders

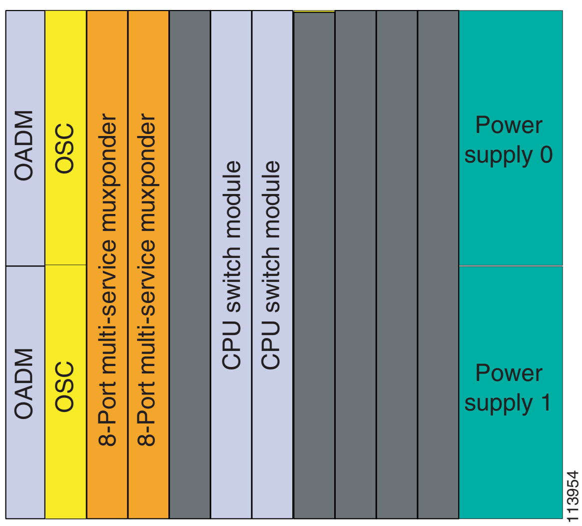
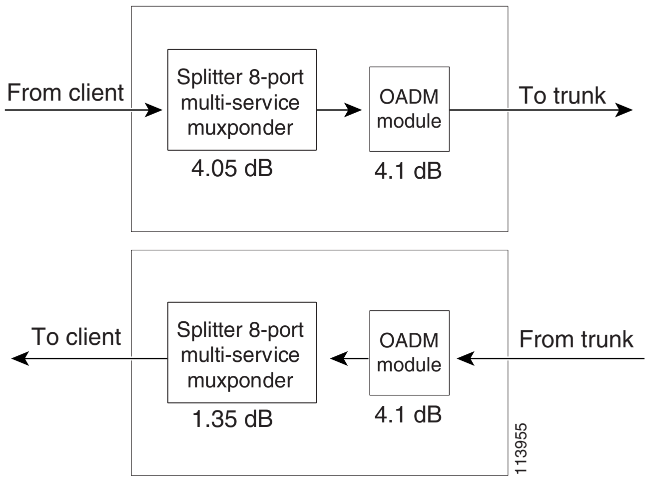


Figure 6-17 shows the optical power budget for a splitter protected configuration using 8-port multi-service muxponders.

Figure 6-17 Optical Power Budget for a Splitter Protected Configuration Using 8-Port Multi-Service Muxponders



Line Card Protected Configurations

This section describes the configuration of the modules and line cards for line card protected configurations.

Figure 6-18 shows an example of a Cisco ONS 15530 shelf in a line card protected configuration using transponder line cards.

Figure 6-18 Line Card Protected Configuration Using Transponder Line Cards

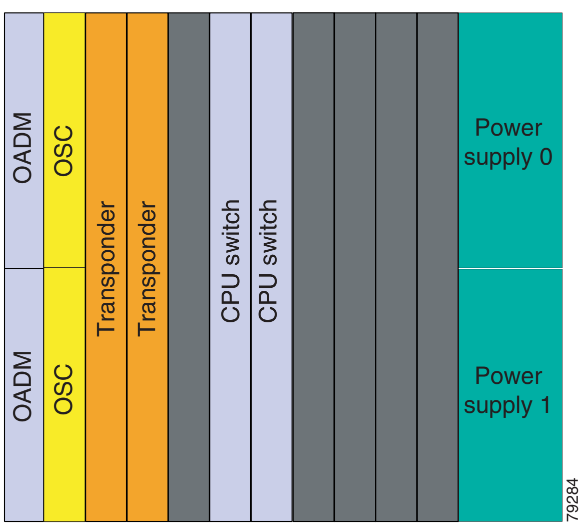


Figure 6-19 shows the optical power budget for a line card protected configuration using nonsplitter transponder line cards.

Figure 6-19 Optical Power Budget for a Line Card Protected Configuration Using Nonsplitter Transponder Line Cards

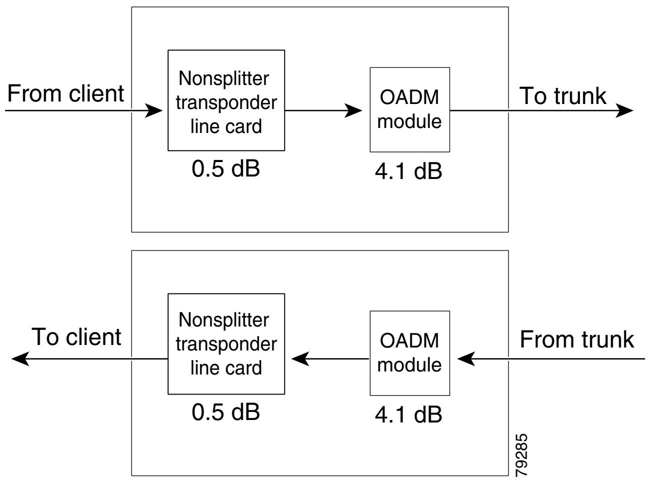


Figure 6-20 shows an example of a Cisco ONS 15530 shelf in a client based line card protected configuration using ESCON aggregation cards and 2.5-Gbps ITU trunk cards.

Figure 6-20 Client Based Line Card Protected Configuration Using ESCON Aggregation Cards and Nonsplitter 2.5-Gbps ITU Trunk Cards

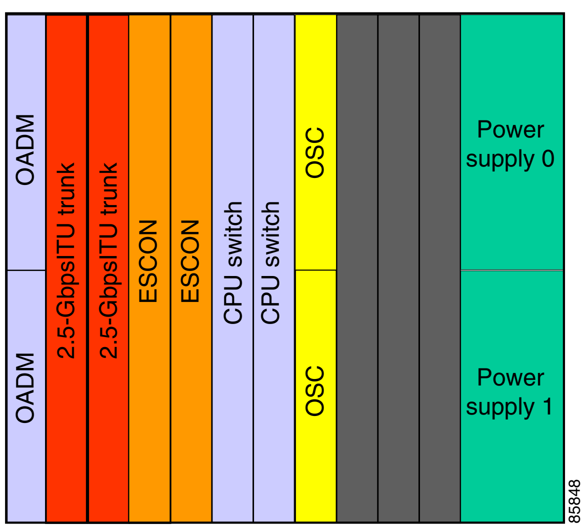


Figure 6-21 shows the optical power budget for a client based line card protected configuration using nonsplitter 2.5-Gbps ITU trunk cards.

Figure 6-21 Optical Power Budget for a Client Based Line Card Protected Configuration Using Nonsplitter 2.5-Gbps ITU Trunk Cards

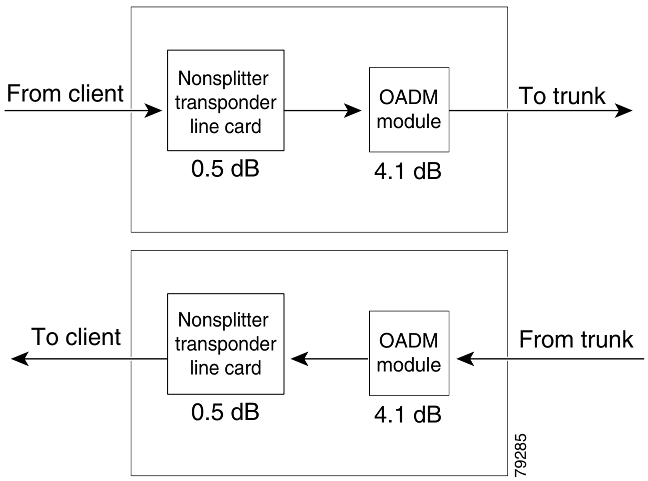


Figure 6-22 shows an example of a Cisco ONS 15530 shelf in a client based line card protected configuration using ESCON aggregation cards and 10-Gbps ITU trunk cards.

Figure 6-22 Client Based Line Card Protected Configuration Using ESCON Aggregation Cards and 10-Gbps ITU Trunk Cards

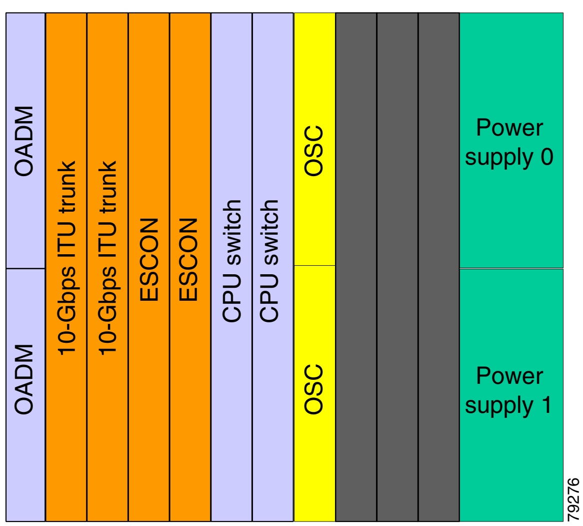


Figure 6-23 shows the optical power budget for a client based line card protected configuration using nonsplitter 10-Gbps ITU trunk cards.

Figure 6-23 Optical Power Budget for a Client Based Line Card Protected Configuration Using Nonsplitter 10-Gbps ITU Trunk Cards

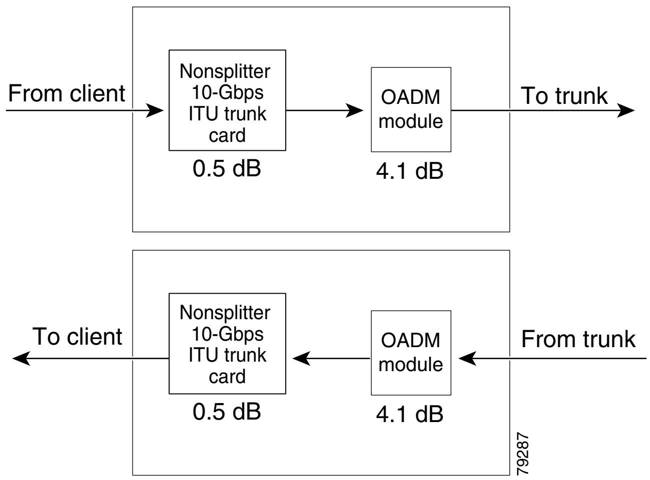


Figure 6-24 shows an example of a Cisco ONS 15530 shelf in a client based line card protected configuration using ESCON aggregation cards and 10-Gbps uplink cards.

Figure 6-24 Client Based Line Card Protected Configuration Using ESCON Aggregation Cards and 10-Gbps Uplink Cards

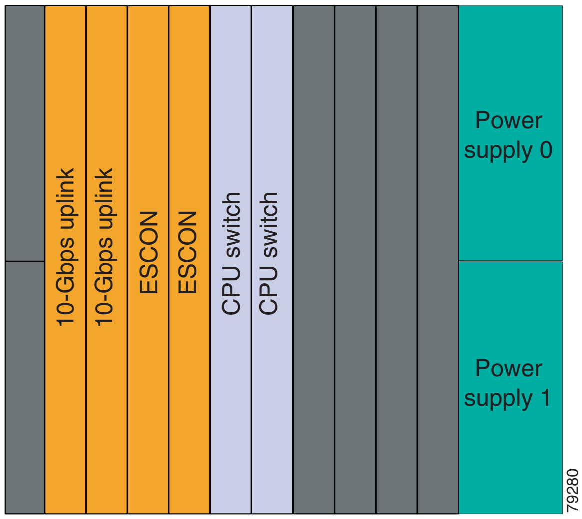


Figure 6-25 shows an example of a Cisco ONS 15530 shelf in a line card protected configuration using nonsplitter 8-port multi-service muxponders.

Figure 6-25 Line Card Protected Configuration Using Nonsplitter 8-Port Multi-Service Muxponders

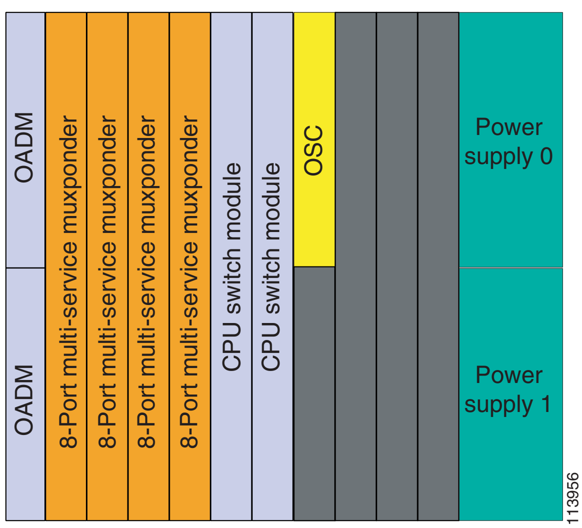
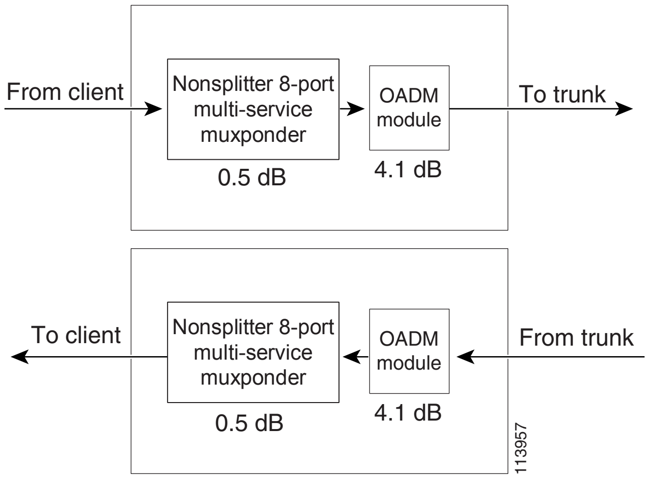


Figure 6-26 shows the optical power budget for a line card protected configuration using nonsplitter 8-port multi-service muxponders.

Figure 6-26 Optical Power Budget for a Line Card Protected Configuration Using Nonsplitter 8-Port Multi-Service Muxponders



Switch Fabric Based Line Card Protection Configurations

This section describes the configuration of line cards for switch fabric protected configurations.

Figure 6-27 shows an example of a Cisco ONS 15530 shelf in a switch fabric protected configuration with an ESCON aggregation card and two 2.5-Gbps ITU trunk cards.

Figure 6-27 Switch Fabric Protected Configuration Using Nonsplitter 2.5-Gbps ITU Trunk Cards

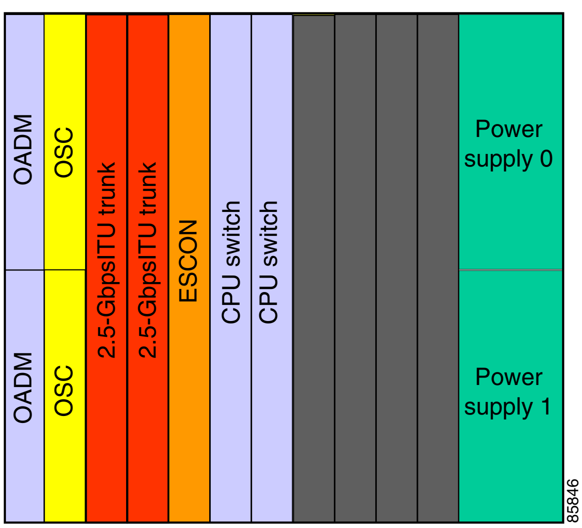


Figure 6-28 shows the optical power budget for a switch fabric based line card protected configuration.

Figure 6-28 Optical Power Budget for Switch Fabric Protected Configurations Using Nonsplitter 2.5-Gbps ITU Trunk Cards

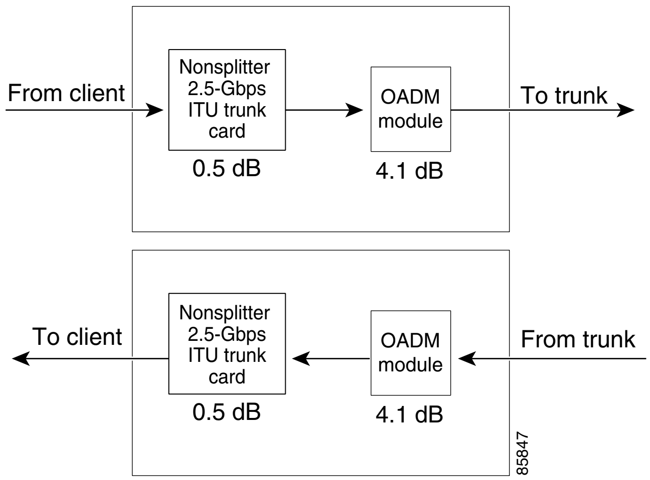


Figure 6-29 shows an example of a Cisco ONS 15530 shelf in a switch fabric protected configuration with an ESCON aggregation card and two 10-Gbps ITU trunk cards.

Figure 6-29 Switch Fabric Protected Configuration Using Nonsplitter 10-Gbps ITU Trunk Cards

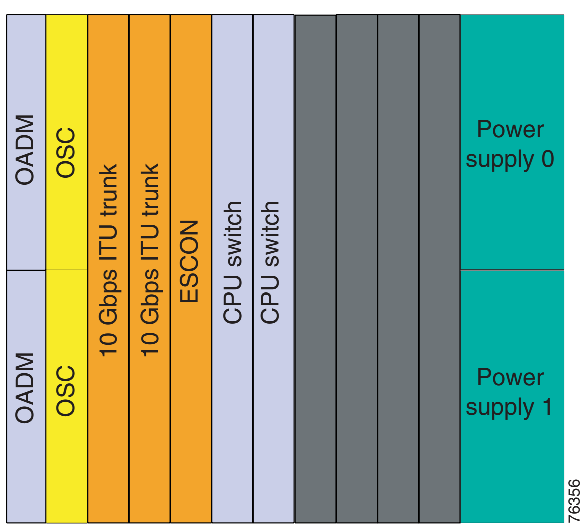


Figure 6-30 shows the optical power budget for a switch fabric based line card protected configuration.

Figure 6-30 Optical Power Budget for Switch Fabric Protected Configurations Using Nonsplitter 10-Gbps ITU Trunk Cards

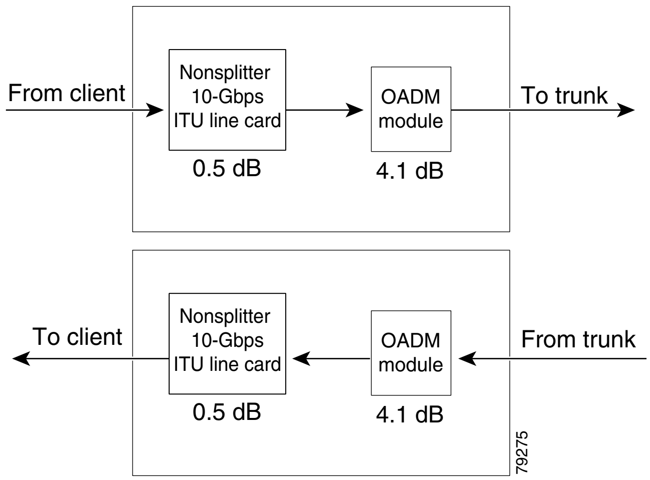
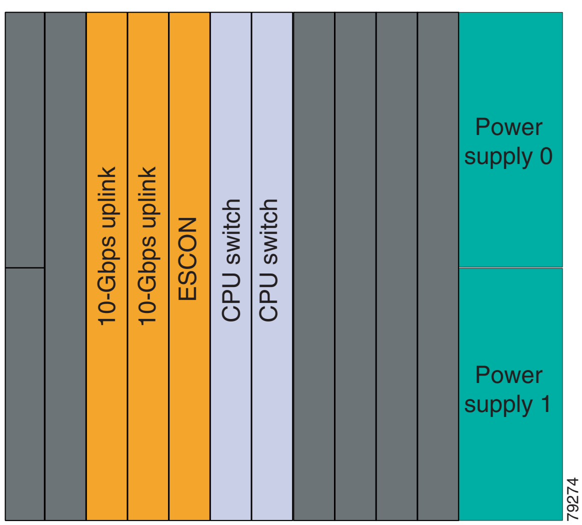


Figure 6-31 shows an example of a Cisco ONS 15530 shelf in a switch fabric based line card protected configuration with an ESCON aggregation card and two 10-Gbps uplink cards.

Figure 6-31 Switch Fabric Based Protected Configuration Using 10-Gbps Uplink Cards



Trunk Fiber Based Protection Configurations

This section describes the configuration of line cards for trunk fiber protected configurations.

Figure 6-32 shows an example of a Cisco ONS 15530 shelf in a trunk fiber protected configuration with transponder line cards.

Figure 6-32 Trunk Fiber Protected Configuration Using Nonsplitter Transponder Line Cards

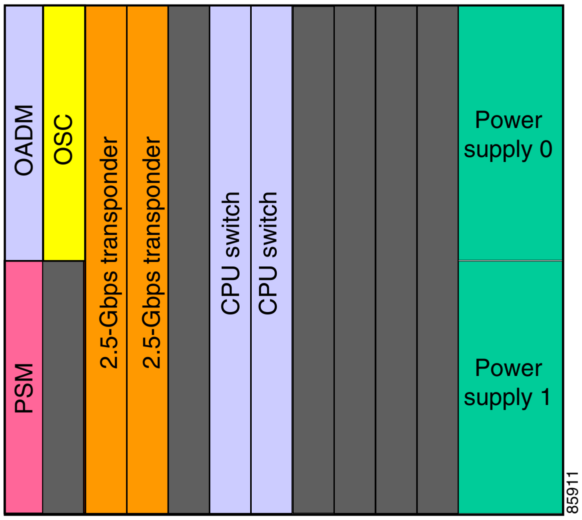


Figure 6-33 shows the optical power budget for a trunk fiber protected configuration with nonsplitter transponder line cards.

Figure 6-33 Optical Power Budget for Trunk Fiber Protected Configurations Using Nonsplitter Transponder Line Cards

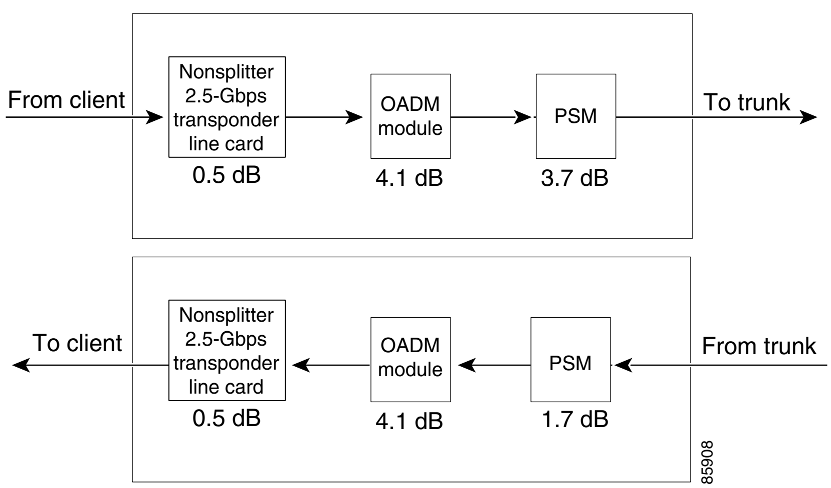


Figure 6-34 shows an example of a Cisco ONS 15530 shelf in a trunk fiber protected configuration with 8-port multi-service muxponders.

Figure 6-34 Trunk Fiber Protected Configuration Using Nonsplitter 8-Port Multi-Service Muxponders

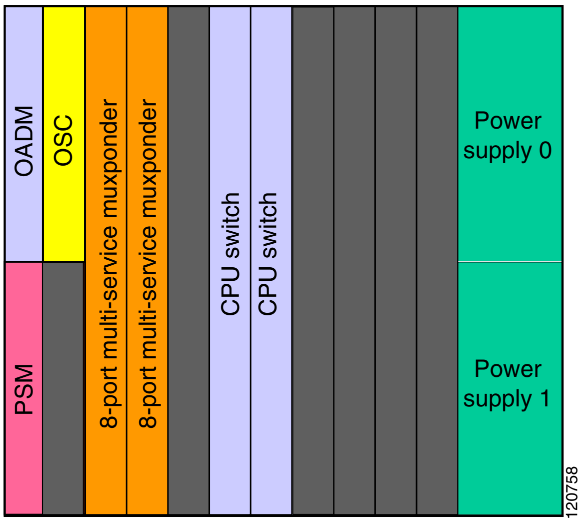


Figure 6-35 shows the optical power budget for a trunk fiber protected configuration with nonsplitter 8-port multi-service muxponders.

Figure 6-35 Optical Power Budget for Trunk Fiber Protected Configurations Using Nonsplitter 8-Port Multi-Service Muxponders

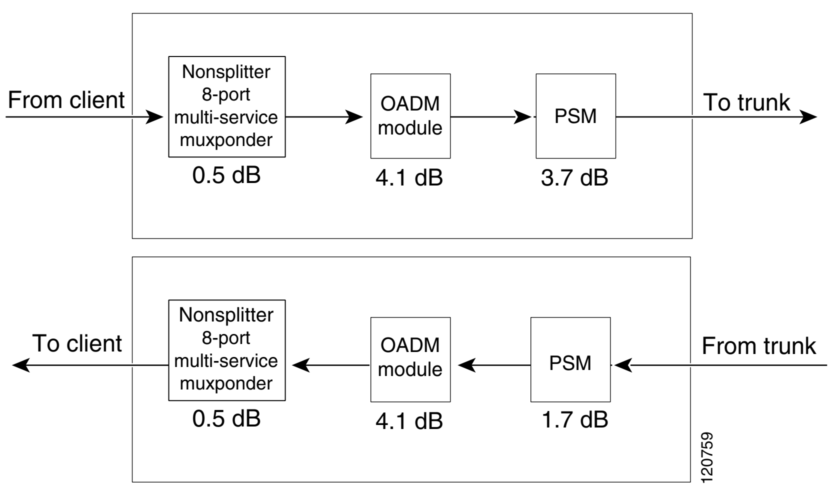


Figure 6-36 shows an example of a Cisco ONS 15530 shelf in a trunk fiber protected configuration with an ESCON aggregation card and two nonsplitter 2.5-Gbps ITU trunk cards.

Figure 6-36 Trunk Fiber Protected Configuration Using a Nonsplitter 2.5-Gbps ITU Trunk Card

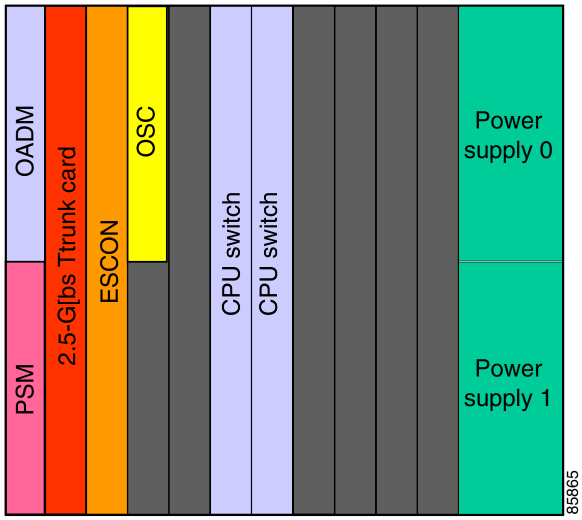


Figure 6-37 shows the optical power budget for a trunk fiber protected configuration.

Figure 6-37 Optical Power Budget for Trunk Fiber Protected Configurations Using Nonsplitter 2.5-Gbps ITU Trunk Cards

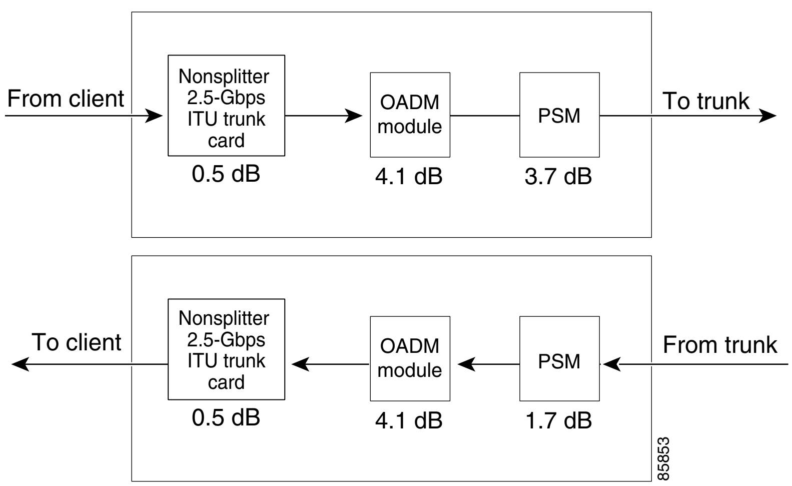


Figure 6-38 shows an example of a Cisco ONS 15530 shelf in a trunk fiber protected configuration with an ESCON aggregation card and two 10-Gbps ITU trunk cards.

Figure 6-38 Trunk Fiber Protected Configuration Using Nonsplitter a 10-Gbps ITU Trunk Card

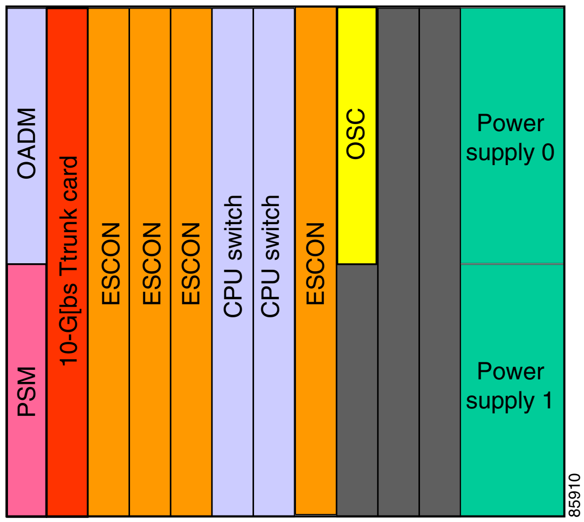
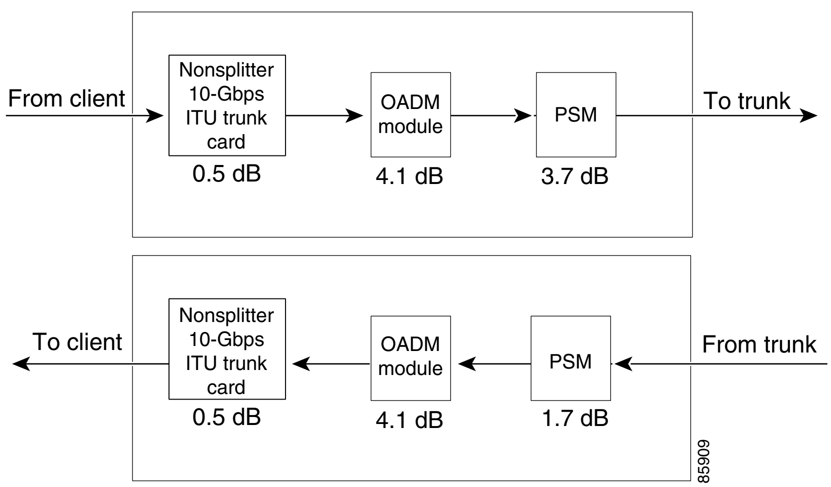


Figure 6-39 shows the optical power budget for a trunk fiber protected configuration.

Figure 6-39 Optical Power Budget for Trunk Fiber Protected Configurations Using Nonsplitter 10-Gbps ITU Trunk Cards



Note The PSM can also connect directly to a transponder line card or an ITU trunk card. That configuration would not include the loss for the OADM modules.

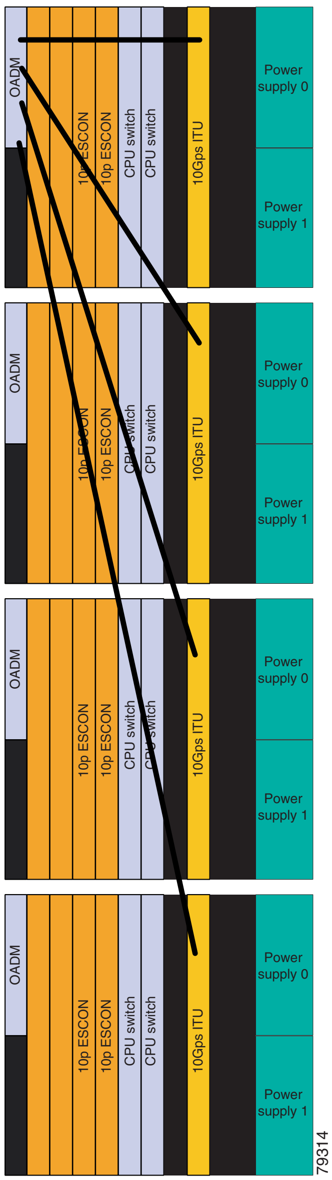
Multiple Shelf Node Configurations

This section describes multiple shelf nodes consisting of only Cisco ONS 15530 shelves and multiple shelf nodes consisting of Cisco ONS 15530, Cisco ONS 15540 ESP, and Cisco ONS 15540 ESPx shelves.

ITU Linked Configuration

Figure 6-40 shows a multiple shelf node with three Cisco ONS 15530 shelves linked to the OADM modules on a fourth Cisco ONS 15530 shelf.

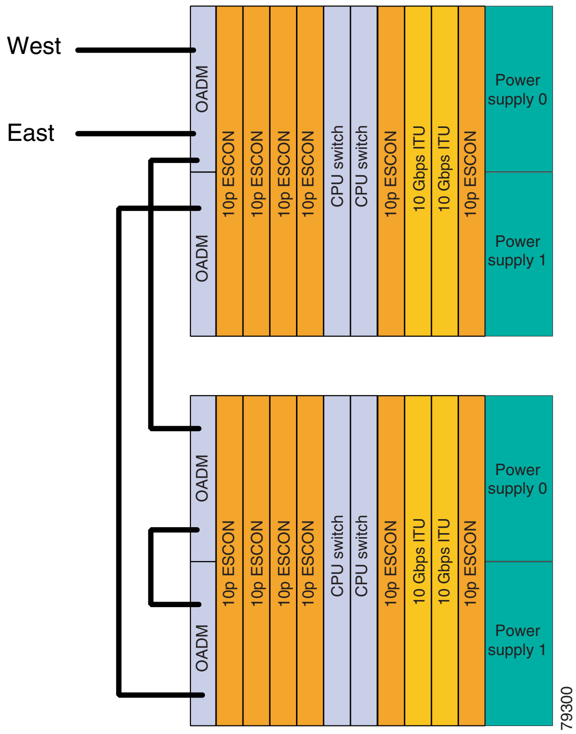
Figure 6-40 Cisco ONS 15530 Multiple Shelf Node with ITU Uplinking



DWDM Linked Configuration

Figure 6-41 shows an example of DWDM linking with two Cisco ONS 15530 shelves linked together via the OADM modules to form a single logical node.

Figure 6-41 DWDM Linking With Two Cisco ONS 15530 Shelves



10-GE Client Signal Uplink Configuration

Figure 6-42 shows an example of an unprotected 10-GE client signal linking a Cisco ONS 15530 shelf and a Cisco ONS 15540 ESPx or Cisco ONS 15540 ESP shelf.

Figure 6-42 Unprotected 10-GE Client Signal Linking

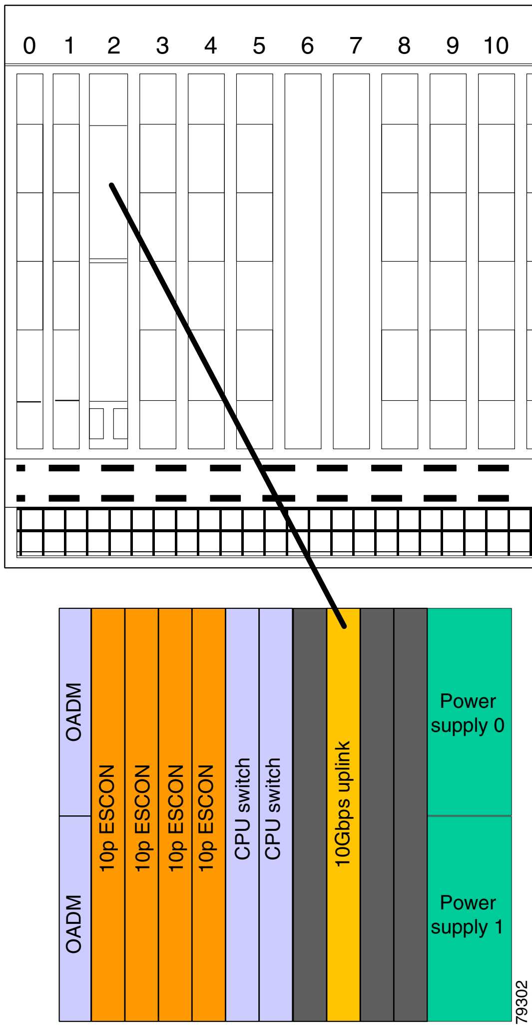
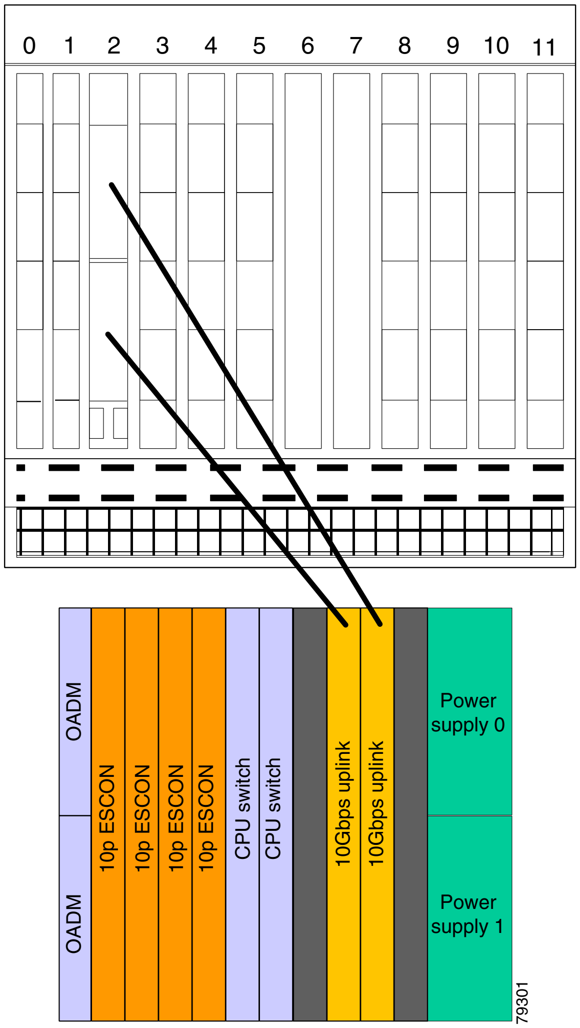


Figure 6-43 shows an example of protected 10-GE client signal linking between a Cisco ONS 15530 shelf and a Cisco ONS 15540 ESPx or Cisco ONS 15540 ESP shelf.

Figure 6-43 Protected 10-GE Client Signal Linking



Cisco ONS 15530 Topologies

The section describes network topologies consisting only of Cisco ONS 15530 shelves. The Cisco ONS 15530 can be configured in the following types of topologies:

- Point-to-point
- Meshed ring
- Hubbed ring with a multiple shelf hub

Point-to-Point Topologies

The Cisco ONS 15530 supports point-to-point topologies, with or without signal protection. A single shelf supports up to four protected channels and up to eight unprotected channels. To supports more channels, multiple shelf nodes can be used.

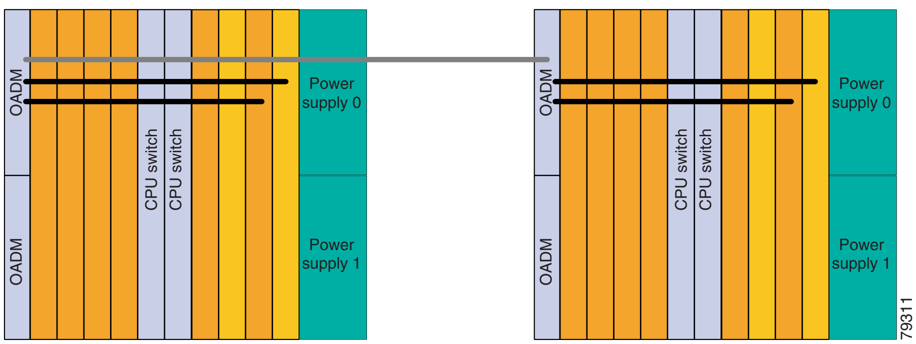
Use following criteria to determine the equipment needed for a point-to-point topology:

- Distance between nodes
- Potential topology changes in the future (such as migration to a ring)
- Presence of OSC

Unprotected Point-to-Point Topology

Figure 6-44 shows an example of an unprotected point-to-point topology between two Cisco ONS 15530 shelves.

Figure 6-44 Unprotected Point-to-Point Topology



Protected Point-to-Point Topology

Figure 6-45 shows an example of a splitter protected point-to-point topology between two Cisco ONS 15530 shelves.

Figure 6-45 Protected Point-to-Point Topology

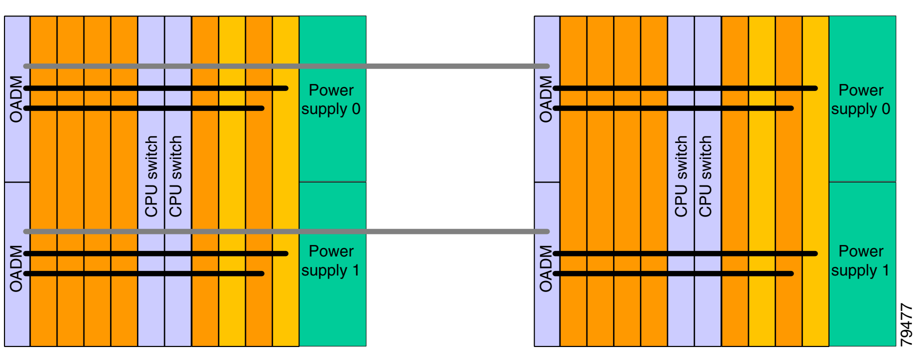
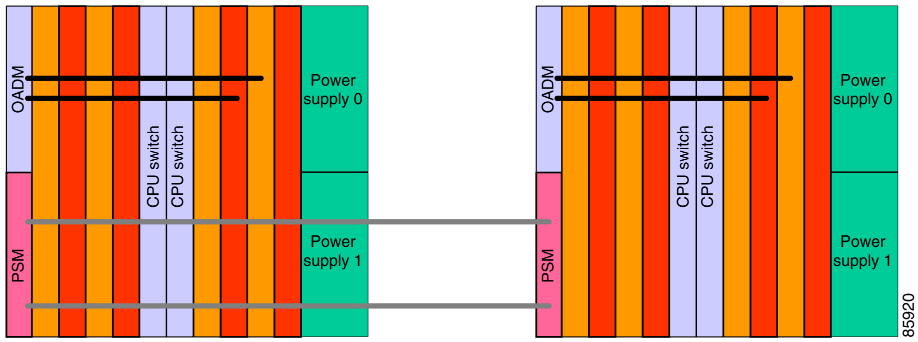


Figure 6-46 shows an example of a trunk fiber protected point-to-point topology between two Cisco ONS 15530 shelves.

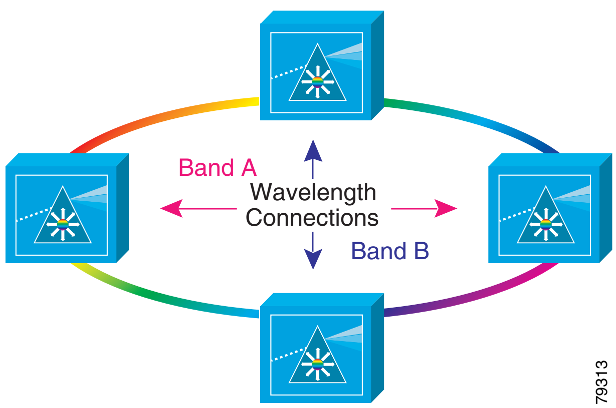
Figure 6-46 Protected Point-to-Point Topology



Meshed Ring Topologies

Figure 6-47 shows a logical view of a meshed ring topology consisting of only Cisco ONS 15530 shelves.

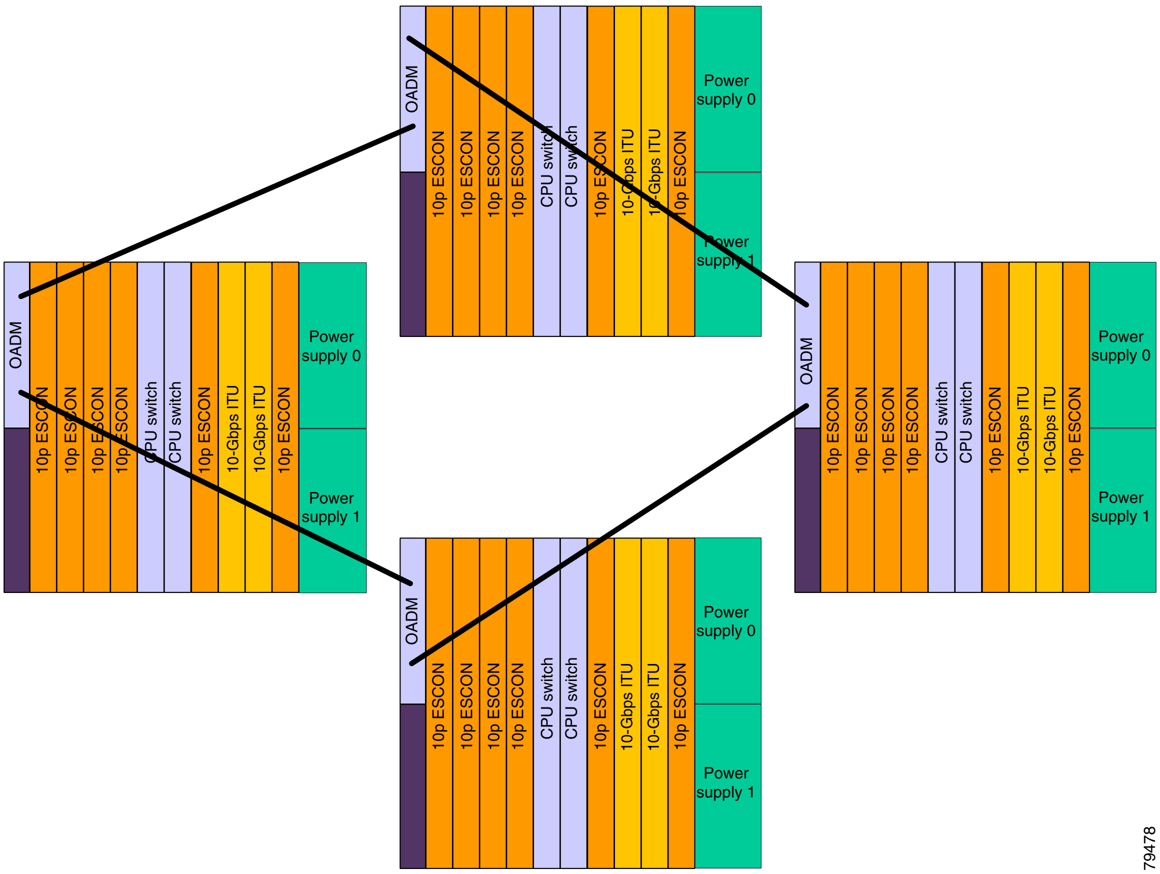
Figure 6-47 Meshed Topology



Unprotected Meshed Ring Topology

Figure 6-48 shows an example of an unprotected meshed ring topology consisting of only Cisco ONS 15530 shelves and supporting on four channels.

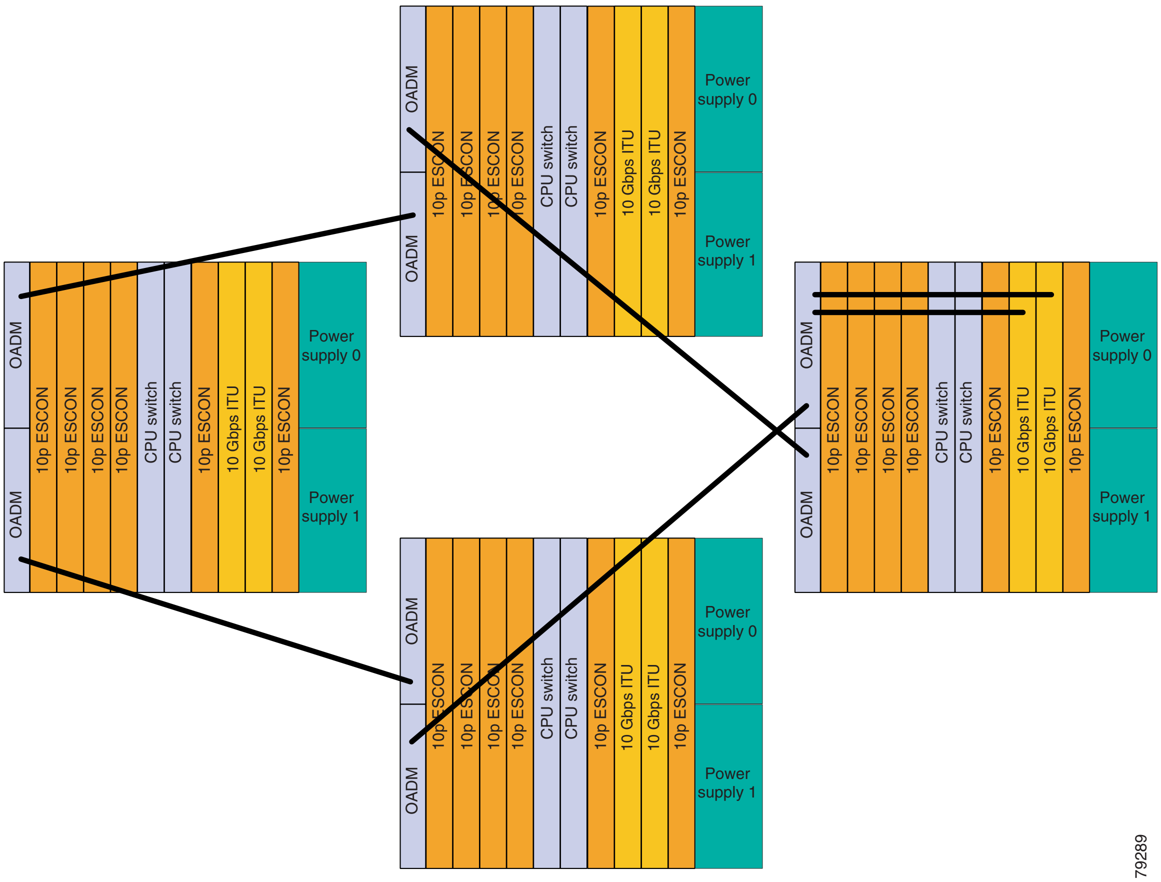
Figure 6-48 Unprotected Meshed Ring Topology



Protected Meshed Ring Topology

Figure 6-49 shows an example of a protected meshed ring topology consisting of only Cisco ONS 15530 shelves.

Figure 6-49 Protected Meshed Ring Topology

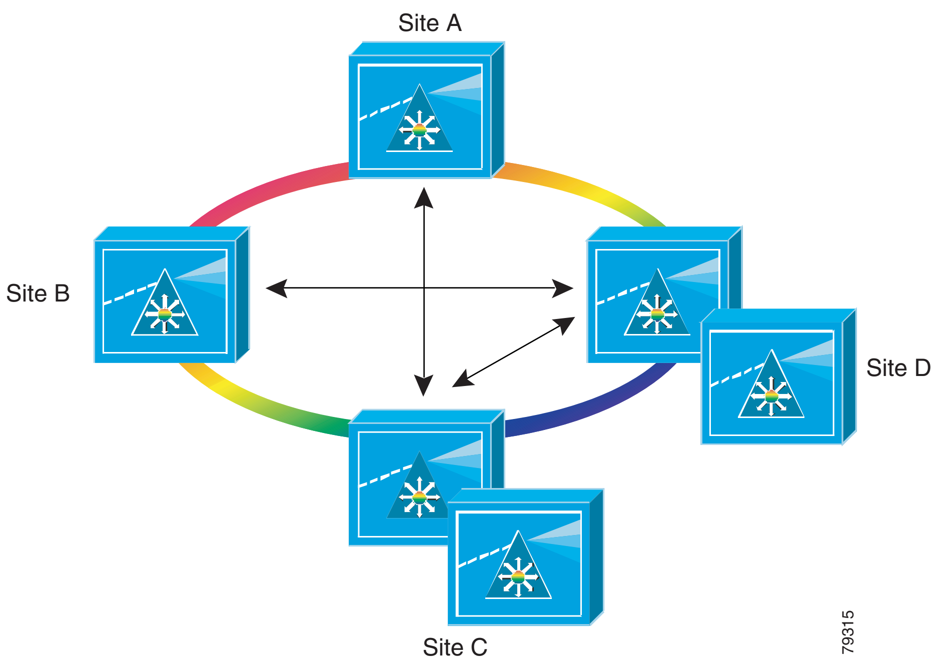


Meshed Ring Topology Using Multiple Cisco ONS 15530 Shelf Nodes

You can configure the Cisco ONS 15530 shelves in a meshed ring topology. The most common application for this configuration is when multiple bands are supported on a node.

Figure 6-50 shows a logical view of a meshed ring topology consisting of Cisco ONS 15530 shelves with multiple shelf nodes.

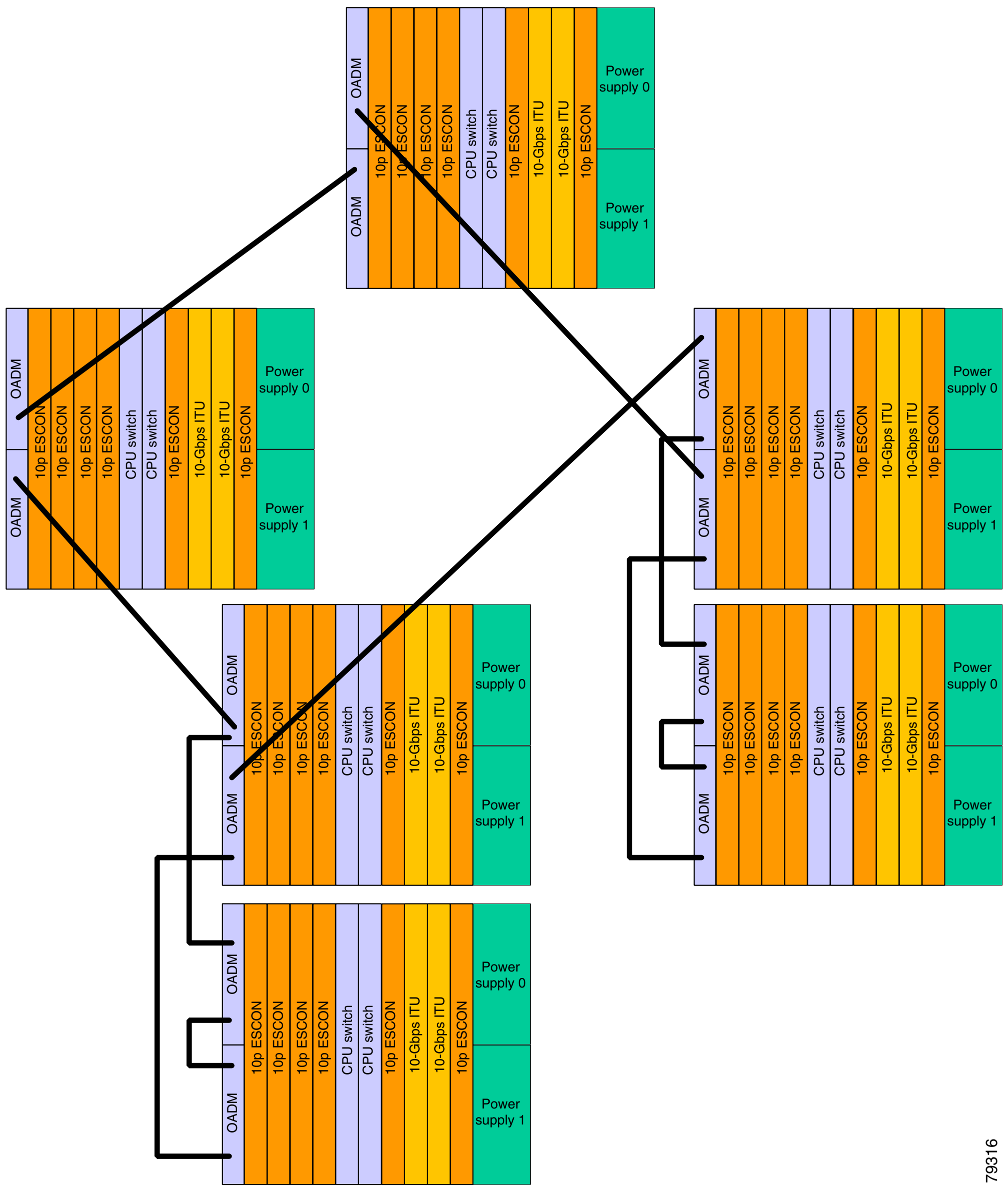
Figure 6-50 Meshed Ring Topology with Multiple Shelf Nodes



Protected Meshed Ring Topology

Figure 6-51 shows a protected meshed ring topology consisting of Cisco ONS 15530 shelves with multiple shelf nodes.

Figure 6-51 Protected Meshed Ring Topology with Multiple Shelf Nodes

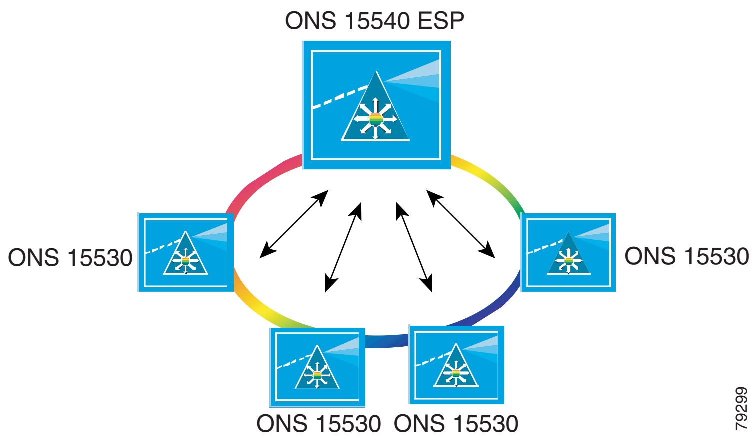


Cisco ONS 15530 and Cisco ONS 15540 Mixed Topologies

The Cisco ONS 15530, Cisco ONS 15540 ESP, and Cisco ONS 15540 ESPx systems can be used in the same network topology. The most common application is using a Cisco ONS 15540 ESP or Cisco ONS 15540 ESPx as the hub node in a hubbed ring topology.

Figure 6-52 shows a logical view of an hubbed ring topology consisting of a Cisco ONS 15540 ESP as the hub node and Cisco ONS 15530 shelves as the spoke nodes. The configuration supports transparent services.

Figure 6-52 Hubbed Ring Topology With a Cisco ONS 15540 ESP Hub

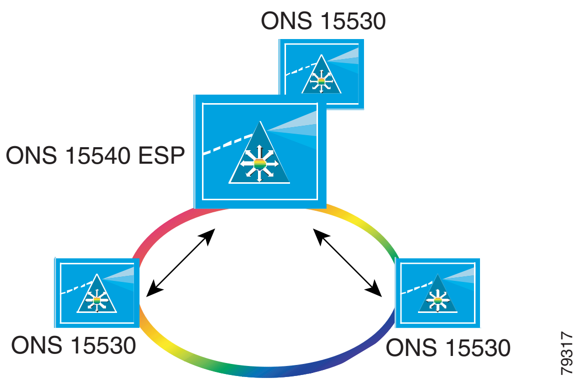


Cisco ONS 15530 and Cisco ONS 15540 Collocated Topologies

The Cisco ONS 15530 can be combine with a Cisco ONS 15540 ESP or Cisco ONS 15540 ESPx system in the same network node. The most common application is using a Cisco ONS 15540 ESP or Cisco ONS 15540 ESPx as the hub node in a hubbed ring topology where aggregated services are required.

Figure 6-53 shows a logical view of an hubbed ring topology consisting of collocated Cisco ONS 15540 ESPx and Cisco ONS 15530 shelves as the hub node and Cisco ONS 15530 shelves as the spoke nodes. This configuration can support transparent and aggregated services.

Figure 6-53 Hubbed Ring Topology With Collocated Cisco ONS 15540 ESP and Cisco ONS 15530 Hub



APPENDIX A

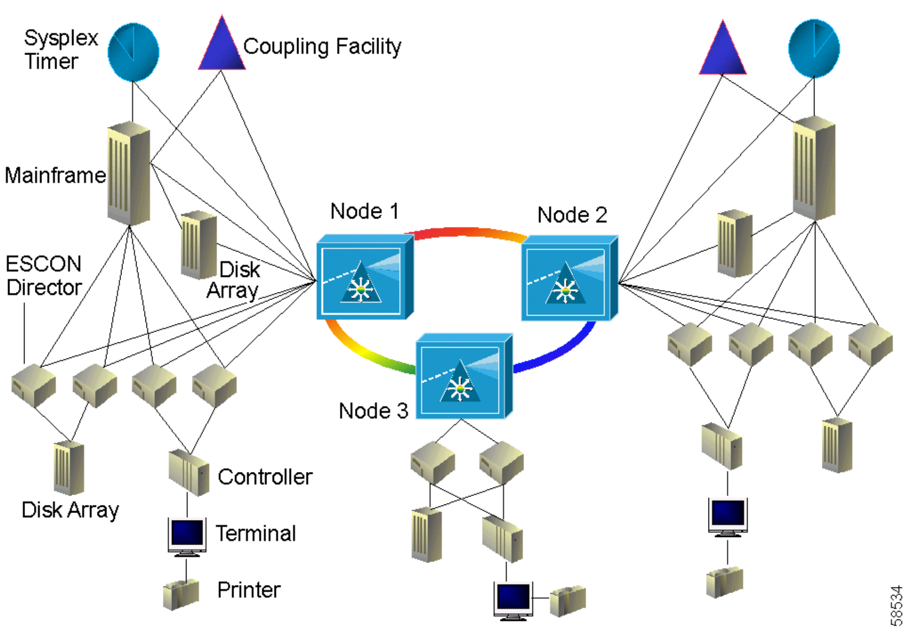
IBM Storage Protocol Support

This appendix provides descriptions and design considerations for protocols used in an IBM storage environment. This appendix contains the following major sections:

IBM Storage Environment

Figure A-1 shows a an IBM storage environment application with GDPS (Geographically Dispersed Parallel Sysplex). SANs (storage area networks) are attached to node 1 and node 2, and a LAN is attached to node 3.

Figure A-1 IBM Storage Environment with GDPS and DWDM



Supported Protocols

The Cisco ONS 15530 can provide the transport layer for the following IBM storage related protocols:

- ESCON
- FICON
- Coupling Facility
- Sysplex Timer links

The Cisco ONS 15530 can also be used to help implement the high availability features for the following applications:

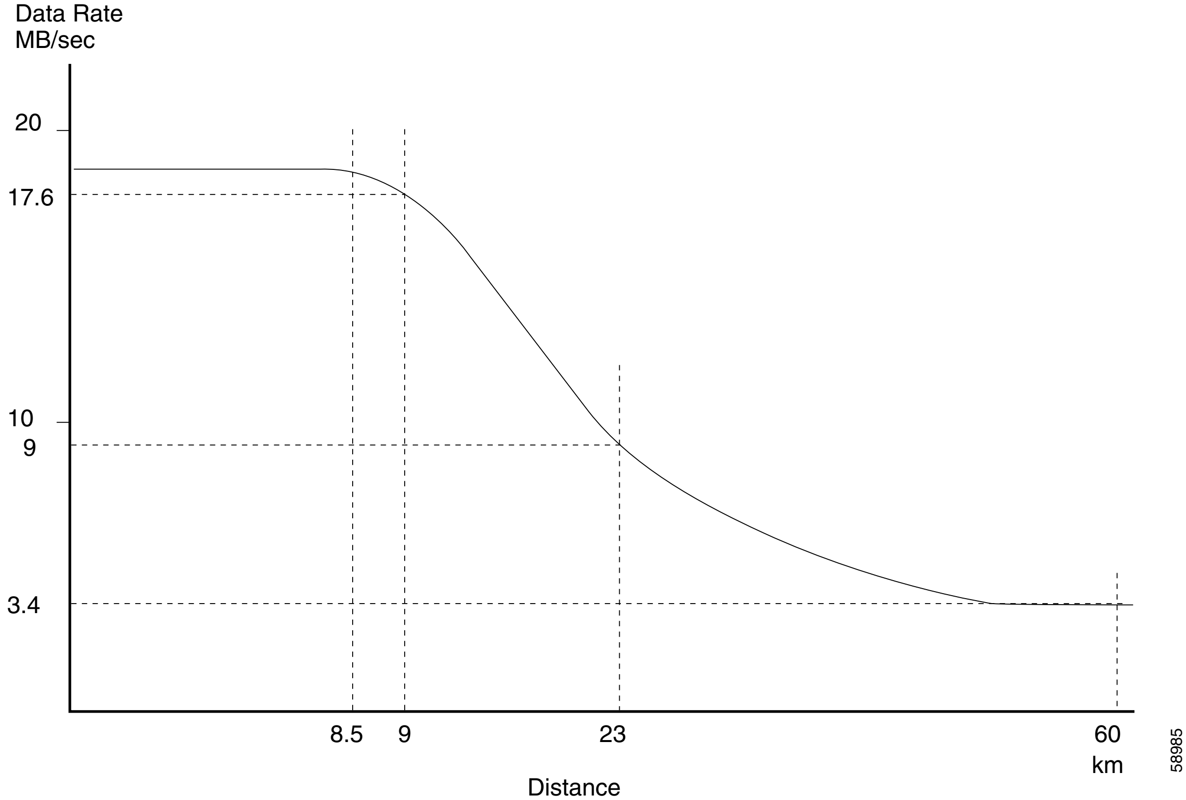
- PPRC
- XRC
- GDPS

ESCON

ESCON (Enterprise System Connection) is a 200-Mbps unidirectional serial bit transmission protocol used to dynamically connect mainframes with their various control units. ESCON provides nonblocking access through either point-to-point connections or high speed switches, called ESCON Directors. In the Parallel Sysplex or GDPS environment, ESCON performance is seriously affected if the distance spanned is greater than approximately 8 km. For instance, measurements have shown that ESCON performance at 20 km is roughly 50% of maximum performance. Performance degradation continues as distance is further increased.

Figure A-2 shows an estimate of how the effective data rate decreases as the path length increases. At a distance of 9 km, performance begins to decrease precipitously. This data point is referred to as the *distance data rate droop point*.

Figure A-2 ESCON Data Rate as a Function of Distance



FICON

FICON (Fiber Connection) is the next generation bidirectional channel protocol used to connect mainframes directly with control units or ESCON aggregation switches (ESCON Directors with a bridge card). FICON runs over Fibre Channel at a data rate of 1.062 Gbps. One of the main advantages of FICON is the lack of performance degradation over distance that is seen with ESCON. FICON can reach a distance of 100 km before experiencing any significant drop in data throughput.

Coupling Facility

Coupling Facility (CF) links, also known as ISC (InterSystem Channel) links, are used to connect mainframes to a CF. The CF is used by multiple mainframes to share data in a sysplex or Parallel Sysplex environment. This data sharing capability is key to the high availability features of a GDPS. Coupling links run over Fibre Channel at data rates of 1.0625 Gbps (called ISC1 or ISC compatibility) and 2.1 Gbps (called ISC peer).

Sysplex Timer

Sysplex Timer links are the links used to provide the clock synchronization between the mainframes in a Parallel Sysplex. There are two types of links used. The first is the link between each mainframe and the Sysplex Timer, known as the ETR (external throughout rate) links. The second is the link between redundant Sysplex Timers, referred to as the CLO (control link oscillator) links. In a high availability GDPS environment, redundant Sysplex Timers are connected to each mainframe over ETR links, while the timers are connected to each other over the CLO links. This protocol operates at 16 Mbps.

PPRC

PPRC (peer-to-peer remote copy) is a facility used in certain IBM disk controllers that allows synchronous mirroring of data.

XRC

XRC (extended remote copy) is a facility used with certain IBM disk controllers that allows asynchronous mirroring of data.

GDPS

GDPS (Geographically Dispersed Parallel Sysplex) is a multisite parallel sysplex with sites up to 40 km apart. It uses custom automation to manage mirroring of critical data and to balance workload for regular use or for disaster recovery.

Client Optical Power Budget and Attenuation Requirements

Table A-1 shows the client optical power budget and attenuation requirements for the IBM storage protocols and IBM's implementation of other common protocols with high-end IBM servers that support ESCON, FICON, and Fibre Channel. For each protocol, the table shows the transmit power and receiver sensitivity ranges on the IBM server interface, the transponder type that supports this protocol on the Cisco ONS 15530, the resulting client loss budget, and what attenuation is required at 0 km. Refer to the *Cisco ONS 15530 Hardware Installation Guide* for the transmit powers and receiver sensitive ranges of the Cisco ONS 15530 transponder interfaces.

Table A-1 Optical Power Budget and Attenuation Requirements with High-End IBM Servers

Protocol	IBM Server Transmit (dBm)	IBM Server Receive (dBm)	Cisco ONS 15530 Transponder Type	Cisco ONS 15530 Client Loss Budget/Minimum Attenuation at 0 km
ESCON, SM	–3 to –8	–3 to –28	SM	Rx: 11 to 16 dB/none Tx: 23 to 28 dB/–3 dB
ESCON, MM ETR/CLO, MM	–15 to –20.5	–14 to –29	MM	Rx: 4.5 to 10 dB/none Tx: 24 to 29 dB/–14 dB
FICON, SM/LX	–4 to –8.5	–3 to –22	SM	Rx: 11.5 to 15 dB/none Tx: 17 to 22 dB/–3 dB
ATM 155, SM	–8 to –15	–8 to –32.5	SM	Rx: 4 to 11 dB/none Tx: 27.5 to 32.5 dB/–8 dB
ATM 155, MM	–14 to –19	–14 to –30	MM	Rx: 6 to 11 dB/none Tx: 25 to 30 dB/–14 dB
FDDI, MM	–14 to –19	–14 to –31.8	MM	Rx: 6 to 11 dB/none Tx: 26.8 to 31.8 dB/–14 dB
ISC, 1Gbps	–3 to –11	–3 to –20	SM	Rx: 8 to 16 dB/none Tx: 15 to 20 dB/–3 dB

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