Cisco ONS 15454 MSPP

Engineering Planning Guide – Release 4.0
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About this Guide

This guide provides the following information about the Cisco ONS 15454 Multi-service Provisioning Platform (MSPP):

- Features
- Engineering
- Applications
- Configurations
- Specifications
- Compliance
- Ordering

To install, turn up, provision, and maintain a Cisco ONS 15454 node and network, refer to the *Cisco ONS 15454 Procedure Guide*.

For explanation and information about the Cisco ONS 15454 system, refer to the *Cisco ONS 15454 Reference Manual*.

Helpful procedures for alarm clearing, general troubleshooting, and hardware replacement can be found in the *Cisco ONS 15454 Troubleshooting Guide*.

For a list of TL1 commands and autonomous messages supported by the Cisco ONS 15454, refer to the *Cisco ONS 15454 and Cisco ONS 15327 Common TL1 Commands* manual. Refer to the *Cisco ONS 15454 and Cisco ONS 15327 TL1 Command Guide*, for a complete description of TL1 commands.

Purpose for Reissue

This document is being reissued to address new hardware and software features supported in Release 4.0 for the ONS 15454.

Table 1 provides a revision history for this document.

Table 1: Document Revision History

Date	Revision	Comments
1/20/2000	1.7	Initial Version
11/21/2000	2.2	Updated document with Release hardware and software 2.2 features.
5/23/2002	3.3	Updated document with Release 3.3 hardware and software features.
12/23/2002	3.4	Updated document with Release 3.4 hardware and software features.
3/31/2003	4.0	Updated document with Release 4.0 hardware and software features.

Intended Audience

The Engineering Planning Guide is intended for network planners and engineers.

Document Organization

This document provides information about the features, engineering guidelines, applications, configurations, and technical specifications for the Cisco ONS 15454 MSPP. The guide is organized into chapters listed in Table 2. Information about regulatory and standards compliances, basic SONET principles, an introduction to Dense Wave Division Multiplexing (DWDM), and information on how to order ONS 15454 equipment, software, and training is provided in the appendices listed in Table 3.

Table 2: Cisco ONS 15454 Engineering Planning Guide Chapters

Title	Summary
Chapter 1 – System Overview	This chapter provides a brief introduction to the Cisco ONS 15454 MSPP and list of new features for Release 4.0.
Chapter 2 – SONET Transport	This chapter contains specific information about Synchronous Optical Network (SONET) line rates, signal format, overhead functions, and payload mappings for the Cisco ONS 15454.
Chapter 3 – SDH Transport Over SONET	This chapter explains how the ONS 15454 transports SDH traffic over SONET.
Chapter 4 – DWDM Design Guidelines	This chapter provides general Dense Wave Division Multiplexing (DWDM) design guidelines using Cisco's OC48 ELR ITU-T cards in conjunction with third party DWDM equipment.
Chapter 5 – Ethernet Applications and Features	This chapter describes the Ethernet applications and features supported by the series of ONS 15454 Ethernet cards.
Chapter 6 – Product Description and Specifications	This chapter provides a description and the technical specifications of the ONS 15454 system.
Chapter 7 – System Planning and Engineering	This chapter provides the basic planning and engineering information required to configure an ONS 15454 MSPP for deployment.
Chapter 8 – IP Networking	This chapter provides an understanding of how to manage ONS 15454 nodes within a TCP/IP network environment.
Chapter 9 – Applications and Configurations	This chapter provides examples of common ONS 15454 network applications and shelf configurations.

Table 3: Appendices

Title	Summary
Appendix A – Compliance	This appendix lists ONS 15454 compliance with regulatory and industry standards relevant to Class A, Type 2 and Type 4 devices.
Appendix B – SONE Primer	This appendix provides an introduction to Synchronous Optical Network (SONET) as defined by ANSI.
Appendix C – DWDM Primer	This appendix provides an introduction into dense wave division multiplexing (DWDM) principles.
Appendix D – List of Parts	This appendix describes how to order Cisco equipment and provides a list of part numbers for Cisco ONS 15454 equipment, software, documentation, and training.
Acronyms	This appendix lists acronyms and abbreviations used in this document.
Glossary	This appendix defines common terms used in this document.
Index	Provides an alphanumerical list of key product names and subjects, referencing the pages where they are located.

Obtaining Documentation

The following sections provide sources for obtaining documentation from Cisco Systems.

World Wide Web

You can access the most current Cisco documentation on the World Wide Web at the following sites:

http://www.cisco.com
http://www-china.cisco.com
http://www-europe.cisco.com

Optical Networking Product Documentation CD-ROM

Optical networking-related documentation, including Release 3.3 of the Cisco ONS 15454 Installation and Operations Guide, Cisco ONS 15454 Troubleshooting and Reference Guide, and the Cisco ONS 15454 TL1 Command Guide, is available in a CD-ROM package that ships with your product. The Optical Networking Product Documentation CD-ROM, a member of the Cisco Connection Family, is updated as required. Therefore, it might be more current than printed documentation. The CD-ROM package is available as a single package or as an annual subscription. You can also access Cisco documentation on the World Wide Web at http://www.cisco.com, http://www.china.cisco.com, or http://www.europe.cisco.com.

Ordering Documentation

Cisco documentation is available in the following ways:

Registered Cisco Direct Customers can order Cisco Product documentation, including the Optical Networking Product CD-ROM, from the Networking Products MarketPlace: http://www.cisco.com/cgi-bin/order/order_root.pl

Nonregistered Cisco.com users can order documentation through a local account representative by calling Cisco corporate headquarters (California, USA) at 408 526-7208 or, in North America, by calling 800 553-NETS(6387).

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Obtaining Technical Assistance

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business processes and improve productivity. Through cisco.com, you can find information about Cisco and our networking solutions, services, and programs. In addition, you can resolve technical issues with online technical support, download and test software packages, and order Cisco learning materials and
merchandise. Valuable online skill assessment, training, and certification programs are also available.

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Technical Assistance Center

The Cisco TAC website is available to all customers who need technical assistance with a Cisco product or technology that is under warranty or covered by a maintenance contract.

Contacting TAC by Using the Cisco TAC Website

If you have a priority level 3 (P3) or priority level 4 (P4) problem, contact TAC by going to the TAC website: http://www.cisco.com/tac

P3 and P4 level problems are defined as follows:

> P3—Your network performance is degraded. Network functionality is noticeably impaired, but most business operations continue.
>
> P4—You need information or assistance on Cisco product capabilities, product installation, or basic product configuration.

In each of the above cases, use the Cisco TAC website to quickly find answers to your questions.

To register for cisco.com, go to the following website: http://www.cisco.com/register/

If you cannot resolve your technical issue by using the TAC online resources, Cisco.com registered users can open a case online by using the TAC Case Open tool at the following website: http://www.cisco.com/tac/caseopen

Contacting TAC by Telephone

If you have a priority level 1 (P1) or priority level 2 (P2) problem, contact TAC by telephone and immediately open a case. The toll-free Optical Networking Assistance number is 1-877-323-7368.

P1 and P2 level problems are defined as follows:

> P1—Your production network is down, causing a critical impact to business operations if service is not restored quickly. No workaround is available.
>
> P2—Your production network is severely degraded, affecting significant aspects of your business operations. No workaround is available.

Warning The ONS 15454 is not intended for direct electrical connection to outside plant equipment. It meets NEBS specifications for Type 2 and Type 4 equipment, which is intended for installation in restricted access areas. A restricted access area is where access can only be gained by service personnel through the use of a special tool, lock, key, or other means of security. A restricted access area is controlled by the authority responsible for the location.

The ONS 15454 is suitable for mounting in 19-inch or 23-inch equipment racks installed on concrete or raised flooring surfaces only.

Caution Unused card slots should be filled with a blank faceplate (Cisco P/N 15454-BLANK). The blank faceplate ensures proper airflow when operating the ONS 15454 without the front door attached, although Cisco recommends that the front door remain attached.

Note The ONS 15454 is designed to comply with GR-1089-CORE Type 2 and Type 4. Install and operate the ONS 15454 only in environments that do not expose wiring or cabling to the outside plant. Acceptable applications include Central Office Environments (COEs), Electronic Equipment Enclosures (EEEs), Controlled Environment Vaults (CEVs), huts, and customer premises.

Fiber Optic Safety

The ONS 15454 uses Class 1 lasers in its optics cards. The laser is activated when an optics card (except for the OC-192 card) is booted. The port does not have to be placed "in service" for the laser to be on. The OC-192 optics card has a safety key which controls activation of the laser. Invisible laser radiation may be emitted from the end of the unterminated fiber cable or connector. Do not stare into the beam or view directly with optical instruments. Viewing the laser output with certain optical instruments (for example, eye loupes, magnifiers, and microscopes) within a distance of 100 mm may pose an eye hazard. Use of controls or adjustments or performance of procedures other than those specified may result in hazardous radiation exposure.

Caution Remember that fiber optic cable and jumpers are made of very pure glass. Never handle exposed fiber with bare hands or touch it to bare skin, because fiber particles can penetrate the skin and cause irritation.

Metallic Interfaces

Warning Metallic interfaces for connection to outside plant lines (such as T1/E1/T3/E3 etc.) must be connected through a registered or approved network terminating device such as CSU/DSU or NT1.

Class A Device

Warning This is a Class A Information Product. When used in a residential environment, it may cause radio frequency interference. Under such circumstances, the use of RF filters and/or shielding may be required to counter any interference.

Electrostatic Discharge (ESD) Considerations

Caution All of the ONS 15454 plug-in cards contain integrated circuit packs that can be damaged by static electricity that builds up on work surfaces and personnel. Observe the following precautions to prevent damage by electrostatic discharge (ESD):

> When handling plug-in cards (storing, inserting, removing, etc.) or when working on the backplane, always wear a grounded wrist strap connected to the ONS 15454 shelf assembly or wear a heel strap and stand on a grounded, static-dissipating floor mat.
>
> Handle all plug-in cards by the faceplate or latch and by the top and bottom outermost edges. Never touch the card's integrated circuit leads or circuitry.
>
> Observe warning labels on plug-in card bags and shipping containers. Whenever possible, do not remove plug-in cards from their antistatic packaging until ready to insert them into slots.
> Always transport and store circuit packs in their static-safe packaging. Shielding is not required unless specified.

Note To reduce the possibility of ESD damage, the ONS 15454 shelf assemblies are equipped with a grounding jack to enable personnel to ground themselves using wrist straps while handling plug-in cards or working on a shelf. The jack is located at the lower right-hand corner of each shelf and labeled ESD. The wrist straps should be checked periodically with a wrist strap tester to ensure that they are working properly.

CISCO SYSTEMS

Chapter 1 – System Overview

Note: The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

Purpose

This chapter provides a brief introduction to the Cisco ONS 15454 MSPP and list of new features for Release 4.0.

Contents

The following topics are covered in this chapter:

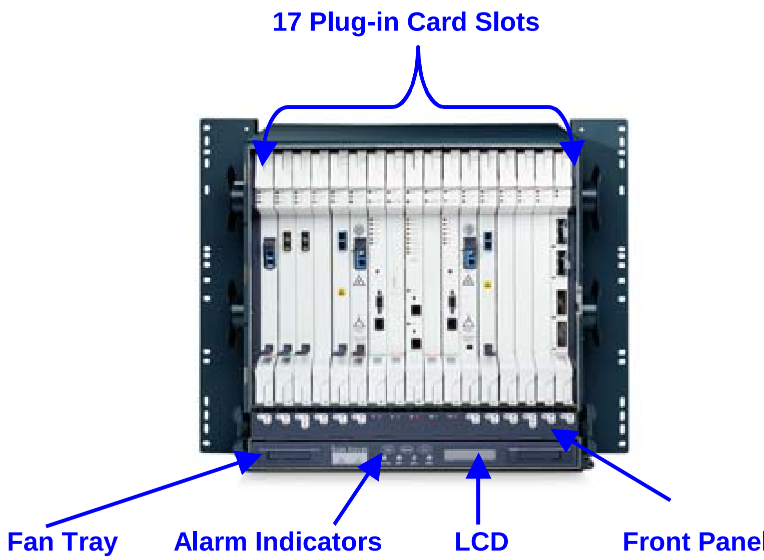
Introduction to the ONS 15454 MSPP

The Cisco ONS 15454 MSPP provides efficient bandwidth delivery and management in optical networks. It is a flexible SONET add/drop multiplexer (ADM) that offers service aggregation and high-bandwidth transport of voice and data traffic in a single platform. The ONS 15454 allows you to easily manage services and increase capacity without disrupting services. The ONS 15454 carries traditional time-division multiplexing (TDM) and high-speed data traffic over a single mode fiber optic system.

ONS 15454 Shelf Assembly and Backplane Hardware

The ONS 15454 temperature-hardened shelf assembly shown in Figure 1-1 contains 17 plug-in card slots, a backplane interface, a fan tray, a front panel with an LCD, and alarm indicators. You can install the ONS 15454 in a 19- or 23-inch rack. The shelf assembly weighs approximately 55 pounds with no cards installed.

Figure 1-1: Cisco ONS 15454 Shelf Assembly



When installed in an equipment rack, the ONS 15454 assembly is typically connected to a fuse and alarm panel to provide centralized alarm connection points and distributed power for the ONS 15454. Fuse and alarm panels are third-party equipment and are not covered in this document. The front door of the ONS 15454 allows access to the shelf assembly, fan tray, and cable management area. The shelf assembly can be installed in both EIA-standard and Telcordia-standard racks.

The shelf assembly is a total of 17 inches wide with no mounting ears attached. Ring runs are not provided by Cisco and may hinder side-by-side installation of shelves where space is limited. The ONS 15454 measures 18.5 inches high, 19 or 23 inches wide (depending on which way the mounting ears are attached), and 12 inches deep (47 by 48.3 by 30.5 cm). You can install up to four ONS 15454 shelves in a seven-foot equipment rack. The ONS 15454 must have 1 inch of airspace below the installed shelf assembly to allow air flow to the fan intake. If a second ONS 15454 is installed underneath the shelf assembly, the air ramp on top of the lower shelf assembly provides the air spacing needed and should not be modified in any way.

The backplanes provide access to alarm contacts, external interface contacts, power terminals, and BNC/SMB connectors. The lower section of the ONS 15454 backplane is covered by a clear plastic protector.

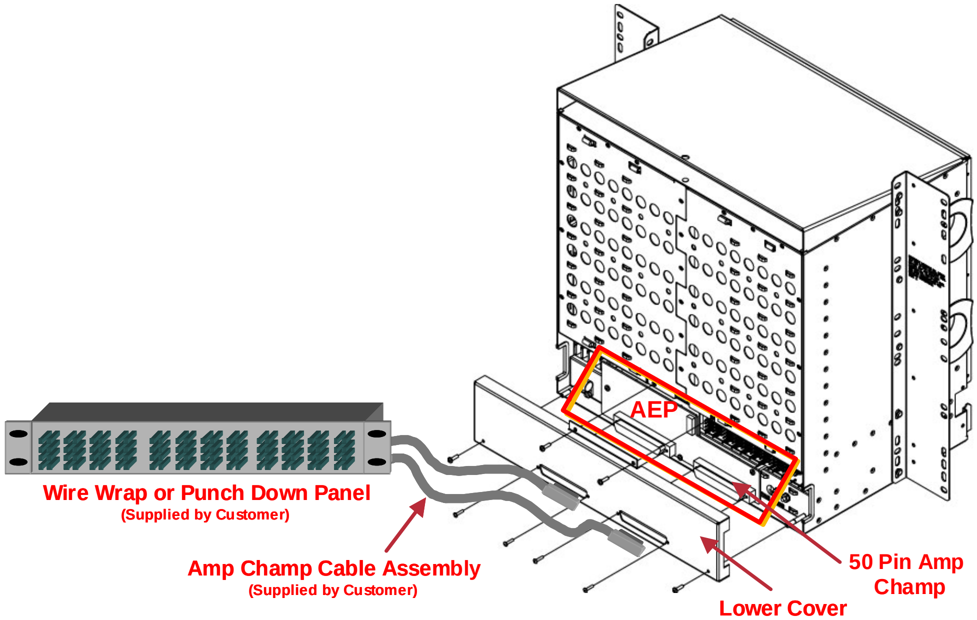
Electrical Interface Assemblies

Electrical Interface Assemblies (EIAs) are attached to the shelf assembly backplane to provide electrical interface cable connections. EIAs must be ordered when using DS-1, DS-3, DS3XM-6, or EC-1 cards. EIAs are available with SMB and BNC connectors for DS-3 or EC-1 cards. EIAs are available with AMP Champ connectors for DS-1 cards. You must use SMB EIAs for DS-1 twisted-pair cable installation. EIAs are typically pre-installed when ordered with the ONS 15454.

Alarm Expansion Panel

The ONS 15454 Alarm Expansion Panel (AEP) is used with the Alarm Interface Card (AIC-I) card to provide 48 dry alarm contacts for the ONS 15454 system, 32 of which are inputs and 16 outputs. The AEP is a printed circuit board assembly that is installed on the backplane. Figure 1-2 shows the AEP board.

Figure 1-2: Alarm Expansion Panel



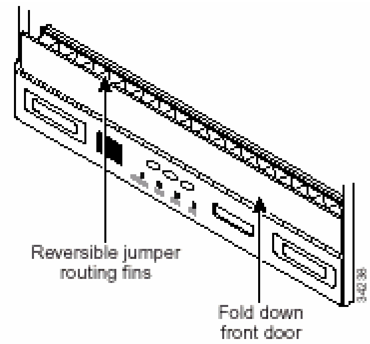
Cable Routing and Management

ONS 15454 optical cards have SC or small form LC connectors on the card faceplate. Fiber optic cables are routed into the front of the destination cards. Electrical cards (DS-1, DS-3, DS3XM-6, and EC-1) require EIAs to provide the cable connection points for the shelf assembly.

The ONS 15454 cable management facilities include the following:

A cable-routing channel that runs the width of the shelf assembly.
Plastic horseshoe-shaped fiber guides at each side opening of the cable-routing channel. that ensure the proper bend radius is maintained in the fibers. You can remove the fiber guide if necessary to create a larger opening (if you need to route CAT-5 Ethernet cables out the side, for example).
A fold-down door that provides access to the cable-management tray.
Cable tie-wrap facilities on EIAs that secure cables to the cover panel.
Reversible jumper routing fins that enable you to route cables out either side by positioning the fins as desired.
Jumper slack storage reels (2) on each side panel that reduce the amount of slack in cables that are connected to other devices.
Figure 1-3 shows the cable management facilities that you can access through the fold-down front door, including the cable-routing channel and the jumper routing fins.

Figure 1-3: Managing Cables on the Front Panel



ONS 15454 Plug-in Cards and Slot Requirements

ONS 15454 cards have electrical plugs at the back that plug into electrical connectors on the shelf assembly backplane. When the ejectors are fully closed, the card plugs into the assembly backplane.

The ONS 15454 shelf assembly has 17 card slots numbered sequentially from left to right. Slots 1 through 4 and 14 through 17 are multispeed slots. They can host any ONS 15454 card, except the OC48IR 1310, OC48LR 1550, OC48ELR 1550, and OC192LR 1550 cards. Slots 5, 6, 12 and 13 are high-speed slots. They can host all ONS 15454 cards, except the OC12/STM4-4 card. You can install the OC48 IR/STM16 SH AS 1310 and the OC48 LR/STM16 LH AS 1550 cards in any multispeed or high-speed card slot.

Slots 7 and 11 are dedicated to TCC+ cards. Slots 8 and 10 are dedicated to cross-connect (XC, XCVT, XC10G) cards. Slot 9 is reserved for the optional Alarm Interface Controller (AIC) card. Slots 3 and 15 can also host DS1N-14 and DS3N-12 cards that are used in 1:N protection.

Shelf assembly slots have symbols indicating the type of cards that you can install in them. Each ONS 15454 card has a corresponding symbol. The symbol on the card must match the symbol on the slot. Table 1-1 shows the slot and card symbol definitions.

Table 1-1: Plug-in Card Symbols and Definitions

Symbol Color/Shape	Definition
Orange/Circle	Multispeed slot (all traffic cards except the OC48IR 1310, OC48LR 1550, and OC192 LR 1550 cards). Only install ONS 15454 cards with a circle symbol on the faceplate.
Blue/Triangle	High-speed slot (all traffic cards including the OC48IR 1310, OC48LR 1550, and OC192LR 1550 cards, except the OC12/STM4-4 card). Only install ONS 15454 cards with circle or a triangle symbol on the faceplate.
Purple/Square	TCC+ slot. Only install ONS 15454 cards with a square symbol on the faceplate.
Green/Cross	Cross-connect (XC/XCVT/XC10G) slot. Only install ONS 15454 cards with a cross symbol on the faceplate.
Red/P	Protection slot in 1:N protection schemes.
Red/Diamond	AIC Slot. Only install ONS 15454 cards with a diamond symbol on the faceplate.
Gold/Star	Multispeed slot (OC12/STM4-4 card). Only install ONS 15454 cards with a star symbol on the faceplate.

ONS 15454 Common Control Cards

Table 1-2 lists the six common control cards available for the Cisco ONS 15454 and summarizes their functions.

Table 1-2: List of ONS 15454 Common Control Cards

Card	Function	Page
TCC+	The enhanced Timing Control Card (TCC+) is required for System Releases from R2.2.2 to R4.0. The TCC+ performs system initialization, provisioning, alarm reporting, maintenance, diagnostics, IP address detection/resolution, SONET Data Communications Channel (DCC) termination, and system fault detection for the ONS 15454.	193
TCC2	The new TCC2 is Cisco's next generation Timing Control Card that performs the same functions as the TCC+. The TCC2 is the standard processor card shipped with System Releases 4.0 and higher.	193
XC-VT	The XC-VT establishes STS-1 and VT 1.5 connections and performs SONET TDM switching at the STS-1 level.	193
XC-10G	The XC-10G provides the same features as the XC-VT, but has four times the bandwidth. The XC-10G is required with the OC-192 OC-48 any-slot, and ML-series Ethernet cards.	193
AIC	The Alarm Interface Controller (AIC) card provides environmental alarm inputs and output controls, orderwire, and user data channel capabilities and is not required for system operation for System Releases 3.3 and lower.	193
AIC-I	The optional Alarm Interface Controller card (AIC-I) replaces the AIC card for System Releases 3.4 and higher. It provides four main capabilities including 1) environmental alarm interconnection, 2) orderwire, 3) A- and B-side input voltage monitoring, 4) access to user data channels.	193

ONS 15454 Interfaces

The ONS 15454 is architected for maximum flexibility. A single ONS 15454 shelf assembly supports a variety of card configurations and interfaces ranging from 1.5Mb/s to 10Gb/s as listed below in Table 1-3.

Table 1-3: List of Cisco ONS 15454 Interfaces

Interface	Description	Page
SONET/SDH		
OC-3/STM-1	The OC3 IR 4/STM1 SH 1310 card provides four intermediate or short range SONET/SDH OC-3 ports compliant with the International Telecommunication Union's G.707, G.957, and Telcordia's GR-253.	195
"	The new The OC-3 IR 8/STM1 1310 card provides eight (8) intermediate reach SONET compliant 155.520 Mbps interfaces operating at a nominal wavelength of 1310nm.	195
OC-12/STM-4	The OC12 IR/STM4 SH 1310 card provides one intermediate or short range SONET/SDH OC-12 port compliant with the International Telecommunication Union's G.707, G.957, and Telcordia's GR-253.	195
"	The OC12 IR/STM4 SH 1310-4 card provides four intermediate or short range SONET/SDH OC-12/STM-4 ports compliant with the International Telecommunication Union's G.707, G.957, and Telcordia's GR-253.	195
"	The OC12 LR/STM4 LH 1310 card provides one long-range, ITU-T G.707, ITU-T G.957, and Telcordia-compliant, GR-253 SONET OC-12 port per card.	195
"	The OC12 LR/STM4 LH 1550 card provides one long-range SONET/SDH OC-12 port compliant with the International Telecommunication Union's G.707, G.957, and Telcordia's GR-253.	195
OC-48/STM-16	The OC48 IR 1310 card provides one intermediate-range, Telcordia-compliant, GR-253 SONET OC-48 port per card.	195
"	The OC48 IR/STM16 SH AS 1310 card provides one intermediate-range SONET/SDH OC-48 port compliant with the International Telecommunication Union's G.707, G.957, and Telcordia's GR-253.	196
"	The OC48 LR 1550 card provides one long-range, Telcordia-compliant, GR-253 SONET OC-48 port per card.	196
"	The OC48 LR/STM16 LH AS 1550 card provides one long-range SONET/SDH OC-48 port compliant with the International Telecommunication Union's G.707, G.957, and Telcordia's GR-253.	196
OC-192	The OC192 LR/STM64 LH 1550 card provides one long-range SONET/SDH OC-192 port compliant with the International Telecommunication Union's G.707, G.957, and Telcordia's GR-1377 and GR-253.	197
"	The new OC-192/STM64 IR 1550 card provides an intermediate reach SONET compliant 9.95328 Gbps high-speed interface operating at a nominal wavelength of 1550nm.	197
"	The new OC-192/STM64 SR 1310 card provides a short-reach SONET compliant 9.95328 Gbps high-speed interface operating at a nominal wavelength of 1310nm.	197
ITU-T		
OC-48-100 GHz	Thirty-seven distinct OC-48 ELR ITU 100GHz dense wavelength division multiplexing (DWDM) cards operating within the 1530nm to 1562nm frequency band.	196
OC-48-200 GHz	Eighteen distinct OC-48 ELR ITU 200GHz dense wavelength division multiplexing (DWDM) cards operating within the 1530nm to 1562nm frequency band.	197
OC-192	The new OC-192 LR ITU 100GHz cards provide eight distinct dense wavelength division multiplexing (DWDM) channels operating within the 1530nm to 1562nm frequency band.	197

Electrical		
DS1	The ONS 15454 DS1-14 card provides 14 Telcordia-compliant, GR-499 DS-1 ports.	194
“	The DS1N-14 card can function as a working or protect card in 1:1 protection schemes and as a working card in 1:N protection schemes.	194
DS3	The ONS 15454 DS3-12 card provides 12 Telcordia-compliant, GR-499 DS-3 ports per card.	194
“	The DS3N-12 card operates as a working or protect card in 1:1 protection schemes and as a working card in 1:N protection schemes.	194
“	The DS3-12E card provides 12 Telcordia-compliant ports per card and enhanced performance monitoring functions.	194
“	The DS3N-12E card also provides enhanced performance monitoring functions and can operate as a working or protect card in 1:1 protection schemes and as a working card in 1:N protection schemes.	194
EC1	The EC1-12 card provides 12 Telcordia-compliant, GR-253 STS-1 electrical ports per card.	194
DS3XM (Transmux)	The DS3XM-6 card, commonly referred to as a transmux card, provides six Telcordia-compliant, GR-499-CORE M13 multiplexing functions.	194
Ethernet		
10/100	The E100T-12 card is used for Ethernet (10 Mb/s) and Fast Ethernet (100 Mb/s) when the XC or XC-VT cross-connect cards are in use. It provides 12 switched, IEEE 802.3-compliant, 10/100 Base-T Ethernet ports that can independently detect the speed of an attached device (auto-sense) and automatically connect at the appropriate speed.	199
“	E100T-G card is used for Ethernet (10 Mb/s) and Fast Ethernet (100 Mb/s) when the XC-10G cross-connect card is in use. It provides 12 switched, IEEE 802.3-compliant, 10/100 Base-T Ethernet ports that can independently detect the speed of an attached device (auto-sense) and automatically connect at the appropriate speed.	199
“	The new Cisco IOS-based ML-100T-12 card is used for Ethernet (10 Mb/s) and Fast Ethernet (100 Mb/s) when the XC-10G cross-connect card is in use. It supports Layer 2 and Layer 3 services and provides up to 2.4 Gbps of transport bandwidth, software provisionable in transport bandwidths from 50Mbps to the ports full line rate, in STS1, STS3c, STS6c, STS9c, STS12c and STS24c. Additionally, each service interface will support bandwidth guarantees down to 1Mbps, allowing SLAs above and beyond that provided by the provisionable transport bandwidth.	199
GigE	The E1000-2 cards are used for Gigabit Ethernet (1000 Mb/s) when the XC or XC-VT cross-connect cards are in use. It provides two IEEE-compliant, 1000 Mb/s ports for high-capacity customer LAN interconnections.	199
“	The E1000-2-G cards are used for Gigabit Ethernet (1000 Mb/s), when the XC-10G cross-connect card is in use. It provides two IEEE-compliant, 1000 Mb/s ports for high-capacity customer LAN interconnections.	199
“	The G1000-4 cards are used for Gigabit Ethernet (1000 Mb/s) transport, when the XC-10G cross-connect card is in use. It provides four ports of IEEE-compliant, 1000 Mb/s interfaces.	199
“	The new G-1K-4 card operates identically to the G1000-4 card, except the new card will interoperate with the XC or XC-VT cards, when installed in the high-speed multiservice card slots (5, 6, 12 & 13). The G-1K-4 card will be backward compatible to R3.2 software.	199
“	The new Cisco IOS-based ML-1000-2 card is used for Gigabit Ethernet (1000 Mb/s) when the XC-10G cross-connect card is in use. It supports Layer 2 and Layer 3 services and provides up to 2.4 Gbps of transport bandwidth, software provisionable in transport bandwidths from 50Mbps to the ports full line rate, in STS1, STS3c, STS6c, STS9c, STS12c and STS24c. Additionally, each service interface will support bandwidth guarantees down to 1Mbps, allowing SLAs above and beyond that provided by the provisionable transport bandwidth.	199
GBICs		
SX	Is an IEEE 1000Base-SX compliant, 850 nm multi-mode optical module.	220
LX	Is an IEEE 1000Base-LX-compliant, 1300 nm single-mode optical module.	220
ZX	Is an IEEE 1000Base-ZX-complaint, 1550 nm single-mode optical module.	220

ONS 15454 Network Management

The Cisco ONS 15454 supports CORBA, SNMPv1/v2, and TL1 as protocols for Operations Support System (OSS) interfaces. The OSS interface is TCP/IP based. The service provider's OSS can access the ONS 15454 through either an external LAN (10BaseT) or a TL1 terminal interface. A LAN modem can also be used to connect remotely via a dial-in connection and a standard modem can be used to connect remotely to the TL1 terminal interface. The ONS 15454 accepts TL1 scripts via a telnet session through the RS232 or LAN interfaces.

The ONS 15454 is compatible with several network management protocols, such as Simple Network Management Protocol (SNMP), Proxy Address Resolution Protocol (ARP), and Open Shortest Path First (OSPF) protocol. If OSPF is not available, static routes can also connect to ONS 15454s through routers. DCC tunneling is provided for interoperability with other vendors' equipment.

Craft Interface

The Cisco ONS 15454 allows users to easily manage services and quickly increase capacity without disrupting service. Workstations and laptop PCs connect to the ONS 15454 using either direct, LAN, WAN, or DCC connections. Every time you log into the ONS 15454, it automatically downloads the Cisco Transport Controller (CTC) craft interface application on to your workstation or laptop. CTC uses simple point-and-click GUI screens and online help, which makes it easy for anyone to configure the ONS 15454, build circuits, and shoot trouble. Because CTC is embedded in every ONS 15454 Timing Control Card (TCC), the application is always in sync with the features and functionality of the current system software load running on the ONS 15454 network.

Network Configurations

The ONS 15454 supports a variety of network configurations, including terminal mode (TM), linear ADM, Path Protection Configuration, two- and four-fiber bi-directional line switched ring (BLSR), subtending rings, path protected meshed networks (PPMNs), and regenerator mode. The ONS 15454 can be combined with other Cisco ONS products or interoperate with equipment from third-parties to provide end-to-end solutions for SONET and dense wave division multiplexing (DWDM) networks.

New Features in Release 4.0

Table 1-4 lists the new hardware and software features provided in Release 4.0 that are covered in this document.

Table 1-4: New Hardware and Software Feature

New Features in Release 4.0		Page
Hardware	OC-192LR-ITU Cards	197
	OC-192IR-1550 Card	197
	OC-192SR Card	197
	ML-100T-12 Ethernet Card	199
	ML-1000-2 Ethernet Card	149, 199
	G-1K-4 Ethernet Card	141, 199
	OC-3IR-8-1310 Card	199
	TCC2 Card	193
Software	E-Series Ethernet Private Line (PL) Mode	128
	Dual Ring Interconnect - Path Protection Configuration	73
	Password Failed Attempts (Spinning)	298
	User Log-in Notification	298
	Invalid Username Log-in Attempt	298
	List of Logged-in Users	298
	Superuser Log-out Control	298
	Single Log-in per User Name	298
	Audit Trail Management	298
	IP Address Display Configuration	243
	CTC Audit Trail Improvements	298
	CTC Timeout Duration	297
	DS-1 Facility Data Link (FDL) Support	224
	CTC in NAT/PAT (Proxy Server Port Reduction)	286

Chapter 2 – SONET Transport

Note: The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

Purpose

This chapter contains specific information about Synchronous Optical Network (SONET) line rates, signal format, overhead functions, and payload mappings for the Cisco ONS 15454. For an introduction to SONET, see the SONET/SDH primer in Appendix C. For information about Telcordia's generic requirements for SONET, see GR-253-CORE.

Contents

The following topics are found in this chapter:

Rates and Format

Inside the ONS 15454, STS-N connections may be allowed that do not correspond to the standard signal definitions. For example, Ethernet card connections in the ONS 15454 may be made with the standard signals and also STS-6 and STS-24 line rates, because the STS-6 and STS-24 signals are carried within standard SONET links and never appear outside of the ONS 15454 system. Table 2-1 lists the SONET line rates supported by the ONS 15454.

Table 2-1: Supported SONET Line Rates

STS-N Electrical Level	Optical Carrier (OC-N) Level	Line Rate (Mb/s)	Hierarchical Relationship
STS-1	OC-1	51.840	Standard
STS-3	OC-3	155.52	3 times STS-1
STS-12	OC-12	622.08	4 times STS-3
STS-48	OC-48	2,488.32	4 times STS-12
STS-192	OC-192	9,953.28	4 times STS-48

STS Concatenation

In the ONS 15454, valid concatenated payloads exist from STS-1 to STS-192c and are carried in the optical OC-N signal or STS-N electrical signal. Valid STS-Nc payloads for the ONS 15454 are listed in Table 2-2.

Table 2-2: Supported Concatenated Bandwidth Sizes

STS-Nc Signal	Payload Bandwidth (Mb/s)	Inside or Outside the ONS 15454 Network
STS-1	49.536	Both
STS-3c	148.608	Both
STS-6c	297.216	Inside Only
STS-12c	594.432	Both
STS-24c	1,188,864	Both
STS-48c	2,377.728	Both
STS-192c	9,510.912	Both

When STS-1's are concatenated, the path overhead in the first STS-1 controls the payload. Path overhead in the remaining STS-1's is still carried, but it is not used.

VT Structure

Signals with bit rates less than DS3 at 45 Mb/s can be carried in the ONS 15454 by mapping these lower rate signals into sections of an STS-1 frame. These sections are each called a Virtual Tributary (VT). Each STS-1 frame is divided into exactly 7 virtual tributary groups (VTG).

A single STS-1 frame cannot be partially filled with VTGs and use its remaining payload for something else, like ATM cell transport. The STS-1 can either be sectioned off into exactly 7 VTGs or left whole. The 7 VTGs in an STS-1 frame consists of 108 bytes each.

The ONS 15454 system utilizes the Asynchronous VT1.5 structure, which is diagramed in Figure 2-1. Note that there are 27 bytes in the VT1.5. 24 bytes make up the payload of the DS1 signal. The remaining 3 bytes are used for path overhead.

Figure 2-1: VT1.5 Structure

3 Columns

9 Rows

1	2	3
4	5	6
7	8	9
10	11	12
13	14	15
16	17	18
19	20	21
22	23	24
25	26	27

Each STS-1 can support 28 VT1.5 mapped DS1 signals. Table 2-3 illustrates how the ONS 15454 numbers these VT1.5 mapped signals compared to the VT Group numbering scheme defined in GR-253-CORE.

Table 2-3: ONS 15454 VT1.5 Numbering Scheme

DS1 Number	ONS 15454 VT1.5 Number	GR-253-CORE VT Group Number	GR-253-CORE VT Number
1	VT1-1	1	1
2	VT2-1	2	1
3	VT3-1	3	1
4	VT4-1	4	1
5	VT5-1	5	1
6	VT6-1	6	1
7	VT7-1	7	1
8	VT1-2	1	2
9	VT2-2	2	2
10	VT3-2	3	2
11	VT4-2	4	2
12	VT5-2	5	2
13	VT6-2	6	2
14	VT7-2	7	2
15	VT1-3	1	3
16	VT2-3	2	3
17	VT3-3	3	3
18	VT4-3	4	3
19	VT5-3	5	3
20	VT6-3	6	3
21	VT7-3	7	3
22	VT1-4	1	4
23	VT2-4	2	4
24	VT3-4	3	4
25	VT4-4	4	4
26	VT5-4	5	4
27	VT6-4	6	4
28	VT7-4	7	4

Multiplexing

The ONS 15454 provides M13 multiplexing via its 6-port transmux card (DS3XM-6). This card can accept up to six DS-3 signals. Each DS3 signal is partitioned into M-frames mapped to 28 DS-1 signals in an M13 multiplex unit. The 28 DS-1 signals are then converted to VT1.5 payloads (1.728 Mb/s) for DS-1 transport.

Conversely, the transmux card can take 28 T-1s and multiplex them into a channeled C-bit or M13 framed DS-3. This is accomplished in two steps. In the first step, 4 DS-1 signals are multiplexed to reached a 6.312 Mb/s transmission rate inside the M13 multiplex unit. The M13 unit then multiplexes 7 of the 6.312 Mb/s signals to generate the DS-3 output.

Overhead Mapping

The individual SONET overhead byte designations are laid out in Table 2-4.

Table 2-4: SONET Transport and Path Overhead Byte Designations

Transport Overhead			
Section	**Framing**		**Trace**
	A1	A2	J0/Z0
	BIP-8	**Orderwire**	**User**
	B1/undefined	E1/undefined	F1/undefined
	Section DCC		
	D1/undefined	D2/undefined	D3/undefined
Line	**Pointer**	**Pointer**	**Pointer Action**
	H1	H2	H3
	BIP-8	**APS**	**APS**
	B2/undefined	K1/undefined	K2/undefined
	Line DCC		
	D4/undefined	D5/undefined	D6/undefined
	Line DCC		
	D7/undefined	D8/undefined	D9/undefined
	Line DCC		
	D10/undefined	D11/undefined	D12/undefined
	SSM	**REI-L**	**Orderwire**
	S1/Z1	M0 or M1/Z2	E2/undefined

Path Overhead
Trace J1
BIP-8 B3
Signal Label C2
Path Status G1
User Channel F2
Indicator H4
Growth Z3
Growth Z4
Tandem Connection Z5

Table 2-5 provides a list of supported and unsupported SONET overhead bytes for the Cisco ONS 15454.

Table 2-5: Supported and Unsupported SONET Overhead Bytes

Section	A1 –A2	Framing	Supported
	J0	Section Trace	Not Supported
	Z0	Section Growth	Supported
	B1	Section BIP-8	Supported
	E1	Local Orderwire	Supported
	F1	Section User Channel	Not Supported
	D1 – D3	Section DCC	Supported
Line	H1 – H3	STS Pointer	Supported
	B2	Line BIP-8	Supported
	K1 – K2	APS Channel	Supported
	K2	Bits 6-8, RDI-L & AIS-L Detect	Supported
	D4-D12	Line DCC	Supported
	S1	Synch Status Messaging	Supported
	M0 – M1	REI-L	Supported
	E2	Express Orderwire	Supported
STS Path	H1 –H3	STS Pointer	Supported
	H1 – H2	AIS-P Detect	Supported
	J1	STS Path Trace	Supported
	B3	STS Path BIP-8	Supported
	C2	STS Path Signal Label	Supported
	C2	PDI-P	Supported
	G1 bits 1-4	REI-P	Supported
	G1 bits 5-7	ERDI-P	Not Supported
	F2	Path User Channel	Not Supported
	H4	Multi-Frame Indicator (VT only)	Supported
	H4	Other	Not Supported
	Z3	Growth	Not Supported
	F2, H4, Z3	DQDB Mapping	Not Supported
	Z4	Growth	Not Supported
	Z5	Growth	Not Supported
	Z5	Tandem Connect Channel	Not Supported
	V1 – V3	VT Pointer	Supported
VT Path	V1 – V3	VT Pointer	Supported
	V1 –V2	AIS-V Detect	Supported
	V5 bits 1, 2	VT Path BIP-2	Supported
	V5 bit 3	REI-V	Supported
	V5 bit 4	FRI-V (byte sync only)	Not Supported
	V5 bits 5-7	VT Path Signal Label	Not Supported
	V5 bit 8	RDI-V	Not Supported
	J2	VT Path Trace	Not Supported
	Z6	Growth	Not Supported
	Z7 bits 5-7	ERDI-V	Not Supported
	Z7	Growth	Not Supported

Data Control Channel (DCC) Operations

Note Starting with System Release 4.0, there can be 1 Section Data Control Channel (SDCC) termination per OC-N span, with a maximum of 32 SDCC terminations per ONS 15454. Previous system releases can support 1 SDCC termination per OC-N span, with a maximum of 10 SDCC terminations per ONS 15454.

The ONS 15454 uses the DCC to transport information about operation, administration, maintenance, and provisioning (OAM&P) over a SONET interface. DCCs can be located in the

SDCC or Line DCC (LDCC). Unused SDCCs and LDCCs can be used to tunnel DCCs from third-party equipment across ONS 15454 networks.

The SDCC is defined in the first STS-1 of an STS-N frame. Looking at the Section Overhead in Table 2-4 you will find the D1, D2 and D3 bytes. These bytes are combined together to form the SDCC. Since each of these bytes represents a 64Kb/s message-based channel, the SDCC represents a 192Kb/s data channel.

SDCC channels need to be terminated via a provisioning session at each ONS 15454 node in the ring before messages can flow between nodes. After the SDCC channels have been terminated, OAM&P will start up automatically within each ONS 15454 node. If there are two ONS 15454 nodes connected by multiple OC-N spans, the SDCC on each of these spans does not have to be terminated at each node to start the flow of OAM&P information. You only need to terminate the SDCCs on the ports of the OC-N cards that are going to serve as the OC-N trunk ports for the ring. SDCCs that are not terminated are available for DCC tunneling.

A SONET link that carries payload from an ONS 15454 node to a third-party's SONET node will also have an SDCC defined in the Section Overhead. However, OAM&P messages will not be recognized by the third-party's node, and the SDCC should not be enabled. Disabling the SDCC will not have any affect on the DS3, DS1, and other payload signals carried between nodes.

DCC Tunneling

Note Starting in System Release 4.0, each Cisco ONS 15454 can have up to 84 DCC tunnel connections. Previous system releases can support up to 32 DCC tunnel connections. Terminated SDCCs used by the ONS 15454 cannot be used as a DCC tunnel end-point, and a SDCC that is used as an DCC tunnel end-point cannot be terminated. All DCC tunnel connections are bi-directional.

DCC Termination Guidelines

The following guidelines govern the provisioning of SDCC terminations:

Each ONS 15454 can have up to 84 DCC tunnel connections.
Each ONS 15454 can have up to 10 SDCC terminations.
Line DCCs and the Section DCC (when not used as a DCC termination by the ONS 15454) can be provisioned as DCC tunnels.
A SDCC that is used as a DCC tunnel end-point cannot be terminated.
All DCC tunnel connections are bi-directional.

Cisco recommends using Line DCCs to tunnel DCCs from third-party equipment across ONS 15454 networks. Looking at the Line Overhead in Table 2-4 there are 3 DCC channels, D4-D5-D6, D7-D8-D9, and D10-D11-D12. In the North American SONET standard, these 192Kb/s message-based channels are unassigned. Therefore, an ONS 15454 node can use these channels to support up to 3 DCC tunnels. A forth tunnel can be created if necessary when the ONS 15454 management SDCC termination is disabled.

Third-party SONET equipment may be connected end-to-end through any network consisting of ONS 15454 nodes. The SONET payload can be connected in the standard way. The third-party SONET equipment SDCC channels may be connected together via Line DCC tunnels, when the SDCC is not used for ONS 15454 DCC terminations. This means the third-party SONET equipment OAM&P will operate through the DCC tunnel as if the third-party SONET equipment were directly connected together with fiber.

In the ONS 15454, a DCC tunnel end-point is defined by Slot number (OC-N), Port number, and DCC, where DCC can be either the SDCC, Tunnel 1, Tunnel 2, or Tunnel 3 (LDCCs). You can link an SDCC to an LDCC (Tunnel 1, Tunnel 2, or Tunnel 3), and an LDCC to an SDCC. You can also link LDCCs to LDCCs and link SDCCs to SDCCs. To create a DCC tunnel, you connect the tunnel end-points from one ONS 15454 OC-N port to another (see Figure 2-2).

Figure 2-2: Selecting DCC Tunnel End-Points

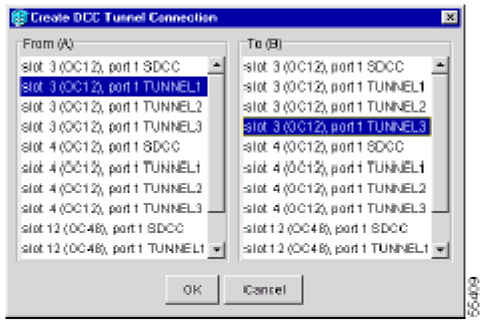


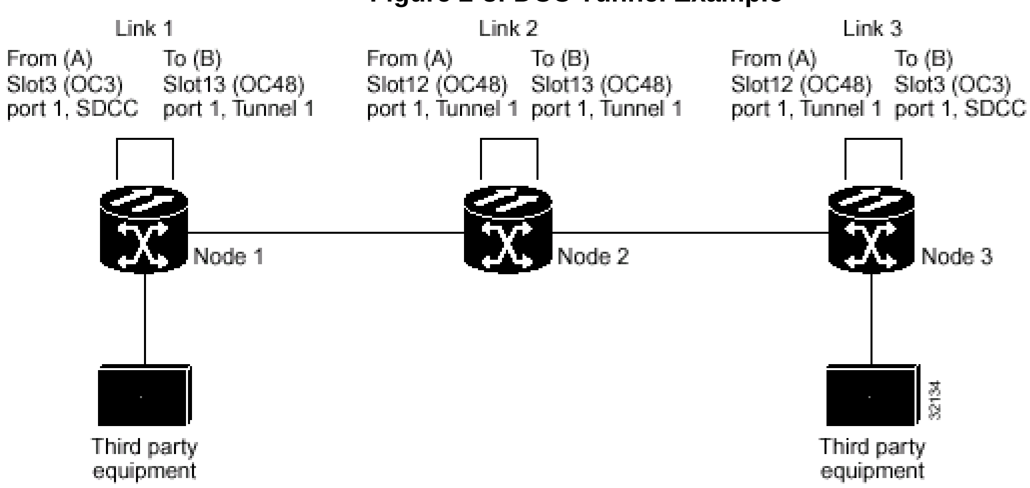
Table 2-6 shows the DCC tunnels that you can create through the Cisco ONS 15454.

Table 2-6: Allowable DCC Tunnels

DCC	SONET Layer	SONET Bytes	OC-3 (All Ports)	OC-12 (All Ports)	OC-48, OC-192
SDCC	Section	D1 – D3	Yes	Yes	Yes
Tunnel 1	Line	D4 – D6	No	Yes	Yes
Tunnel 2	Line	D7 – D9	No	Yes	Yes
Tunnel 3	Line	D10 – D12	No	Yes	Yes

Figure 2-3 shows an example of a DCC tunnel. Third-party equipment is connected to OC-3 cards at Node 1/Slot 3/Port 1 and Node 3/Slot 3/Port 1. OC-48 trunk cards connect each ONS 15454 node. In the example, 3 tunnel connections are created, 1 at Node 1 (OC-3 to OC-48), 1 at Node 2 (OC-48 to OC-48), and 1 at Node 3 (OC-48 to OC-3).

Figure 2-3: DCC Tunnel Example



K1 and K2 Byte Switching

The K1 and K2 bytes in the Line Overhead are used for automatic protection switching (APS) commands and error conditions between pieces of SONET node equipment. These two bytes are only used in the first STS-1 of an STS-N signal. The meaning of the K1 and K2 bytes depends on the type of protection used. For example, bits 1-4 of the K1 byte have the following meaning shown in Table 2-7 when a 1+1 fiber protection scheme is used.

Table 2-7: Meaning of K1 Bits 1-4

1111 Lockout of Protection	1110 Forced Switch
1101 SF - High Priority	1100 SF - Low Priority
1011 SD - High Priority	1010 SD - Low Priority
1001 (not used)	1000 Manual Switch
0111 (not used)	0110 Wait-to-Restore (Note 3)
0101 (not used)	0100 Exercise (Note 4)
0011 (not used)	0010 Reverse Request (Note 5)
0001 Do Not Revert	0000 No Request

Remember that the SONET overhead is sent with the SONET frame every 125 microseconds between nodes. So if a SONET node detects a fault on the receive bit stream from a node, the receiving node can notify the transmitting node immediately by changing the state of the K1 and K2 bytes. The transmitting node does not have to compose a message and send it through the DCC channels. The node receiving the new K1/K2 state must begin processing the change within three frame receptions (3 times 125 microseconds or 375 microseconds). The ONS 15454 conforms to the GR-253-CORE standard for K1 and K2 state signaling, so other vendor equipment should be interoperable with ONS 15454 transmission payload and protection signaling.

K3 Byte Remapping

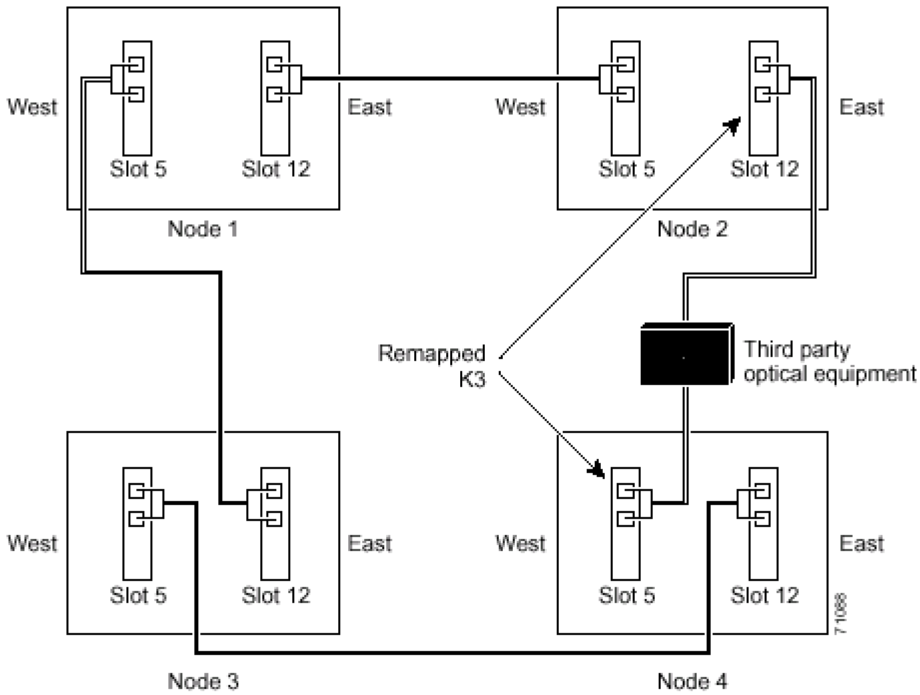
Warning Do not perform K3 byte remapping on the Cisco ONS 15454 unless it is required to complete a BLSR that connects to third-party equipment.

The Cisco ONS 15454 uses the undefined K1 byte within STS-2 to improve BLSR switching times. Cisco renamed the K1 byte within STS-2 the K3 byte. The improved switching time allows a Cisco to support the 50ms BLSR switch time in rings with up to 16 ONS 15454 nodes.

If a BLSR is routed through third-party equipment that cannot transparently transport the K3 byte, you can remap it to either the Z2, E2, or F1 bytes on the ONS 15454 OC-48 any slot (AS) cards. K3 byte remapping is not available on other OC-N cards. If you remap the K3 byte, you must remap it to the same byte on each BLSR trunk card that connects to the third-party equipment. All other BLSR trunk cards should remain mapped to the K3 byte.

For example, in Figure 2-4, a BLSR span between Node 2 and Node 4 passes through third-party equipment. Because this equipment cannot transparently transport the K3 byte, the OC-48AS card at Node 2/Slot 12 and the OC-48AS card at Node 4/Slot 5 are provisioned to use an alternate byte. Other BLSR trunk cards are not changed.

Figure 2-4: BLSR Provisioned with Remapped K3 Byte



J1 Path Trace

The SONET J1 Path Trace is a repeated, fixed-length string comprised of 64 consecutive J1 bytes. J1 Path Trace can be used to carry a remote hostname, an interface name/number, an IP address, or anything that can be used to uniquely identify a circuit. Is commonly used to troubleshoot circuit paths through networks. The Cisco ONS 15454 can monitor the J1 Path Trace strings on each STS and compare the received string with the transmitted string. A TIM-P alarm is raised If the string received at a circuit drop port does not match the string the port expects to receive. Two path trace modes are available:

Automatic — The receiving port assumes the first J1 string it receives is the baseline J1 string.

Manual — The receiving port uses a string that you manually enter as the baseline J1 string.

Table 2-8 shows the ONS 15454 cards that support J1 Path Trace. DS-1 and DS-3 cards can transmit and receive the J1 field, while the EC-1, OC-3, OC-48AS, and OC-192 can only receive it. A new feature added in System Release 4.0 gives the ONS 15454 the ability to support J1 Path Trace monitoring while a BLSR switch is in effect. Cards not listed in the table do not support the J1 byte.

Table 2-8: ONS 15454 Cards Supporting J1 Path Trace

J1 Function	Cards
Transmit and Receive	DS1-14, DS1N-14
	DS3-12E, DS3N-12E, DS3XM-6
	G1000-4
	ML-100T-12, ML-1000-2
Receive (Monitor Only)	EC1-12
	OC3 IR 4 1310, OC3/STM1 IR 8 1310
	OC12/STM4-4
	OC48 IR/STM16 SH AS 1310, OC48 LR/STM16 LH AS 1550
	OC192 LR/STM64 LH 1550, OC192 IR/STM64 1550, OC192 SR/STM64 SR 1310
BLSR Switch (Monitor Only)	OC12/STM4-4
	OC48 IR/STM16 SH AS 1310, OC48 LR/STM16 LH AS 1550
	OC192 LR/STM64 LH 1550, OC192 IR/STM64 1550, OC192 SR/STM64 SR 1310

Payload Mapping

The SONET and SDH payloads supported by the ONS 15454 are shown in Table 2-9.

Table 2-9: SONET and SDH Payloads Supported

SONET	SDH
STS-1	
STS-3C	STM-1
STS-12C	STM-4
STS-48C	STM-16
STS-192C	STM-64

The SONET payload mappings for each interface supported by the Cisco ONS 15454 are shown in Table 2-10.

Table 2-10: ONS 15454 SONET Payload Mappings

ONS 15454 Card Type	I/O Format	# of I/O Ports	Internal SONET Mapping	# of STSs
EC1-12	DS3 mapped STS, VT1.5 mapped STS or clear channel STS (Electrical).	12	DS3, VT1.5s mapped in an STS or STS-1.	12
DS1-14 DS1N-14	DS1	14	VT1.5s mapped in an STS.	1
DS3-12 DS3N-12	Any type of DS3 mapping: M13, M23, clear channel, DS3 ATM, etc.	12	DS3 mapped in an STS.	12
DS3-12E DS3N-12E	Any type of DS3 mapping, plus J1 path trace.	12	DS3 mapped in an STS.	12
DS3XM-6	M13 mapped DS3	6	VT1.5 mapped in an STS	6

ONS 15454 Card Type	I/O Format	# of I/O Ports	Internal SONET Mapping	# of STSs
All OC3 Cards	Any type of DS3 mapped STS, VT1.5 mapped STS, clear channel STS or OC-Nc ATM (Optical).	4 or 8	This card's mapping can be a DS3 mapped STS or a VT1.5 mapped STS. However, it does not convert between the two different mappings. Mapping can also be STS-N or STS-Nc. Each of the STS streams can be configured to any combination of STS-1 or STS-3c, provided the sum of the circuit sizes that terminate on a card do not exceed STS-12c for the 4-port OC3 card or 24c for the 8-port card.	12 or 24
All OC12 Cards	Any type of DS3 mapped STS, VT1.5 mapped STS, clear channel STS or OC-Nc ATM (Optical).	1 or 4	This card's mapping can be a DS3 mapped STS or a VT1.5 mapped STS. However, it does not convert between the two different mappings. Mapping can also be STS-N or STS-Nc. Each of the STS streams can be configured to any combination of STS-1, STS-3c, STS-6c, STS-9c, and STS-12c, provided the sum of the circuit sizes that terminate on a card do not exceed STS-12c for the single port OC12 card or 48c for the 4-port card.	12 or 48
All OC48 Cards	Any type of DS3 mapped STS, VT1.5 mapped STS, clear channel STS or OC-Nc ATM (Optical).	1	This card's mapping can be a DS3 mapped STS or a VT1.5 mapped STS. However, it does not convert between the two different mappings. Mapping can also be STS-N or STS-Nc. Each of the STS streams can be configured to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, and STS-48c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-48c.	48
All OC192 Cards	Any type of DS3 mapped STS, VT1.5 mapped STS, clear channel STS or OC-Nc ATM (Optical).	1	This card's mapping can be a DS3 mapped STS or a VT1.5 mapped STS. However, it does not convert between the two different mappings. Mapping can also be STS-N or STS-Nc. Each of the STS streams can be configured to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, STS-48c, and STS-192c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-192c.	192
E100T E100T-G	Ethernet (Electrical)	12	Ethernet in HDLC, mapped in an STS-Nc.	12
E1000-2 E1000-G	Ethernet (Electrical)	2	Ethernet in HDLC, mapped in an STS-Nc.	12

ONS 15454 Card Type	I/O Format	# of I/O Ports	Internal SONET Mapping	# of STSs
G1000-4 & G1K-4	Ethernet (Optical)	4	Ethernet in HDLC, mapped in an STS-Nc. You can map the 4 ports on the G1000-4 independently to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, and STS-48c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-48c. To support a gigabit Ethernet port at full line rate, an STS circuit with a capacity greater or equal to 1Gb/s (bi-directional 2 Gb/s) is needed. An STS-24c is the minimum circuit size that can support a gigabit Ethernet port at full line rate. The G1000-4 supports a maximum of two ports at full line rate.	48
ML-100T-12	Ethernet (Optical) Layer 2/Layer 3 Routing	12	Ethernet in HDLC, mapped in an STS-Nc. You can map the 2 ports on the ML-series cards independently to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, and STS-24c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-48c. Up to 2 STS-24c circuits are supported.	48
ML-1000-2	Ethernet (Optical) Layer 2/Layer 3 Routing	2	Ethernet in HDLC, mapped in an STS-Nc. You can map the 2 ports on the ML-series cards independently to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, and STS-24c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-48c. To support a gigabit Ethernet port at full line rate, an STS circuit with a capacity greater or equal to 1Gb/s (bi-directional 2 Gb/s) is needed. An STS-24c is the minimum circuit size that can support a gigabit Ethernet port at full line rate. Up to 2 STS-24c circuits are supported.	48

When considering card mappings on the ONS 15454, it is important to look at the I/O format and the internal SONET mappings. Cards having the same internal format can be cross-connected.

Note

The DS3 and DS3XM cards cannot be cross-connected on the ONS 15454, because the DS3 cards are DS3 mapped and the DS3XM cards are VT1.5 mapped.

Cross-connects

A cross-connect is a point-to-point connection between ports. Cross-connects are established when a circuit is created in the ONS 15454 node. The ONS 15454 cross-connect cards manage these cross-connects. The cross-connect cards work with the ONS 15454 Timing Control Cards (TCCs) to perform port-to-port time-division-multiplexing (TDM). The ONS 15454 holds redundant cross-connect cards in slots 8 and 10. Always use the same type of cross-connect card in an ONS 15454 node to ensure proper operation of the system.

There are three versions of cross-connect cards: the XC, XCVT, and the XC-10G. The cross-connect capacity of these cards is summarized in Table 2-11.

Table 2-11: Capacity of ONS 15454 Cross-connect Cards

Cross-Connect Card	STS and VT1.5 Capacities
XC	288 STS Bi-directional Ports 144 STS Bi-directional Cross-connects Fully Non-blocking @ STS Level STS-1/3c/6c/12c/48c Cross-connects
XC-VT	288 STS Bi-directional Ports 144 STS Bi-directional Cross-connects 672 VT1.5 Ports Via 24 Logical STS Ports 336 VT1.5 Bi-directional Cross-connects Fully Non-blocking @ STS Level STS-1/3c/6c/12c/48c Cross-connects
XC-10G	1152 STS Bi-directional Ports 576 STS Bi-directional Cross-connects 672 VT1.5 Ports Via 24 Logical STS Ports 336 VT1.5 Bi-directional Cross-connects Fully Non-blocking @ STS Level STS-1/3c/6c/12c/48c/192c Cross-connects

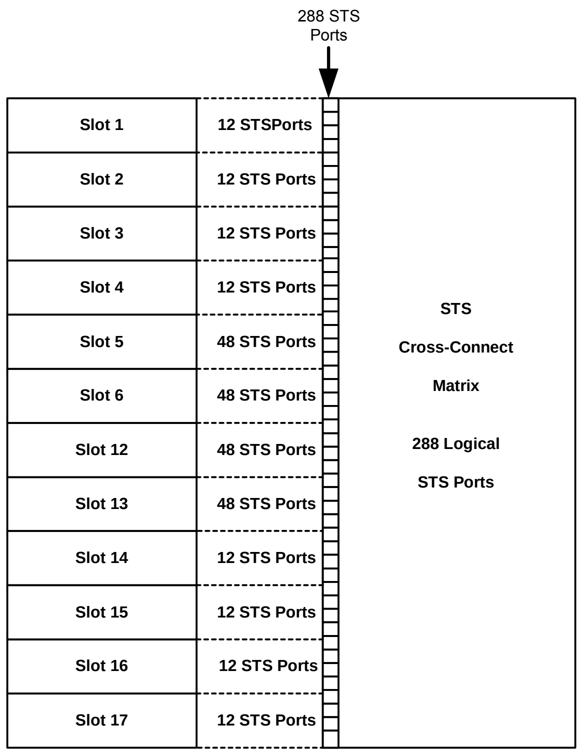
XC Cross-connect Card

The XC performs STS to STS switching only. The XC establishes connections and performs time division switching (TDS) at the STS-1 level between ONS 15454 multi-service interface cards. XC cards have the capacity to terminate 288 STSs, or 144 point-to-point STS cross-connections. There is no switching at the VT level. However, VTs can be tunneled through the STSs. When tunneling, there is a direct mapping, no Time Slot Interchange (TSI), between the incoming and outgoing VTs in an STS flow.

The switch matrix on the XC card consists of 288 bi-directional ports. When creating bi-directional STS-1 cross-connects, each cross-connect uses two STS-1 ports. This results in 144 bi-directional STS-1 cross-connects. The switch matrix is fully cross-point, non-blocking, and broadcast supporting. Any STS-1 on any port can be connected to any other port, meaning that the STS cross connections are non-blocking. This allows network operators to concentrate or groom low-speed traffic from line cards onto high-speed transport spans and to drop low-speed traffic from transport spans onto line cards.

The XC card has 12 input ports and 12 output ports. Four input and output ports operate at either STS-12 or STS-48 rates. The remaining eight input and output ports operate at the STS-12 rate. An STS-1 on any of the input ports can be mapped to an STS-1 output port, thus providing full STS-1 time slot assignments (TSA). Figure 2-5 is a block diagram of the XC cross-connect matrix.

Figure 2-5: XC Cross-connect Matrix



Point-to-multipoint connections are used for drop and continue sites in Path Protection Configuration and BLSR nodes. It is very important to note that when creating point-to-multipoint connections, the ratio of ports-to-connections is not 2:1, as it is in point-to-point cross-connections. Therefore, when calculating capacities, count terminating STS ports, not connections. When creating a point-to-point circuit, "Connection A," from Slot 1/Port 3/STS 2 (1/3/2) to Slot 2/Port 2/STS 4, consumes 2 ports. Creating a point-to-multipoint circuit, "Connection B," where Slot 2/Port 2/STS 2 maps to Slot 4/Port 4/STS 4 and Slot 5/Port 5/STS 5, consumes 3 ports. Subtracting the sum of Connection A (2 ports) and Connection B (3 ports) yields 288 – 5 = 283 logical ports remaining on the STS cross-connect. If these were unidirectional flows, Connection A would use 1 port and Connection B would use 1.5 ports. Unidirectional connections can be measured in .5 increments, because the cross-connect views a bi-directional flow as 2 unidirectional connections. An STS-1 on any input port can be mapped to any output port. Therefore the STS cross-connect is non-blocking, because it has the capacity to switch all 288 ports and STSs to all 288 ports and STSs.

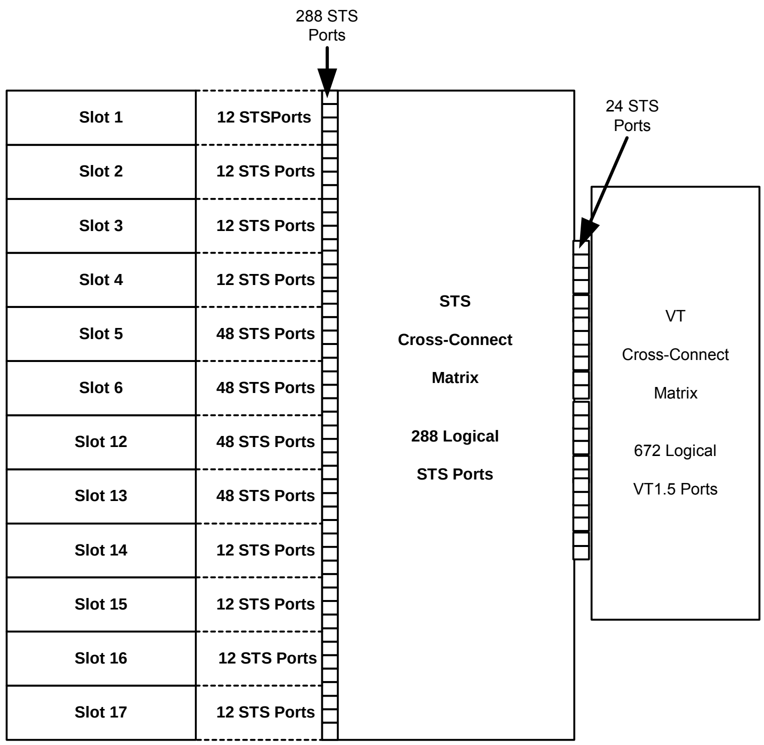
XC-VT Cross-connect Card

The XC-VT has all of the STS cross-connect functions that the XC does, including the Virtual Tributary (VT) tunneling. The XCVT provides non-blocking STS-48 capacity to all of the high-speed slots and non-bi-directional blocking STS-12 capacity to all multispeed slots. Any STS-1 on any port can be connected to any other port, meaning that the STS cross-connections are non-blocking.

The STS-1 switch matrix on the XC-VT card consists of 288 bi-directional ports and adds a VT matrix that can manage up to 336 bi-directional VT1.5 ports or the equivalent of a bi-directional STS-12. The VT1.5 cross-connect matrix is used when mapping VT1.5 signals from one STS to multiple STSs, or performing TSI on the VT1.5s. The VT1.5 signals can be cross-connected, dropped, or rearranged. The switch matrices are fully cross-point and broadcast supporting. If

VTs are tunneled as in the XC, they do not pass through the VT1.5 cross-connect matrix. Figure 2-6 is a block diagram of XC-VT cross-connect matrix.

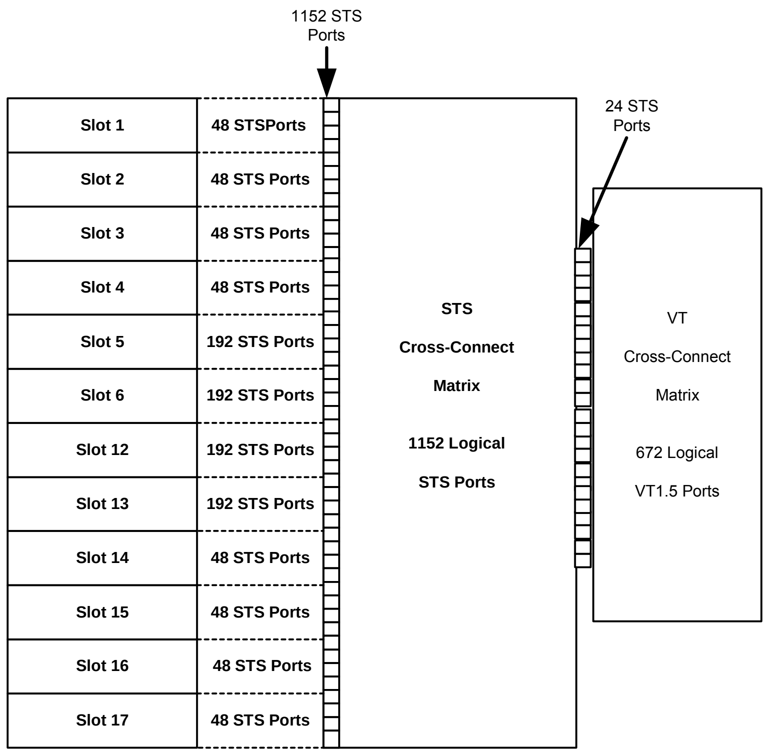
Figure 2-6: XC-VT Cross-connect Matrix



XC-10G Cross-connect Card

The XC-10G is required for OC-192 transport. It has all the STS cross-connect and VT cross-connect functions as the XC-VT, but supports four times the STS bandwidth of the XC and XC-VT cards. The switch matrix on the XC-10G card has 1152 bi-directional STS ports capable of supporting 576 STS cross-connect. The XC-10G also includes a VT switch matrix consisting of 672 bi-directional VT1.5 ports capable of supporting up to 336 bi-directional VT1.5 cross-connects. As with the XC and XC-VT cards, the XC-10G card also supports VT tunneling. There are with 24 of those ports available for VT1.5 switching. Figure 2-7 is a block diagram of the XC-10G cross-connect matrix.

Figure 2-7: XC-10G Cross-connect Matrix



I/O Interfaces Cross-connect Capabilities

Twelve card slots, 1 through 6 and 12 through 17, hold multi-service interface cards. These slots are commonly referred to as I/O slots. Table 2-12 shows the cross-connect capability of each I/O slot on the Cisco ONS 15454.

Table 2-12: Cross-connect Capability of I/O Slots

I/O Slot	High- or Multi-Speed Slot	Cross-connect Capability
1	Multi-Speed	STS12 / STS48
2	Multi-Speed	STS12 / STS48
3	Multi-Speed	STS12 / STS48
4	Multi-Speed	STS12 / STS48
5	High-Speed	STS12 / STS48 / STS192
6	High-Speed	STS12 / STS48 / STS192
12	High-Speed	STS12 / STS48 / STS192
13	High-Speed	STS12 / STS48 / STS192
14	Multi-Speed	STS12 / STS48
15	Multi-Speed	STS12 / STS48
16	Multi-Speed	STS12 / STS48
17	Multi-Speed	STS12 / STS48

VT1.5 Cross-connects

The XC-VT and XC-10G cards can each map up to 24 STS ports for VT1.5 traffic. Because one STS can carry 28 VT1.5s, the XC-VT and XC-10G cards can terminate up to 672 VT1.5s, or 336 VT1.5 cross-connects. You must meet the following requirements to terminate 336 VT1.5 cross-connects:

Each STS cross-connect mapped for VT1.5 traffic must carry 28 VT1.5 circuits.

ONS 15454 nodes must be in a BLSR. Source and drop nodes in Path Protection Configuration or 1+1 (linear) protection have capacity for only 224 VT1.5 cross-connects, because an additional STS port is used on the VT1.5 matrix for the protect path.

Table 2-13 shows the VT1.5 and VT Tunnel capacities for ONS 15454 cross-connect cards. All capacities assume each VT1.5-mapped STS carries 28 VT1.5 circuits.

Table 2-13: VT1.5 Cross-connect and VT Tunnel Capacities

Cross-connect Card	Total VT1.5 Ports	VT1.5 Cross-connect Capacity (BLSR)	VT1.5 Cross-connect Capacity (Path Protection Configuration or 1+1)	VT Tunnel Capacity (BLSR, Path Protection Configuration, or 1+1)
XC	0	0	0	144
XC-VT	672	336	224	144
XC-10G	672	336	224	576

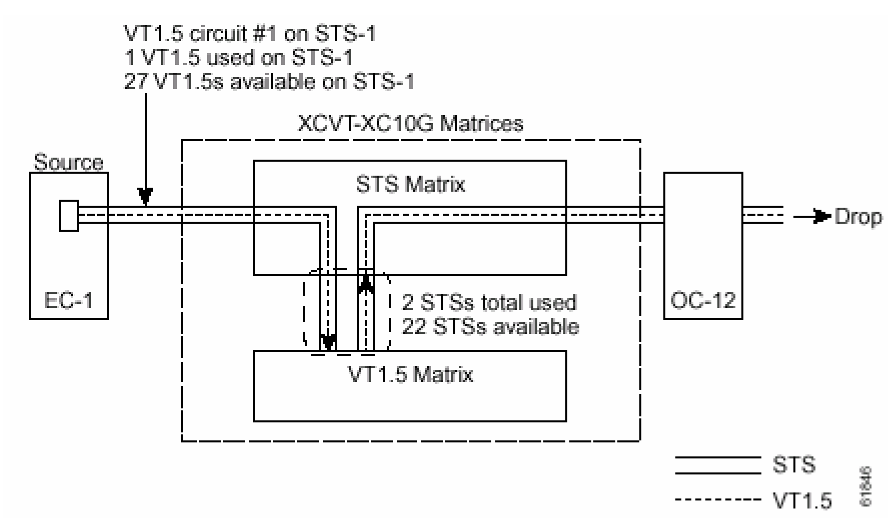
Figure 2-8 shows the logical flow of a VT1.5 circuit through the XCVT and XC-10G STS and VT1.5 matrices at a BLSR node. The circuit source is an EC-1 card using STS-1. After the circuit is created:

2 of the 24 STS ports available to for VT1.5 traffic on the VT1.5 matrix are used (1 STS for VT1.5 input into the VT matrix and 1 STS for VT1.5 output).

22 STS ports on the VT1.5 matrix remain available for VT1.5 circuits.

The STS-1 from the EC-1 card has capacity for 27 more VT1.5 circuits.

Figure 2-8: Example of a VT1.5 Circuit in a BLSR



When calculating the VT cross-connect capacity, it is not important to count VT1.5 connections or VT1.5 ports. Instead, count the number of STS ports terminating on the VT1.5 matrix because the terminations on the VT1.5 matrix are STS-based, not VT-based. In an STS that needs VT1.5 cross-connecting, even if an STS is only partially filled, every VT1.5 in the STS is terminated on the VT1.5 matrix. Like the STS matrix, the VT1.5 matrix is also non-blocking. Even when every VT1.5 in an STS is used, and all of the STS ports are consumed on the VT1.5 matrix, there is enough capacity on the VT1.5 matrix to switch every VT1.5 in every terminated STS. Therefore, it is important to count STS terminations instead of VT 1.5 terminations.

The number of STS ports in the VT1.5 matrix is 24. When those 24 ports are consumed, no additional VT1.5s can have access to the VT cross-connect matrix.

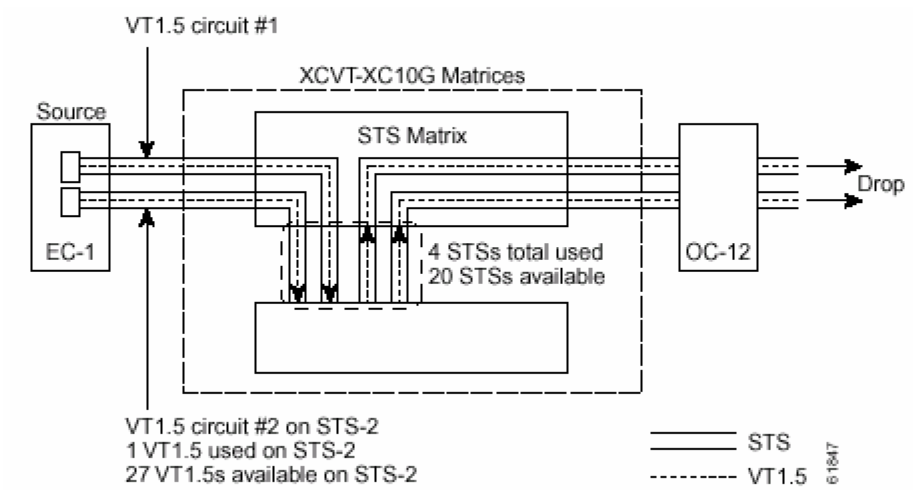
In Figure 2-9, a second VT1.5 circuit is created from the EC-1 card example illustrated in Figure 2-8. In this example, the circuit is assigned to STS-2:

2 of the remaining 22 STS ports available for VT1.5 traffic are used on the VT1.5 matrix.

20 STS ports remain available on the VT1.5 matrix for VT1.5 circuits.

STS-2 can carry 27 additional VT1.5 circuits.

Figure 2-9: Example of Two VT1.5 Circuits in a BLSR



If you create VT1.5 circuits on nodes in Path Protection Configuration or 1+1 protection, an additional STS port is used on the VT1.5 matrix for the protect path at the source and drop nodes. Figure 2-10 shows a VT1.5 circuit at a Path Protection Configuration source node. When the circuit is completed:

3 of the 24 STS ports available for VT1.5 mapping on the VT1.5 matrix are used (one input and two outputs, one output for the working path, and one output for the protect path).

21 STS ports remain available for VT1.5 circuits.

Figure 2-10: Example of a VT1.5 Circuit in a Path Protection Configuration or 1+1 Protected Network

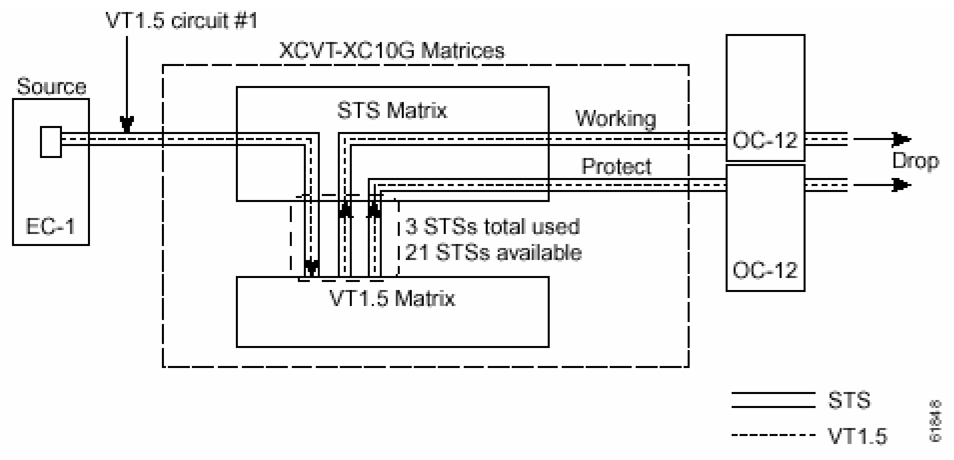
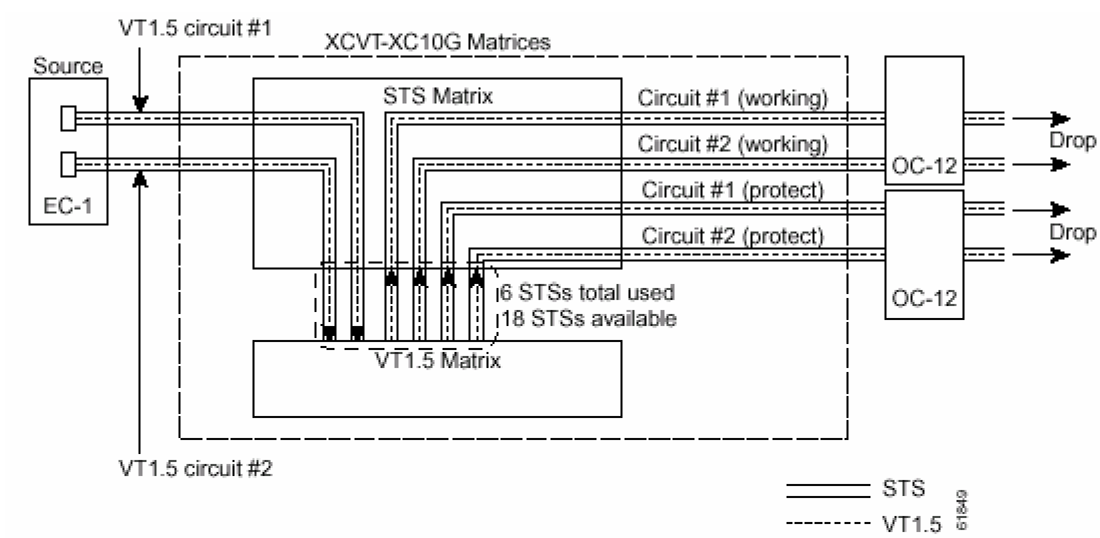


Figure 2-11 shows a second VT1.5 circuit that was created using STS-2. When the second VT1.5 circuit is created:

3 more VT1.5-mapped STS ports are used on the VT1.5 matrix.

18 STS ports remain available on the VT1.5 matrix for VT1.5 circuits.

Figure 2-11: Example of Two VT1.5 Circuits in a Path Protection Configuration or 1+1 Protected Network



Unless you create VT tunnels, VT1.5 circuits use STS ports on the VT1.5 matrix at each node that the circuit passes through.

2 STS ports are used on the VT1.5 matrix at the source and drop nodes in the Figure 2-8 example, and no STS ports are used at the pass-through nodes using VT tunnels. In the Figure 2-10 example 3 STS ports are used on the VT1.5 matrix at the source and drop nodes and no STS ports are used at the pass-through nodes using VT tunnels. Without VT tunnels, 2 STS ports are used on the VT1.5 matrix at each node in the Figure 2-8 example, and 3 STS ports are used at each node in the Figure 2-10 example.

In the Figure 2-9 example, 4 STS ports are used on the VT1.5 matrix at the source and drop nodes and no STS ports are used at pass-through nodes using VT tunnels. In Figure 2-11, 6 STS ports are used on the VT1.5 matrix at the source and drop nodes and no STS ports at the pass-through nodes using VT tunnels. Without VT tunnels, 4 STS ports are used on the VT1.5 matrix at each node in the Figure 2-9 example, and 6 STS ports are used at each node in the Figure 2-11 example.

VT Tunnels

To maximize VT1.5 matrix resources, you can tunnel VT1.5 circuits through ONS 15454 pass-through nodes (nodes that are not a circuit source or drop). The number of VT tunnels that each ONS 15454 node can support is directly related to the cross-connect capacity of the STS matrix (see Table 2-13). VT1.5 tunnels provide the following benefits:

They allow you to route VT1.5 circuits through ONS 15454 nodes that have XC cards. (VT1.5 circuits require XC-VT or XC-10G cards at circuit source and drop nodes.)

When tunneled through nodes with XC-VT or XC-10G cards, VT1.5 tunnels do not use VT1.5 matrix capacity, thereby freeing the VT1.5 matrix resources for other VT1.5 circuits.

Figure 2-12 shows a VT tunnel through the XC-VT and XC-10G cross-connect matrices. No VT1.5-mapped STSs are used by the tunnel, which can carry 28 VT1.5s. However, the tunnel does use 2 STS matrix ports on each node through which it passes.

Figure 2-12: An Example of a VT Tunnel

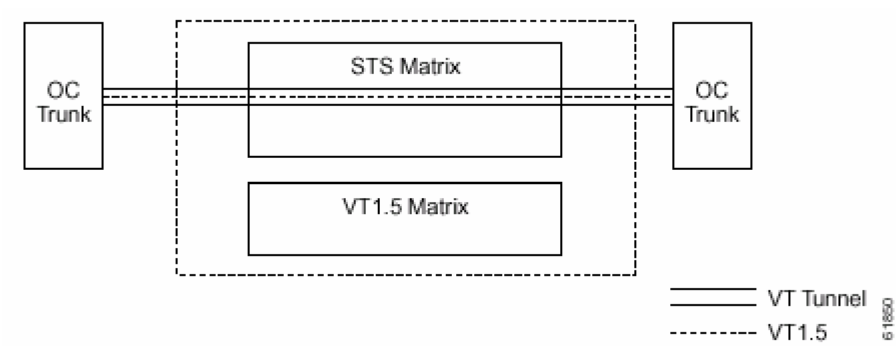


Figure 2-13 shows a six-node ONS 15454 ring with two VT tunnels. One tunnel carries VT1.5 circuits from Node 1 to Node 3. The second tunnel carries VT1.5 circuits from Node 1 to Node 4. Table 2-11 shows the STS usage on the VT 1.5 matrix at each node in a ring based on a given protection scheme and use of VT tunnels. In the Figure 2-16 example, the circuits travel clockwise (east) through Nodes 2, 3, and 4. Subsequently, STS usage on the VT1.5 matrix at these nodes is greater than at Nodes 5 and 6.

Figure 2-13: Example of a Six Node Ring with Two VT Tunnels

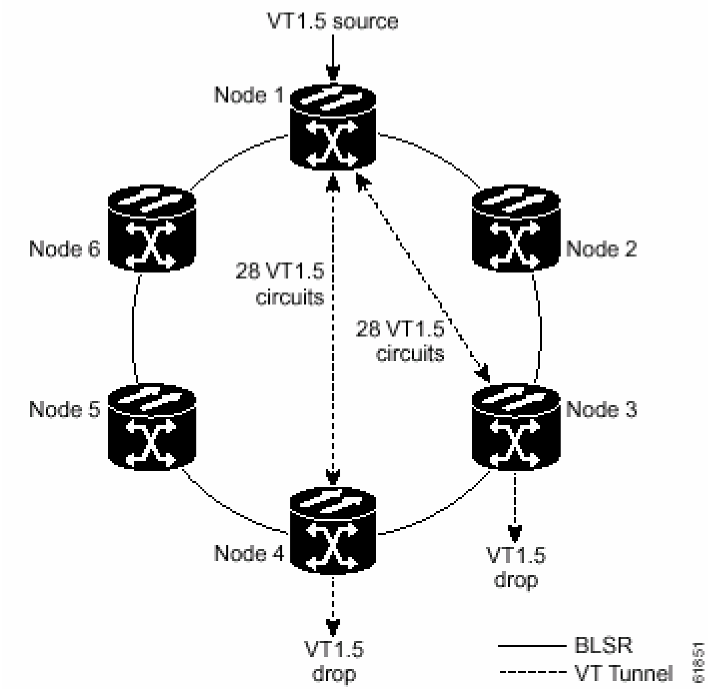


Table 2-14: STS Usage on the VT1.5 Matrix

Node	VT Tunnel (BLSR)	VT Tunnel (Path Protection Configuration or 1+1)	No VT Tunnel (BLSR)	No VT Tunnel Path Protection Configuration	No VT Tunnel (1+1)
1	4	6	4	6	6
2	0	0	4	6	6
3	2	3	4	6	6
4	2	3	4	6	6
5	0	0	4	6	6
6	0	0	4	6	6

When planning VT1.5 circuits, weigh the benefits of using tunnels with the need to maximize STS capacity. For example, a VT1.5 tunnel between Node 1 and Node 4 passing (transparently) through Nodes 2 and Node 3 is advantageous if a full STS is used for Node 1 to Node 4 VT1.5 traffic (that is, the number of VT1.5 circuits between these nodes is close to 28). A VT tunnel is required if:

Node 2 or Node 3 have XC cards, or

All STSs on the VT1.5 matrix at Node 2 and Node 3 are in use

However, if the Node 1 to Node 4 tunnel carries a few VT1.5 circuits, creating a regular VT1.5 circuit between Nodes 1, 2, 3, and 4 might maximize STS capacity.

When you create a VT1.5 circuit during provisioning, the Cisco Transport Controller (CTC) determines whether a tunnel already exists between source and drop nodes. If a tunnel exists, CTC checks the tunnel capacity. If the capacity is sufficient, CTC routes the circuit on the existing tunnel. If a tunnel does not exist, or if an existing tunnel does not have sufficient capacity, CTC displays a dialog box asking whether you want to create a tunnel. Before you create the tunnel, review the existing tunnel availability, keeping in mind future bandwidth needs. In some cases, you may want to manually route a circuit rather than create a new tunnel.

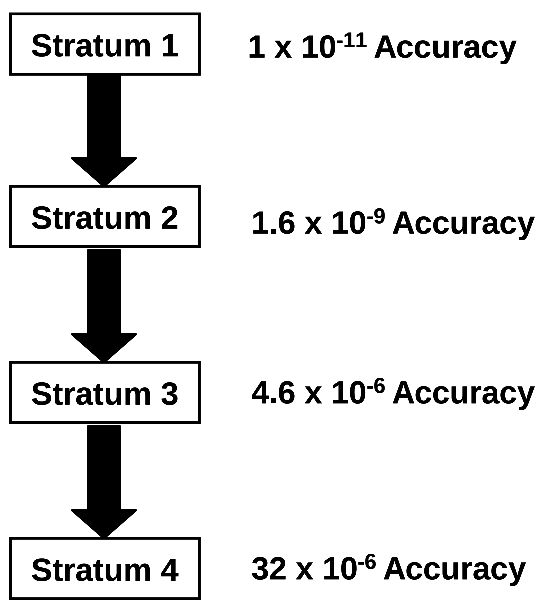
Synchronization and Timing

Network synchronization and timing are critical elements within a SONET network. The goal is to create a fully synchronous optical hierarchy by ensuring that all ONS 15454 nodes derive timing traceable to a primary reference source (PRS). An ONS 15454 network may use more than one PRS. A PRS is equipment that provides a timing signal whose long-term accuracy is maintained at 10-11 or better with verification to Universal Time Coordinated (UTC), and whose timing signal is used as the basis of reference for the control of other clocks within a network.

Network Clock Sources

A stratum 1 timing source is typically the Primary Reference Source (PRS) within a network, because it ensures the highest level of performance of a SONET network. Other types of clocks used in the synchronized network include stratum 2, 3E, 3, 4E, and 4, In most cases these clocks are components of a digital synchronization network and are synchronized to other clocks within that network using a hierarchical master-slave arrangement. In this arrangement, each clock receives timing, usually in the form of primary and secondary reference signals, from another clock of the same or better quality. Figure 2-14 shows the timing accuracy hierarchy supported by the ONS 15454.

Figure 2-14: ONS 15454 Timing Hierarchy



The clocks used to synchronize ONS 15454 nodes must be stratum 3 (or better quality) to meet ANSI T1.101 synchronization requirements.

Building Integrated Timing Supply (BITS)

In the United States, a Building Integrated Timing Supply (BITS) clock is commonly used to distribute timing signals from Stratum clocks to an ONS 15454 node. BITS timing references run over the working and protect SONET paths.

Cesium Clock

Local Cesium clocks (often referred to as atomic clocks) can also be used to provide stratum 1 quality synchronization. The advantage of a Cesium clock is that it never needs recalibration. However, the cost for each unit is very high.

Global Positioning System (GPS)

Compared to Cesium clocks, the Navstart Global Positioning Satellites provide a lower cost alternative source for network synchronization. These satellites are accessible throughout North America and have internal cesium clocks that can be used as a Stratum 1 source. A GPS receiver costs much less than a Cesium clock.

ONS 15454 Timing Guidelines

The Cisco ONS 15454 is designed to operate in networks compliant with the Telcordia GR-253-CORE, and GR-436-CORE.

Timing guidelines for the ONS 15454 evolve around the following conditions:

Where BITS timing is available, configure the ONS 15454 node to be externally timed from the BITS clock.

Where no BITS timing is available, configure the ONS 15454 node to be lined timed from an OC-N signal.

Where both external and line time references are to be used, configure the ONS 15454 for mixed-timing.

Timing and Synchronization Features

Timing and synchronization in the ONS 15454 is controlled by the Timing Control Card (TCC), which is stratum 3 compliant. A redundant architecture protects against failure or removal of one TCC card. For timing reliability, the TCC card selects either a recovered clock, a BITS clock, or an internal stratum as the system timing reference. You can provision any of the clock inputs as primary or secondary timing sources. If you identify two timing references, the secondary reference provides protection. A slow-reference tracking loop allows the TCC to track the selected timing reference and synchronize to the recovered clock and provide holdover in the event the reference is lost. In a fail-over scenario, selection of the next timing reference is governed by the availability of the next best (clock quality) timing reference as defined by the Stratum hierarchy (discussed in the next section). The timing modes available on the ONS 15454 include the following:

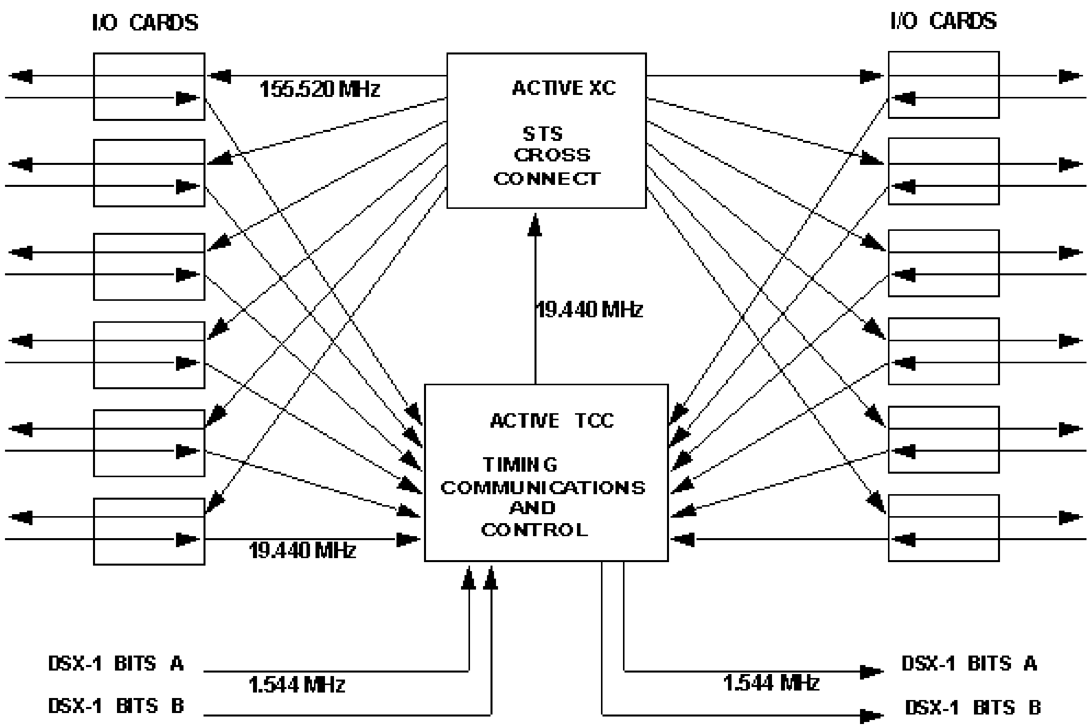
External (BITS) timing
Line (Optical) timing
Mixed (both External and Internal) sources
Holdover (automatically provided when all references fail)
Free-running (a special case of holdover)

Warning Timing loops can be created when you select both external and line timing references. Use Mixed mode of timing with caution.

Through-timing and per-port loop timing are additional timing modes available, but are not supported for the optical synchronous interfaces. DS1 and DS3 asynchronous interfaces are through-timed and do not reference the system timing. For these asynchronous ports, transmit timing is derived from the received timing for that asynchronous signal.

The transmit timing on all optical synchronous interfaces is derived from the system timing reference provided by the TCC cards. Figure 2-15 illustrates how timing signals flow through the ONS 15454. The TCC selects a timing reference from one of several sources as discussed above and distributes this reference to the synchronous interface cards.

Figure 2-15: ONS 15454 Timing Flow



The TCC synchronization functions include:

Reference monitoring, qualification and selection
Filtering and locking to the active reference
Distribution of 19.44MHz system clock
Termination of two BITS inputs
Generation of two BITS outputs
Processing and generating SSM (Synchronization Status Messages)

External BITS Timing

The external timing input signal on the Cisco ONS 15454 must come from a synchronization source whose timing characteristics are better than the stratum 3 internal clock. The TCC will track the external reference with the internal clock.

The BITS signal is a DS-1 level, 1.544 MHz signal, formatted either as Superframe (SF, 12 frames per superframe) or the Extended Superframe (ESF, 24 frames per superframe) ESF. For the ONS 15454, the default setting for the BITS framing reference is ESF, but you may change this to SF if necessary. The default setting for BITS line coding reference is B8ZS, however this can be changed to AMI if required. The default setting for BITS State is OOS (out of service). For nodes using external timing or the external BITS Out, you must change this setting to IS (in-service). The redundant architecture of the ONS 15454 provides two inputs for connection to external BITS clocks – BITS1 and BITS2. If these inputs have been selected as the primary and secondary synchronization sources, the active and standby TCC cards will monitor both inputs. If the primary input fails, the secondary input will be selected. Failure switching is discussed in more detail later. It is recommended, but not necessary, to have redundant BITS inputs. However, if only a single BITS source is available, the secondary source can be set to Internal or Line synchronization.

Note that DS-1s delivered over traffic links are not suitable BITS sources. The primary reason is that SONET compensation for off-frequency DS-1s results in jitter since controlled slips are not performed.

Table 2-15 provides a summary of the BITS input physical connections and signal formats for the ONS 15454.

Table 2-15: Summary of BITS Inputs and Signal Formats

Number of BITS Inputs	BITS Input Physical Connection	BITS Input Signal Format
2	4 wire-wrap pins provide connections for redundant BITS clock inputs.	1.544 Mb/s DSX-1 with either SF or ESF (required for SSM support) framing format.

Line Timing

The ONS 15454 can accept reference timing from any optical port. For increased reliability, optical cards with multiple ports (e.g. 4-port OC-3) can only have one of its ports provisioned as a timing reference. The optical cards divide down the recovered clock to 19.44 MHz and transmit it to the working and protect TCC cards, where it is qualified for use as a timing reference.

Synchronization Status Messaging (SSM) can be optionally enabled or disabled on an optical port. A controller on the optical card monitors the received SSM and reports any changes to the TCC synchronization process. If an optical port (receiver) is selected as the active timing reference, the SSM value DUS (Don't Use for Synchronization) is transmitted (on the transmit port) to help prevent timing loops. If SSM is disabled, the controller does not monitor the received SSM value and transmits the SSM value STU (Synchronized, Traceability Unknown). More information on SSM is available later in this chapter.

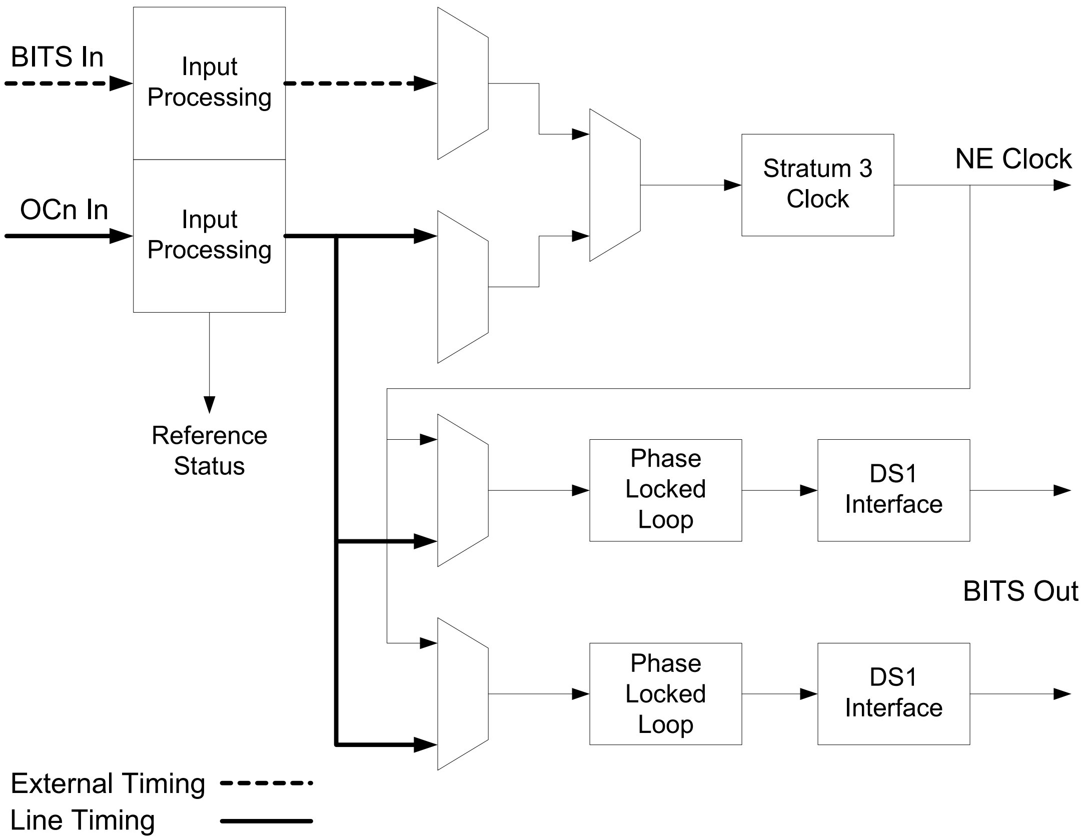
Mixed Mode Timing

Caution

Mixed Mode Timing allows you to select both external and line timing sources. However, Cisco does not recommend its use because it can create timing loops. Caution must be used when using Mixed Mode timing as it can result in inadvertent timing loops. The most common reason for using Mixed Mode Timing is so that an OC-N timing source can be provisioned as a backup for the BITS timing source.

The Mixed Mode Timing feature enhances the provisioning options for the NE Reference only. The rules associated with the BITS Out timing source have not changed. To review these rules, Figure 2-16 has been provided to show the ONS 15454 timing circuit.

Figure 2-16: ONS 15454 Timing Circuit



The operation of the timing circuit shown above is as follows:

The incoming references from the BITS input and the OC-N recovered clocks are monitored for errors.

Depending on the timing mode, the multiplexers select the appropriate input reference for the Stratum 3 clock.

The timing reference is then filtered through the Stratum 3 clock and the resulting output is the NE clock.

The source of the BITS outputs can be selected from either the OC-N recovered clock or the NE clock.

Note If the NE clock is derived from the BITS In (i.e., when the node is provisioned for External Timing or Mixed Mode Timing), then the NE clock cannot be used as the source for a BITS Output.

Free-running Mode

The ONS 15454 is considered to be in Free-run state when it is operating on its own internal clock. The ONS 15454 has an internal clock in the TCC that is used to track a higher quality reference, or in the event of node isolation, provide holdover timing or a free-running clock source. The internal clock is a certified stratum 3 clock with enhanced capabilities that match the stratum 3E specifications for:

Free-run accuracy
Holdover frequency drift
Wander tolerance
Wander generation
Pull-In and Hold-In
Reference locking/Settling time
Phase transient (tolerance and generation)

Table 2-16 provides the timing characteristics of stratum 3 and stratum 3E clocks, and compliance details for the ONS 15454.

Table 2-16: Stratum 3 and 3E Compliance

Timing Characteristics	Stratum 3	Stratum 3E	ONS 15454 Compliance
Free Run Accuracy	4.6 ppm	4.6 ppm	Comply with stratum 3E
Holdover Stability			
Holdover - Initial Offset	50 ppb	1ppb	5 ppb
Holdover - Frequency Drift	4.63×10^{-7}	1.16×10^{-8}	Comply with stratum 3E
Holdover - Temperature Stability	280 ppb	10 ppb	Comply with stratum 3
Wander Tolerance	per GR-253	per GR-253	Comply with stratum 3E
Wander Transfer	0.1Hz	0.01Hz	Comply with stratum 3
Wander Generation	per GR-253	per GR-253	Comply with stratum 3E
Pull-In and Hold-In Reference	4.6×10^{-6}	4.6×10^{-6}	Comply with stratum 3E
Locking/Settling Time	700 ms	100 ms	Comply with stratum 3E
Phase Transients			
Tolerance	1us	1us	Comply with stratum 3E
Generation	per GR-253	per GR-253	Comply with stratum 3E
Build-Out	None	>3.5us	Comply with stratum 3E[1]

[1] Line Build Out (LBO) is not supported in system releases prior to Release 3.3.

Holdover Mode

Holdover is the operating condition of a clock that has lost its external references, but continues to use reference information that was acquired during normal operation. Holdover is a failover state after a system clock has been continuously "locked & synchronized" to a more accurate reference for more than 140 seconds. It "holds" the original operating parameters for a defined period. The holdover frequency will start to drift over time, particularly when the "holdover period" has expired. Holdover conditions can be caused by:

Failure of the External BITS timing reference
Failure of the optical Line timing reference

Holdover frequency is a measure of a clock's performance while in holdover mode. The holdover frequency offset for stratum 3 is 50×10^{-9} initially (the first minute), and an additional 40×10^{-9} for the next 24 hours. The ONS 15454 goes into Holdover when the last available reference is lost and the node was synchronized to that reference for more than 140 seconds. During this period, the internal clock is held at the last known value of the Phase Lock Loop (PLL) parameters when the node was still synchronized to the reference clock. If the holdover frequency value is corrupted, the ONS 15454 will switch to Free-run mode.

BITS Out

BITS Out provides a clock source for other network elements that do not have a BITS or Line clock source. In the ONS 15454, the BITS Out clock is extracted from an optical Line source, regardless of the selected timing mode (External, Line, or Mixed). If a BITS clock is available at the facility, the other network elements should be timed directly from the BITS source. In Line timed mode, in addition to the optical Line sources, the BITS Out Reference list includes 'NE Reference'. 'NE Reference' enables the node's active Line reference to be automatically selected as the BITS Out signal. This option is not available in External or Mixed timing modes.

Table 2-17 provides a summary of the physical connections and signal formats for BITS Out.

Table 2-17: BITS Out connections and Signal Formats

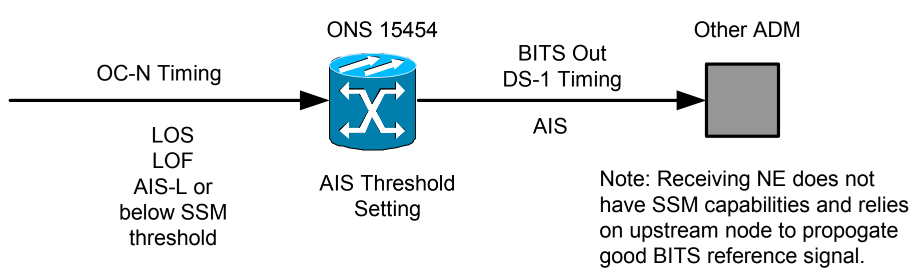
Number of BITS Outputs	BITS Output Physical Connection	BITS Output Signal Characteristics
2	4 BITS pins provide connections for redundant BITS clock outputs on the ONS 15454 backplane.	1.554 Mb/s DSX-1 signal. DS-1 format per BITS Facilities setting.

As indicated in the table, BITS Out is a DS-1 signal (same as BITS input). BITS Out framing (ESF or SF) and coding (AMI or B8ZS) formats are configured in the BITS Facilities section in the Cisco Transport Controller (CTC). The configured framing and coding formats apply to both, the BITS Out and BITS input signals.

For both ESF and SF, BITS Out is a framed, "all ones" signal (not to be confused with AIS, which is an unframed "all ones" signal). SSM is available only with ESF framing. The SSM value of the selected optical reference for BITS Out is passed through to the BITS Out signal.

SSM is not available with SF formatted DS-1. However, to insure reliability, when the BITS Out signal is used with equipment in SF mode or with no SSM capability, an AIS Threshold Settings can be provisioned in CTC. In this configuration, AIS will be sent as the BITS Out signal when the quality level of all selected optical references fall below the set threshold. The connected equipment can then switch to an alternate timing reference. Figure 2-17 provides a list of conditions under which AIS will be sent on the BITS Out facility.

Figure 2-17: BITS Out AIS Conditions



Synchronous Status Messaging (SSM)

Caution The use of SSM in a timing network does not automatically prevent timing loops. Proper synchronization planning is required.

The BITS signal is a DS-1 level, 1.544 MHz signal, formatted either as Superframe (SF, 12 frames per superframe) or the Extended Superframe (ESF, 24 frames per superframe) ESF. For BITS sources, SSM is supported by messages embedded into the 4 kbps, 'Facility Data Link' of DS-1 ESF signals. SSM is not available with DS-1 SF signals. In the SF mode, the AIS signal (unframed 'all-ones') indicates an unsuitable reference.

In the SONET protocol, SSM is carried in the S1 byte of the SONET line overhead. SSM enables SONET devices to automatically select the highest quality timing reference and helps to avoid timing loops. If the timing signal is lost on the active path, the NE switches to an alternate path for timing according to the SSM hierarchy.

The ONS 15454 node supports two sets of SSMs: Generation 1 and Generation 2. Generation 1 is the most widely used SSM message set. Generation 2 is a newer version that defines additional quality levels. Table 2-18 describes the Generation 1 message set and Table 2-19 describes the Generation 2 message set.

Table 2-18: SSM Generation 1 Message Set

Message	Quality Level	Description	S1 Bits 5-6-7-8
PRS	1	Primary reference source traceable – Stratum 1	0001
STU	2	Synchronized - traceability unknown	0000
ST2	3	Stratum 2 Traceable	0111
ST3	4	Stratum 3 Traceable	1010
SMC	5	SONET Minimum Clock traceable	1100
ST4	6	Stratum 4 Traceable	NA
DUS	7	Do not use for timing synchronization	1111
RES	User Defined	Reserved - quality level set by user	1110

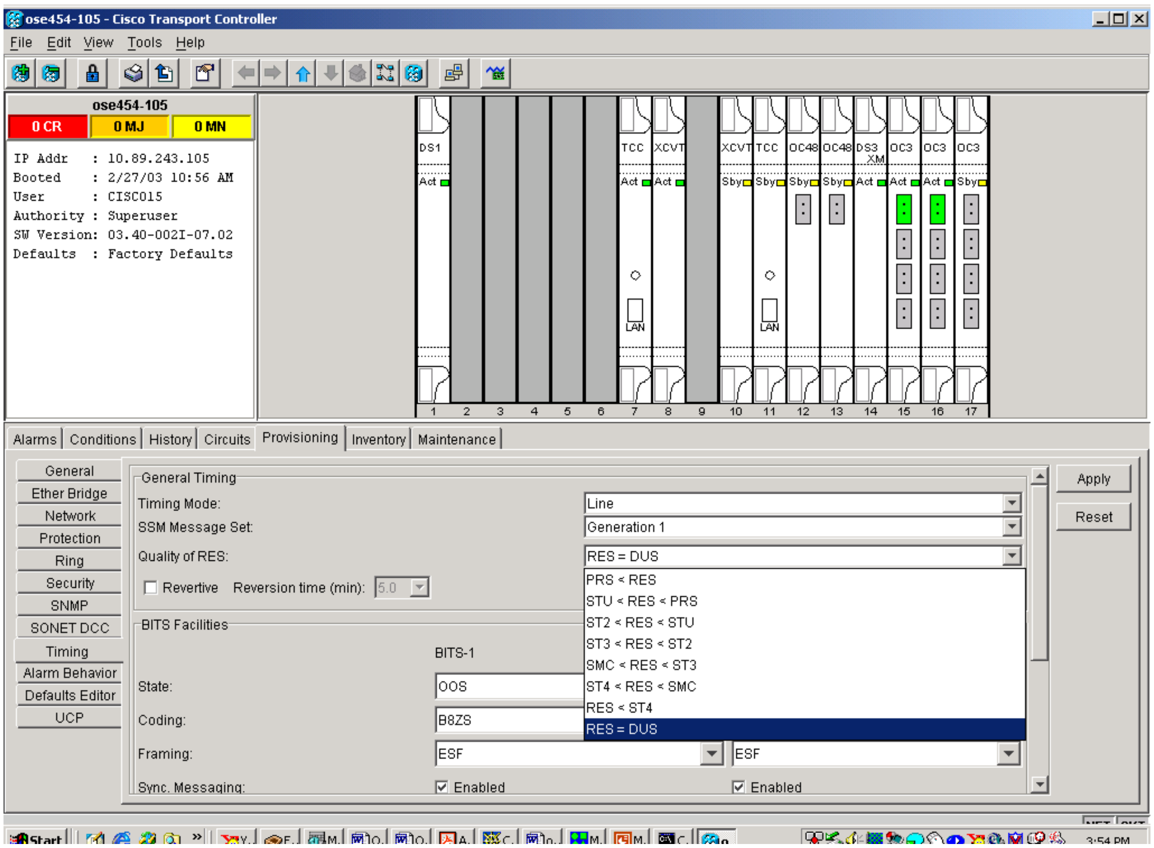
Table 2-19: SSM Generation 2 Message Set

Message	Quality Level	Description	S1 Bits 5-6-7-8
PRS	1	Primary reference source - Stratum 1	0001
STU	2	Synchronized - traceability unknown	0000
ST2	3	Stratum 2 Traceable	0111
TNC	4	Transit node clock	0100
ST3E	5	Stratum 3E Traceable	1101
ST3	6	Stratum 3 Traceable	1010
SMC	7	SONET minimum clock	1100
ST4	8	Stratum 4 Traceable	NA
DUS	9	Do not use for timing synchronization	1111
RES	User Defined	Reserved - quality level set by user	1110

Setting Quality of RES

RES is a user-defined SSM value that enables the quality level of a clock source to be set between any of the defined standard levels. For example, if there are two Stratum 1 sources in the network, with one being of slightly lower quality than the other (GPS source versus a Cesium source), its SSM value can be set to RES, instead of PRS. The Cesium source will be PRS. In every node in the network, Quality of RES can be set to “STU<RES<PRS”. This setting defines PRS as the highest quality clock and RES as the next highest quality clock (RES is greater than STU, but less than PRS). The CTC screen in Figure 2-18 shows the available settings for RES. If the RES SSM is used in an ONS 15454 network, its assigned quality level must be provisioned in every node in the network. The default setting is RES=DUS.

Figure 2-18: Quality of RES Settings



Using the ONS 15454 Without SSM

Older BITS clock sources may not provide SSM to the ONS 15454 BITS input signals. In this case, Sync Messaging must be disabled in CTC for the BITS 1 and BITS 2 inputs. The SSM value of STU (Synchronized, Traceability Unknown) will be assigned to the BITS inputs and used in the S1 byte on the optical ports. Note that a different SSM value (such as PRS) cannot be provisioned for the S1 byte to manually define the quality of the node’s clock. A BITS input is considered to be failed when AIS is present at the input.

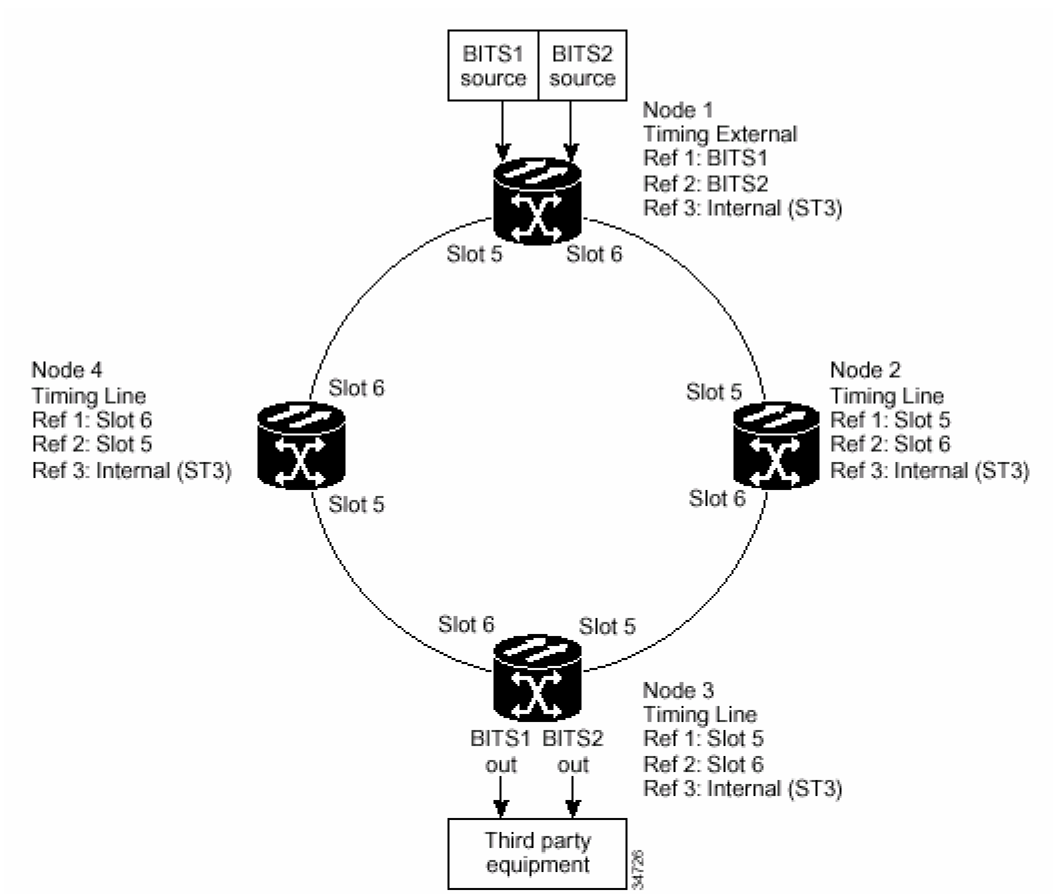
Network Timing Example

Figure 2-19 shows a typical ONS 15454 network timing setup example. Node 1 is set to external timing. Two timing references are set to BITS. These are Stratum 1 timing sources wired to the

BITS input pins on the backplane of Node 1. The third reference is set to internal clock. The BITS output pins on the backplane of Node 3 are used to provide timing to outside equipment, such as a Digital Access Line Access Multiplexer.

In the example, Slots 5 and 6 contain the OC-N trunk cards in each node. Timing at Nodes 2, 3, and 4 is set to line, and the timing references are set to the port of the trunk OC-N cards based on distance from the BITS source. NE Reference 1 is set to the port of the OC-N trunk card closest to the BITS source. At Node 2, the NE Reference 1 is the port of the OC-N card in Slot 5, because it is connected to Node 1. At Node 4, the NE Reference 1 is set to the port of the OC-N card in Slot 6, because it is connected to Node 1. At Node 3, the NE Reference 1 could be the port of either OC-N trunk card because they are equal distance from Node 1.

Figure 2-19: An ONS 15454 Network Timing Example



Failure Switching

Depending on the network condition, the ONS 15454 will operate in one of the following synchronization modes.

Normal Mode: The system clock is synchronized to a reference source. The output frequency of the clock is the same as the input reference frequency over the long term. The Sync LED on the TCC card indicates Normal Mode.

Fast Start Mode: Used for fast pull-in of a reference clock, Fast Start is active when the internal reference frequency is offset from the external reference clock. If the frequency is offset by more than 2ppm (parts per million) in every 30 seconds (called the "wander threshold"), the secondary reference source will be selected. The ONS 15454 will revert back to the primary reference source when it is within the specified threshold (i.e. +/- 15ppm). During the switching process, the internal clock will be in Fast Start mode. Fast Start is sometimes referred to as the "Acquire State".

Holdover Mode: The ONS 15454 goes into Holdover when the last available reference is lost and the node was synchronized to that reference for more than 140 seconds. During this period, the internal clock is held at the last known value of the Phase Lock Loop (PLL) parameters when the node was still synchronized to the reference clock. If the holdover frequency value is corrupted, the ONS 15454 will switch to Free-run mode.

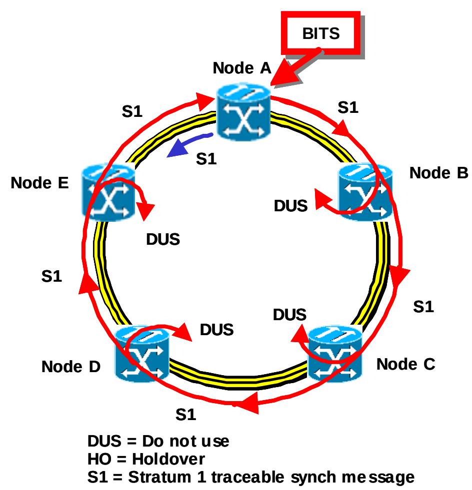
Free-run Mode: The ONS 15454 is considered to be in Free-run state when it is operating on its own internal clock. Free-run accuracy for the ONS 15454 and most SONET nodes is stratum 3. The minimum accuracy for any SONET node must be better than the SONET Minimum Clock (SMC), which is +/- 20ppm.

A timing reference is considered failed if its SSM message is traceable to a source that is worse than the quality of the ONS 15454 internal clock. For example, a node with an internal Stratum 3 clock would consider a reference to be failed if it has a SSM message traceable to SMC or ST4 clock. Also, the node will not select a reference for timing if it has the DUS (Don't Use for Synchronization) SSM message.

Switching Example

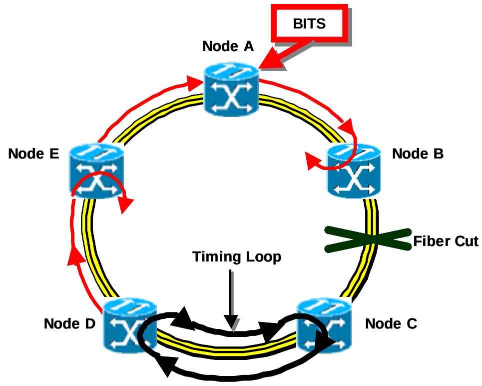
The Cisco ONS 15454 generates the synchronization message in the outgoing SONET signals. The synchronization messaging allows the ONS 15454 nodes in a ring to maintain their correct configuration. In Figure 2-20, the BITS clock is connected to Node A and timing is maintained around the ring from Node A to Node E. The SSM is a Stratum 1 traceable signal that passes from Node A, (external timed) to all the other nodes (line timed).

Figure 2-20: Normal Operation



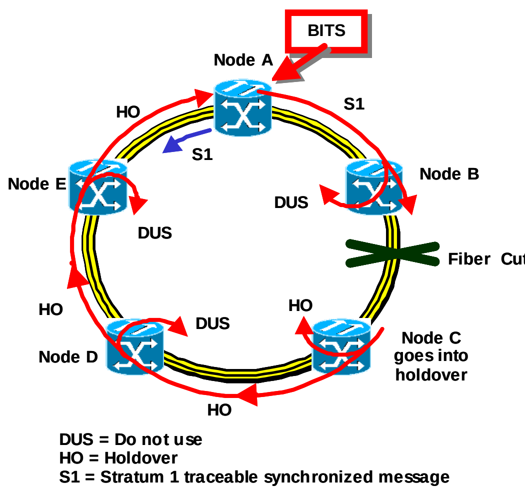
Fiber is cut between Node B and Node C, causing a failure. A ring failure in a system without SSM that uses simple reference switching results in a timing loop shown in Figure 2-21.

Figure 2-21: Ring Failure and Timing Loop



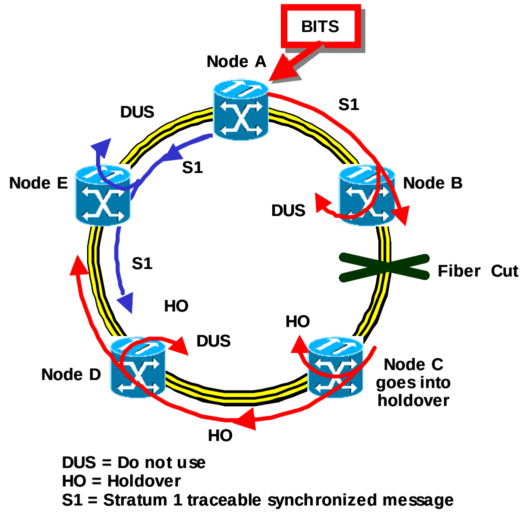
In a system using SSM, the fiber cut in Figure 2-22 interrupts the timing signal around the ring. Since Node C was the receiving clock from Node B (line timed), and has lost signal, Node C goes into short-term holdover and uses its internal clock.

Figure 2-22: Ring Failure with SSM



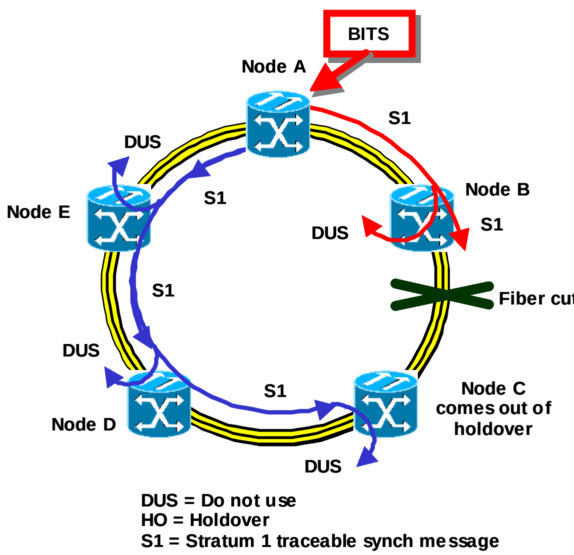
In Figure 2-23, synchronization message 1 is now being sent to Node E directly from Node A (counterclockwise) instead of clockwise around the ring. At this point, Node E switches to lime timing from Node A.

Figure 2-23: Synchronization Switch



Synchronization message S1 continues to Nodes E, D, and C in the counterclockwise direction as shown in Figure 2-24. All nodes switch their line timing to the line receiving S1, which allows Node C to exit holdover. At this point, the ring is reconfigured and all nodes are again synchronized to BITS.

Figure 2-24: Synchronization Reconfigures Around the Ring



Switching Time

On a failure or when the SSM value indicates that a higher quality reference is available, switching is instantaneous. The Wait To Restore period is ignored if reversion to the higher priority reference is active. However, if two references have the same SSM value, the Wait To Restore period must elapse before the ONS 15454 will revert back to the higher priority reference.

Network Synchronization Design

In most ONS 15454 networks, at least one or more nodes must be set to External timing. All other nodes can be set to Line timing. The timing architecture should insure that timing loops do not occur when there is a network failure. Externally timed nodes receive timing from a BITS source wired to the BITS backplane pins. The BITS source, in turn, gets its timing from a PRS, such as a stratum 1 clock or GPS signal. In networks with multiple BITS sources, the “STU<RES<PRS” SSM value can be used as described earlier. The Line timed nodes receive timing from optical pots.

Caution Some DS-1 sources have slip buffers that enable controlled slips of the DS-1 signal to be performed. The ONS 15454 does not support controlled slips on it synchronization inputs.

Number of Line Timed Spans (Daisy-chained)

Currently, test results validate that 13 line-timed nodes can be daisy-chained without any effect on timing wander and jitter. The timing architecture can be arranged such that a single Externally timed source can provide Line timing for 13 nodes in the east direction and 13 nodes in the west direction for a total of 26 nodes.

DWDM Spans (2R vs 3R)

In spans with 2R (Re-shape and Re-amplify, but not Re-time) DWDM systems the synchronization characteristics are simply passed-through (i.e., jitter is passed through) and there is no effect on network synchronization. However, with 3R (Re-shape and Re-amplify, Re-time) DWDM systems, the re-timing must be done from a stratum 1 source.

Protection Switching

Optical protection switching occurs automatically in response to detected faults, as well as manual requests initiated by local or remote users. The Cisco ONS 15454 supports 50 milliseconds (ms) 1+1 unidirectional or bi-directional protection switching upon detecting a signal failure or condition such as LOS, LOF, AIS-L or high BER on one or more of the optical card’s ports. Revertive and nonrevertive switching options are available down to the circuit level.

The protection modes supported by the Cisco ONS 15454 are described in Table 2-20.

Table 2-20: Protection Modes

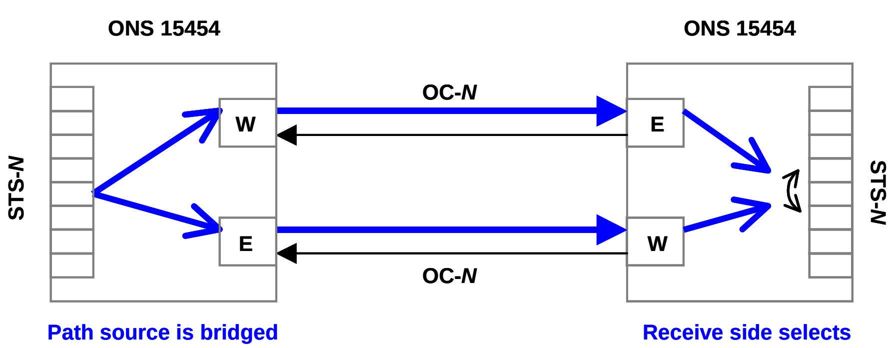
Mode	Description
Unidirectional	Each ONS 15454 node bridges it's transmit information on the working and protect lines. When traffic is switched from a bad line, only the receiving node performs a switch. The APS channel (which is carried in the K1 and K2 bytes of the signal on the protection line) is used to indicate the local switch action and the mode of operation. Path Protection Configuration is the default mode for 1+1 protection groups in the ONS 15454.
Bi-directional	Each ONS 15454 node monitors it's receive bit stream on the currently active path. When a problem is detected, both nodes transfer their transmit bit stream to the protection line. Switching of only one direction is not allowed. Head end to tail end signaling is accomplished using the APS channel. The ONS 15454 Bi-directional Path Switched Ring (BLSR) protection mode is configured by the user during initial turn up of the ring.
Revertive	In revertive mode, a failure is detected and the working line temporarily switches to the protect line using the K1/K2 bytes. When the working line is restored and meets the BER criteria, a wait-to-restore (WTR) timer is initiated in the ONS 15454 to prevent "switch bouncing." Traffic is switched back to the working line at both ONS 15454 nodes when the working line has recovered from the failure and the WTR interval has been met, or the manual switch command is cleared. Traffic will revert back to the working line again using the K1/K2 bytes. Revertive protection is illustrated in Figure 2-28.
Non-Revertive	In non-revertive mode, the ONS 15454 detects a failure and switches the working line to the protect line using the K1/K2 bytes. The protect line now becomes the working line and the previous working line will become the protect line. If the line that failed is restored, traffic will not switch back. There is no WTR setting for non-revertive switching. Traffic will not be switched back unless the current working line develops trouble. Non-revertive protection is illustrated in Figure 2-29.

Path Protection Switching

Path protection switching in an ONS 15454 system means, first, discovering that the active path is no longer performing as desired, and second, switching the payload to an alternate path that is flawless (or at least better than the active path). In the STS Path level protection example shown in Figure 2-25, the path signal is bridged or split at the "head end" or at the source. Two copies of the signal are transmitted to the destination point, where the receiver selects the best signal based on Path level parameters (B3 and AIS). STS Path switching is automatically initiated by any of the following conditions:

Loss of Pointer (LOP)
STS or VT Alarm Indication Signal (AIS)
STS Payload Defect Indicator (PDI-P)
Excessive BIP-8 Errors of STS Path
Excessive BIP-2 Errors for VT Path

Figure 2-25: STS Path Switching

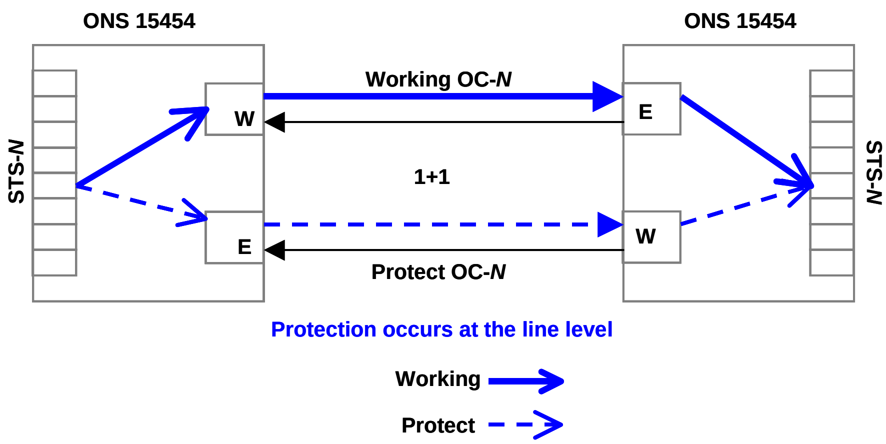


Line Protection Switching

The Line protection switching example shown in Figure 2-26, a single copy of the signal goes through the working line of the system. If the working line fails, then traffic will switch over to protection using line layer parameters (K1, K2, and B2). The ONS 15454 will automatically initiate a Line protection switch if any of the following conditions occur:

Loss of Signal (LOS)
Loss of Frame (LOF)
Line AIS
SD (Excessive BIP-8 errors in the Line overhead)

Figure 2-26: Line Protection Switching



Automatic Protection Switching

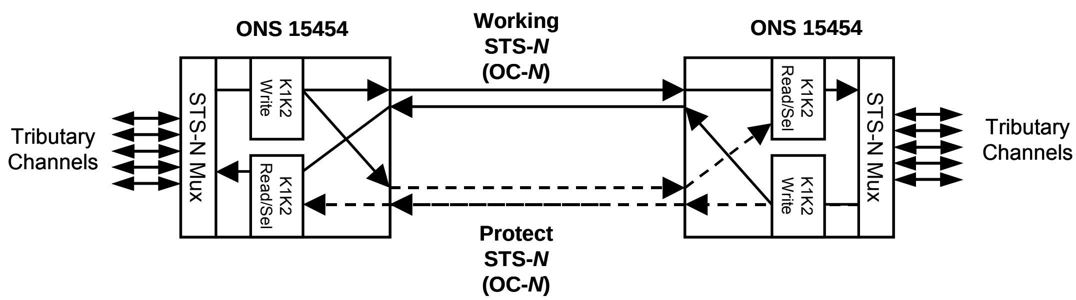
Automatic Protection Switching (APS) is switching that is initiated by the ONS 15454 based on built-in algorithms, assisted by Performance Management (PM) threshold settings and protection options stored in the TCC database. The first setting stored in the TCC is the type of SONET OC-N) cards that have been installed in the ONS 15454 (i.e., OC-3, OC-12, OC-48, OC-192). Each OC-N port has two pre-selected thresholds for protection switching: Signal Fail (SF) and Signal Degrade (SD).

SF is a "hard failure" condition detected on the incoming OC-N signal. The ONS 15454 monitors the bit error rate (BER) on the incoming OC-N signal and will switch to the protect span if the BER exceeds 1E-3 (one bit error in 1,000 bits) or if the ONS 15454 detects a Loss of Signal (LOS), Loss of Frame (LOF), or Alarm Indication Signal (AIS). If a span goes into the SF condition, the ONS 15454 will switch traffic to the protect span, even if that span is in the SD condition. The BER default threshold setting is 1E-4 (one bit error in 10,000 bits), but it may be changed to 1E-3 or 1E-5.

SD is a "soft failure" condition resulting from the Line BER exceeding 1E-6. When the ONS 15454 detects a BER exceeding 1E-6 on the incoming OC-N, it will announce the SD condition on that line and switch away from it, if possible. The BER default setting is 1E-7 (one bit error in 10,000,000 bits), but it may be changed to 1E-5, 1E-6, 1E-8 or 1E-9.

Other protection settings to be entered into the TCC database include the type of protection and whether the protection is unidirectional, bi-directional, revertive, or non-revertive, and reversion time in minutes (if revertive is chosen). APS is illustrated in Figure 2-27.

Figure 2-27: APS Example



1+1 Protection Switching

The Cisco ONS 15454 supports 1+1 protection switching where you have a working span (i.e., OC-3, OC-12, OC-48 or OC-192) and another span of equal bit rate as the protection span. If anything happens to the working span carrying the traffic, the entire SONET payload is transferred to the protect span.

The ONS 15454 also employs a protection switch that can transfer service from any member of a group of working lines to a spare line within the maintenance span. In this configuration the ONS 15454 monitors all incoming lines so that performance monitoring of a line with poor performance can continue even after service has been switched to the protection line.

Figure 2-28: Revertive Switching

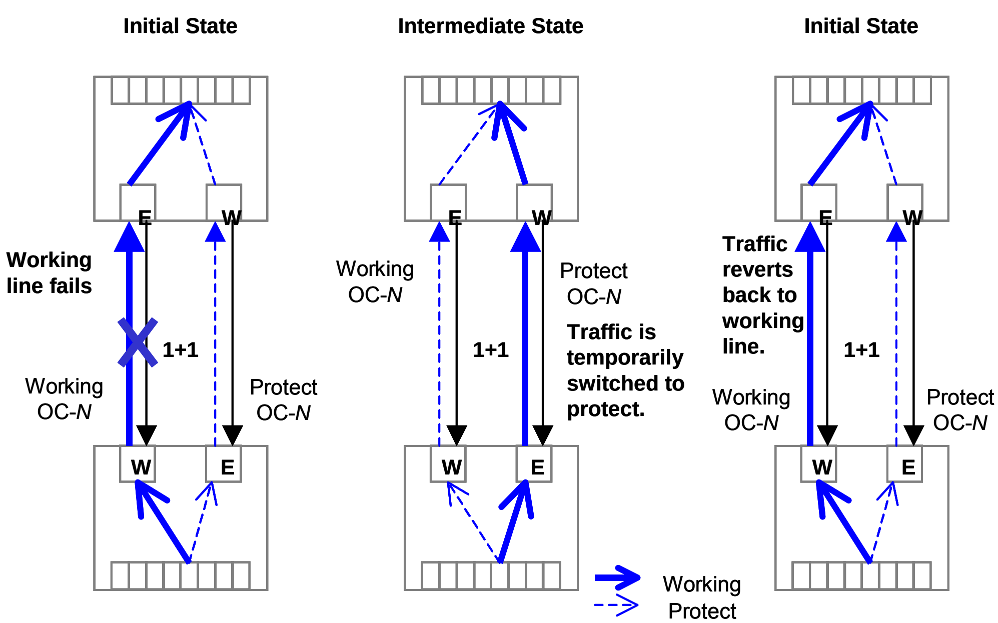
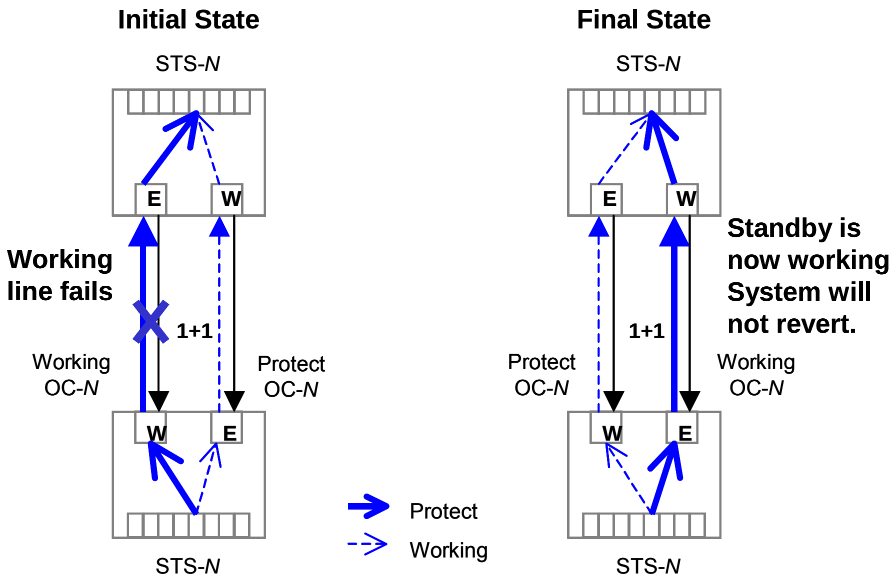


Figure 2-29: Nonrevertive Switching



Network Topologies

There are several ways that ONS 15454 nodes may be connected together to form a network. The ONS 15454 supports point-to-point terminals, linear add/drop multiplexers, Path Protection Configuration, 2-fiber and 4-fiber bi-directional line switched rings (BLSRs), subtending rings, path protected mesh network (PPMN), and virtual rings.

Terminal Mode

In a Terminal Mode (TM) topology, the entire SONET payload is terminated at each end of the fiber span. The nodes are connected by 2 fibers. Protection spans can be added by installing another trunk card, such as an OC-48, or by using additional ports on a multiport optical card, such as an OC-3 or OC-12. TM systems are generally deployed for basic transport applications calling only for a single system solution routed point-to-point. Figure 2-33 shows the traffic flow for a typical TM configuration.

Figure 2-33: Terminal Network Traffic Flow

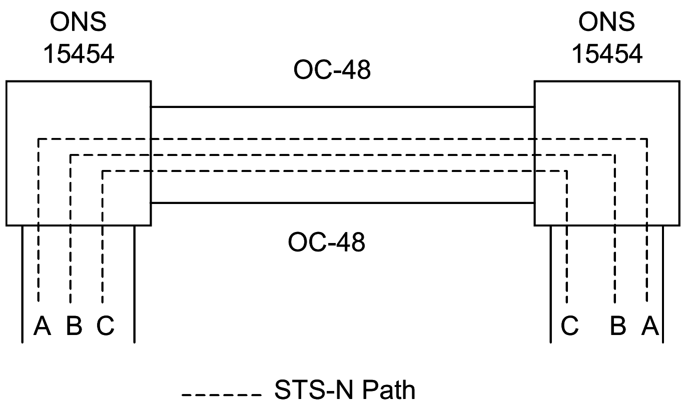
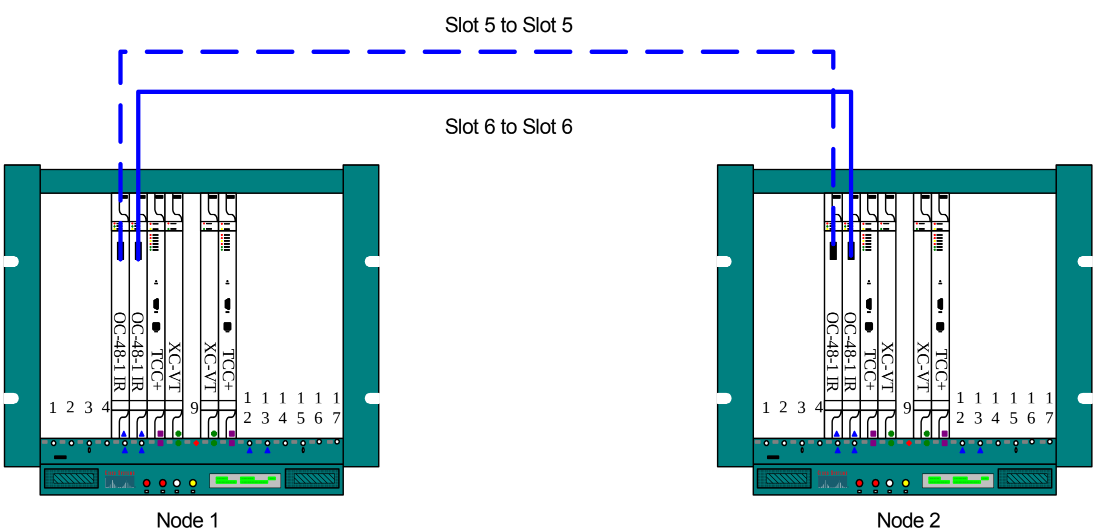


Figure 2-34 shows the node configuration for a point-to-point TM ONS 15454 network. Working traffic flows from Node 1/Slot 6 to Node 2/Slot 6. The protect path runs from Node 1/Slot 5 to Node 2/Slot 5.

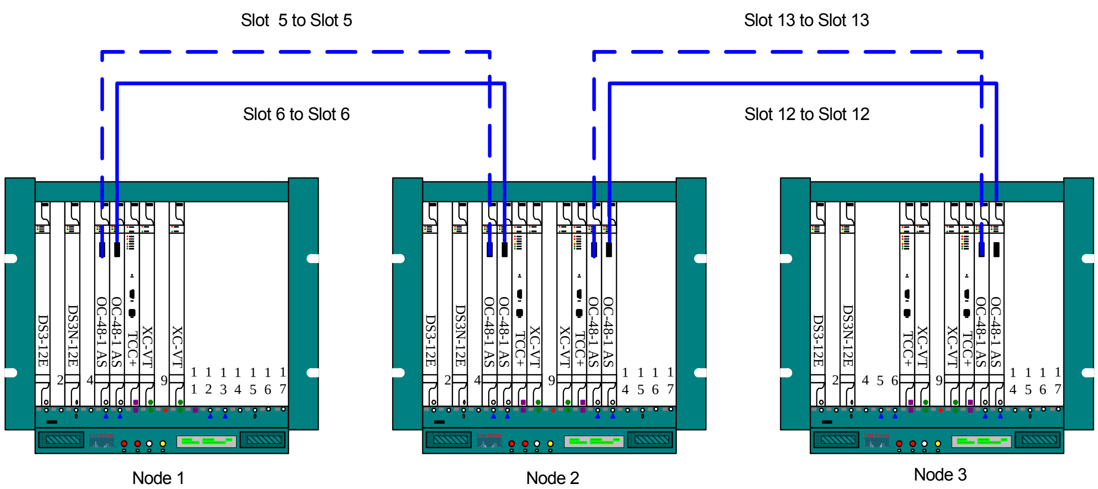
Figure 2-34: Terminal Node Network Configuration



Linear Add/Drop Multiplexer Network

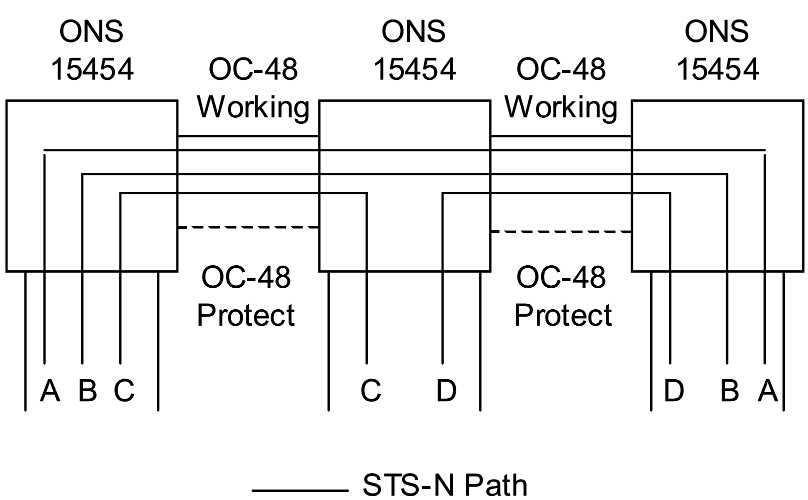
Any ONS 15454 node can be designed as an add/drop multiplexer (ADM) and provide add/drop for DS1, DS3, EC-1, OC-3, OC-12, and OC-48 signals as shown in Figure 2-35. A linear ADM ONS 15454 system can be provisioned for unidirectional or bi-directional OC-N line switching. In unidirectional switching, the OC-N receiver can switch independently from the OC-N transmitter. In bi-directional switching, the OC-N transmitter and receiver switch as a pair. The 1+1 line switching is nonrevertive for either case.

Figure 2-35: Three Node Linear ADM Network



When used in a Linear ADM configuration, each ONS 15454 has direct access to Westbound or Eastbound STS channels at intermediate sites along the fiber route. Cisco ONS 15454 ADM configurations eliminate the need for costly "back-to-back" terminal nodes, and can be enhanced with protection spans for any OC-N rate. Figure 2-36 shows the traffic flow for a typical linear ADM network. Each ONS 15454 node requires two fibers, working and protect optical transmitters and receivers in both directions, and local drops for insertion and termination of any signal in the route.

Figure 2-36: Linear ADM Traffic Flow



2-Fiber Bi-directional Path Switched Ring

A Bi-directional Line Switched Ring (BLSR) is a self-healing ring configuration used to connect two or more adjacent ONS 15454 nodes. The protected network design of a BLSR helps it survive cable cuts and node failures by providing redundant, geographically diverse paths for each SONET span.

The ONS 15454 BLSR functionality is based on criteria found in GR-1230-CORE. Since the flow of traffic between nodes is bi-directional, traffic can be added at one node and dropped at the next without traveling around the entire ring. This allows you to reuse the available STS bandwidth between the other nodes for additional traffic. Thereby enabling a BLSR to carry more traffic than a Path Protection Configuration. Table 2-22 shows the bi-directional capacity for 2-Fiber BLSRs. The capacity is the OC-N rate divided by two, multiplied by the number of nodes in the ring minus the
number of pass-through STS-1 circuits.

Table 2-22: 2-Fiber BLSR Capacities

OC-N Rate	Working Bandwidth	Protection Bandwidth	Ring Capacity
OC-12	STS 1-6	STS 7-12	6 x N[1] – PT[2]
OC-48	STS 1-24	STS 25-48	24 x N – PT
OC-192	STS 1-96	STS 97-192	96 x N - PT

[1] N equals the number of ONS 15454 nodes configured as BLSR nodes.
[2] PT equals the number of STS-1 circuits passed through ONS 15454 nodes in the ring (capacity can vary depending on the traffic pattern).

Starting with System Release 3.4, you can use the protection capacity of a 2-Fiber BLSR to provide unprotected transport for extra traffic when no failures are present. Table 2-23 shows the maximum number of 2-Fiber BLSRs each ONS 15454 node can support.

Table 2-23: Maximum Number of 2-Fiber BLSRs Supported

System Release	Maximum Number of 2- Fiber BLSRs
$\leq$ Release 4.0	2

Each 2-Fiber BLSR can have up to 32 ONS 15454 nodes. Because the working and protect bandwidths must be equal, you can create only OC-12, OC-48, or OC-192 BLSRs.

Note For best performance, BLSRs should have one LAN connection for every 10 nodes in the BLSR.

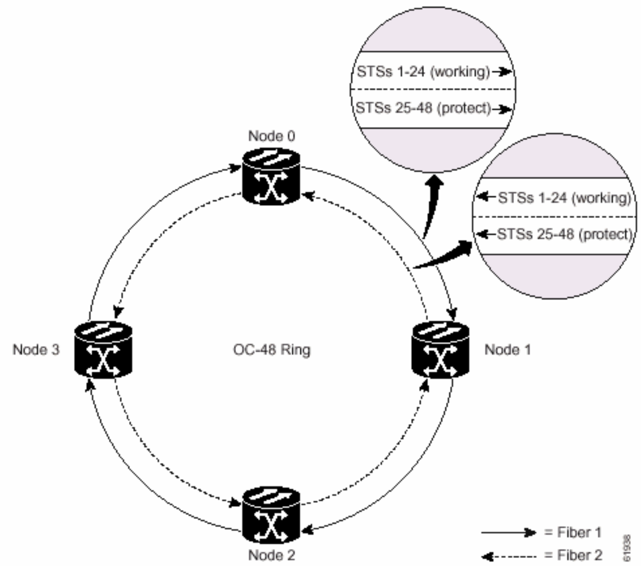
The ONS 15454 automatically creates a squelch table when you provision BLSR circuits. The squelch table works at the STS-1 level. VT1.5 squelching will be supported in a future system release. It is important to remember that bandwidth reuse should not be done at the VT1.5 level. If a VT1.5 circuit passes between two ONS 15454 nodes within an assigned STS, that same VT1.5 bandwidth should not be used to form any other path around the BLSR. Not reusing that same VT1.5 bandwidth around the ring will avoid the potential for incorrect termination upon a protection switch, due to the lack of VT1.5 squelching.

2-Fiber BLSR is the most common topology used by Local Exchange Carriers (LECs) in major metropolitan areas. A 2-Fiber BLSR can provide protection against the failure of an individual fiber pair on the ring. The bi-directional operation of the BLSR provides symmetrical delay for data users. Since only 2-fibers are used to close the ring, 2-Fiber BLSRs are economical to deploy.

In 2-Fiber BLSRs, each fiber is divided into working and protect bandwidths. In the OC-48 BLSR example shown in Figure 2-44, STSs 1 through 24 carry the working traffic, and STSs 25 through 48 are reserved for protection. Working traffic (STSs 1 – 24) travels in one direction on one fiber and in the opposite direction on the second fiber. each BLSR must be assigned a unique Ring ID, which is a number between 0 and 9999. Nodes in the same BLSR must have the same Ring

ID. Each node within a BLSR must be assigned a unique Node ID, which is a number between 0 and 31. CTC's circuit routing routines calculate the "shortest path" for circuits based on many factors, including requirements set by the circuit provisioner, traffic patterns, and distance. For example, in Figure 2-44, circuits going from Node 0 to Node 1 typically will travel on Fiber 1, unless that fiber is full, in which case circuits will be routed on Fiber 2 through Node 3 and Node 2. Traffic from Node 0 to Node 2 (or Node 1 to Node 3), may be routed on either fiber, depending on circuit provisioning requirements and traffic loads.

Figure 2-44: A 4-Node, 2-Fiber BLSR



The SONET K1 and K2 bytes carry the information that governs BLSR protection switches. Each BLSR node monitors the K bytes to determine when to switch the SONET signal to an alternate physical path. The K bytes communicate failure conditions and actions taken between nodes in the ring. If a Cisco ONS 15454 BLSR span passes through third party equipment that cannot transparently transport the K3 byte, remap the BLSR extension byte on the trunk cards on each end of the span.

If a break occurs on one fiber, working traffic targeted for a node beyond the break switches to the protect bandwidth on the second fiber. The traffic travels in reverse direction on the protect bandwidth until it reaches its destination node. At that point, traffic is switched back to the working bandwidth. Figure 2-45 shows a sample traffic pattern on a 4-node, 2-Fiber BLSR.

Figure 2-45: 4-Node, 2-Fiber BLSR Sample Traffic Pattern

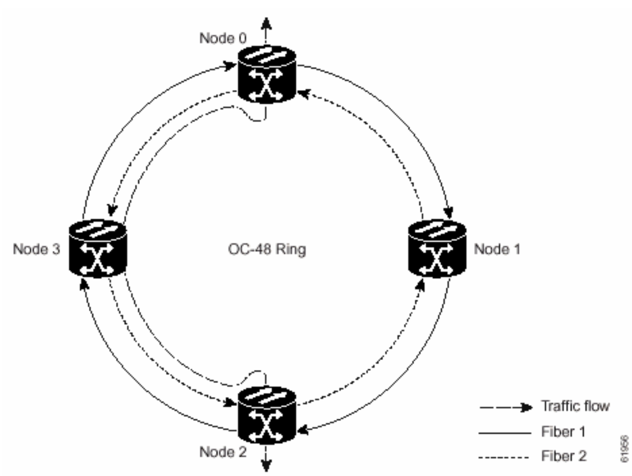
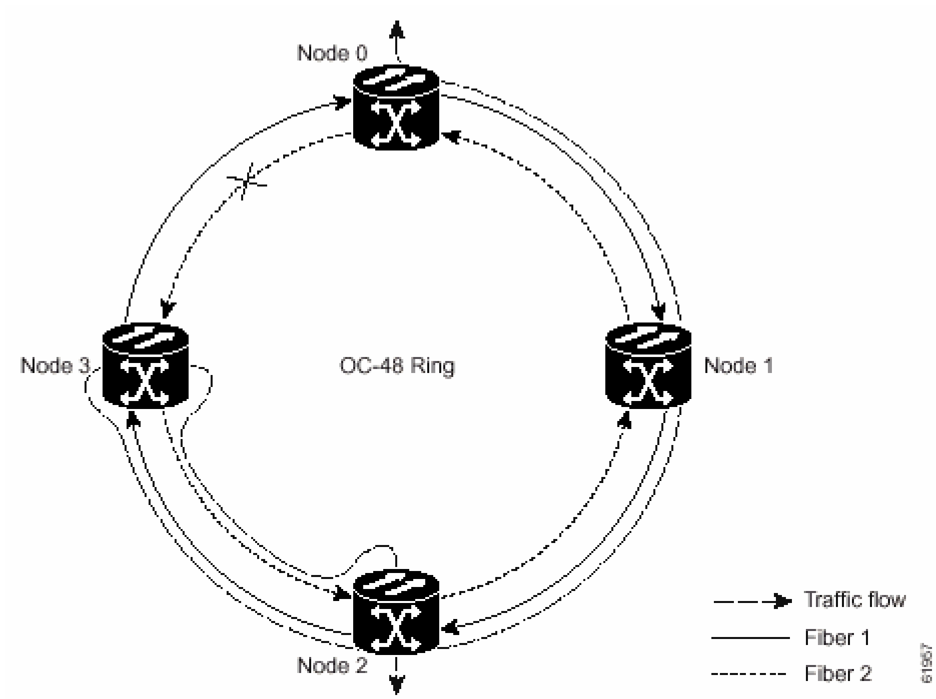


Figure 2-46 shows how traffic is rerouted following a line break between Node 0 and Node 3.

All circuits originating on Node 0 carried to Node 2 on Fiber 2 are switched to the protect bandwidth of Fiber 1. For example, a circuit carried on STS-1 on Fiber 2 is switched to STS-25 on Fiber 1. A circuit carried on STS-2 on Fiber 2 is switched to STS-26 on Fiber 1. Fiber 1 carries the circuit to Node 3 (the original routing destination). Node 3 switches the circuit back to STS-1 on Fiber 2 where it is routed to Node 2 on STS-1.

Circuits originating on Node 2 that were normally carried to Node 0 on Fiber 1 are switched to the protect bandwidth of Fiber 2 at Node 3. For example, a circuit carried on STS-2 on Fiber 1 is switched to STS-26 on Fiber 2. Fiber 2 carries the circuit to Node 0 where the circuit is switched back to STS-2 on Fiber 1 and then dropped to its destination.

Figure 2-46: 4-Node, 2-Fiber BLSR Traffic Pattern Following Line Break



4-Fiber BLSR

Four-fiber BLSRs double the bandwidth of two-fiber BLSRs. Because they allow span switching as well as ring switching, four-fiber BLSRs increase the reliability and flexibility of traffic protection. Two fibers are allocated for working traffic and two fibers for protection, as shown in Figure 2-47. To implement a 4-Fiber BLSR, you must install 4 OC-48 or OC-48AS cards, or 4 OC-192 cards at each BLSR node.

Table 2-24 shows the maximum number of 4-Fiber BLSRs each ONS 15454 node can support.

Table 2-24: Maximum Number of 2-Fiber BLSRs Supported

System Release	Maximum Number of 4- Fiber BLSRs
< Release 4.0	1

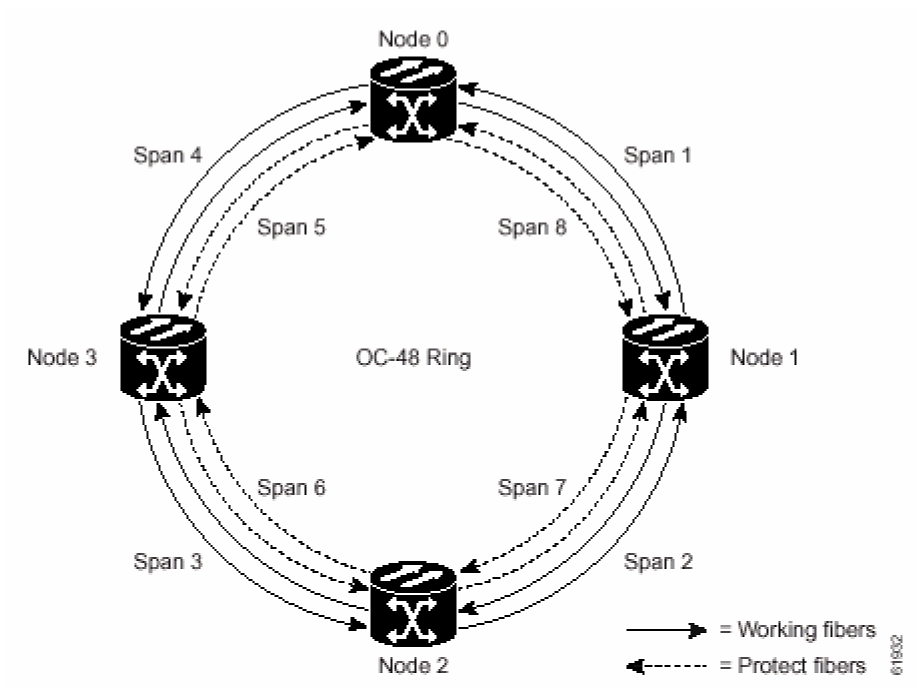
Each 4-Fiber BLSR can have up to 32 ONS 15454 nodes. Because the working and protect bandwidths must be equal, you can create only OC-48, or OC-192 BLSRs. Table 2-25 shows the bi-directional bandwidth capacities of 4-Fiber BLSRs.

Table 2-25: 4-Fiber BLSR Capacities

OC-N Rate	Working Bandwidth	Protection Bandwidth	Ring Capacity
OC-48	STS 1-48 (Fiber 1)	STS 1-48 (Fiber 2)	48 x N[1] – PT[2]
OC-192	STS 1-192 (Fiber 1)	STS 1-192 (Fiber 2)	192 x N – PT

[1] N equals the number of ONS 15454 nodes configured as BLSR nodes.
[2] PT equals the number of STS-1 circuits passed through ONS 15454 nodes in the ring (capacity can vary depending on the traffic pattern).

Figure 2-47: A 4-Node, 4-Fiber BLSR



4-Fiber Span and Ring Switching

Cisco ONS 15454 4-Fiber BLSRs provide span and ring switching as follows:

> Span switching, shown in Figure 2-48, occurs when a working span fails. Traffic switches to the protect fibers in less than 50 ms between Node 0 and Node 1 and then returns to the working fibers. Multiple span switches can occur at the same time. Multiple span switches can be present on a 4-Fiber BLSR and not cause traffic to drop.
>
> Ring switching, shown in Figure 2-49, occurs when a span switch cannot recover traffic, such as when both the working and protect fibers fail on the same span. In a ring switch, traffic is routed within 50 ms to the protect fibers throughout the full ring.

The K1 byte of the Line Overhead carries the bridge request and associated priorities. These priorities are used to determine if a bridge request can be fulfilled, when an existing ring or span switch is present on the 4-Fiber BLSR. Within the K1 byte, bits 1 through 4 define the “request pre-emption priority". Bits 5 through 7 of the K1 byte are designated for the Destination Node ID, and "indicate the node ID of the adjacent node to which the K1 byte is destined."

Figure 2-48: A 4-Fiber BLSR Span Switch

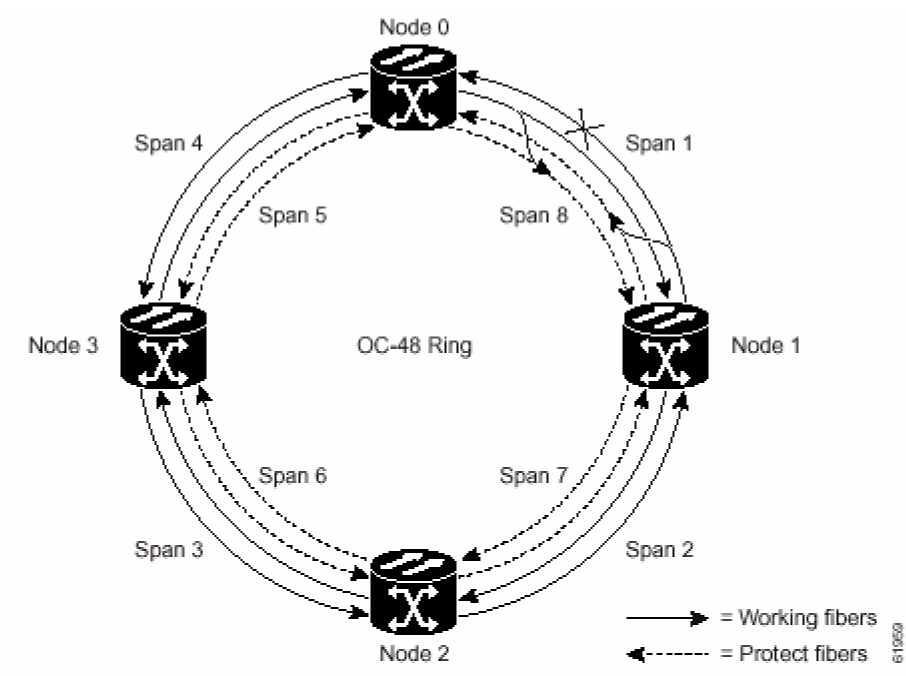
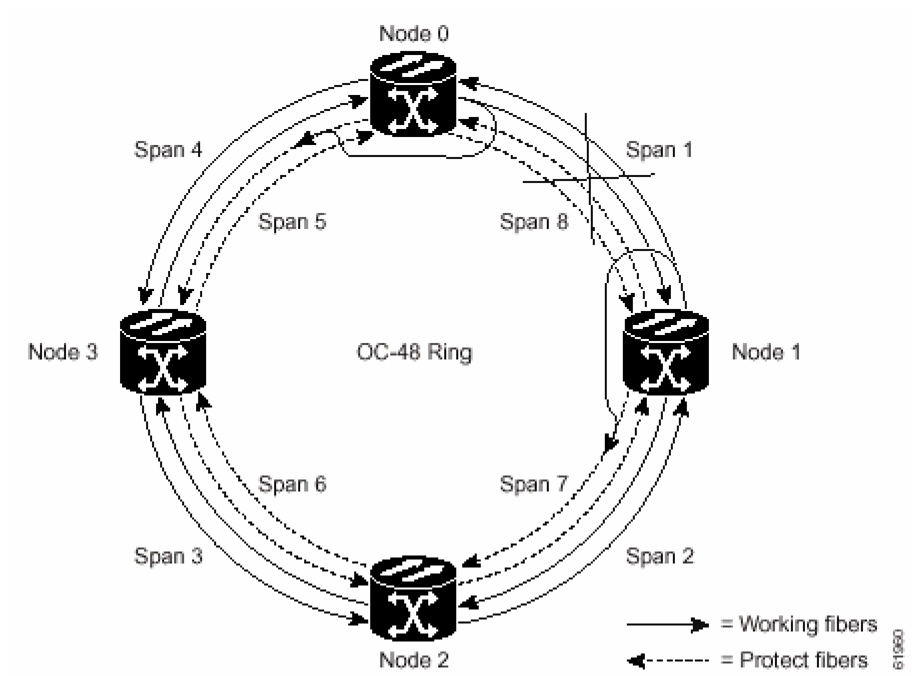


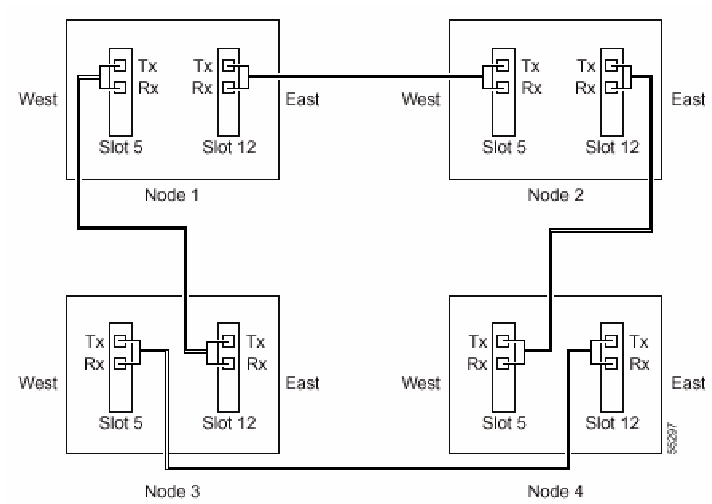
Figure 2-49: A 4-Fiber BLSR Ring Switch



BLSR Fiber Connections

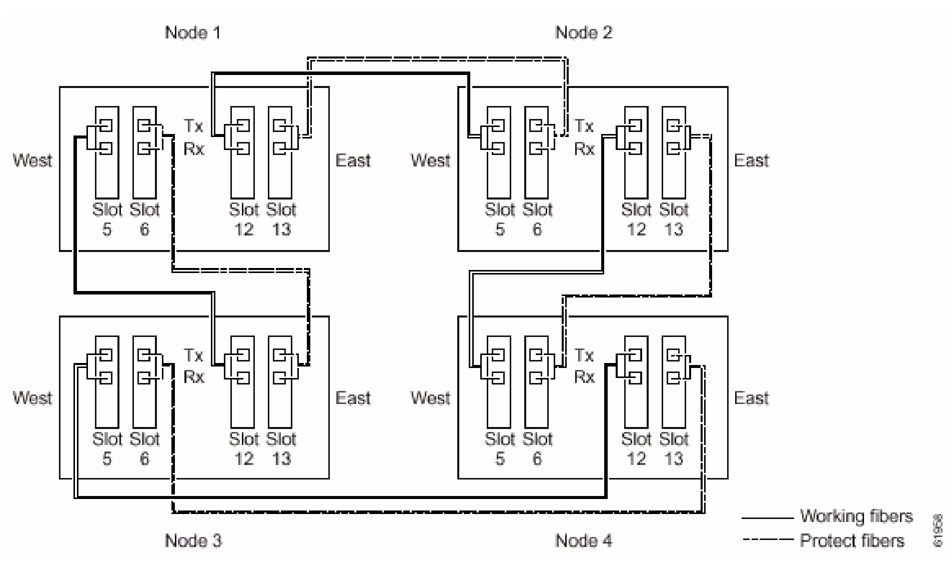
Plan your fiber connections and use the same plan for all BLSR nodes. For example, make the East port the farthest slot to the right and the West port the farthest left. Plug fiber connected to an East port at one node into the West port on an adjacent node. Figure 2-50 shows fiber connections for a 2-Fiber BLSR with trunk cards in Slot 5 (West) and Slot 12 (East).

Figure 2-50: Connecting Fiber to a 4-Node, 2-Fiber BLSR



For 4-Fiber BLSRs, use the same East—West connection pattern for the working and protect fibers. Do not mix working and protect card connections. The BLSR will not function if working and protect cards are interconnected. Figure 2-51 shows fiber connections for a 4-Fiber BLSR. Slot 5 (West) and Slot 12 (East) carry the working traffic. Slot 6 (West) and Slot 13 (East) carry the protect traffic.

Figure 2-51: Connecting Fiber to a 4-Node, 4-Fiber BLSR



Topology Conversions

Caution Topology conversions are service affecting. In-service topology conversions will be provided in a future system release.

For explanations on how to convert from one network topology to another, refer to the following procedures in the *Cisco ONS 15454 Procedure Guide*:

1. NTP-154 Upgrade a Point-to-Point to a Linear ADM.
2. NTP-155 Upgrade a Point-to-Point or a Linear ADM to a Two-Fiber BLSR.
3. NTP-156 Upgrade a Point-to-Point or Linear ADM to a Path Protection Configuration.
4. NTP-157 Upgrade a Path Protection Configuration to a BLSR.
5. NTP-158 Upgrade a Two-Fiber BLSR to a Four-Fiber BLSR.
6. NTP-159 Modify a BLSR.

Convert a Point-to-Point to a Linear ADM

In a point-to-point configuration, two OC-N cards are connected to two OC-N cards on a second node. Any multispeed slot (OC-3, OC-12, OC12-4, OC48AS cards only) or high-speed slot (any OC-N card except the OC12-4) can be used if connections between nodes are consistent. For example, Slot 5 on the first point-to-point node connects to Slot 5 on the second point-to-point node for the working path, and Slot 6 connects to Slot 6 for the protect path. The OC-N ports have DCC terminations, and the OC-N cards are in a 1+1 protection group.

Convert a Point-to-Point or a Linear ADM to a 2-Fiber BLSR

An OC-12, OC-48, and OC-192 Point-to-Point or a Linear ADM can be converted to a 2-Fiber BLSR. Prior to beginning this conversion you should have assigned a unique Ring ID number to identify the new BLSR and a unique Node ID number for each node on the ring.

At least 50% of the available bandwidth must be unassigned to convert to a BLSR. For example, if the span is an OC-48, no more than 24 STSs can be provisioned on the span. If the span is an OC-192, no more than 96 STSs can be provisioned on the span. If the span is an OC-12, no more than 6 STSs can be provisioned on the span. Refer to your local procedures for relocating circuits if these requirements are not met. Bridge and roll will be supported in a future system release.

Convert a Point-to-Point or a Linear ADM to a Path Protection Configuration

When converting a Point-to-Point or Linear ADM to a Path Protection Configuration, all circuits will be deleted and re-provisioned.

Convert a Path Protection Configuration to a BLSR

An OC-12, OC-48, and OC-192 Path Protection Configuration can be converted to a BLSR. When converting a Path Protection Configuration to a BLSR, all circuits will be deleted and re-provisioned. Prior to beginning this conversion you should have assigned a unique Ring ID number to identify the new BLSR and a unique Node ID number for each node on the ring.

At least 50% of the available bandwidth must be unassigned to convert to a BLSR. For example, if the span is an OC-48, no more than 24 STSs can be provisioned on the span. If the span is an OC-192, no more than 96 STSs can be provisioned on the span. If the span is an OC-12, no more than 6 STSs can be provisioned on the span. Refer to your local procedures for relocating circuits if these requirements are not met. Bridge and roll will be supported in a future system release.

Convert a 2-Fiber BLSR to a 4-Fiber BLSR

2-fiber OC-48 or OC-192 BLSRs can be upgraded to 4-Fiber BLSRs. To upgrade, you install two additional OC-48 or OC-192 cards at each 2-Fiber BLSR node, then log into CTC and upgrade the BLSR from 2-fiber to 4-fiber. The fibers that were divided into working and protect bandwidths for the 2-Fiber BLSR will become fully allocated for working BLSR traffic.

Alarms Reported During BLSR Conversion

Some or all of the following alarms will display during BLSR setup: E-W MISMATCH, RING MISMATCH, APSCIMP, APSDFLTK, BLSROSYNC. The alarms will clear after you configure all the nodes in the BLSR. For definitions of these alarms, see the *Cisco ONS 15454 Troubleshooting Guide*.

SONET Span Upgrades

A span is the optical fiber connection between two ONS 15454 nodes. In a span (optical speed) upgrade, the transmission rate of a span is upgraded from a lower to a higher OC-N signal but all other span configuration attributes remain unchanged. With multiple nodes, a span upgrade is a coordinated series of upgrades on all nodes in the ring or protection group in which traffic carried at a lower OC-N rate is transferred to a higher OC-N. You can perform in-service span upgrades for the following ONS 15454 cards:

Single-port OC-12 to four-port OC-12
Single-port OC-12 to OC-48
Single-port OC-12 to OC-192
OC-48 to OC-192

Use the XC10G card, the TCC+ card, Software R3.1 or later and the new 15454-SA-ANSI shelf assembly to enable the OC48 IR/STM16 SH AS 1310, OC48 LR/STM16 LH AS 1550, and the OC192 LR/STM64 LH 1550 cards.

To perform a span upgrade, the higher-rate optical card must replace the lower-rate card in the same slot. If the upgrade is conducted on spans residing in a BLSR, all spans in the ring must be upgraded. The protection configuration of the original lower-rate optical card (two-fiber BLSR, four-fiber BLSR, Path Protection Configuration, and 1+1) is retained for the higher-rate optical card.

When performing span upgrades on a large number of nodes, Cisco recommends that you upgrade all spans in a ring consecutively and in the same maintenance window. Until all spans are upgraded, mismatched card types will be present.

Cisco recommends using the Span Upgrade Wizard to perform span upgrades. Although you can also use the manual span upgrade procedures, the manual procedures are mainly provided as error recovery for the wizard. The Span Upgrade Wizard and the Manual Span Upgrade procedures require at least two technicians (one at each end of the span) who can communicate with each other during the upgrade. Upgrading a span is non-service affecting and will cause no more than three switches, each of which is less than 50 ms in duration.

Span Upgrade Wizard

The Span Upgrade Wizard automates all steps in the manual span upgrade procedure (BLSR, Path Protection Configuration, and 1+1). The wizard can upgrade both lines on one side of a four-fiber BLSR or both lines of a 1+1 group; the wizard upgrades Path Protection Configurations and two-fiber BLSRs one line at a time. The Span Upgrade Wizard requires that spans have DCC enabled. For an explanation on how to use the Span Upgrade Wizard, refer to the *Cisco ONS 15454 Procedures Guide*.

The Span Upgrade Wizard provides no way to back out of an upgrade. In the case of an abnormal error, you must exit the wizard and initiate the manual procedure to either continue with the upgrade or back out of it. To continue with the manual procedure, examine the standing conditions and alarms to identify the stage in which the wizard failure occurred.

Manual Span Upgrades

Manual Span Upgrades are mainly provided as error recovery for the Span Upgrade Wizard, but they can be used to perform span upgrades. Downgrading can be performed to back out of a span upgrade. The procedure for downgrading is the same as upgrading except that you choose a lower-rate card type. You cannot downgrade if circuits exist on the STSs that will be removed (the higher STSs).

The following manual span upgrade options are available the *Cisco ONS 15454 Procedures Guide*:

1. Perform a Manual Span Upgrade on a 2-Fiber BLSR
2. Perform a Manual Span Upgrade on a 4-Fiber BLSR
3. Perform a Manual Span Upgrade on a Path Protection Configuration
4. Perform a Manual Span Upgrade on a 1+1 Protection Group

Chapter 3 – SDH Transport Over SONET

Purpose

As with SONET TDM and data services, Synchronous Digital Hierarchy (SDH) traffic can also be aggregated and transported across an ONS 15454 network. STM-1 to STM-64 payloads can be transported over SONET from any port on a Cisco ONS 15454 OC-N card provisioned to support SDH signals. This chapter explains how the ONS 15454 transports SDH traffic over SONET.

Contents

This following topics are found in this chapter:

Provisioning OC-N Ports for SDH

All port on Cisco ONS 15454 OC-N cards support both SONET and SDH signals. Once an OC-N port is provisioned as an SDH signal, through the port-provisioning screen in CTC, the optical card processes the received signal as follows:

Termination of the incoming SDH signal [RSOH, MSOH and AU pointer(s)]

Note The SS byte value is not checked.

Pointer(s) processing to locate the J1 byte, the 1st byte of the VC-3 or VC-4 POH (Au3 or Au4)

VC-4-Nc mapping into a STS-Mc where M=3xN or VC-3 mapping into a STS-1 for Au3 SDH

Note The POH and payload are not touched since that path is not terminated.

STS-Mc insertion into an OC-M facility where the SPE pointer is created and the S1S0 bits of the H1 byte are set to 00 (received as 10 from the SDH line)

At the far end of a SDH circuit, the reverse process takes place, transitioning the signal from SONET to SDH as follows:

Drop STS-Nc from OC-N facility (SPE pointer processed and J1 byte of the HO-POH located)

STS-Nc mapping into a VC-4-Nc where M=3xN

AU pointer creation with the value 10 for the SS bits as required for SDH

STM-N signal generation with MSOH and RSOH

During this process, the only bytes modified are the H1, H2 and H3 bytes. All the other bytes are passed transparently. The H bytes are modified to allow 1) pointer justifications that may be necessary and 2) the SS bits are set to 10 when the frame leaves the OC-N card provisioned as SDH.

Note If any connected SDH equipment is using any different interpretation of SS bits, LOP may result.

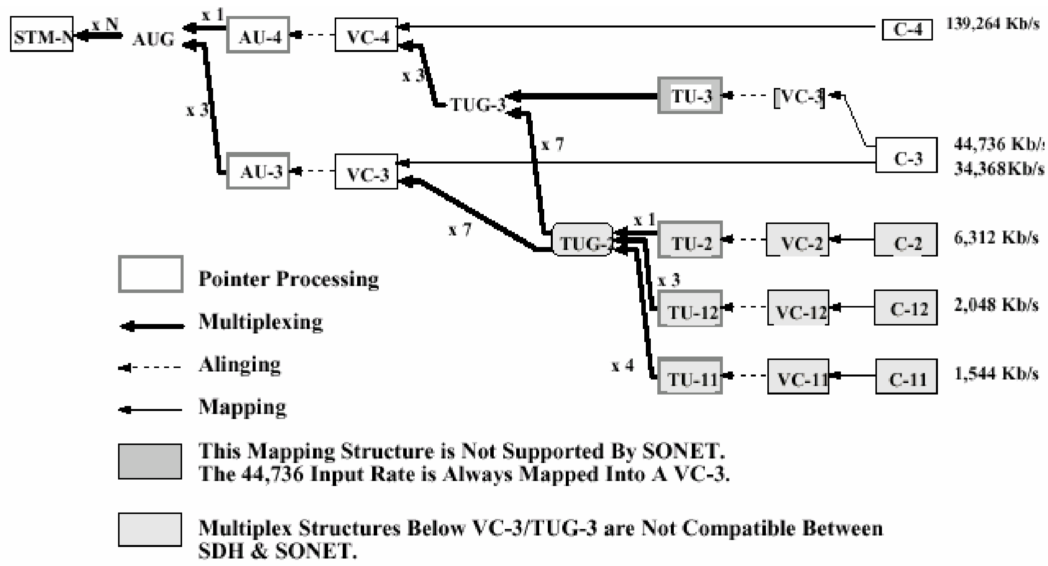
SDH to SONET Mapping

The SDH to SONET mapping depends on the SDH payload type being transported and is manually set by the user during the creation of the SONET circuits used to transport the SDH traffic. For example, an STM-4 port can be mapped in a number of alternative ways, depending upon the content of the signal including:

One STS-12c circuit to transport a 622Mb/s concatenated data payload.
Four (4) STS-3c circuits for an Au4 mapped SDH interface (see Table 3-1).
Twelve (12) STS-1 circuits for an Au3 mapped SDH interface (see Table 3-2).

Figure 3-1 shows how the SDH and SONET multiplexing structures meet at AU4 (i.e., STS-3c) by byte interleaving 3 STS-1s. The STM-1 (i.e., OC-3c) granularity corresponds to the minimum rate where both SONET and SDH systems share. Multiplex structures below VC-3 and/TUG-3 are not compatible between SDH & SONET. Services carried below VC-3 (i.e., E1) need SDH based ADMs to be added or dropped onto the fiber network.

Figure 3-1: SDH and SONET Multiplexing Structures



The appropriate circuit type selection is required to allow the transport of sub-structured signals from a STM-M port. This circuit selection enables the system to keep track of all Au4 or Au3 pointers and enable the visibility and access to the sub-structure once the signal is converted back to SDH at the end optical interface.

Table 3-1: SDH to SONET Circuit Type Mapping for Au4 SDH

Optical Card	Provisioned SDH Interface	SONET Circuit Type Mapping	Equivalent Au4 SDH Circuits
OC-3/STM-1	STM-1 optical	STS-3c	VC-4
OC-12/STM-4 OC-12-4/STM-4	STM-4 optical	4 x STS-3c or STS-12c depending on payload type	4 x VC-4 or VC-4-4c depending on payload type
OC-48/STM-16 High speed slot	STM-16 optical	16 x STS-3c or 4 x STS-12c or STS-48c or any STS-12c / STS-3c mix depending on payload type	16 x VC-4 or 4 x VC-4-4c or VC-4-16c or any VC-4-4c / VC-4 mix depending on payload type
OC-48/STM-16 Any slot	STM-16 optical	16 x STS-3c or 4 x STS-12c or STS-48c or any STS-12c / STS-3c mix depending on payload type	16 x VC-4 or 4 x VC-4-4c or VC-4-16c or any VC-4-4c / VC-4 mix depending on payload type
OC-192/STM-64	STM-64 optical	64 x STS-3c or 16 x STS-12c or 4 x STS-48c or STS-192c or any STS-48c / STS-12c / STS-3c mix depending on payload type	64 x VC-4 or 16 x VC-4-4c or 4 x VC-4-16c or VC-4-64c or any VC-4-16c / VC-4-4c / VC-4 mix depending on payload type

Table 3-2: SDH to SONET Circuit Type Mapping For Au3 SDH

Optical Card	Provisioned SDH Interface	SONET Circuit Type Mapping	Equivalent Au3 SDH Circuits
OC-3/STM-1	STM-1 optical	3 x STS-1 or STS-3c depending on payload type	3 x VC-3s or VC-4
OC-12/STM-4 OC-12-4/STM-4	STM-4 optical	12 x STS-1 or 4 x STS-3c or STS-12c or any STS-3c / STS-1 mix depending on payload type	12 x VC-3 or 4 x VC-4 or VC-4-4c or any VC-4 / VC-3 mix depending on payload type
OC-48/STM-16 High Speed Slot	STM-16 optical	48 x STS-1 or 16 x STS-3c or 4 x STS-12c or STS-48c or any STS-12c / STS-3c / STS-1 mix depending on payload type	48 x VC-3 or 16 x VC-4 or 4 x VC-4-4c or VC-4-16c or any VC-4-4c / VC-4 / VC-3 mix depending on payload type
OC-48/STM-16 Any slot	STM-16 optical	48 x STS-1 or 16 x STS-3c or 4 x STS-12c or STS-48c or any STS-12c / STS-3c / STS-1 mix depending on payload type	48 x VC-3 or 16 x VC-4 or 4 x VC-4-4c or VC-4-16c or any VC-4-4c / VC-4 / VC-3 mix depending on payload type
OC-192/STM-64	STM-64 optical	192 x STS-1 or 64 x STS-3c or 16 x STS-12c or 4 x STS-48c or STS-192c or any STS-48c / STS-12c / STS-3c / STS-1 mix depending on payload type	192 x VC-3 or 64 x VC-4 or 16 x VC-4-4c or 4 x VC-4-16c or VC-4-64c or any VC-4-16c / VC-4-4c / VC-4 / VC-3 mix depending on payload type

Synchronization

Cisco ONS 15454 nodes used to transport SDH over SONET should be provisioned for Line timing from an incoming SDH signal.

Protection

SDH configured ports should be provisioned as part of 1+1 linear protection group for interconnection with SDH network terminating equipment. The ONS 15454 supports both unidirectional and bi-directional APS signaling for maximum networking flexibility. SNCP and MS-SPRing are not supported.

Alarm Reporting

When the OC-N ports have been provisioned for SDH, the OC-N card will continue to report alarms and performance measurements (PMs) in the same manner as if they were provisioned for standard SONET transport. This allows an ONS 15454 node supporting SDH transport to report alarms in a consistent manner with the rest of the SONET nodes in the network.

When an OC-12/STM-4 (IR, 1310 LR and 1550 LR) or an OC-48/STM-16 high-speed (IR and LR) port is provisioned to support SDH, path alarming is not supported due to improper B3 byte calculation. The signal degrade alarm at the path level (SD-P) must be disabled on the port in order to suppress these unreliable alarm notifications. Additionally, the PM data at the path level will not be reliable and thus the associated threshold values must be set to 0 in order to avoid threshold crossing alerts (TCA) notification on that port. This limitation does not exist with the OC-3/STM-1, OC-48/STM-16 AS (any slot), and OC-192/STM-64 cards.

SDH Over SONET Applications

The SDH transport feature of the ONS 15454 addresses a variety of applications, with three applications depicted in Figures 3-1, 3-2 and 3-3:

STM-n handoffs.

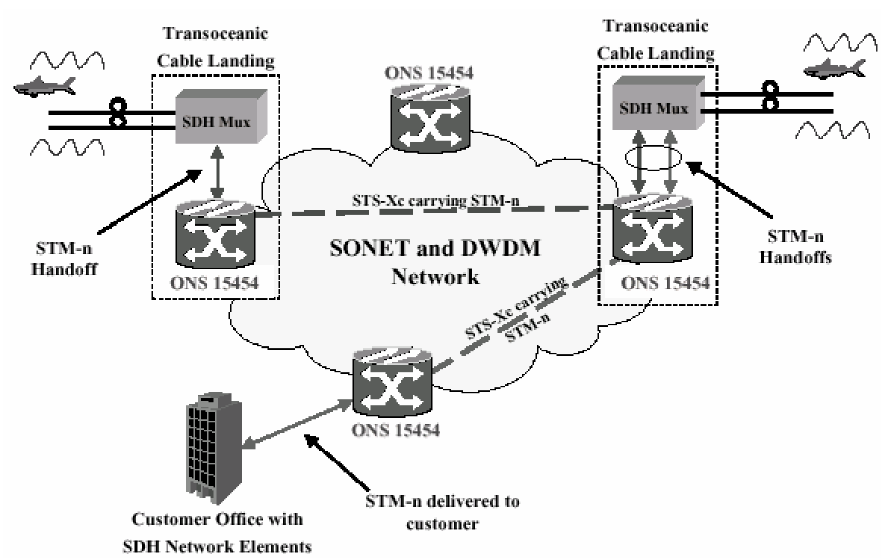
SDH signal aggregation, which allows the user to consolidate lower speed SDH signals into higher speeds, i.e. STM-1s and STM-4s signals into STM-16 or STM-64 signal.

Hybrid interfaces including SONET, SDH, Asynchronous TDM and Ethernet traffic with Au3 SDH mapping only.

STM-n Handoffs

Transoceanic cable landings typically have a mixture of both SDH and SONET transmission equipment. These network elements provide drop interfaces of either STM-N or OC-N. If a pass-through transport element is not available, then a dedicated fiber would be required to transport a foreign optical interface inland. With a pass-through optical transport system, the lower order tributary may be mapped into a fraction of the fiber's capacity and efficiently transported inland. Figure 3-2 illustrates a typical mixed SONET/SDH system (for an STM-n hand-off). The Cisco ONS 15454 will be able to drop SDH type interfaces (i.e., STM-1, STM-4) in addition to SONET and Traditional TDM based services. The SDH traffic is seamlessly transported within the 15454 nodes with an AU-4 (STS-3c) granularity.

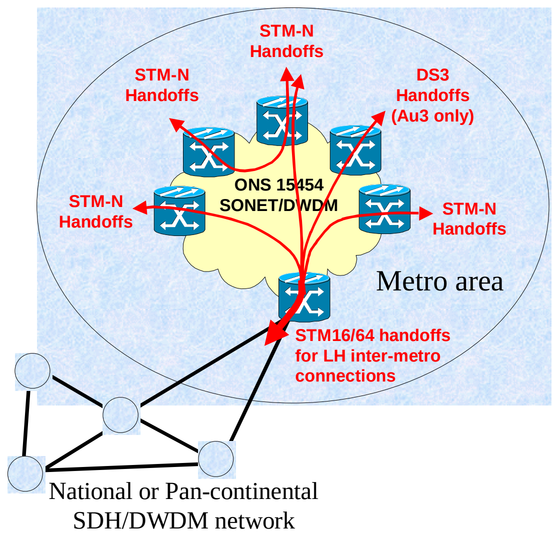
Figure 3-2: Transoceanic STM-n Handoff Application



SDH Aggregation

Service providers positioned in SDH markets to deliver STM-1 and higher speed services can benefit from the Cisco ONS 15454. An ONS 15454 based network can be used to deliver high-speed leased line services to customers leveraging its SDH aggregation and tunneling capability. As illustrated in Figure 3-3, an ONS 15454 network enables service providers to differentiate themselves by offering high-speed native Ethernet connectivity, along with more traditional private line STM-based services. STM-n leased lines can be offered within the Metro network as well as between Metro Area Networks (MANs), leveraging the aggregation capability of SDH payloads for long haul transport. This application is valid for both Au4 and Au3 SDH multiplexing schemes.

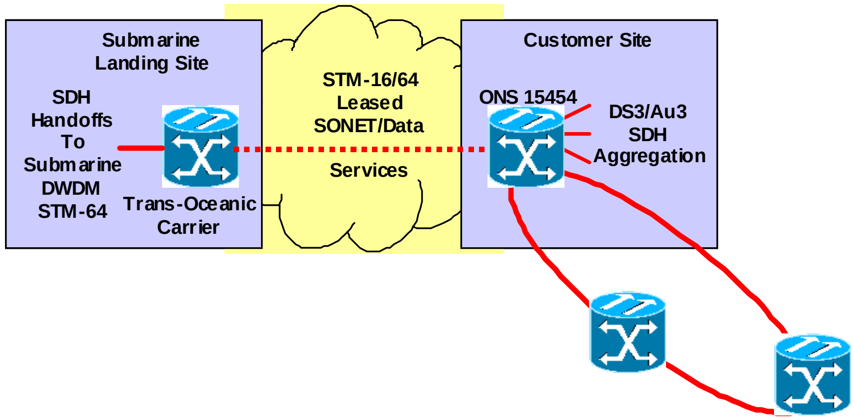
Figure 3-3: SDH Aggregation Applications



Hybrid Au3 SDH Aggregation

To reduce the cost of leased lines, the aggregation of lower order circuits is mandatory for service providers. The ONS 15454 enables service providers to efficiently aggregate mixed service types, including DS1, DS3, and Ethernet signals, into an STM-n interface for transport across a DWDM or other transport network. This capability allows you to fully utilize a leased circuit to transport various payloads without the need for additional multiplexing equipment. Figure 3-4 displays an example of the capability of a DS3/Au3 aggregation application.

Figure 3-4: DS3/Au3 Aggregation Application



SDH Hairpinning

Some rules must be followed when an ONS 15454 is used in an SDH "hairpinning" application. SDH hairpinning applies when a cross-connected circuit is set-up between SDH configured optical cards on the same ONS 15454 node. Table 3-3 shows the optical cards that can be used to hairpin circuits between two SDH configured optical ports on the same ONS 15454 node.

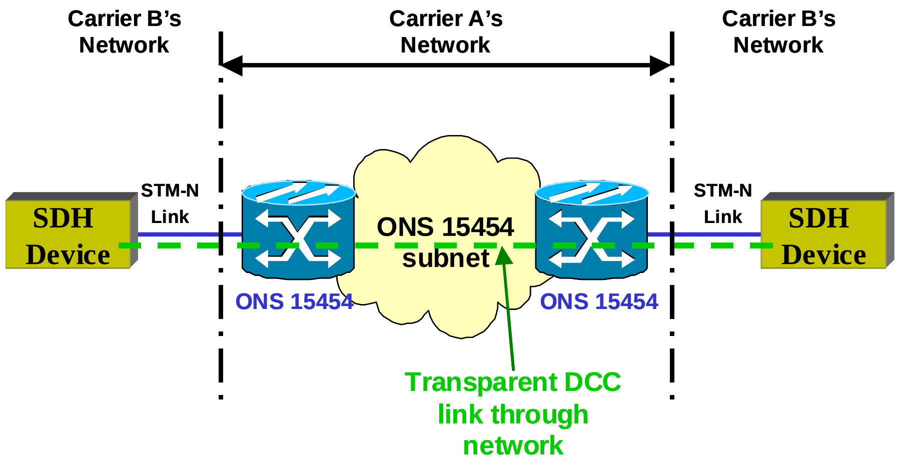
Table 3-3: SDH Hairpinning Compatibility Table

Optical Cards	STM-1	STM-4	STM-16 HS	STM-16 AS	STM-64
OC-3/STM-1	OK	OK	OK	OK	OK
OC-12/STM-4	OK	OK	OK	Not Supported	Not Supported
OC-48/STM-16 High-Speed slot versions	OK	OK	OK	Not Supported	Not Supported
OC-48/STM-16 Any-slot versions	OK	Not Supported	Not Supported	OK	OK
OC-192/STM-64	OK	Not Supported	Not Supported	OK	OK

Managing Third-Party Network Equipment

You can use the DCC tunneling feature of the Cisco ONS 15454 to provide the ability to transparently interconnect third party management channels of the connected SDH networks (see Figure 3-5).

Figure 3-5: Transparent DCC Management



The DCC tunnels from third party SDH devices pass through ONS 15454 nodes without the need for understanding DCC message content. This is possible because the SONET protocol provides four data communication channels (DCCs) for network element operations, administration, maintenance, and provisioning (OAM&P). One data channel is in the SONET section overhead layer (D1-D3 bytes) and three data channels are in the SONET line overhead layer (D4-D12 bytes). The ONS 15454 system allows you to leverage the line overhead to transport the third party's Section DCC (SDCC) overhead. Thus, in the example shown in Figure 3-5, Carrier A can provide Carrier B with both a private line circuit and a DCC tunnel for network visibility between the interconnected networks.

CISCO SYSTEMS

Chapter 4 – DWDM Design Guidelines

Purpose

This chapter provides general Dense Wave Division Multiplexing (DWDM) design guidelines using Cisco's OC48 ELR ITU-T cards in conjunction with third party DWDM equipment. For an introduction to DWDM, see the DWDM Primer in Appendix C.

Contents

The following topics are found in this chapter:

DWDM Design Issues

Designing passive DWDM systems require the resolution of several issues. Excluding cost, the following items influence the network's design:

- Available Channels/Wavelength Frequencies
- Adding More Channels/Wavelengths
- Channel Bit Rate and Modulation
- Wavelength Management
- Multi-Channel Frequency Stabilization
- Channel Performance
- Channel Dispersion
- Power Launched
- Optical Amplification
- Fiber Types
- Optical Power Budget

Available Channels/Wavelength Frequencies

For DWDM system interoperability, the operating center frequency (wavelength) of channels must be the same at the transmitting and at the receiving end. Channel selection (center frequency) and channel width determines the number of non-overlapping channels in the spectrum. Channel width, wavelength, bit rate, type of fiber, and fiber length determine the amount of dispersion. Channel separation should allow for a frequency deviation (~2 GHz) caused by frequency drifts in the laser, filter, and amplifier devices to avoid interchannel interference.

The ITU-T currently recommends 81 channels in the C-band starting from 1528.77 nm, and incrementing in multiples of 50 GHz, to 1560.61 nm. The Cisco ONS 15454 supports this range of wavelengths in increments of 100 GHZ and 200 GHz with its OC48 ITU-T optics, and starting with System Release 4.0, the ONS 15454 supports this range in increments of 100 GHz with its OC192 ITU-T optics . Table 4-1 lists the ITU-T channels available for the ONS 15454.

Table 4-1: Available ITU-T Channels/Wavelengths

Product	C Band Spectrum																		
15454 OC48 ELR 100 GHz ITU-T Cards	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15454 OC48 ELR 200 GHz ITU-T Cards			X		X		X		X		X	X		X		X		X	
Channel (nm)	1528.77	1529.55	1530.33	1531.12	1531.90	1532.68	1533.47	1534.28	1535.04	1535.82	1536.61	1538.19	1538.98	1539.77	1540.56	1541.35	1542.14	1542.94	1543.73
Frequency (THz)	196.1	196.0	195.9	195.8	195.7	195.6	195.5	195.4	195.3	195.2	195.1	194.9	194.8	194.7	194.6	194.5	194.4	194.3	194.2

Product	C Band Spectrum																		
15454 OC48 ELR 100 GHz ITU-T Cards	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15454 OC48 ELR 200 GHz ITU-T Cards				X		X		X		X	X		X		X		X		X
Channel (nm)	1544.53	1546.12	1546.92	1547.72	1548.51	1549.32	1550.12	1550.92	1551.72	1552.52	1554.13	1554.94	1555.75	1556.55	1557.36	1558.17	1558.98	1559.79	1560.61
Frequency (THz)	194.1	193.9	193.8	193.7	193.6	193.5	193.4	193.3	193.2	193.1	192.9	192.8	192.7	192.6	192.5	192.4	192.3	192.2	192.1

Product	C Band Spectrum															
15454 OC192 LR 100 GHz ITU-T Cards					X	X	X	X								
Channel (nm)	1530.33	1531.12	1531.90	1532.68	1534.25	1535.04	1535.82	1536.61	1538.19	1538.98	1539.77	1540.56	1542.14	1542.94	1543.73	1544.53
Frequency (THz)	195.9	195.8	195.7	195.6	195.4	195.3	192.2	192.1	194.9	194.8	194.7	194.6	194.4	194.3	194.2	194.1

Product	C Band Spectrum															
15454 OC192 LR 100 GHz ITU-T Cards					X	X	X	X								
Channel (nm)	1546.12	1546.92	1547.72	1548.51	1550.12	1550.92	1551.72	1552.52	1554.13	1554.94	1555.75	1556.55	1558.17	1558.98	1559.79	1560.61
Frequency (THz)	193.9	193.8	193.7	193.6	193.4	193.3	193.2	193.1	192.9	192.8	192.7	192.6	192.4	192.3	192.2	192.1

The ONS 15454 OC48 ITU-T cards provide you with 37 separate ITU-T channels to choose from. These wavelengths conform to ITU-T 100 GHz and 200 GHz channel spacing, enabling compatibility with most DWDM systems. Integrating the ONS 15454 OC48 ITU-T cards with third party DWDM products enables you to design a low-cost, scalable DWDM system with full add/drop capabilities.

System Release 4.0 offers 8 OC192 ITU-T cards. Each card provides a long reach SONET compliant 9.95328 Gbps high-speed interface operating at a 100GHz spaced, ITU-T compliant wavelength within the 1530 to 1562nm frequency band. The primary application for the OC192 ITU-T card is for use in ultra high-speed Metro inter-office facility (IOF) solutions interconnecting central offices and collocation sites over a DWDM based transport network.

Adding Channels/Wavelengths

You can ensure a smooth upgrade path from a single channel to the maximum number of channels with a minimum disruption of service if the per-channel power of the single channel is properly set from the start. Set the per-channel power so that at full channel loading the total input power is less than -6 dBm (0.25 mW).

For example, if the maximum number of channels at full loading is 18, then you can calculate the power per channel by dividing .25 mW by 18, which equals .0138 mW. This number (.0138 mW) in logarithmic scale is -18.6 dBm.

Use Table 4-2 to calculate per-channel power as a function of the maximum total number of channels at full loading.

Table 4-2: Maximum Power Per Channel

Full Loading – Number of Channels	Maximum per Channel Power (mW)	Maximum per Channel Power (dBm)
1	0.2500	-6.0
2	0.1250	-9.0
3	0.0833	-10.8
4	0.0625	-12.0
5	0.0500	-13.0
6	0.0416	-13.8
7	0.0357	-14.5
8	0.0312	-15.1
9	0.0277	-15.6
10	0.0250	-16.0
11	0.0227	-16.4
12	0.0208	-16.8
13	0.0192	-17.2
14	0.0178	-17.5
15	0.0166	-17.8
16	0.0156	-18.1
17	0.0147	-18.3
18	0.0138	-18.6
19	0.0131	-18.8
20	0.0125	-19.0
21	0.0119	-19.3
22	0.0113	-19.5
23	0.0108	-19.7
24	0.0104	-19.8
25	0.0100	-20.0
26	0.0096	-20.2
27	0.0092	-20.4
28	0.0089	-20.5
29	0.0086	-20.7
30	0.0083	-20.8
31	0.0080	-21.0
32	0.0078	-21.1
33	0.0075	-21.2

34	0.0073	-21.4
35	0.0071	-21.5
36	0.0069	-21.6
37	0.0067	-21.7
38	0.0065	-21.8
39	0.0064	-22.0
40	0.0062	-22.1

Channel Bit Rate and Modulation

The bit rate of a channel and the modulation technique are parameters that determine the limits of channel width and channel separation, as well as channel performance (i.e. BER, Cross-talk, etc.). Dispersion and noise need to be considered, because they affect the signal to noise ratio (SNR), which influences signal integrity. The bit rate and modulation for the ONS OC48 and OC192 ITU-T cards is listed in Table 4-3.

Table 4-3: OC48 and OC192 ITU-T Bit Rate and Modulation

Parameter	OC48 100 GHz	OC48 200 GHz	OC192 100 GHz
Bit Rate	2488.320 Mb/s	2488.320 Mb/s	9.95328 Gb/s
Transmitter (Modulation)	Electro-absorption laser (Externally Modulated)	Electro-absorption laser (Externally Modulated)	Cooled and Wavelocked CW Laser (Externally Modulated)

Wavelength Management

In a DWDM system, if an optical component fails, it will affect one or more wavelengths. Therefore, protection wavelengths should be allocated to replace the faulty ones.

Besides hard faults, there may be wavelengths that perform below acceptable levels (i.e. BER < 10-9). Therefore you should monitor all wavelengths, including the spares. Table 4-4 lists the minimum receiver level and optical signal-to-noise ratio (OSNR) for the ONS 15454 OC48 and OC192 ITU-T cards.

Table 4-4: OC48 and OC192 ITU-T Receiver Level and OSNR

Parameter	OC48 100 GHz	OC48 200 GHz	OC192 100 GHz
Minimum Receiver Level	-27 dBm with BER of 10^{-12}	-27 dBm with BER of 10^{-12}	-22 dBm with BER of 10^{-12}
OSNR	21 dB	21 dB	20 dB

Multi-Channel Frequency Stabilization

In DWDM systems with optical filters, filter detuning or frequency offset takes place, which increases insertion loss. You can use the Variable Optical Attenuation (VOA) feature included in Cisco's ONS 15216 DWDM products or purchase third-party external attenuators to correct or compensate for detuning.

Channel Performance

The DWDM design must be within the BER requirements of the receiver's sensitivity to insure signal integrity is maintained. The BER depends on the interchannel interference, optical power level at the receiver with respect to the sensitivity of the receiver, modulation technique, and other noise sources such as externally couple noise and jitter. Table 4-5 lists the BER for the ONS 15454 OC48 and OC192 ITU-T cards.

Table 4-5: OC48 and OC192 ITU-T BER

Parameter	OC48 100 GHz	OC48 200 GHz	OC192 100 GHz
BER	10^{-12}	10^{-12}	10^{-12}

Channel Dispersion

In a DWDM system, as wavelengths travel through fibers and various optical components (filters, amplifiers, etc.), dispersion or optical pulse widening occurs. Moreover, connectors and splices insert further loss and dispersion as light travels from one fiber to another. As dispersion increases, so does cross-talk and received power, which influence signal integrity and receiver sensitivity. Therefore, it is necessary to calculate the total dispersion of each channel to ensure your DWDM design is within the acceptable receiver sensitivity range of the DWDM system. Table 4-6 lists the dispersion parameters for the ONS 15454 OC48 and OC192 ITU-T cards.

Table 4-6: ONS 15454 OC48 and OC192 ITU-T Dispersion Parameters

Parameter	OC48 100 GHz	OC48 200 GHz	OC192 100 GHz
Dispersion Tolerance	5400 ps/nm	3600 ps/nm	1200 ps/nm
Optical Path Penalty	2 dB	1 dB	2 dB

Power Launched

In a DWDM system, the maximum allowable power per channel launched in the fiber (transmitted power), is the starting point of power calculations to assure that the optical signal at the receiver has enough power to be detected without errors or within a BER objective (e.g. <10-11). The maximum allowable power per channel cannot be arbitrary, because the nonlinear effects increase as coupled power increases. Table 4-7 lists the maximum transmitter output per channel for the ONS 15454 OC48 and OC192 ITU-T cards, with a BER of 10-12.

Table 4-7: ONS 15454 OC48 and OC192 ITU-T Maximum Power Launched Per Channel

Parameter	OC48 ELR GHz	OC48 200 GHz	OC192 100 GHz
Maximum Transmitter Output per Channel	0 dBm with BER 10^{-12}	0 dBm with BER 10^{-12}	6 dBm with BER 10^{-12}

Optical Amplification

Optical signal losses should be carefully budgeted and EDFAs should be used to boost the power of the optical signal if needed. You should attempt to space your EDFAs at equal distances apart, if possible, to assure the DWDM system is properly balanced.

The OC48 ITU-T cards have a single channel span budget of 25 dB. If the span loss is greater than 25 dB, amplification may be used to extend the optical reach of the cards. The OC192 ITU-T cards have a single channel span budget of 30 dB. If the span loss is greater than 30 dB, amplification may be used to extend the optical reach of the cards. Table 4-8 specifies the range of attenuation per span using EDFAs.

Table 4-8: Span Attenuation with EDFAs

# of Spans	# of EDFAs in the Path	Worst Attenuation per Span (dB)
1	1 (1 post amp)	22 - 25
1	2 (1 post, 1 pre amp)	33 - 36
2	3 (1 post, 1 pre, 1 line amp)	25 - 28
3	4 (1 post, 1 pre, 2 line amps)	23 - 26
4	5 (1 post, 1 pre, 3 line amps)	21 - 26

Fiber Types

Various factors, such as amplifier bandwidth and amplifier spontaneous emission (ASE) limit optical transmission. In addition to linear effects, such as fiber attenuation, chromatic dispersion, and polarization mode dispersion (PMD), there are nonlinear effects related to the refractive index and scattering that degrades system performance.

The contribution of the nonlinear effects to transmission is defined as the optical power density (power/effective area) times the length of the fiber. The effective area is defined as the cross-section of the light path in a fiber. Depending on the type of fiber, the effective area varies between 50 and 72 mm2, the lowest corresponding to dispersion-shifted fiber (DSF) and the highest to single-mode fiber (SMF). The higher the optical power density and the longer the fiber, the more the nonlinear contribution.

For a fixed length of fiber, the only variable that can be manipulated to lower the nonlinear contribution is optical power. However, if the optical power is lowered, the bit rate should be lowered to maintain transmission at the expected BER. Table 4-9 specifies the attenuation and chromatic dispersion for some of the types of optical fibers that have been tested with the ONS 15454 using OC 48 ELR ITU-T cards.

Table 4-9: Fiber Span Attenuation and Chromatic Dispersion

Type of Optical Fiber	Manufacturer	Attenuation @ 1550 nm (dB/km)	Chromatic Dispersion (ps/(nm*km))	PMD (ps/km$^{1/2}$)
SMF-28	Corning	0.30	17.0 – 18.0	0.1 – 0.2
LEAF	Corning	0.25	2.0 – 6.0 (1530 nm – 1565 nm)	0.04 – 0.1
Metrocore	Corning	0.25	-10.0 (1530 nm – 1605 nm)	0.1 – 0.2
Allwave	Lucent Technologies	0.25	Unspecified	0 – 0.1
TrueWave RS	Lucent Technologies	0.25	2.6 – 6.0 (1530 nm – 1605 nm)	0 – 0.1

Optical Power Budget

The optical power budget amounts to calculating all signal losses at every component in the optical path (couplers, filters, cross-connects, connectors, splices, mux/demux, fiber, optical patch panels, etc.) between the transmitter and receiver. The main objective is to assure that the power of the optical signal at the receiver is greater than the sensitivity of the receiver.

Power gain and loss (in dB) is additive. Start with the power of the optical signal to be launched into the fiber, expressed a 0 dB. Then, for each loss item, the dB loss is subtracted from it, and for optical amplifiers, the gain is added to it. The remaining is compared with the receiver sensitivity. Typically a net power margin of 3 dB or more is desirable. The power budget formula is as follows:

(Margin) = (Transmitter output power) – (Receiver sensitivity) – (S losses dB)

Table 4-10 specifies the optical power of the composite signal with respect to the number of individual channels being muxed and demux by typical passive DWDM filters.

Table 4-10: Composite Power

Number of channels	Composite Power	Number of channels	Composite Power
1	0 dB	10	+10 dB
2	+3.0 dB	11	+10.4 dB
3	+4.8 dB	12	+10.8 dB
4	+6.0 dB	13	+11.1 dB
5	+7.0 dB	14	+11.5 dB
6	+7.8 dB	15	+11.8 dB
7	+8.5 dB	16	+12.0 dB
8	+9.0 dB	17	+12.3 dB
9	+9.5 dB	18	+12.6 dB

Table 4-10 adopts the standard practice that each channel has the same optical power. It does not take into account insertion loss, however, which must be applied to the table's values. You can typically add 0.3 dB of insertion loss per connector and 0.1 dB of loss per splice. Cisco recommends that you allow a 3 dB optical power design margin and equalize the individual optical signals forming a composite signal.

Metro DWDM Design Example

Caution Network ring designs including amplifiers must include at least one Mux/Demux site. Network rings containing only Optical Add/Drop Multiplexers (OADMs) are not recommended due to the risk of receiver saturation caused by auto-amplification of propagated noise, which may cause the network to collapse.

Caution Extreme care must be taken when meshed channels are patched through a Mux/Demux. If the OADMs belonging to the channel that is patched through the mux/demux are removed, the patch can propagate noise, which is auto-amplified. This may cause the network to collapse. Same care must be taken when patches through a mux/demux site are inserted so that they address the correct wavelengths.

Note Additional loss is introduced to a channel when it passes through multiple Mux/Demux filters due to effects of cascaded filters.

Typically a DWDM network design will fall in one of the following categories:

1. Fixed Distance – Where network locations are already established.
2. Variable Distance – where the designer chooses the network locations.

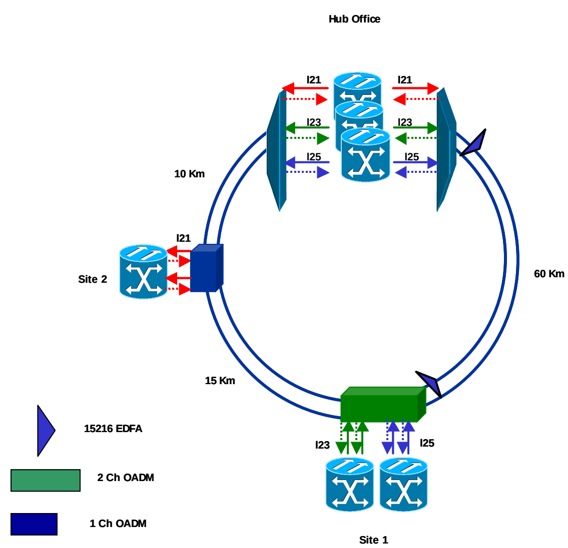
The following example provides a step-by-step approach to designing a Fixed Distance Metro DWDM network using ONS 15454 OC48 200 GHz ITU-T cards and Cisco's ONS 15216 200 GHz passive DWDM products. You can substitute the ONS 15216 DWDM products and specifications with third party passive DWDM equipment without affecting the following steps:

Step 1: Physical Parameters

Using Figure 4-1 as a reference, identify the general characteristics of the network, which includes the following:

Topology
Fiber type and characteristics
Site types (Hub, pass through, add/drop)

Figure 4-1: DWDM Reference Network



The network is configured in a ring topology. For this example, assume the fiber type is SMF-28 and only 2 fibers are available. There are 3 sites, a Hub and two OADM locations. Network Planning has determined a need for three OC-48 channels, with 1+1 protection, between these locations. All three channels will terminate at the Hub Office. Two channels will be dropped and inserted at Site 1 and one channel will be dropped and inserted at Site 2. Network traffic is forecasted to grow at 3% annually over the next five years.

Complete a table for each working (clockwise) and protect (counter-clockwise) span, such as Table 4-11. Span loss is calculated as follows:

Span loss = fiber length x fiber attenuation

Table 4-11: Working and Protect Span Details

Span	Length	Loss
Hub Office – Site 1	60 km	18 dB
Site 1 – Site 2	15 km	4.5 dB
Site 2 – Hub Office	10 km	3 dB
Hub Office – Site 2	10 km	3 dB
Site 2 – Site 1	15 km	4.5 dB
Site 1 – Hub Office	60 km	18 dB

Identify the dispersion characteristics of the optical fiber being used and calculate the maximum fiber path length that would be used without regeneration with the following formula:

Maximum fiber path length = [chromatic dispersion allowance (ps/nm)] / [fiber dispersion (ps/nm/km)]

The chromatic dispersion allowance depends on the characteristics of the source. The fiber dispersion depends on the fiber type, i.e. SMF-28, LEAF, TrueWave, etc. The dispersion for SMF-28 is 18 ps/nm/km and the chromatic dispersion allowance for the ONS 15454 OC48 200 GHz ITU-T optics is 3600 ps/nm. The maximum fiber path length without regeneration for this example is 200 km (3600 ps/nm / 18 ps/nm/km).

Step 2: Channel Plan

Identify the number channels required for the design and select the appropriate ITU-T wavelengths, DWDM filters, and OADMs. Channels are added or dropped at a node in clockwise or counter-clockwise direction, or they are passed directly through the node.

Tip If there are four or fewer add/drop channels in either direction at a site, then the site should use 1- and/or 2-Channel OADMs. If there are five or more add/drop channels at a site, multi-channel DWDM filters should be used.

Channel 21 (1560.61 nm) will be mapped to a 1-Channel OADM unit and Channel 23 (1558.98 nm) and Channel 25 (1557.36 nm) will be mapped to a 2-Channel OADM unit. Channels 23 and 25 are being dropped at Site 1 and Channel 21 is being dropped at Site 2. Multi-channel passive DWDM filters will be used at the Hub Office.

After identifying which channels to use, create a channel plan like the one shown in Table 4-12.

Table 4-12: Channel Plan

Hub Office	Site 1	Site 2
21		21
23	23	
25	25	

For this example, multiplexing 3 channels at 0 dBm yields a 0.3 dBm composite signal (0 dBm + 4.8 dB – 4.5 dB). Demultiplexing an -8 dBm composite signal into 3 channels gives –17.3 dBm of optical power for each channel (-8.0 dBm – 4.8 dB – 4.5 dB). Table 4-13 shows what happens to single channel power as channels are demultiplexed.

Table 4-13: Demultiplexed Signal Power

# of Channels ( )	Total Power (P)
1 , P = 0 dBm	P_{tot} = 0 dBm
2 , P = 0 dBm	P_{tot} = -3 dBm
4 , P = 0 dBm	P_{tot} = -6 dBm
8 , P = 0 dBm	P_{tot} = -9 dBm
16 , P = 0 dBm	P_{tot} = -12 dBm
32 , P = 0 dBm	P_{tot} = -15 dBm

In this example, a composite signal composed of 3 individual optical signals goes through a 1-channel OADM operating at 1560.61 nm. If the power of the composite signal is 0.3 dBm, the power of the 1560.61 nm dropped optical signal is -4.3 dBm (0.3 dBm – 4.8 dB – 2.5 dB). On the other hand, the added 1560.61 nm optical signal has to be manually attenuated by 2.3 dB if coming from a 0 dBm transmitter. With the effect of the add insertion loss, this provides a -6.3 dBm added optical signal which equates for the composite signal going through the throughput path (0.3 dBm – 4.8 dB – 1.8 dB).

Step 3: Regeneration Verification

For each path, the fiber length should be compared to the maximum length calculated in Step 1 to determine whether a regeneration site is needed. If regeneration is needed, the two resulting spans (to and from the regeneration site) should be treated independently. None of the paths exceed the 200 km maximum length calculated in Step 1. Therefore, no regeneration site is required for this example.

Step 4: Channel/Wavelength Selection

The data from the Table 4-12 in Step 2 is used to select the OC48 200 GHz ITU-T cards. For this example, wavelengths 1560.61 nm, 1558.98 nm, and 1557.36 nm were selected. For 1+1 protection, six OC48 200 GHz ITU-T optics cards are required for the Hub Office, four are required for Site 1, and two are required at Site 2.

Step 5: Calculate Path Loss

Calculate the total working path and total protect path losses, based on the type of DWDM filter or OADM used. The formula for total path loss is as follows:

Total Path Loss = (Fiber Loss) + (# of DWDM filters x 4.5 dB) + (# of 1-channel OADMs x 1.8 dB) + (# of 2-channel OADMs x 2.0 dB)

Fiber Loss = Fiber Attenuation x Span Length

The total path loss for each clockwise and counter clockwise span is shown in Table 4-14.

Table 4-14: Total Path Loss

Path	Fiber Loss	DWDM Filter Loss	OADM-1 Loss	OADM-2 Loss	Total Path Loss
Hub Office – Output of Site 1	18 dB	4.5 dB			22.5 dB
Output of Site 1 – Output of Site 2	4.5 dB		1.8 dB		6.3 dB
Output of Site 2 – Hub Office	3.0 dB	4.5 dB		2.0 dB	9.5 dB
Hub Office – Output of Site 2	3.0 dB	4.5 dB		2.0 dB	9.5 dB
Output of Site 2 – Output of Site 1	4.5 dB		1.8 dB		6.3 dB
Output of Site 1 – Hub Office	18 dB	4.5 dB			22.5 dB

Step 6: Amplification

If the total path loss exceeds 22 dB in any channel path, an amplification solution is required. Amplifiers work with total power where $P_{in} + P_{gain} = P_{out}$. For multi-wavelengths, total power is summed as P_{in} = P . In choosing which location to place the EDFAs, identify a reference node. This should be the source node of the channel, because that should have the lowest power level. For this design, the Hub Office is the reference node.

Work from the reference node in one direction, place the first EDFA at the position where there is a loss of 19 dB or the measured power level is -19 dBm per channel. If the -19 dB point is at a midspan position, check the power level at the input of the next node. If this power level is above -22 dBm, the EDFA can be positioned at the next node. Otherwise it should be placed at the preceding node with an attenuator at the input to avoid exceeding the amplifier maximum input power. The attenuator should bring the EDFA input power to -19 dBm. For OADM nodes, it is preferable to place the EDFA after the node instead of before it, because this will make it easier to carry out the channel power equalization for the added channels on that node. If the EDFA is placed before an OADM node, check that the added power can be adjusted to the power level of the pass-through channel.

Because the total loss for the Hub Office to Site 1 working path and Site 1 to Hub Office protect path exceed 22 dB, each of those spans will require an EDFA.

After placing the first EDFA, recalculate the power levels and place the second EDFA where the power level reaches –19 dBm again. To avoid an unexpected OSNR level, place subsequent

EDFAs as close as possible to the -19 dBm power level. If the EDFA power is above -19 dBm, it should be attenuated to -19 dBm. Repeat this process for all remaining amplifiers and then repeat this process in the reverse direction.

The gain and OSNR guidelines for the EDFA used in this example are shown in Table 4-15.

Table 4-15: EDFA Gain and OSNR

P_{in}	P_{out}	SNR @ 0.1 nm	FhB/P_{in}	P_{in}	P_{out}	SNR @ 0.1 nm	FhB/P_{in}
-40	-17	9	9.600^{-02}	-22	1	27	1.521^{-03}
-39	-16	10	7.626^{-02}	-21	2	28	1.209^{-03}
-38	-15	11	6.057^{-02}	-20	3	29	9.600^{-04}
-37	-14	12	4.811^{-02}	-19	4	30	7.626^{-04}
-36	-13	13	3.822^{-02}	-18	5	31	6.057^{-04}
-35	-12	14	3.036^{-02}	-17	6	32	4.811^{-04}
-34	-11	15	2.411^{-02}	-16	7	33	3.822^{-04}
-33	-10	16	1.915^{-02}	-15	8	34	3.036^{-04}
-32	-9	17	1.521^{-02}	-14	9	35	2.411^{-04}
-31	-8	18	1.209^{-02}	-13	10	36	1.915^{-04}
-30	-7	19	9.600^{-03}	-12	11	37	1.521^{-04}
-29	-6	20	7.626^{-03}	-11	12	38	1.209^{-04}
-28	-5	21	6.057^{-03}	-10	13	39	9.600^{-05}
-27	-4	22	4.811^{-03}	-9	14	40	7.626^{-05}
-26	-3	23	3.822^{-03}	-8	15	41	6.057^{-05}
-25	-2	24	3.036^{-03}	-7	16	42	4.811^{-05}
-24	-1	25	2.411^{-03}	-6	17	43	3.822^{-05}
-23	0	26	1.915^{-03}				

For a single optical amplifier between transmitter and receiver, use the value from Table 4-15. For multi-stage optical amplifiers use the following formula:

$SNR_{out} = 1/(1/SNR_{in} + FhfB/P_{in})$

- o Where: SNR_{out} is the OSNR at the output power

SNR IN is the OSNR of the previous amplifier

F is the noise figure (ratio)

h is Planck's constant

f is the light frequency

B is the BW measuring the noise figure

P_{in} is the input power to the amplifier

P_{out} is the output power from the amplifier

Step 7: Attenuation

After placing all of the EDFAs, the channel powers around the network should be calculated again based on a 0dBm input signal and for all add/drop nodes the power levels of the dropped signal and added signal should be calculated. The dropped power level is:

$P_{dropped}$ = Node input power – dropped channel insertion loss

For example, if the power level into an 1-channel OADM is -13 dBm and the dropped channel insertion loss is 2.1 dB, then the dropped channel power will be -15.1 dBm (-13 dBm - 2.1 dB).

If the calculated dropped power is above -15 dBm an appropriate attenuator should be used for those dropped channels to adjust the power level to the -15 dBm level and avoid the overload risk on the receiver for those channels. The added power level is:

P_{added} = Node output power + add channel insertion loss

For example, if the power level out of a 1-Channel OADM is -13 dBm and the added channel insertion loss is 3.2 dB then the added channel's power level to the add point should be -9.8 dBm (-13 dBm + 3.2 dB).

To achieve these add channel power levels, use a VOA (if available) or external attenuators for the OADMs and DWDM filters.

Step 8: Final Design Verification

The final verification of the network is carried out by propagating 9 dBm power from the reference node (Hub Office) and checking whether the power returned back to the same point is 0 dBm as well. Take the following points into consideration when making this verification:

If the reference node does not have pass-through traffic, the received power level should be between -8 dBm and -22 dBm. If the received power level is above -8 dBm, it has to be attenuated to avoid receiver overload. If the power level is below -22 dBm, the design must be revised to reposition the EDFAs or add more EDFAs.

If the reference node does have pass-through traffic, the received power level should be between 0 dBm and -1 dBm. If the received power level is above 0 dBm, it must be attenuated to 0 dBm. If the power level is below -1 dBm, the design must be revised to reposition the EDFAs or add more EDFAs.

It is highly recommended to keep the total gain in the network below the total insertion loss for ring and linear topologies to avoid receiver overdrive and oscillation. The total insertion loss includes accumulated loss for fiber, connectors, filters, and attenuators.

The per channel calculations for the design example are shown below.

Fiber Characteristics:
- Attenuation: 0.3 db/km
- Dispersion: 18 ps/nm*km

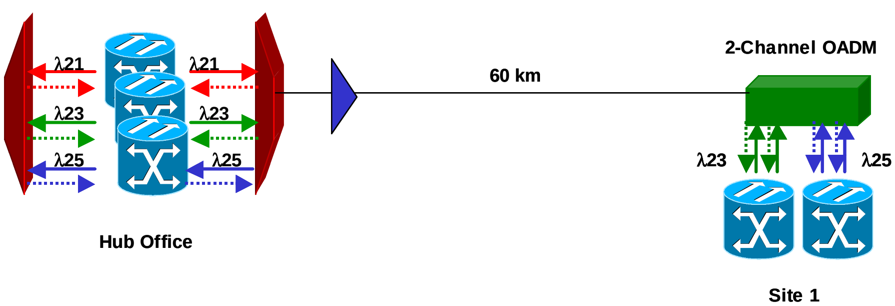
Mux/Demux Characteristics:
- Channel Spacing: 200 GHz
- Mux Insertion Loss: 4.5 dB
- Demux Insertion Loss: 4.5 dB

2-Channel OADM Characteristics:
- Channel Spacing: 200 GHz
- Thru loss: 2 dB
- Drop loss: 2.6 dB
- Add loss: 4.0 dB

1-Channel OADM Characteristics:
- Channel Spacing: 200 GHz
- Thru loss: 1.8 dB
- Drop loss: 2.1 dB
- Add loss: 3.2 dB

From the Hub Office to Site 1 (see Figure 4-2) the following calculations apply:

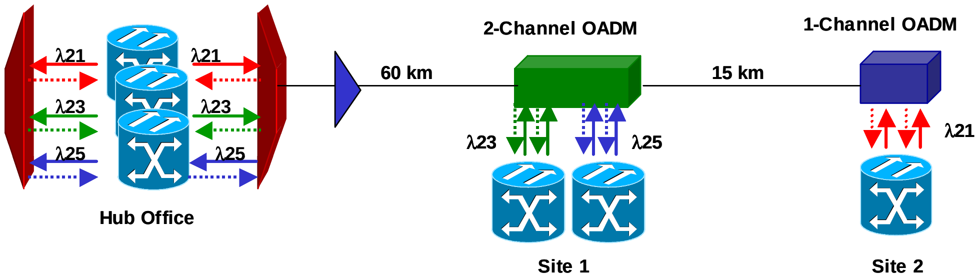
Figure 4-2: Hub Office to Site 1



-2.0 dBm ELR Output
-4.5 dB Mux insertion loss
<u>+4.8 dB Conversion to Composite power</u>
-1.7 dBm Composite power into the EDFA
<u>-4.3 dB VOA added to meet the minimum EDFA input specification</u>
-6.0 dbm Composite power into the EDFA
<u>+23 dB Gain from the EDFA2</u>
+17.0 dBm Composite power out of the EDFA
-18.0 dB For 60 km of span loss
-2.6 dBm Drop loss for the 2-Channel OADM
<u>-4.8 dB Conversion to Channel power</u>
-8.4 dB at the OC48 ITU-T receiver at Site 1

The per channel calculations from the Hub Office to Site 2 (see Figure 4-3) are as follows:

Figure 4-3: Hub Office to Site 2



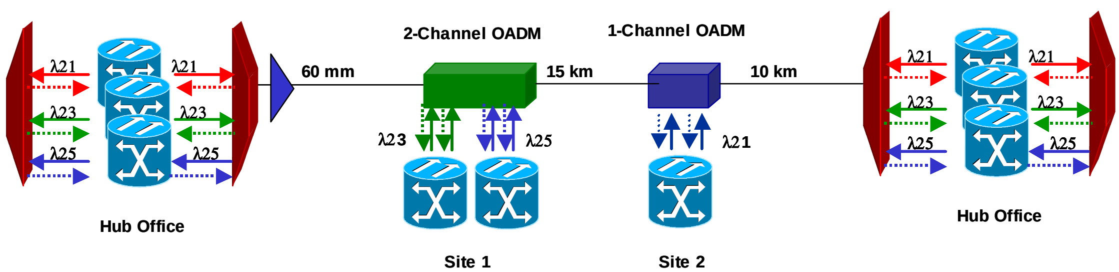
For the pass-through channel power @ site 1: (-5.8-2) = -7.8 dBm

-7.8 dBm out of 2-Channel OADM
-4.5 dB For 15 km of span loss
<u>-2.1 dB Drop loss for the 1-Channel OADM</u>
-14.4 dBm at the OC4 ITU-T receiver of Site 2

The pass thru channel power @ site 2: (-12.3- 1.8) = -13.1 dBm

The per channel calculations from Hub Office to Hub Office (see Figure 4-4) are as follows:

Figure 4-4: Hub Office to Hub Office

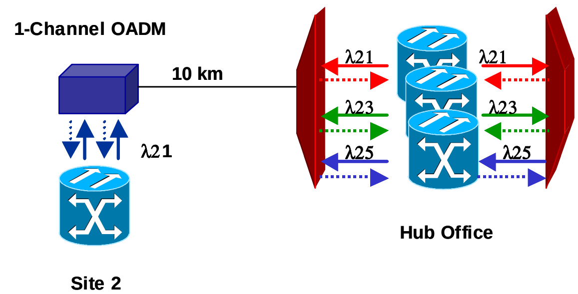


-13.1 dBm out of OADM-1
-4.5 dB For 15 km of span loss
<u>-4.5 dB Drop loss for the Demux</u>
-22.1 dBm at the OC48 ITU-T receiver of the Hub Office

Counter clockwise (protection) calculations are shown below.

The per channel calculations from the Hub Office to Site 2 (see Figure 4-5) are as follows:

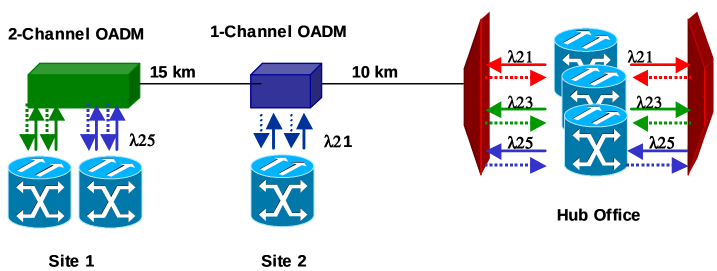
Figure 4-5: Hub Office to Site 2



-2.0 dBm ELR Output
<u>-4.5 dB Mux insertion loss</u>
-6.5 dBm Composite power
-3.0 dB For 10 km of span loss
<u>-2.1 dBm Drop loss for the 1-Channel OADM</u>
-11.6 dB at the OC48 ITU-T receiver at Site 2

The per channel calculations from the Hub Office to Site 1 (see Figure 4-6) are as follows:

Figure 4-6: Hub Office to Site 1

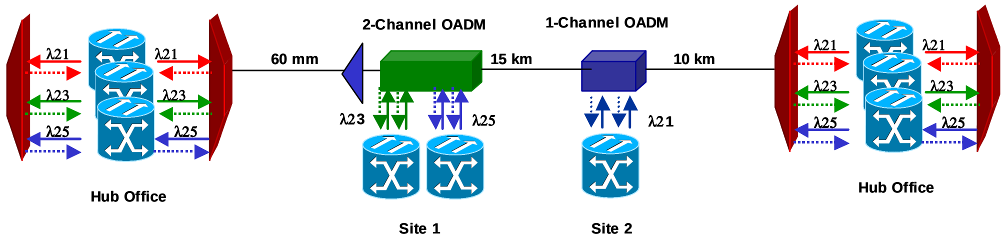


For the pass thru channel power @ site 2: (-9.5-1.8) = -11.3 dBm

-11.6 dBm out of the 1-Channel OADM
-4.5 dB For 15 km of span loss
<u>-2.6 dBm Drop loss for the 2-Channel OADM</u>
-18.7 dB at the OC48 ITU-T receiver of Site 1

The per channel calculations from Hub Office to Hub Office (see Figure 4-7) are as follows:

Figure 4-7: Hub Office to Hub Office



For the pass thru channel power @ site 1: (-16.1-2) = -18.1 dBm

-18.1 dBm out of the 2-Channel OADM
<u>+22 dB Gain from the EDFA</u>
+3.9 dBm Channel power out of the EDFA
-18.0 dB For 60 km of span loss
<u>-4.5 dB Insertion loss of the Passive DWDM filter</u>
-18.6 dBm at the OC48 ITU-T receiver of the Hub Office

Chapter 5 – Ethernet Applications and Features

Note: The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

Purpose

This chapter describes the Ethernet applications and features supported by the series of ONS 15454 Ethernet cards. By supporting Layer 1, Layer 2, and Layer 3 capabilities the various series of ONS 15454 Ethernet cards enable service providers to over-subscribe and efficiently pack their networks with data services, while also maintaining the flexibility to offer dedicated Ethernet Private Line (PL) services. With the new ML-Series cards available in System Release 4.0, efficient Ethernet transport and TDM can coexist on same card, thus enabling low cost interconnectivity for hubs and routers.

Contents

The following topics are found in this chapter:

Major Topics	Sub Topics
ML-Series Overview, *page 149*	Features List, *page 149* SONET Port Encapsulation, *page 151* Link Aggregation (FEC, GEC, and POS), *page 152* SONET Circuits, *page 152* VPN Routing/Forwarding (VRF) Lite, *page 153* Cisco IOS, *page 154* Interface Configuration, *page 154* Packet Over SONET (POS), *page 155* Bridging, *page 155* Spanning Tree Support, *page 156* Rapid Spanning Tree (RSTP) Support, *page 159* VLAN Support, *page 162* ML-Series QoS, *page 165*
ONS 15454 Ethernet Solutions Cross-Reference Charts, *page 166*	

E-Series Overview

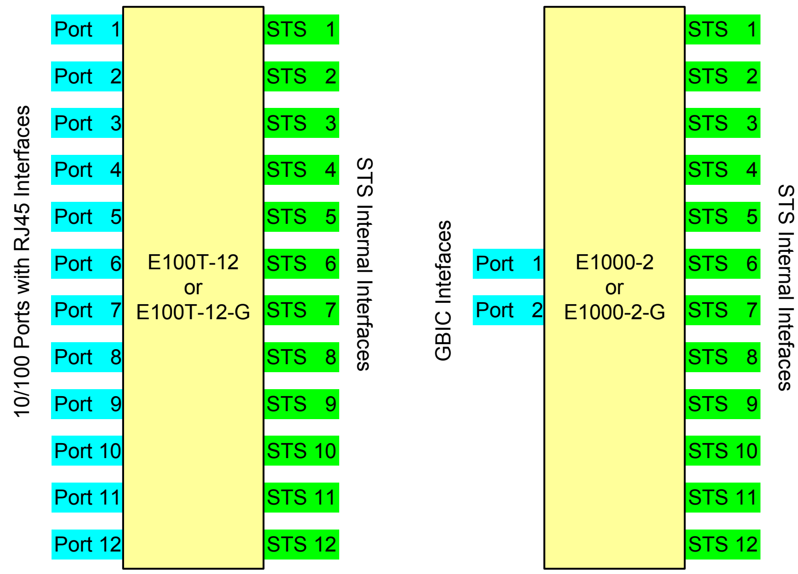
The E-Series cards incorporate layer 2 switching, while the G series card is a straight mapper card. The ONS 15454 E-Series include the following Ethernet cards:

E100T-12
E100T-G
E1000-2
E1000-2-G

Each E100T-12 and E100T-G card has 12 front panel (user side) 10/100 Mb/s Ethernet ports and 12 STS-1 connections (622 Mb/s aggregate bandwidth to the cross-connect card) to the transport side of the network. Each of the user side Ethernet ports can be set for autosensing. Autosensing enables the ports to detect the speed of an attached Ethernet device by auto-negotiation and automatically connect at the appropriate speed and duplex mode (half or full duplex), and also determine whether to enable or disable flow control.

The E1000-2 and E1000-2-G provides 2 modular GBIC (Gigabit Interface Connector) slots ports and 12 STS-1 connections to the internal interface ports on the transport side of the network. Each GBIC slot can be populated with either 1000Base-SX (short reach over multimode fiber at 850nm) or 1000Base-LX (long reach over single mode fiber at 1310nm). The slots are assigned to 12 STS-1s based internal interface transport ports. Figure 5-1 is a block diagram of the E-Series cards.

Figure 5-1: Block Diagram of E-Series Ethernet Cards



The E100T-G is the functional equivalent of the E100T-12. An ONS 15454 using XC-10G cross-connect cards requires the G versions of the E-Series Ethernet cards. The E1000-2 is the functional equivalent of the E1000-2-G. An ONS 15454 using XC-10G cross-connect cards requires the G versions of the E-Series Ethernet cards.

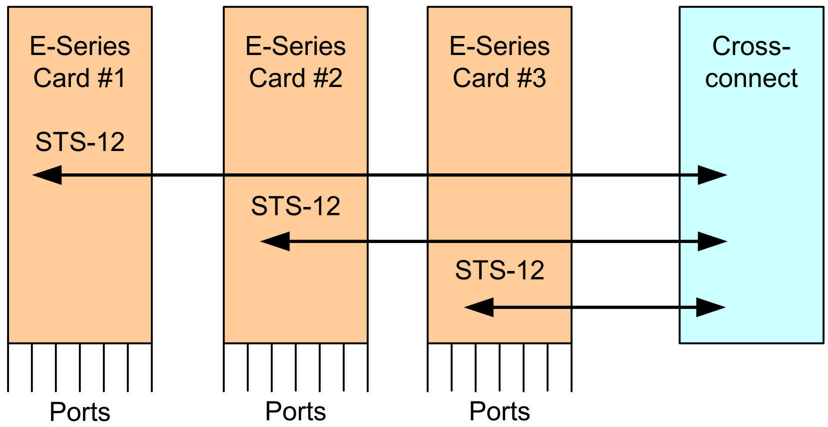
E-Series cards support VLAN, IEEE 802.1Q, spanning tree, and IEEE 802.1D. These cards conform to the general specifications of RFC 1619, but uses Cisco's proprietary HDLC encapsulation protocol. HDLC encapsulation adds 5 overhead bytes to the payload (1 byte = flag, 1 byte = address, 1 byte = control, 1 byte = byte 1 of CRC-16, 1 byte = byte 2 of CRC-16). Because of the proprietary nature of encapsulation, E-Series Ethernet circuits have to be 'book-ended". That is, E-Series Ethernet circuits must terminate only on E-Series cards. E-Series circuits cannot terminate on G-Series cards or be handed off to an external device in its native STS format (via an optical interface).

A single ONS 15454 can support a maximum of ten Ethernet cards, which can be installed in slots 1 to 6 and 12 to 17. The ONS 15454 supports single-card EtherSwitch, multi-card EtherSwitch group, and port-mapped modes for E-Series cards. Port-mapped mode is only available on systems running Release 4.0 and higher.

E-Series Single-card EtherSwitch

Single-card EtherSwitch allows each Ethernet card to remain a single switching entity within the ONS 15454 node. This option allows a full STS-12c worth of bandwidth between two Ethernet circuit points. Figure 5-2 illustrates a single-card EtherSwitch configuration.

Figure 5-2: Single-card EtherSwitch Operation



There is no limit on the number of single-card EtherSwitches that can be provisioned in an ONS 15454 assembly shelf, other than slot availability. All Ethernet cards installed in a node can transmit and receive to any provisioned Ethernet circuit and Virtual Local Area Network (VLAN).

Single-card EtherSwitch supports only point-to-point circuits. This allows a full STS-12c worth of bandwidth between two Ethernet circuit points, which can be divided into bandwidth increments of STS-1, STS-3c, STS-6c, or STS-12c as shown in Table 5-1.

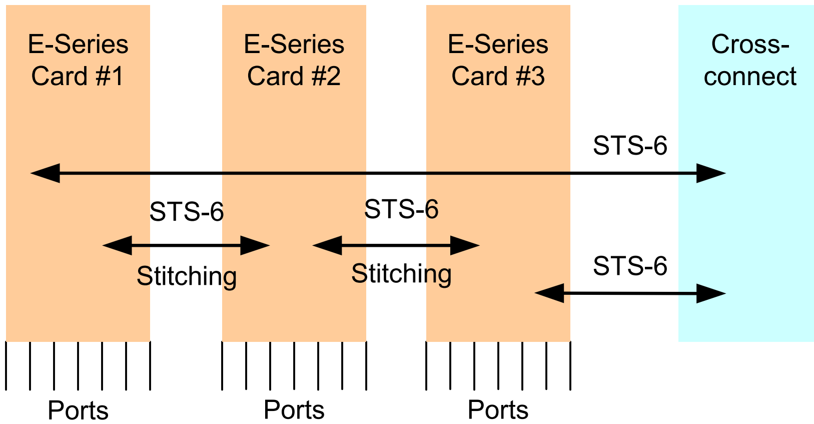
Table 5-1: EtherSwitch Circuit Combinations

	Topology	Unprotected Span Path Protection Configuration	2-Fiber & 4-Fiber BLSR	Linear APS
E-Series Ethernet Circuit Configurations	Point-to-Point	1 STS 12c 2 STS-6c 1 STS-6c and 2 STS-3c 1 STS-6c and 6 STS-1 4 STS-3c 2 STS-3c and 3 STS-1 12 STS-1	1 STS 12c 2 STS-6c 1 STS-6c and 2 STS-3c 1 STS-6c and 6 STS-1 4 STS-3c 2 STS-3c and 3 STS-1 12 STS-1	1 STS 12c 2 STS-6c 1 STS-6c and 2 STS-3c 1 STS-6c and 6 STS-1 4 STS-3c 2 STS-3c and 3 STS-1 12 STS-1
	Shared Packet Ring	1 STS-6c 2 STS-3c 1 STS-3c and 3 STS-1 6 STS-1	1 STS-6c 2 STS-3c 1 STS-3c and 3 STS-1 6 STS-1	Not Applicable

E-Series Multi-card EtherSwitch Group

Multi-card EtherSwitch group provisions two or more Ethernet cards to act as a single Layer 2 switch. It supports one STS-6c shared packet ring, two STS-3c shared packet rings, one STS-3c and three STS-1 shared packet rings, or six STS-1 shared packet rings. Half of each Ethernet card's STS bandwidth is used to "stitch" the cards together in a daisy-chain configuration (see Figure 5-3). The bandwidth of the single switch formed by the Ethernet cards matches the bandwidth of the provisioned Ethernet circuit up to STS-6c worth of bandwidth. Only one EtherGroup can be provisioned in an ONS 15454 assembly shelf. A multi-card EtherSwitch group can co-exist with multiple single-card EtherSwitches in the same node. Multi-card EtherSwitch group mode is required when provisioning shared packet ring circuits, but it can also be used for point-to-point circuits.

Figure 5-3: Multi-card EtherSwitch Group Operation



E-Series Port-Mapped Private Line

System Release 4.0 introduces the E-Series port-mapped mode, which provides a private line (PL) for transporting a guaranteed rate of Ethernet traffic over an ONS 15454. The PL provides a one-to-one association on an E-Series Ethernet port to a SONET circuit. This new association mode for the E-Series cards enables high-speed forwarding of both unicast and multi-cast packets and is transparent to any VLAN tags that may be present on the inbound Ethernet interfaces. VLAN and spanning tree are disabled when the E-Series cards are provisioned in this mode.

E-Series cards provisioned in port-mapped mode can terminate multiple point-to-point circuits per card, with each circuit terminating on a separate Ethernet port. The Ethernet circuits created in port-mapped mode can be protected via Path Protection Configuration, 2-Fiber and 4-Fiber BLSR, as well as linear APS. The supported circuit sizes are identical to the current single-card EtherSwitch applications. Ethernet circuits can traverse any ONS 15454 SONET network as long as they are terminated on another E-Series card provisioned in port-mapped mode.

The benefit of the port-mapped mode, is that it allows Ethernet traffic to be mapped directly onto the SONET circuit without passing through a Layer 2 switching engine. Although the Layer 2 switching capabilities of E-Series cards provide a much wider range of functionality than a simple Layer 1 Ethernet-to-SONET mapping scheme, there are several characteristics unique to the E-Series card's Layer 2 switching engine that may present limitations in some applications. Such limitations of the Layer 2 switching engine on the E-Series card include:

Broadcast and Multicast rate limitation: Unicast packet loss can occur when Broadcast or Multicast traffic is present in the Ethernet circuit (for reference see Field Notice 13171).

Excessive Ethernet circuit down time when a protection switch, TCC switch, or XC switch occurs. This is due to the fact that each circuit must wait for Spanning Tree Protocol (STP) reconvergence, which can take several minutes.

Each card is limited to 8 Spanning Tree instances, limiting the number of VLANs that can be provisioned from one card without implementing provisioning workarounds.

When you place the E-Series card in port-mapped mode, you can realize the following benefits:

No Unicast packet loss due to Multicast or Broadcast traffic.

No Multicast limitations.

No Excessive Ethernet circuit downtime since, there is no STP or need for STP reconvergence.

No limitation on the number of STP instances.

E-Series Circuit Configurations

Ethernet circuits can link ONS 15454 nodes through point-to-point, shared packet ring, or hub and spoke configurations. Two nodes usually connect with a point-to-point configuration. More than two nodes usually connect with a shared packet ring configuration or a hub and spoke configuration. Ethernet manual cross-connects allow you to cross connect individual Ethernet circuits to an STS channel on the ONS 15454 optical interface and also to bridge non-ONS SONET network segments.

E-Series Point-to-Point Ethernet Circuits

The ONS 15454 can set up a point-to-point Ethernet circuit as Single-card EtherSwitch, Multi-card EtherSwitch Group, or Port-mapped. Multi-card EtherSwitch Group mode limits bandwidth to STS-6c of bandwidth between two Ethernet circuit points, but allows adding nodes and cards and making a shared packet ring. Single-card EtherSwitch and port-mapped modes allows a full STS-12c of bandwidth between two Ethernet circuit points. These circuit configurations are illustrated in the following figures:

Figure 5-4: A Multi-card EtherSwitch Point-to-Point Circuit

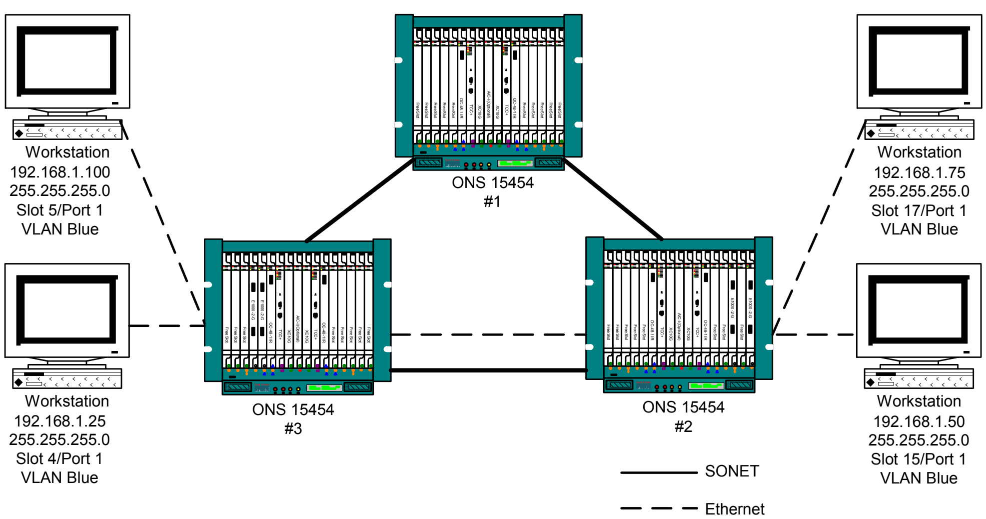


Figure 5-5: A Single-card EtherSwitch Point-to-Point Circuit

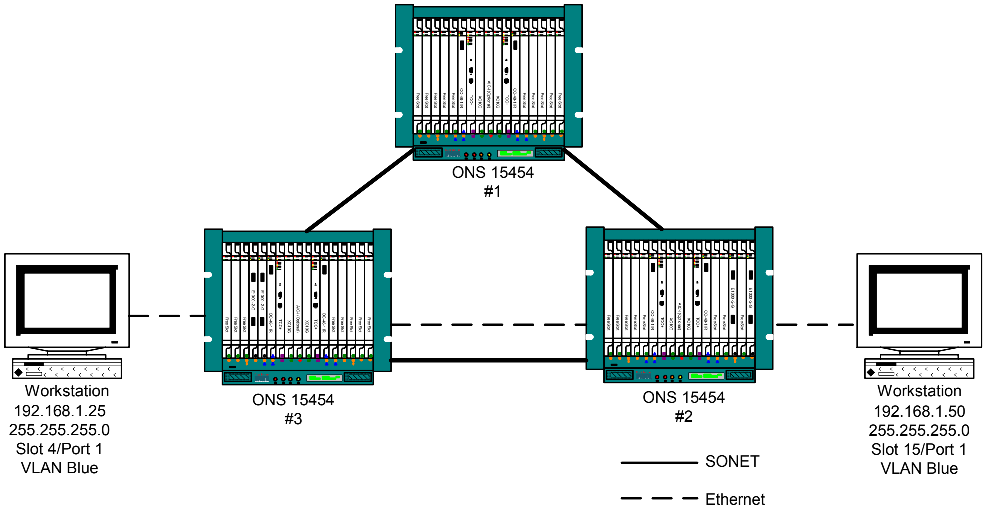
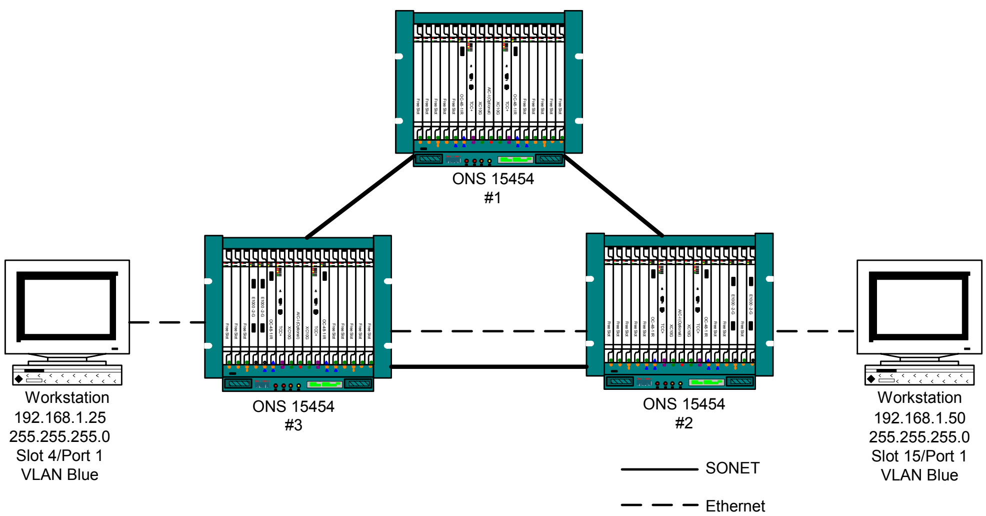


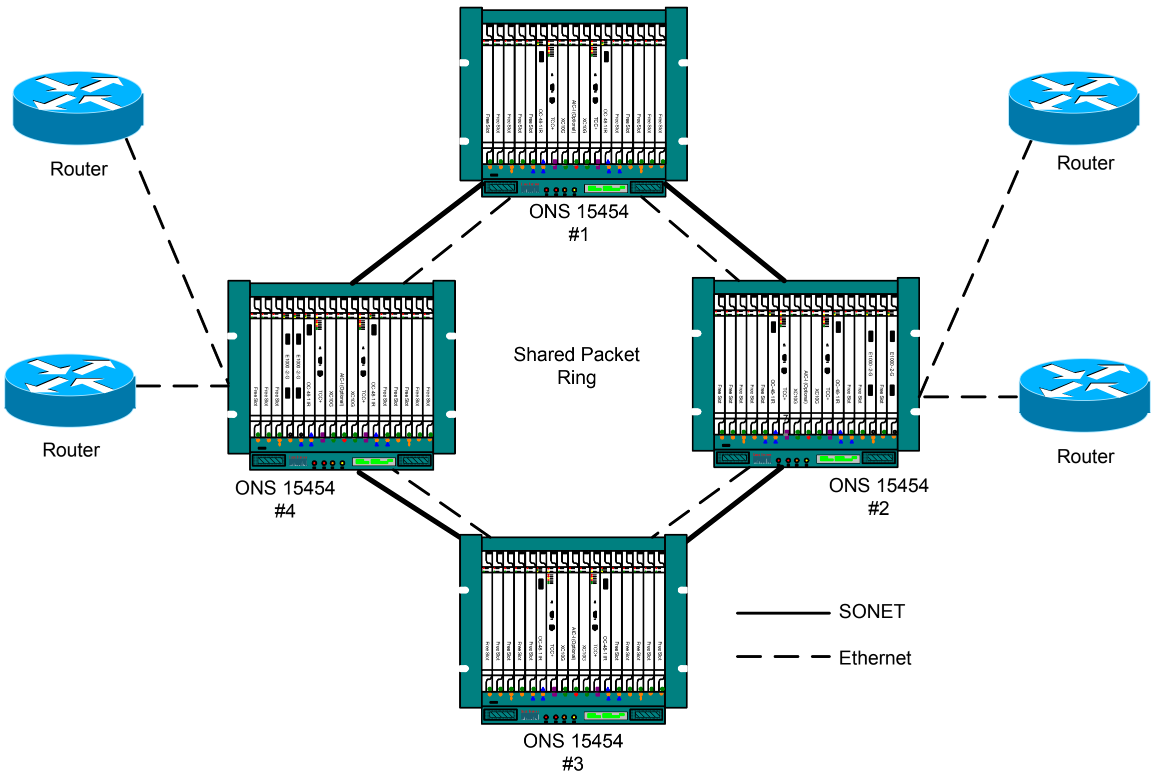
Figure 5-6: A Port-mapped Point-to-Point Circuit



E-Series Shared Packet Ring Ethernet Circuits

Figure 5-7 illustrates a shared packet ring.

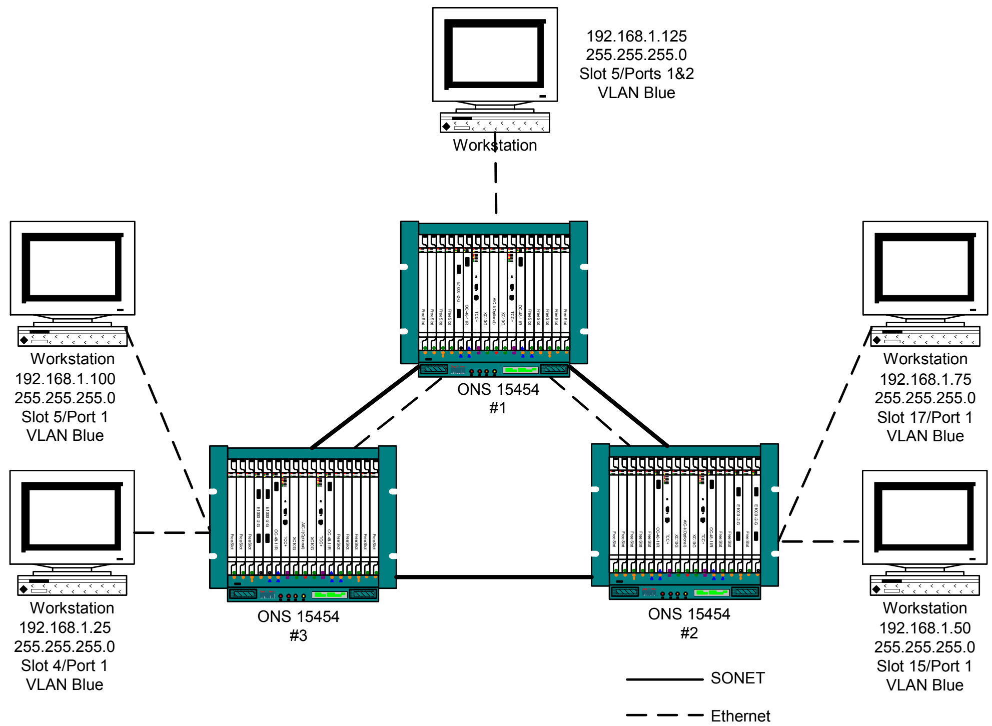
Figure 5-7: A Shared Packet Ring Ethernet Circuit



E-Series Hub and Spoke Ethernet Circuits

The hub and spoke configuration connects point-to-point circuits (the spokes) to an aggregation point (the hub). In many cases, the hub links to a high-speed connection and the spokes are Ethernet cards. Figure 5-8 illustrates a sample hub and spoke ring.

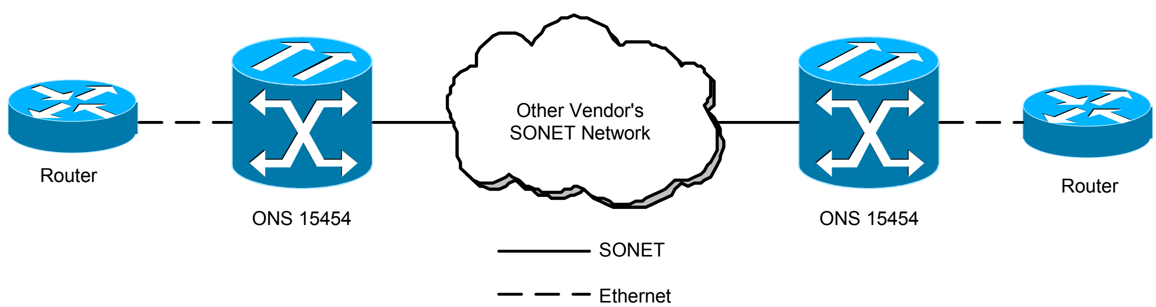
Figure 5-8: A Hub and Spoke Ethernet Circuit



E-Series Ethernet Manual Cross-Connects

ONS 15454 nodes require end-to-end CTC visibility between nodes for normal provisioning of Ethernet circuits. When other vendors' equipment sits between ONS 15454 nodes, OSI/TARP-based equipment does not allow tunneling of the ONS 15454 TCP/IP-based DCC. To circumvent this lack of continuous DCC, the Ethernet circuit must be manually cross connected to an STS channel riding through the other vendors' network. This allows an Ethernet circuit to run from ONS 15454 node to ONS 15454 node utilizing the other vendors' network.

Figure 5-9: Ethernet Manual Cross-connects



E-Series Frame Processing

For all frames, an IEEE 802.3-formatted frame enters the ingress interface on the E-Series Ethernet cards. The 8-byte Ethernet preamble is stripped and the remaining frame is buffered on the card while being processed. The frame check sequence (FCS) for the frame is computed as required by the 802.3 standard. If the frame is in error, (i.e. the computed FCS does not match the embedded FCS), the frame is discarded. Higher layer protocols are responsible for retransmission when traffic is dropped.

For frames on tagged ports, if the frame has entered via a port configured as “Tagged,” the Ethernet card reads the contents of the Tag Control Indicator (TCI) field and determines whether the VLAN tag matches the list of configured VLANs that are eligible for ingress on that port. If the frame is not “eligible” it is dropped (in this scenario, the “dropped-frames” counter is not incremented). Based on the priority setting in the TCI field, the frame is queued for further processing.

For frames on untagged ports, if the ingress port has been configured as “Untagged,” a tag corresponding to the assigned VLAN for that port is inserted into the TCI field. The addition of 802.1q tagging adds 4 bytes to the previously untagged frame. All Tagged frames will be dropped. However, if a Tagged frame with the same VLAN ID as that assigned to the port enters the port, it will pass through and will not be dropped. At the egress port the 802.1Q/p header is stripped from the frame.

Note There is an issue when a 64-byte Tagged frame with the same VLAN ID as that assigned to the port enters the port. At the egress port, when the tag is stripped, no padding is added to the frame and this results in a non-compliant 60-byte frame to be transmitted.

For frames on Untagged ports, the provisioned priority setting for the Untagged port is also inserted in the TCI field and the frame is queued for further processing based on that priority. At the egress port, the priority is removed along with the TCI field.

For all frames, the source MAC address is read and checked against the MAC forwarding table. If a frame from this source has not been received previously, a new entry is made in the table with the MAC address, the VLAN associated with it, and the slot/port/STS it was received on. The destination MAC address is checked against the MAC forwarding table. If the destination MAC address is not present in the table, the Ethernet cards will broadcast to its connected neighbors on the same VLAN to determine the appropriate egress port or STS. If the destination is known, the frame is switched to the appropriate destination slot, port, or STS. Once the destination has been determined, the entire Ethernet frame is inserted into a High-level Data Link Control (HDLC) frame. This adds 5 bytes of overhead to the payload (1 byte = flag, 1 byte = address, 1 byte = control, 1 byte =byte 1 of CRC-16, 1 byte = byte 2 of CRC-16). The newly formatted frame leaves the Ethernet card and is inserted into the appropriate STS payload.

For all frames being switched to an STS payload, the Ethernet card inserts a value of 0001 in the C2 byte of the SONET Path Overhead indicating that the contents of the STS SPE contains “Equipped – non-specific payload”. The purpose of this is to allow for first level verification by confirming that both ends of the path are using the same SPE content and protocol.

E-Series Frame Length

The ONS 15454 E-Series cards can support 1522-byte frames on Tagged ports. On Untagged ports the E-Series can support frames up to 1518 bytes. Frames greater than 1522 bytes will be dropped for both the Tagged and Untagged ports.

MPLS and VLAN Trunking (also referred to as Q-in-Q) require frame lengths exceeding 1522 bytes. The E-Series cards cannot support these protocols. However, a workaround is possible using an externally connected device.

Large frame support makes it possible to provide MPLS Ethernet. However, many Ethernet switches, including the existing E-Series cards, do not support large frames, thus forcing routers to compensate as a workaround. The router that needs to put an over-sized MPLS frame onto an Ethernet interface must fragment the data and adjust for an MTU of 1500 bytes. However, some IP packets may be marked as do-not-fragment (DF bit), which should trigger MTU negotiation via ICMP. If the initiating host doesn't support MTU discovery, the DF bit can be cleared on the Cisco device and force fragmentation. However, fragmentation may hurt routing performance, particularly on a core device.

E-Series Buffer Size

E-Series cards have a distributed, shared memory architecture. So the aggregate buffer memory applies to all ports and STSs on the card. The E100T-12-G has 32 Mb of physical buffer memory. Of this, 8 Mb is addressable for forwarding frames. The E1000-2-G has 24 Mb of physical memory, with 6 Mb that is addressable.

IEEE 802.3x Flow Control

The E-Series Ethernet cards support IEEE 802.3x flow control and frame buffering to reduce data traffic congestion. Approximately 8MB on the E100T-12-G and 6MB on the E1000-2-G of total buffer memory is available for the transmit and receive channels to buffer over-subscription. When the Ethernet connected device nears capacity, it will issue an 802.3x flow control frame called a “pause frame” which instructs the E-Series card to stop sending packets for a specific period of time.

E-Series Ethernet cards will only respond to 802.3x “pause frames” connected to 802.3x compliant stations. E-Series Ethernet cards will not issue 802.3x “pause frames” to end stations.

EtherChannel

E-Series cards do not support fast or Gigabit EtherChannel.

E-Series Rate-Limiting

For E-Series Ethernet cards, you can specify a value of exactly 10 Mb/s, 100 Mb/s or 1000 Mb/s per port on the user-interface side or STS-1, STS-3c, STS-6c or STS-12c on the optical transport side. If the STS-N circuit is shared by multiple ONS 15454 nodes, the bandwidth per node cannot be limited. Also, if multiple ports on the same node share the STS-N, the bandwidth per port cannot be limited.

There are work-around solutions available to limit the amount of bandwidth allocated to a port. For example, if you need Ethernet rate shaping, Cisco can provide a solution using a switch such as the Cisco Catalyst 3550.

E-Series Latency

Store-and-forward latency is the time delay between the Last-bit-In and the First-bit-Out (LIFO). The LIFO latency of an E-Series card depends on the offered packet size and ranges from 10 to 55 microseconds (ms). Average LIFO latency through an E-Series card between local Ethernet ports is as follows:

Packet Size (bytes)	Latency (ms)
64	10
128	10
256	14
512	22
1024	36
1280	47
1518	55

The latency to switch frames between front-side Ethernet ports versus back-end STS circuit connections is equivalent. However, when measuring end-to-end Ethernet latency across the SONET network, the delay will include the time for the E-Series switching, cross-connection, and the OC-N line card for each side of the connection, as well as the propagation delay through the fiber. The data above only characterizes latency of the E-Series card itself.

E-Series VLAN Support

You can provision up to 509 VLANs. Specific sets of ports define the broadcast domain for the ONS 15454. The definition of VLAN ports includes all Ethernet and packet-switched SONET port types. All VLAN IP address discovery, flooding, and forwarding is limited to these ports.

The ONS 15454 802.1Q-based VLAN mechanism provides logical isolation of subscriber LAN traffic over a common SONET transport infrastructure. Each subscriber has an Ethernet port at each site, and each subscriber is assigned to a VLAN. Although the subscriber's VLAN data flows over shared circuits, the service appears to the subscriber as a private data transport.

E-Series Q-Tagging (IEEE 802.1Q)

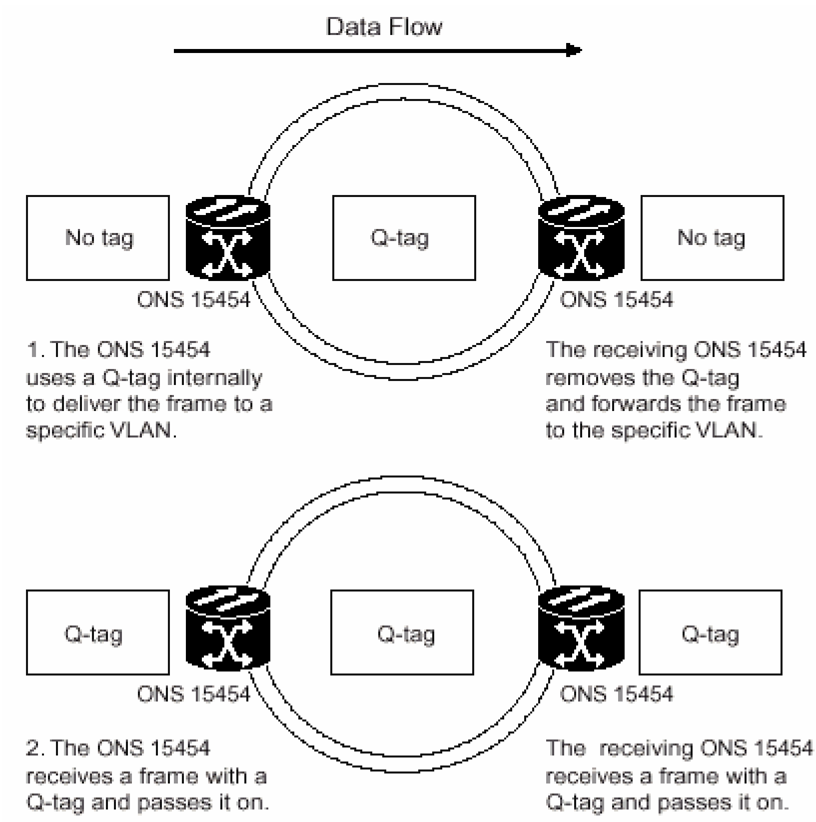
IEEE 802.1Q allows the same physical port to host multiple 802.1Q VLANs. Each 802.1Q VLAN represents a different logical network. The E-Series cards work with external Ethernet devices that support IEEE 802.1Q and those that do not support IEEE 802.1Q. If a device attached to an E-Series Ethernet port does not support IEEE 802.1Q, the ONS 15454 only uses Q-tags internally. The ONS 15454 associates these Q-tags with specific ports.

With Ethernet devices that do not support IEEE 802.1Q, the ONS 15454 node takes non-tagged Ethernet frames that enter the ONS 15454 network and uses a Q-tag to assign the packet to the VLAN associated with the network's ingress port. The receiving ONS 15454 node removes the Q-tag when the frame leaves the ONS 15454 network (to prevent older Ethernet equipment from incorrectly identifying the 8021.Q packet as an illegal frame). The ingress and egress ports on the E-Series Ethernet cards must be set to Untag for this process to occur. Untag is the default setting for ONS 15454 Ethernet ports. Example #1 in Figure 5-10 illustrates Q-tag use only within an ONS 15454 Ethernet network.

With Ethernet devices that support IEEE 802.1Q, the ONS 15454 uses the Q-tag attached by the external Ethernet devices. Packets enter the ONS 15454 network with an existing Q-tag; the ONS 15454 node uses this same Q-tag to forward the packet within the ONS 15454 network and leaves the Q-tag attached when the packet leaves the ONS 15454 network. Set both entry and egress ports on the E-Series Ethernet cards to Tagged for this process to occur. Example #2 in

Figure 5-10 illustrates the handling of packets that both enter and exit the ONS 15454 network with a Q-tag.

Figure 5-10: A Q-tag Moving Through a VLAN



E-Series Priority Queuing (IEEE 802.1Q)

Note IEEE 802.1Q was formerly IEEE 802.1P.

Networks without priority queuing handle all packets on a first-in-first-out basis. Priority queuing reduces the impact of network congestion by mapping Ethernet traffic to different priority levels. The ONS 15454 supports priority queuing. The ONS 15454 takes the eight priorities specified in IEEE 802.1Q and maps them to two queues shown in Table 5-2. Q-tags carry priority queuing information through the network.

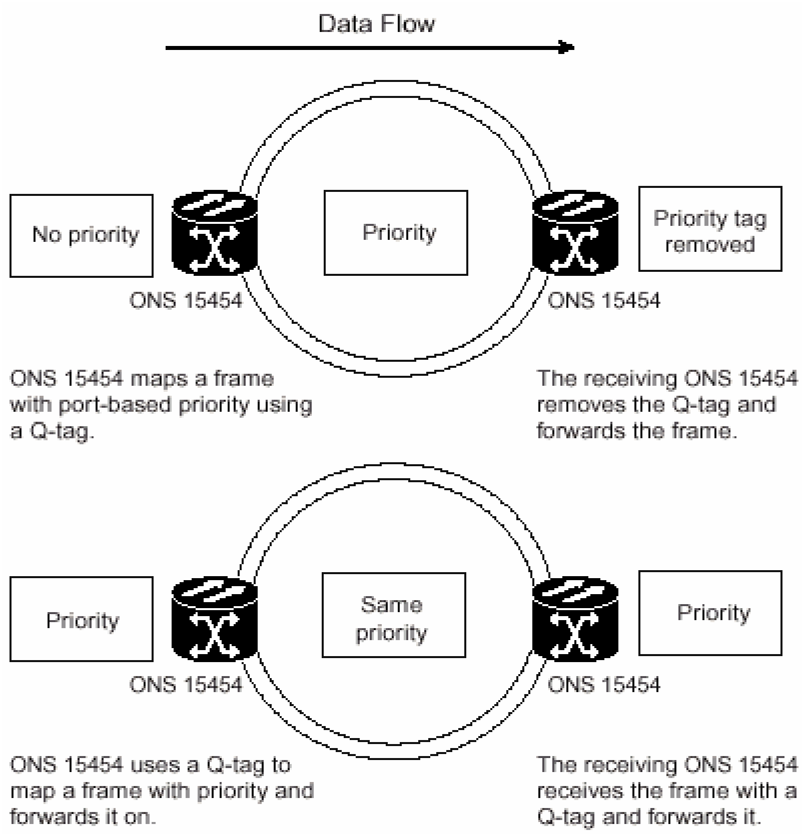
Table 5-2: Priority Queuing

User Priority	Queue	Allocated Bandwidth
0, 1, 2, 3	Low	30%
4, 5, 6, 7	High	70%

The ONS 15454 uses a “leaky bucket” algorithm to establish a weighted priority (not a strict priority). A weighted priority gives high-priority packets greater access to bandwidth, but does not totally preempt low-priority packets. During periods of network congestion, roughly 70% of bandwidth goes to the high-priority queue and the remaining 30% goes to the low-priority queue.

A network that is too congested will drop packets. Figure 5-11 illustrates the priority queuing process.

Figure 5-11: The Priority Queuing Process



E-Series Spanning Tree (IEEE 802.1D)

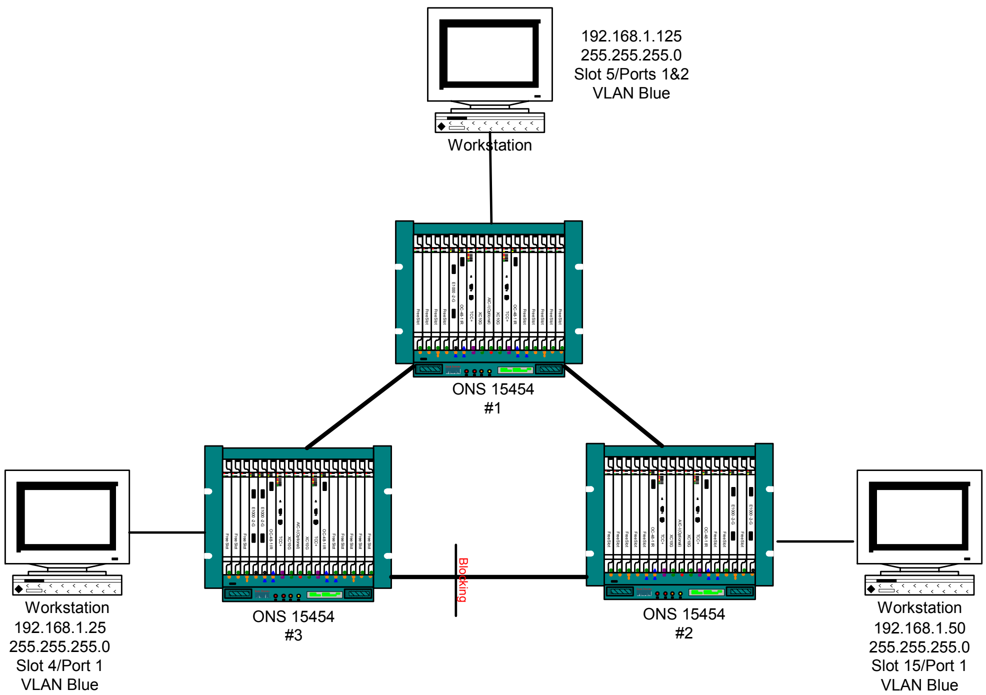
The Cisco ONS 15454 operates spanning tree protocol (STP) according to IEEE 802.1D when an E-Series Ethernet card is installed. The spanning tree algorithm places each Ethernet port into either a *forwarding* state or *blocking* state. All the ports in the forwarding state are considered to be in the current spanning tree. The collective set of forwarding ports creates a single path over which frames are sent. E-Series cards can forward frames out ports and receive frames in ports that are in forwarding state. E-Series cards do not forward frames out ports and receive frames in ports that are in a blocking state.

STP operates over all packet-switched ports including Ethernet and OC-N ports. On Ethernet ports, STP is enabled by default but may be disabled with CTC by placing a check in the box under the Provisioning > Ether Port tabs at the card-level view. You can also disable or enable spanning tree on a circuit-by-circuit basis on unstitched E-Series Ethernet cards in a point-to-point configuration. However, turning off spanning tree protection on a circuit-by-circuit basis means that the ONS 15454 system is not protecting the Ethernet traffic on this circuit, and the Ethernet traffic must be protected by another mechanism in the Ethernet network. On OC-N interface ports, STP activates by default and cannot be disabled.

You can enable STP on the Ethernet ports to allow redundant paths to external Ethernet equipment. STP spans the ONS 15454 multi-service cards so that both equipment and facilities are protected against failure.

STP detects and eliminates network loops. When STP detects multiple paths between any two network hosts, STP blocks ports until only one path exists between any two network hosts as shown in Figure 5-12. The single path eliminates possible bridge loops. This is crucial for shared packet rings, which naturally include a loop.

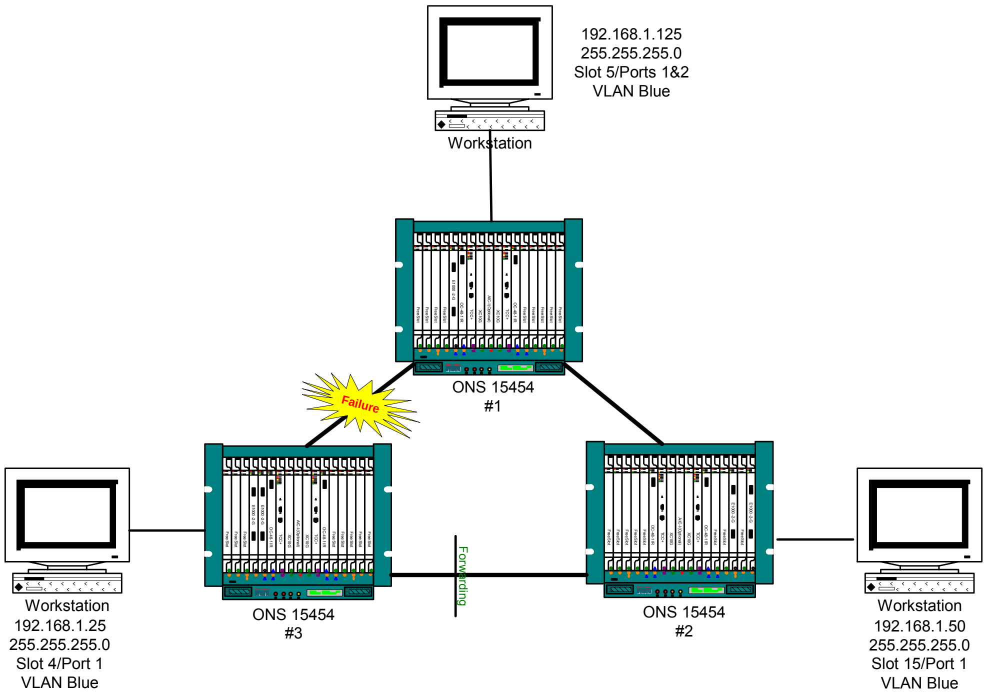
Figure 5-12: ONS 15454 Network with STP



Now when the Workstation connected to ONS 15454 #1 sends a frame to the Workstation connected to ONS 15454 #3, the frame does not loop. ONS 15454 #1 sends a copy to ONS 15454 #3, but ONS 15454 #3 cannot forward it to ONS 15454 #2 out its Ethernet port because it is blocking.

If the link between ONS 15454 #1 and ONS 15454 #3 fails, STP would reconverge so that ONS 15454 #3 would no longer block. For example, in Figure 5-13, that link has failed and STP has changed. Typically STP takes about 30-50 seconds to reconverge. However, since the ONS 15454 has SONET protection, the physical layer reroutes in less than 50 ms and STP does not have to reconverge. The links that are blocked by STP are unused, until a topology (physical connectivity) change. segments.

Figure 5-13: ONS 15454 Network with STP After Link Failure



E-Series Multi-Instance Spanning Tree and VLANs

The ONS 15454 can operate multiple instances of STP to support VLANs in a looped topology. The ONS 15454 supports one STP instance per circuit and a maximum of eight STP instances per ONS 15454. You can dedicate separate circuits across the SONET ring for different VLAN groups (i.e., one for private TLS services and one for Internet access). Each circuit runs its own STP to maintain VLAN connectivity in a multi-ring environment.

Spanning Tree on a Circuit-by-Circuit Basis

You can also disable or enable spanning tree on a circuit-by-circuit basis on unstitched Ethernet cards in a point-to-point configuration. This feature allows customers to mix spanning tree protected circuits with unprotected circuits on the same card. It also allows two single-card EtherSwitch Ethernet cards on the same node to form an intranode circuit.

E-Series Spanning Tree Parameters

Default spanning tree parameters listed in Table 5-3 are appropriate for most situations, but can be modified as required.

Table 5-3: Spanning Tree Parameters

Parameter	Description	Default	Range
BridgeID	ONS 15454 unique identifier that transmits the configuration bridge protocol data unit (BPDU); the bridge ID is a combination of the bridge priority and the ONS 15454 MAC address	Read Only	Read Only
Priority	Defines bridge priority	32768	0 - 65535
TopoAge	Amount of time in seconds since the last topology change	Read Only	Read Only
TopoChanges	Number of times the spanning tree topology has been changed since the node booted up	Read Only	Read Only
DesignatedRoot	Identifies the spanning tree's designated root for a particular spanning tree instance	Read Only	Read Only
RootCost	Identifies the total path cost to the designated root	Read Only	Read Only
RootPort	Port used to reach the root	Read Only	Read Only
MaxAge	Maximum time that received-protocol information is retained before it is discarded	20	6 - 40 seconds
HelloTime	Time interval, in seconds, between the transmission of configuration BPDUs by a bridge that is the spanning tree root or is attempting to become the spanning tree root	2	1 - 10 seconds
HoldTime	Minimum time period, in seconds, that elapses during the transmission of configuration information on a given port		
ForwardDelay	Time spent by a port in the listening state and the learning state	15	4 - 30 seconds

E-Series Utilization Formula

Line utilization is calculated with the following formula:

((inOctets + outOctets) + (inPkts + outPkts) * 20)) * 8 / 100 % interval * maxBaseRate * 2.

The interval is defined in seconds. maxBaseRate is defined by raw bits/second in one direction for the Ethernet port (i.e. 1 Gb/s). maxBaseRate is multiplied by 2 in the denominator to determine the raw bit rate in both directions.

Table 5-4: maxRate for STS Circuits

Circuit Size	Bit Rate
STS-1	51840000
STS-3c	155000000
STS-6C	311000000
STS-12c	622000000

MAC Forwarding Table

A MAC address is a hardware address that physically identifies a network device. The ONS 15454 MAC forwarding table, will allow you to see all the MAC addresses attached to the enabled ports of an E-Series Ethernet card or an E-Series Ethernet Group. This includes the MAC address of the network device attached directly to the Ethernet port and any MAC addresses on the ONS 15454 network linked to the port. The MAC addresses table lists the MAC addresses stored by the ONS 15454 and the VLAN, Slot/Port/STS, and circuit that links the ONS 15454 to each MAC address.

Hash Table

Hashing is an algorithm for organizing the MAC forwarding table. In the E-Series cards, the hash table consists of approximately 1500 “buckets” with capacity for 5 MAC address entries in each bucket. The hash algorithm reduces a MAC address to smaller pseudo-random index values used to streamline lookup performance. In this scenario, MAC addresses that equate to the same hash value, post the first five learned entries for that index bucket, may not be included in the forwarding table; and therefore may not be recognized. Frames destined for unknown MAC addresses are flooded. Hashing is common practice and will most likely not be an issue in your applications, since proliferated MAC addresses are fairly random.

G-Series Overview

The G-Series Ethernet cards support high bandwidth, low latency, point-to-point Gigabit Ethernet connectivity. Each interface will negotiate for full-duplex operation and 802.3z flow control (asymmetric) with a maximum bandwidth of 1 Gb/s (2 Gb/s bi-directional) per port up to 2.5 Gb/s (5 Gb/s bi-directional) per card. The ONS 15454 G-Series include the following Ethernet cards:

G1000-4
G-1K-4

The G1000-4 card supports bandwidth guarantees on a per port basis through the provisioning of SONET STS based circuits between card ports. You can map the four ports on the G1000-4 independently to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, and STS-48c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-48c.

The G-Series cards provide up to 4 circuits and offer multiple protection capabilities, depending upon the users needs. The transported Gigabit Ethernet (Gig-E) circuits can be protected using SONET switching, Path Protection Configuration, BLSR, or PPMN; offering sub 50 ms restoration in the event of a transport network outage. The “client” card interface may be protected by leveraging Gigabit EtherChannel or link aggregation protocols. This allows you to provision two or more circuits between terminal devices, allowing these circuits to be routed over multiple G-Series cards. The Gig-E circuits can also be operated over unprotected OC-N spans.

The new G-1K-4 card introduced in System Release 4.0, is a high density GE card. It provides four GBIC interfaces. The G-1K-4 card operates identically to the G1000-4 card, except the new card will interoperate with the XC or XC-VT cross-connect cards, when installed in the high-speed multi-service I/O slots (5, 6, 12, and 13). Both, the G-1K-4 and G1000-4 cards can be installed in any multipurpose I/O slot when interoperating with the XC-10G cross-connect card. The G-1K-4 card is backward compatible to System Release 3.2 software.

The following GBIC modules are available as separate orderable products:

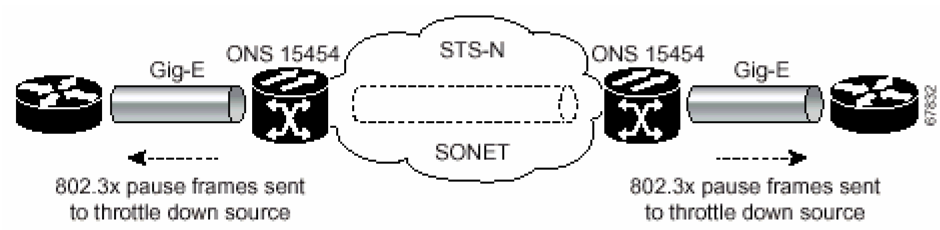
IEEE 1000Base-SX compliant 850nm optical module
IEEE 1000Base-LX compliant 1300nm optical module
IEEE 1000Base-Zx 1550nm optical modules

The 850nm SX optics are designed for multi-mode fiber and distances of up to 220 meters on 62.5micron fiber and up to 550 meters on 50 micron fiber. The 1300nm LX optics are designed for single mode fiber and distances of up to 5 kilometers. The 1550nm very long reach ZX optics are designed for a distances of up to 70 kilometers.

G-Series Ethernet Example

Figure 5-14 shows an example of a G-Series Ethernet application. In this example, data traffic from the Gig-E port of a high-end router travels across the ONS 15454 point-to-point circuit to the Gig-E port of another high-end router.

Figure 5-14: Data Traffic Using a G1000-4 Point-to-Point Circuit



The G-Series cards can carry over a SONET network any Layer 3 protocol that can be encapsulated and transported over Gigabit Ethernet, such as IP or IPX. The data is transmitted on the Gig-E fiber into a standard Cisco GBIC on a G1000-4 or G-1K-4 card. These Ethernet cards transparently map Ethernet frames into the SONET payload by multiplexing the payload onto a SONET OC-N card. When the SONET payload reaches the destination node, the process is reversed and the data is transmitted from a standard Cisco GBIC in the destination G-Series card onto the Gig-E fiber.

The G-Series cards discard certain types of erroneous Ethernet frames rather than transport them over SONET. Erroneous Ethernet frames include corrupted frames with CRC errors and under-sized frames that do not conform to the minimum 60-byte length Ethernet standard. The G-Series cards forward valid frames unmodified over the SONET network. Information in the headers is not affected by the encapsulation and transport. For example, packets with formats that include IEEE 802.1Q information will travel through the process unaffected.

802.3x Flow Control and Frame Buffering

The G-Series Ethernet cards supports 802.3x flow control and frame buffering to reduce data traffic congestion. To buffer over-subscription, 512 kb of buffer memory is available for the receive and transmit channels on each port. When the buffer memory on the Ethernet port nears capacity, the ONS 15454 uses 802.3x flow control to send back a pause frame to the source at the opposite end of the Gigabit Ethernet connection.

The pause frame instructs that source to stop sending packets for a specific period of time. The sending station waits the requested time before sending more data. Figure 5-14 illustrates pause frames being sent from the ONS 15454s to the sources of the data. The G-Series cards do not respond to pause frames received from client devices.

This flow-control mechanism matches the sending and receiving device throughput to that of the bandwidth of the STS circuit. For example, a router may transmit to the Gig-E port on the G1000-4. This particular data rate may occasionally exceed 622 Mbps, but the ONS 15454 circuit assigned to the G1000-4 port may be only STS-12c (622.08 Mbps). In this example, the ONS 15454 sends out a pause frame and requests that the router delay its transmission for a certain period of time.

With a flow control capability combined with the substantial per-port buffering capability, a private line service provisioned at less than full line rate capacity (STS-24c) is nevertheless very efficient because frame loss can be controlled to a large extent.

Some important characteristics of the flow control feature on the G1000-4 include:

Flow control is now symmetric. Previous to System Release 4.0, the G1000-4 card only supported asymmetric flow control, where flow control frames were sent to the external equipment but no response from the external equipment is necessary or acted upon.

Received flow control frames are quietly discarded. They are not forwarded onto the SONET path, and the G-Series cards do not respond to the flow control frames.

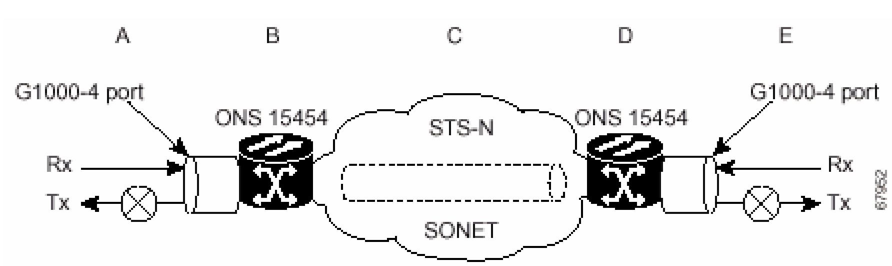
You can only enable flow control on a port when auto-negotiation is enabled on the device attached to that port. For more information, Refer to the Provision Path Trace on Circuit Source and Destination Ports (DLP130) in the *Cisco ONS 15454 Procedure Guide*.

Ethernet Link Integrity Support

The G-Series cards support end-to-end Ethernet link integrity. This capability is integral to providing an Ethernet private line service and correct operation of Layer 2 and Layer 3 protocols on the external Ethernet devices attached at each end. End-to-end Ethernet link integrity essentially means that if any part of the end-to-end path fails the entire path fails. Failure of the entire path is ensured by turning off the transmit lasers at each end of the path. The attached Ethernet devices recognize the disabled transmit laser as a loss of carrier and consequently an inactive link.

As shown in Figure 5-15, a failure at any point of the path (A, B, C, D or E) causes the G1000-4 card at each end to disable its Tx transmit laser at their ends, which causes the devices at both ends to detect link down. If one of the Ethernet ports is administratively disabled or set in loopback mode, the port is considered a “failure” for the purposes of end-to-end link integrity because the end-to-end Ethernet path is unavailable. The port “failure” also cause both ends of the path to be disabled. The G-1K-4 operates in the same manner.

Figure 5-15: End-to-End Ethernet Link Integrity Support



Note Some network devices can be configured to ignore a loss of carrier condition. If such a device attaches to a G-Series card at one end then alternative techniques (such as use of Layer 2 or Layer 3 protocol keep alive messages) are required to route traffic around failures. The response time of such alternate techniques is typically much longer than techniques that use link state as indications of an error condition.

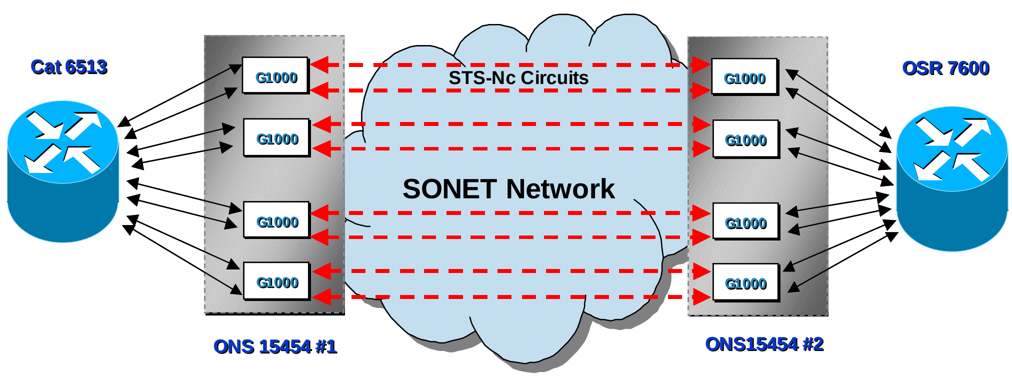
Note Enabling or disabling port level flow control on the test set or other Ethernet device attached to the Gig-E port can affect the transmit (Tx) laser of the G-Series Ethernet card. This can result in unidirectional traffic flow, if flow control is not enabled on the test set or other Ethernet device.

Gigabit EtherChannel/802.3ad Link Aggregation

The end-to-end Ethernet link integrity feature of G-Series cards can be used in combination with Gigabit EtherChannel capability on attached devices. The combination provide an Ethernet traffic restoration scheme that has a faster response time than alternate techniques such as spanning tree re-routing, yet is more bandwidth efficient because spare bandwidth does not need to be reserved.

G-Series Ethernet cards supports all forms of Link Aggregation technologies including Gigabit EtherChannel (GEC) which is a Cisco proprietary standard as well as the IEEE 802.3ad standard. The end-to-end link integrity feature of the G-Series cards allows a circuit to emulate an Ethernet link. This allows all flavors of Layer 2 and Layer 3 re-routing, as well as technologies such as link aggregation, to work correctly with the G-Series cards. The G-Series cards support Gigabit EtherChannel (GEC), which is a Cisco proprietary standard similar to the IEEE link aggregation standard (IEEE 802.3ad). Figure 5-16 illustrates G-Series GEC support.

Figure 15-16: G-Series Gigabit EtherChannel (GEC) Support



Although G-Series cards do not actively run GEC, they do supports the end-to-end GEC functionality of attached Ethernet devices. If two Ethernet devices running GEC connect through G-Series cards to an ONS 15454 network, the ONS 15454 SONET side network is transparent to the EtherChannel devices. The EtherChannel devices operate as if they are directly connected to each other. Any combination of Gig-E parallel circuit sizes can be used to support GEC throughput.

GEC provides line-level active redundancy and protection (1:1) for attached Ethernet equipment. It can also bundle parallel Gig-E data links together to provide more aggregated bandwidth. STP operates as if the bundled links are one link and permits GEC to utilize these multiple parallel paths. Without GEC, STP only permits a single non-blocked path. GEC can also provide G-Series card-level protection or redundancy because it can support a group of ports on different cards (or different nodes) so that if one port or card has a failure, then traffic is re-routed over the other port or card.

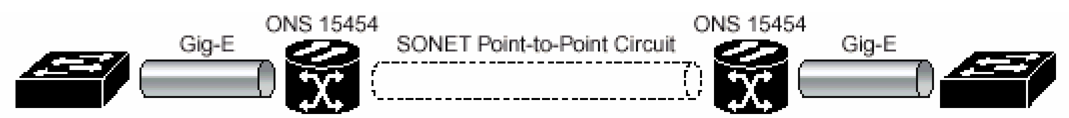
G-Series Ethernet Circuit Configurations

G-Series Ethernet cards support point-to-point circuits and Ethernet manual cross-connects. Ethernet manual cross-connects allow you to cross connect individual Ethernet circuits to an STS channel on the ONS 15454 optical interface and also to bridge non-ONS SONET network segments. G-Series cards do not interoperate with the E-series cards. Circuits created on a G-Series card must terminate on another G-Series card.

Point-to-Point Ethernet Circuits

Figure 5-17 shows the G-Series Ethernet cards supporting a point-to-point circuit configuration. Provisionable circuit sizes are STS 1, STS 3c, STS 6c, STS 9c, STS 12c, STS 24c and STS 48c. Each Ethernet port maps to a unique STS circuit on the SONET side of the G-Series card.

Figure 15-17: A G1000-4 Point-to-Point Circuit



G-Series cards support any combination of up to four circuits from the list of valid circuit sizes, however the circuit sizes can add up to no more than 48 STSs. Due to hardware constraints, the card imposes additional restrictions on the combinations of circuits that can be dropped onto a G1000-4 card. These restrictions are transparently enforced by the ONS 15454, and you do not need to keep track of restricted circuit combinations.

The restriction occurs when a single STS-24c is dropped on a card. In this instance, the remaining circuits on that card can be another single STS-24c or any combination of circuits of STS-12c size or less that add up to no more than 12 STSs (i.e. a total of 36 STSs on the card). No circuit restrictions are present, if STS-24c circuits are not being dropped on the card. The full 48 STSs bandwidth can be used (for example using either a single STS-48c or 4 STS-12c circuits).

Since the restrictions only apply when STS-24cs are involved but do not apply to two STS-24c circuits on a card, you can easily minimize the impact of these restrictions. Group the STS-24c circuits together on a card separate from circuits of other sizes. The grouped circuits can be dropped on other G-Series cards on the ONS 15454.

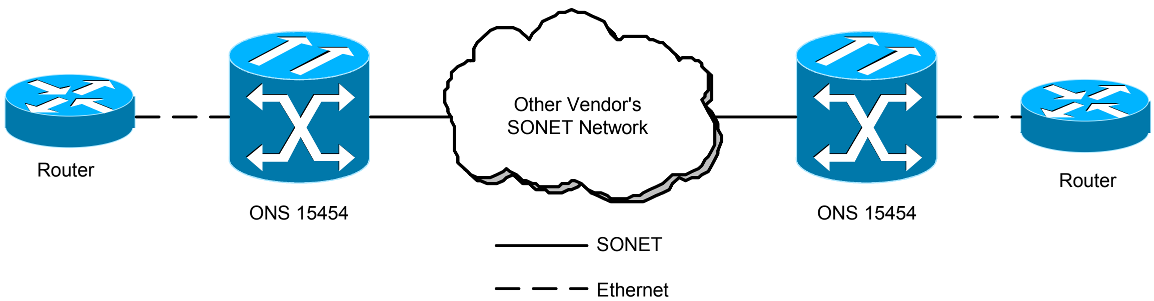
Note G-Series cards use STS cross-connects only. No VT level cross-connects are used.

Note All SONET side STS circuits must be contiguous.

Manual Cross-Connects

ONS 15454 nodes require end-to-end CTC visibility between nodes for normal provisioning of Ethernet circuits. When other vendors' equipment sits between ONS 15454 nodes, OSI/TARP-based equipment does not allow tunneling of the ONS 15454 TCP/IP-based DCC. To circumvent this lack of continuous DCC, the Ethernet circuit must be manually cross connected to an STS channel riding through the other vendors' network as shown in Figure 5-18. This allows an Ethernet circuit to run from ONS 15454 node to ONS 15454 node utilizing the other vendors' network.

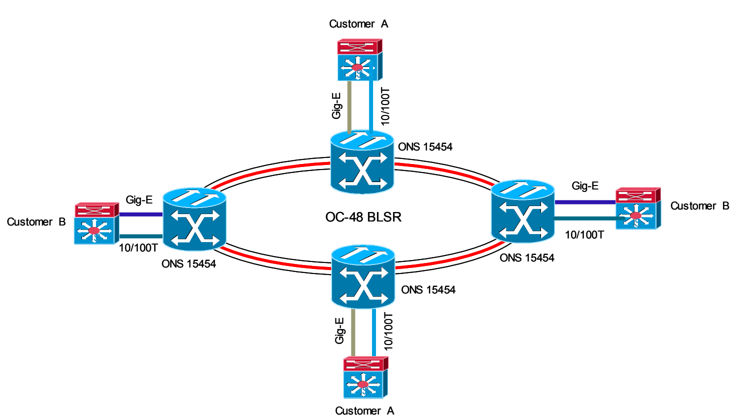
Figure 15-18: G-Series Manual Cross-connects



Transparent LAN Service (TLS)

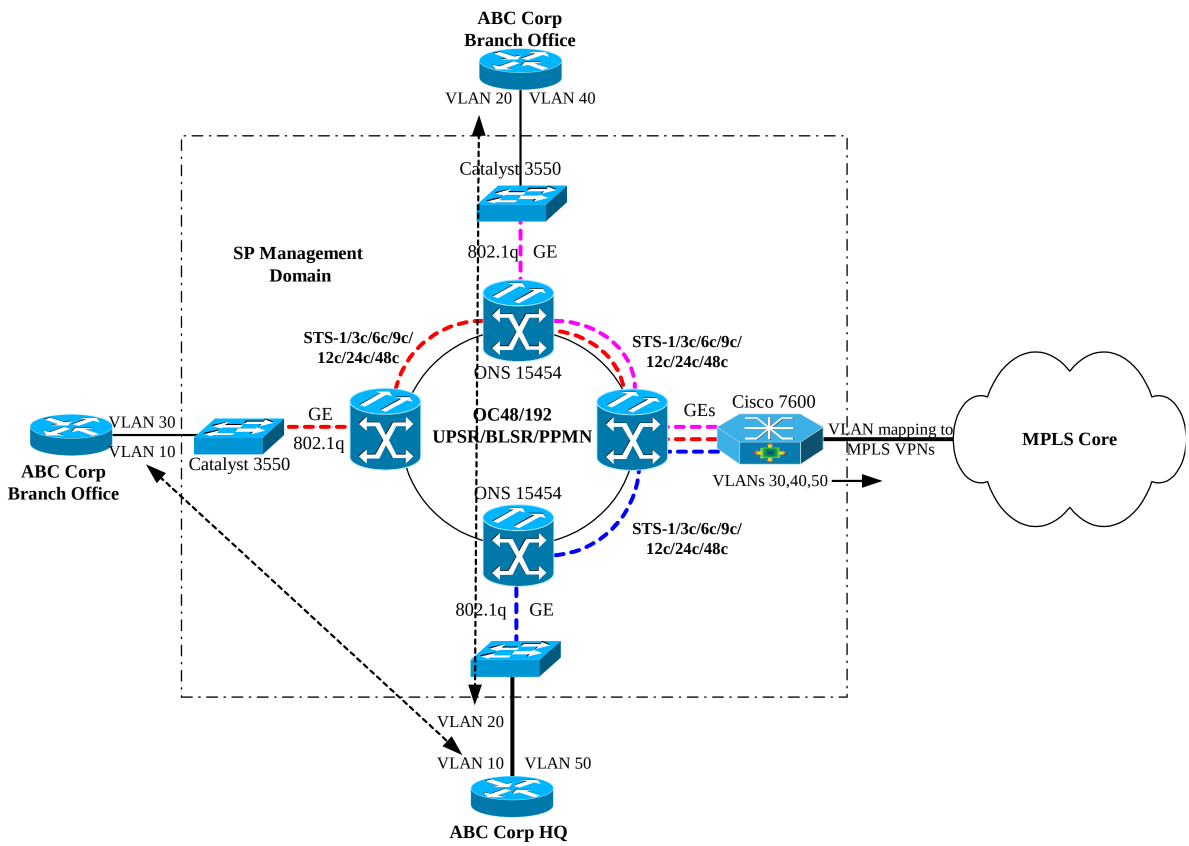
A TLS is a Virtual Ethernet Connection (VEC) that appears to act as an Ethernet wire, where all Ethernet traffic is seen by all remote ends. The customer only sees its end devices and the traffic generated or going through these equipments. In other words, the Metro network devices do not send any Protocol Data Units (PDUs) to the customer network. The Layer 2 protocols such as STP, CDP, VTP and EtherChannel must be transported transparently across the TLS as they would be over "dark fiber". The Metro network appears as an Ethernet segment to the customer. In addition, this service must allow any number of customer VLANs to be tunneled together the Metro network run, so that the customer is not limited by number nor forced by the service provider to use specific assigned VLANs. This service is a multi-point to multi-point connection type of service illustrated in Figure 15-19.

Figure 15-19: Transparent LAN Service Architecture



As illustrated on the Figure 5-20, several types of services can be delivered through the same client network interface with this architecture. The TLS between the corporate office and the ranch offices (VLAN 10 and 20) and Access to MPLS VPNs are delivered over the same UNI and Gig-E circuits. The Ethernet Virtual Circuit Service is locally switched and is indicated logically by the dashed arrows (VLANs 10, 20). Access to the corporate network is provided via mapping VLANs (30, 40, and 50) to MPLS VPNs in the SONET network. Both of these services can operate at the same time over the same UNI. Only three STSs or Virtual Circuits (VCs) are needed to provision these two services.

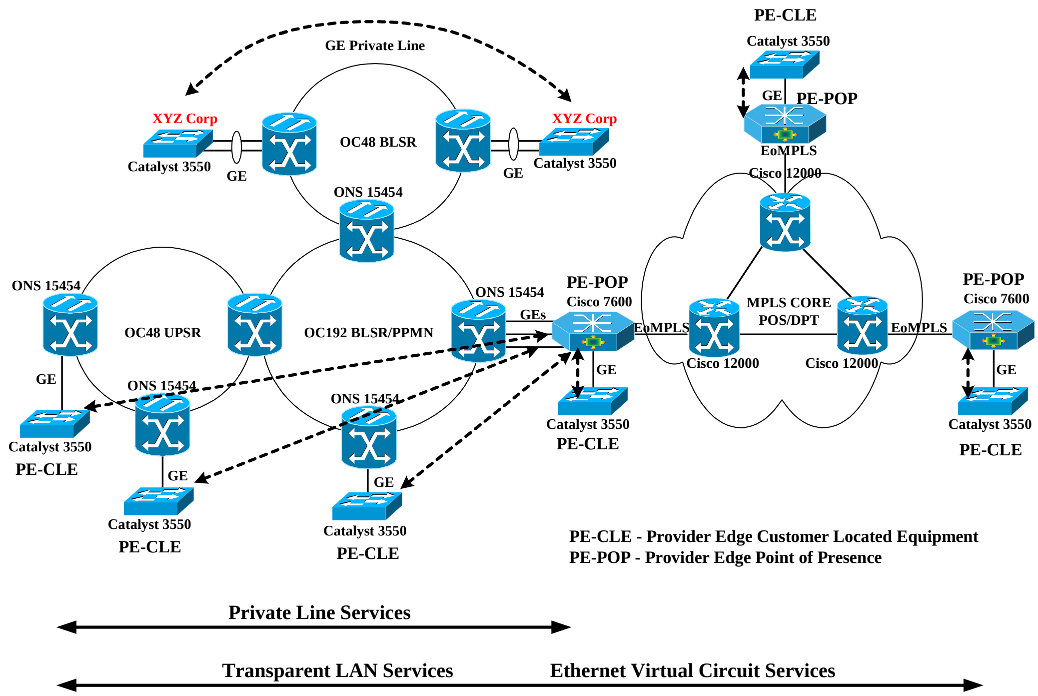
Figure 5-20: Transparent LAN Service Example



Metro Ethernet Solution

A complete Metro Ethernet solution illustrating TLS and Gig-E private line services or Ethernet Virtual Circuit services is shown in Figure 5-21. The G-Series cards support frame forwarding for unicast, multicast, and broadcast traffic, so Multicast traffic can be transported transparently by this TLS Metro Ethernet solution over the optical Metro network.

Figure 5-21: Metro Ethernet Solution



J1 Path Trace Support

J1 path trace is supported on the G-Series Ethernet circuits. J1 path trace enables you to provision a character string for the transmitted signal at each G1000-4 or G-1K-4 port. At the receive end of a circuit, an expected character string is entered or is inserted automatically by the user when the J1 path trace mode is set to AUTO. If the TRANSMIT string and EXPECTED RECEIVE string fields on a circuit path do not match, then a Trace Identifier Mismatch-Path [TIM-P) alarm with be raised. This feature helps you to identify if a cross-connection has been improperly provisioned.

Utilization Formula

Line utilization is calculated with the following formula:

((inOctets + outOctets) + (inPkts + outPkts) * 20)) * 8 / 100% interval * maxBaseRate * 2.

The interval is defined in seconds. maxBaseRate is defined by raw bits/second in one direction for the Ethernet port (i.e. 1 Gbps). maxBaseRate is multiplied by 2 in the denominator to determine the raw bit rate in both directions.

ML-Series Overview

The ML-Series cards integrate high-performance Ethernet transport, switching, and routing into a single card. Think of an ML-Series card as a Cisco Catalyst switch on a blade. There are two ML-Series cards:

ML100T-12 (Fast Ethernet)
ML1000-2 (Gigabit Ethernet)

The ML100T-12 features 12 RJ-45 interfaces and the ML1000-2 features two Small Form Factor Pluggable (SFP) slots supporting short wavelength (SX) and long wavelength (LX) optical modules. The ML100T-12 and the ML1000-2 use the same hardware and software base and offer the same feature sets.

An ML-Series card can be installed in any of the multi-service I/O slots (1-6 and 12-17) when interoperated with the TCC+ or TCC2 and XC-10G cross-connect. When interoperated with an TCC+ or TCC2 and XC or XC-VT, the ML-Series cards can only be installed in the four high-speed I/O slots (5, 6, 12, and 13). Once installed, an ML-Series card interoperates with the cross-connect via two virtual ports. Each virtual port can support circuits up to 24c.

Each ML-Series card is an independent data switch that processes up to 5.7 Mp/s of Layer 2 and Layer 3 switching. The card ships loaded with Cisco IOS Release 12.1(14)EB, which controls the data functions of the card. You can access the Cisco IOS to provision the cards in three ways:

1. The console port on the faceplate of the card
2. The Ethernet ports on the ML-Series card assigned to a management VLAN
3. A Telnet session initiated through a terminal program on the PC or through CTC

The Cisco IOS command-line interface (CLI) is the primary user interface for configuring the ML-Series card. Most provisioning for the card, such as Ethernet port, bridging and VLAN, can only be done via the Cisco IOS CLI. CTC is used for ML-Series status information, SONET alarm management, Cisco IOS Telnet session initialization, Cisco IOS configuration file management, and SONET (STS) cross-connect provisioning. SONET cross-connects can only be provisioned through CTC or TL1.

The Cisco IOS software image used by the ML-Series card is permanently stored in the flash memory of the TCC+/TCC2 card, not in the Ethernet cards. During a hard reset, when an ML-Series card is physically removed and reinserted, the Cisco IOS software image is downloaded from the flash memory of the TCC+/TCC2 to the memory cache of the ML-Series card. The cached image is then decompressed and initialized for use by the ML-Series card.

During a soft reset, when the ML-Series card is reset through CTC or Cisco IOS CLI commands, the ML-Series card checks its cache for an IOS image. If a valid and current IOS image exists, the ML-Series card decompresses and initializes the image. If the image does not exist, the ML-Series requests a new copy of the IOS image from the TCC+/TCC2. Caching the IOS image provides a significant time savings when a warm reset is performed.

Features List

The features of the ML-Series cards are listed below.

Layer 1 Features:

10/100BASE-TX half-duplex and full-duplex data transmission
1000BASE-SX, 1000BASE-LX full-duplex data transmission
Two SONET virtual ports with maximum bandwidth of STS-48c per card

HDLC port encapsulation (no VLAN trunking support)
Point-to-Point Protocol/Bridge Control Protocol (PPP/BCP) port encapsulation (VLAN trunking supported via BCP)
LEX SONET/SDH port encapsulation (G-Series card protocol, which supports VLAN trunking)
Packet-over-SONET/SDH (POS)
POS channel (with LEX encapsulation only)
PPP
G-Series card compatible
PPP over SONET/SDH (IP POS and bridging with VLANs)

Layer 2 Bridging Features:
- Layer 2 transparent bridging
- Layer 2 MAC learning, aging, and switching by hardware
- Spanning Tree Protocol (IEEE 802.1D) per bridge group
- Protocol tunneling
- A maximum of 255 active bridge groups
- Up to 60,000 MAC addresses per card, with a supported limit of 8,000 per bridge group
- Integrated routing and bridging (IRB)

VLAN Features:
- 802.1P/Q-based VLAN trunking
- 802.1Q VLAN tunneling
- 802.1D Spanning Tree and 802.1W Rapid Spanning Tree

Layer 3 Routing, Switching, and Forwarding:
- Default routes
- IP unicast and multicast forwarding support
- Simple IP access control lists (ACLs) (both Layer 2 and Layer 3 forwarding path)
- Extended IP ACLs in software (control-plane only)
- IP and IP multicast routing and switching between Ethernet ports
- Load balancing among equal cost paths based on source and destination IP addresses
- Up to 18,000 IP routes
- Up to 20,000 IP host entries
- Up to 128 IP multicast groups

Supported Routing Protocols:
- Virtual Private Network (VPN) Routing and Forwarding Lite (VRF Lite)
- Intermediate System-to-Intermediate System (IS-IS) Protocol
- Routing Information Protocol (RIP and RIP II)
- Enhanced Interior Gateway Routing Protocol (EIGRP)
- Open Shortest Path First (OSPF) Protocol
- Protocol Independent Multicast (PIM)—Sparse, sparse-dense and dense modes
- Secondary addressing
- Static routes
- Local proxy ARP
- Border Gateway Protocol (BGP)
- Classless interdomain routing (CIDR)

Fast EtherChannel (FEC) Features (ML100T-12):
- Bundling of up to four Fast Ethernet ports
- Load sharing based on source and destination IP addresses of unicast packets
- Load sharing for bridge traffic based on MAC addresses

IRB on the Fast EtherChannel
IEEE 802.1Q trunking on the Fast EtherChannel
Up to 6 active FEC port channels

Gigabit EtherChannel (GEC) Features (ML1000-2):
Bundling the two Gigabit Ethernet ports
Load sharing for bridge traffic based on MAC addresses
IRB on the Gigabit EtherChannel
IEEE 802.1Q trunking on the Gigabit EtherChannel

Access List (ACL) Features:
IP standard ACL
IP extended ACL

VLAN Features:
IEEE 802.1Q-based VLAN routing and bridging

QoS Features:
Service Level Agreements (SLAs) with 1-Mbps granularity
Input policing
Guaranteed bandwidth (weighted round-robin [WDRR] plus strict priority scheduling)
Classification based on Layer 2 priority, VLAN ID, Layer 3 TOS/DSCP, and port
Low latency queuing support for unicast VoIP

Additional Protocols and Features:
Cisco Discovery Protocol (CDP) support on Ethernet ports
Dynamic Host Configuration Protocol (DHCP) relay
Hot Standby Router Protocol (HSRP) over 10/100 Ethernet, Gigabit Ethernet, FEC, GEC, and Bridge Group Virtual Interface (BVI)
Internet Control Message Protocol (ICMP)
IRB routing mode support
Simple Network Management Protocol (SNMP)
Transaction Language 1 (TL1)

SONET Port Encapsulation

The ML-Series supports three forms of SONET port encapsulation:

1. Cisco HDLC
2. PPP/BCP
3. LEX

Cisco HDLC is standard on most Cisco data devices. It does not offer VLAN trunking support. PPP/BCP is a popular standard linked to RFC 2878. It supports VLAN trunking via BCP. LEX is a protocol used by the G-Series cards. This protocol supports VLAN trunking and is based on PPP over HDLC.

This allows the ML-Series to connect to the OC-N ports of switches and routers supporting POS, as well as the G-Series Ethernet cards on the Cisco ONS 15454 MSPP. All three formats support bridging and routing, standard SONET payload scrambling, and HDLC frame check sequence.

Link Aggregation (FEC, GEC, and POS)

The ML-Series offers Fast EtherChannel, Gigabit EtherChannel, and Packet-over-SONET (POS) channel link aggregation. Link aggregation groups multiple ports into a larger logical port and provides resiliency during the failure of any individual ports. The ML-Series supports a maximum of 4 Ethernet ports in Fast EtherChannel, 2 Ethernet ports in Gigabit EtherChannel, and 2 SONET/SDH virtual ports in the POS channel. The POS channel is only supported with LEX encapsulation.

Traffic flows map to individual ports based on MAC source address (SA)/destination address (DA) for bridged packets and IP SA/DA for routed packets. There is no support for policing or class-based packet priorities when link aggregation is configured.

Traditionally EtherChannel is a trunking technology that groups together multiple full-duplex 802.3 Ethernet interfaces to provide fault-tolerant high-speed links between switches, routers, and servers. EtherChannel is a logical aggregation of multiple Ethernet interfaces. EtherChannel forms a single higher bandwidth routing or bridging endpoint. EtherChannel is designed primarily for host-to-switch connectivity. The ML-Series card extends this link aggregation technology to bridged POS interfaces.

Link aggregation provides the following benefits:

- Logical aggregation of bandwidth
- Load balancing
- Fault tolerance

The EtherChannel interface, consisting of multiple Fast Ethernet, Gigabit Ethernet or POS interfaces, is treated as a single interface, which is called a port channel. You must perform all EtherChannel configurations on the EtherChannel interface (port channel) rather than on the individual member Ethernet interfaces. You can create the EtherChannel interface by entering the interface port-channel interface configuration command. Each ML100T-12 supports up to 7 Fast EtherChannel (FEC) interfaces or port channels (6 Fast Ethernet and 1 POS). Each ML1000-2 supports up to 2 Gigabit EtherChannel (GEC) interfaces or port channels (1 Gigabit Ethernet and 1 POS.)

EtherChannel connections are fully compatible with IEEE 802.1Q trunking and routing technologies. 802.1Q trunking can carry multiple VLANs across an EtherChannel.

Cisco’s FEC technology builds upon standards-based 802.3 full-duplex Fast Ethernet to provide a reliable high-speed solution for the campus network backbone. FEC provides bandwidth scalability within the campus by providing up to 400-Mbps full-duplex Fast Ethernet on the ML100-12.

Cisco’s GEC technology provides bandwidth scalability by providing 2-Gbps full-duplex aggregate capacity on the ML1000-2.

Cisco’s POS channel technology provide bandwidth scalability by providing up to 48 STSs or VC4-16c of aggregate capacity on either the ML100-12 or the ML1000-2.

SONET Circuits

ML-Series cards feature two SONET virtual ports with a maximum combined bandwidth of STS-48. Each port carries an STS circuit with a size of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, or STS-24c. The ML-Series cards support the SONET circuits listed in Table 5-5.

Table 5-5: Transmission Rates Supported by ML-Series Cards

Topology	SONET Circuit Sizes
Circuits terminated by two ML-Series cards	STS-1, STS-3c, STS-6c, STS-9c, STS-12c, and STS-24c
Circuits terminated by G-Series card and ML-Series card	STS-1, STS-3c, STS-6c, STS-9c, STS-12c
Circuits terminated by ML-Series card and External POS device	STS-3c and STS-12c

VPN Routing/Forwarding (VRF) Lite

VPN Routing/Forwarding Lite (VRF Lite) is an ML-Series specific implementation of a VPN routing/forwarding instance (VRF). Unlike standard VRF, VRF Lite does not contain Multi-Protocol internal BGP (MP-iBGP).

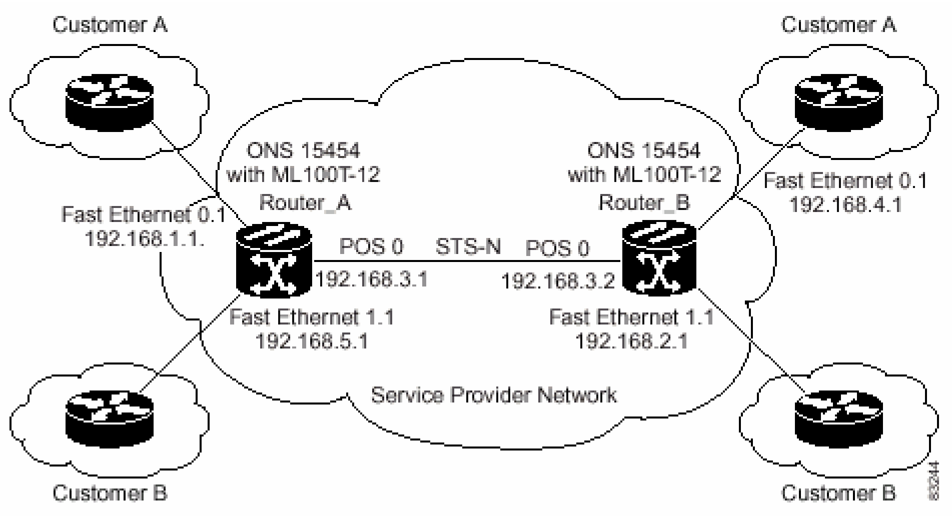
Standard VRF is an extension of IP routing that provides multiple routing instances and separate IP routing and forwarding tables for each VPN. It provides a separate IP routing and forwarding table to each VPN. VRF is used in concert with internal MP-iBGP. MP-iBGP distributes the VRF information between routers to provide Layer 3 Multiprotocol Label Switching (MPLS)-VPN. However, ML-Series VRF implementation is without MP-iBGP. With VRF Lite, the ML Series is considered as either a PE-extension or a customer equipment (CE)-extension. It is considered a PE-extension since its has VRF (but without MP-iBGP); it is considered a CE-extension since this CE can have multiple VRFs and serves many customer with one CE box.

VRF Lite stores VRF information locally and does not distribute the VRF information to connected equipment. VRF information directs traffic to the correct interfaces and subinterfaces when the traffic is received from customer routers or from service provider router(s).

VRF Lite allows an ML-Series card, acting as customer equipment, to have multiple interfaces and subinterfaces with service provider equipment. The customer ML-Series card can then service multiple customers. Normal customer equipment serves a single customer.

Under VRF Lite, an ML-Series CE can have multiple interfaces/subinterfaces with PE for different customers (while a normal CE is only for one customer). It holds VRFs (routing information) locally; it does not distribute the VRFs to its connected PE(s). It uses VRF information to direct traffic to the correct interfaces/subinterfaces when it receives traffic from customers' routers or from Internet service provider (ISP) PE router(s). Figure 5-22 shows an example of a VRF Lite configuration.

Figure 5-22: VRF Lite Example



Cisco IOS

Cisco IOS controls the data functions of the ML-Series card and comes preloaded on the ONS 15454 TCC+/TCC2 card.

You cannot update the ML-Series Cisco IOS image in the same manner as the Cisco IOS system image on a Cisco Catalyst Series. An ML-Series Cisco IOS image upgrade can only be accomplished through CTC. Cisco IOS images for the ML-Series card are available only as part of an ONS 15454 system software release. This Cisco IOS image is included on the standard ONS 15454 SONET System Software CD under the package file name M_I.bin and full file name ons15454m-i7-mz. The images are not available for download or shipped separately.

Interface Configuration

The main function of an ML-Series card is to relay packets from one data link to another. Consequently, you must configure the characteristics of the interfaces, which receive and send packets. Interface characteristics include, but are not limited to, IP address, address of the port, data encapsulation method, and media type.

Many features are enabled on a per-interface basis. Interface configuration mode contains commands that modify the interface operation (for example, of an Ethernet port). When you enter the interface command, you must specify the interface type and number.

The following general guidelines apply to all physical and virtual interface configuration processes:

All interfaces have a name which is comprised of an interface type (word) and a Port ID (number). For example, FastEthernet 2.

Configure each interface with a bridge-group or IP address and IP subnet mask.

VLANs are supported through the use of subinterfaces. The subinterface is a logical interface configured separately from the associated physical interface.

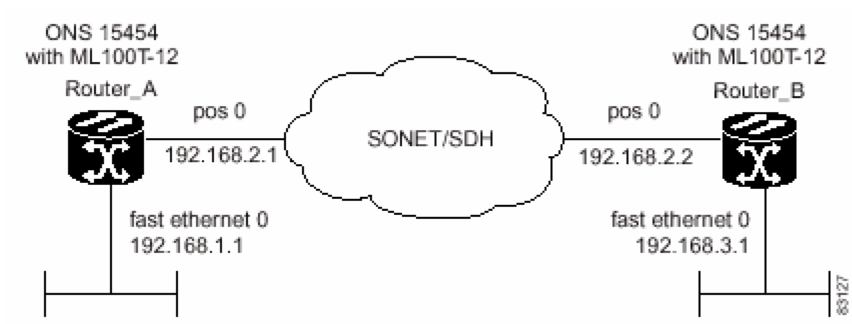
Each physical interface and the internal Packet-over-SONET/SDH (POS) interfaces, have an assigned MAC address.

For information on how to configure the ML-Series cards, go to the *Cisco ONS 15454 SONET/SDH ML-Series Multilayer Ethernet Card Software Feature and Configuration Guide*.

Packet Over SONET (POS)

Packet over SONET (POS) is a high-speed method of transporting IP traffic between two points. This technology combines the Point-to-Point Protocol (PPP) with SONET interfaces. Figure 5-23 illustrates a POS configuration between two ML-Series cards.

Figure 5-23: ML-Series Card-to-ML-Series Card POS Configuration



POS interfaces use a value of 0x16 or 0xCF in the C2 byte depending on whether ATM-style scrambling is enabled or not. RFC 2615, which defines PPP over SONET, mandates the use of these values based on scrambling settings as follows:

If scrambling is enabled, POS interfaces use a C2 value of 0x16 (PPP and HDLC encapsulation).

If scrambling is disabled, POS interfaces use a C2 value of 0xCF (PPP and HDLC encapsulation).

LEX encapsulation uses a C2 value of 0x01 regardless of the scrambling setting.

Bridging

The ML-Series card can be configured to serve as an IP router and a bridge. Cisco IOS software supports transparent bridging for Fast Ethernet, Gigabit Ethernet, and POS. Cisco IOS software functionality combines the advantages of a spanning tree bridge and a router. This combination provides the speed and protocol transparency of a spanning tree bridge, along with the functionality, reliability, and security of a router.

To configure bridging, you must perform the following tasks in the modes indicated:

In global configuration mode:

- o Enable bridging of IP packets.
- o Select the type of Spanning Tree Protocol.

In interface configuration mode:

- o Determine which interfaces belong to the same bridge group.

These interfaces become part of the same spanning tree, allowing the ML-Series card to bridge all non-routed traffic among the network interfaces comprising the bridge group. Interfaces not participating in a bridge group cannot forward bridged traffic.

If the destination address of the packet is known in the bridge table, the packet is forwarded on a single interface in the bridge group. If the packet's destination is unknown in the bridge table, the packet is flooded on all forwarding interfaces in the bridge group. The bridge places source addresses in the bridge table as it learns them during the process of bridging.

A separate spanning tree process runs for each configured bridge group. Each bridge group participates in a separate spanning tree. A bridge group establishes a spanning tree based on the bridge protocol data units (BPDUs) it receives on only its member interfaces.

Spanning Tree Support

The ML-Series supports the per-VLAN spanning tree (PVST+) and a maximum of 255 spanning tree instances.

802.1T Spanning Tree Extensions

The ML-Series cards support the 802.1T spanning tree extensions, and some of the bits previously used for the switch priority are now used as the bridge ID. The result is that fewer MAC addresses are reserved for the switch, and a larger range of VLAN IDs can be supported, all while maintaining the uniqueness of the bridge ID. As shown in Table 5-6, the two bytes previously used for the switch priority are reallocated into a 4-bit priority value and a 12-bit extended system ID value equal to the bridge ID. In earlier releases of spanning tree the switch priority is a 16-bit value.

Table 5-6: Switch Priority Value and Extended System ID

Switch Priority Value				Extended System ID (Set Equal to the Bridge ID)											
Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16
32768	16384	8192	4096	2048	1024	512	256	128	64	43	16	8	4	2	1

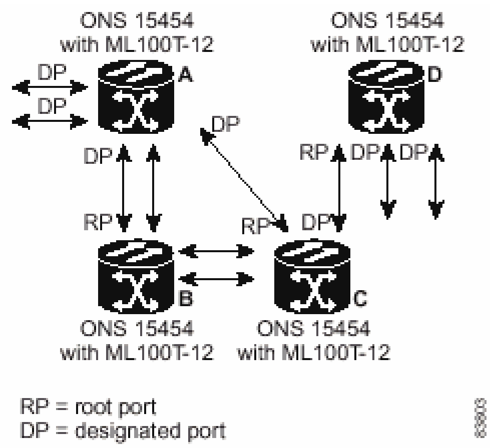
Spanning tree uses the extended system ID, the switch priority, and the allocated spanning tree MAC address to make the bridge ID unique for each VLAN.

Creating the Spanning Tree Topology

When the spanning tree topology is calculated based on default parameters, the path between source and destination end stations in a switched network might not be ideal. For instance, connecting higher-speed links to an interface that has a higher number than the root port can cause a root-port change. The goal is to make the fastest link the root port as shown in the following example.

In Figure 5-24, A is elected as the root switch because the switch priority of all the switches is set to the default (32768) and A has the lowest MAC address. However, because of traffic patterns, number of forwarding interfaces, or link types, A might not be the ideal root switch. By increasing the priority (lowering the numerical value) of the ideal switch so that it becomes the root switch, you force a spanning tree recalculation to form a new topology with the ideal switch as the root.

Figure 5-24: Spanning Tree Topology

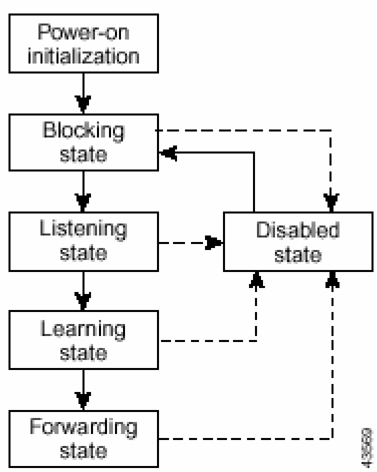


Spanning Tree Interface States

Propagation delays can occur when protocol information passes through a switched LAN. As a result, topology changes can take place at different times and at different places in a switched network. When an interface transitions directly from nonparticipation in the spanning tree topology to the forwarding state, it can create temporary data loops. Interfaces must wait for new topology information to propagate through the switched LAN before starting to forward frames. They must allow the frame lifetime to expire for forwarded frames that have used the old topology.

Figure 5-25 illustrates how an interface moves through the states.

Figure 5-25: Spanning Tree Interface States



When you power up the ML-Series card, STP is enabled by default, and every interface in the switch, VLAN, or network goes through the blocking state and the transitory states of listening and learning. Spanning tree stabilizes each interface at the forwarding or blocking state.

When the spanning tree algorithm places a Layer 2 interface in the forwarding state, this process occurs:

1. The interface is in the listening state while spanning tree waits for protocol information to transition the interface to the blocking state.

2. While spanning tree waits for the forward-delay timer to expire, it moves the interface to the learning state and resets the forward-delay timer.

3. In the learning state, the interface continues to block frame forwarding as the switch learns end-station location information for the forwarding database.

4. When the forward-delay timer expires, spanning tree moves the interface to the forwarding state, where both learning and frame forwarding are enabled.

Spanning Tree Address Management

IEEE 802.1D specifies 17 multicast addresses, ranging from 0x00180C2000000 to 0x0180C2000010, to be used by different bridge protocols. These addresses are static addresses that cannot be removed.

The ML-Series card switches supported BPDUs (0x0180C2000000 and 01000CCCCCCD) when they are being tunneled via the protocol tunneling feature.

STP and IEEE 802.1Q Trunks

When you connect a Cisco switch to a non-Cisco device through an 802.1Q trunk, the Cisco switch uses PVST+ to provide spanning tree interoperability. PVST+ is automatically enabled on 802.1Q trunks after users assign a protocol to a bridge group. The external spanning tree behavior on access ports and Inter-Switch Link (ISL) trunk ports is not affected by PVST+.

Spanning Tree and Redundant Connectivity

You can create a redundant backbone with spanning tree by connecting two ML-Series interfaces to another device or to two different devices. Spanning tree automatically disables one interface but enables it if the other one fails. If one link is high speed and the other is low speed, the low-speed link is always disabled. If the speeds are the same, the port priority and port ID are added together, and spanning tree disables the link with the lowest value.

You can also create redundant links between switches by using EtherChannel groups.

Accelerated Aging to Retain Connectivity

The default for aging dynamic addresses is 5 minutes, which is the default setting of the bridge bridge-group-number aging-time global configuration command. However, a spanning tree reconfiguration can cause many station locations to change. Because these stations could be unreachable for 5 minutes or more during a reconfiguration, the address-aging time is accelerated so that station addresses can be dropped from the address table and then relearned.

Because each VLAN is a separate spanning tree instance, the switch accelerates aging on a per-VLAN basis. A spanning tree reconfiguration on one VLAN can cause the dynamic addresses learned on that VLAN to be subject to accelerated aging. Dynamic addresses on other VLANs can be unaffected and remain subject to the aging interval entered for the switch.

CISCO SYSTEMS

Rapid Spanning Tree (RSTP) Support

ML-Series cards support per-VLAN rapid spanning tree (PVRST) and a maximum of 255 rapid spanning tree instances.

The RSTP provides rapid convergence of the spanning tree by assigning port roles and by determining the active topology. The RSTP builds upon the IEEE 802.1D STP to select the switch with the highest switch priority (lowest numerical priority value).

In a stable topology with consistent port roles throughout the network, the RSTP ensures that every root port and designated port immediately transition to the forwarding state while all alternate and backup ports are always in the discarding state (equivalent to blocking in 802.1D). The port state controls the operation of the forwarding and learning processes. Table 5-7 provides a comparison of 802.1D and RSTP port states.

Table 5-7: Port State Comparison

Operational Status	STP Port State	RSTP Port State	Is Port Included in the Active Topology?
Enabled	Blocking	Discarding	No
Enabled	Listening	Discarding	No
Enabled	Learning	Learning	Yes
Enabled	Forwarding	Forwarding	Yes
Disabled	Disabled	Discarding	No

Rapid Convergence

The RSTP provides for rapid recovery of connectivity following the failure of a ML-Series card, a a ML-Series port, or a LAN. It provides rapid convergence for new root ports and ports connected through point-to-point links as follows:

Root ports: If the RSTP selects a new root port, it blocks the old root port and immediately transitions the new root port to the forwarding state.

Point-to-point links: If you connect a port to another port through a point-to-point link and the local port becomes a designated port, it negotiates a rapid transition with the other port by using the proposal-agreement handshake to ensure a loop-free topology.

Synchronization of Port Roles

When the ML-Series card receives a proposal message on one of its ports and that port is selected as the new root port, the RSTP forces all other ports to synchronize with the new root information. The ML-Series card is synchronized with superior root information received on the root port if all other ports are synchronized.

If a designated port is in the forwarding state, it transitions to the blocking state when the RSTP forces it to synchronize with new root information. In general, when the RSTP forces a port to synchronize with root information and the port does not satisfy any of the above conditions, its port state is set to blocking.

After ensuring all of the ports are synchronized, the ML-Series card sends an agreement message to the designated switch corresponding to its root port. When the ML-Series cards connected by a point-to-point link are in agreement about their port roles, the RSTP immediately transitions the port states to forwarding.

Bridge Protocol Data Unit Format and Processing

The RSTP BPDU format is the same as the IEEE 802.1D BPDU format except that the protocol version is set to 2. A new Length field is set to zero, which means that no version 1 protocol information is present. Table 5-8 shows the RSTP flag fields.

Table 5-8: RSTP BPDU Flags

Bit	Function
0	Topology Change (TC)
1	Proposal
2-3: 00 01 10 11	Port Role: Unknown Alternate Port Root Port Designated Port
4	Learning
5	Forwarding
6	Agreement
7	Topology Change Acknowledgement

The sending ML-Series port sets the proposal flag in the RSTP BPDU to propose itself as the designated switch on that LAN. The port role in the proposal message is always set to the designated port. The sending ML-Series port sets the agreement flag in the RSTP BPDU to accept the previous proposal. The port role in the agreement message is always set to the root port.

The RSTP does not have a separate topology change notification (TCN) BPDU. It uses the topology change (TC) flag to show the topology changes. However, for interoperability with 802.1D switches, the RSTP switch processes and generates TCN BPDUs.

The learning and forwarding flags are set according to the state of the sending port.

Processing Superior BPDU Information

If a ML-Series port receives superior root information (lower bridge ID, lower path cost, etc.) than currently stored for the port, the RSTP triggers a reconfiguration. If the port is proposed and is selected as the new root port, RSTP forces all the other ports to synchronize.

If the BPDU received is an RSTP BPDU with the proposal flag set, the switch sends an agreement message after all of the other ports are synchronized. If the BPDU is an 802.1D BPDU, the ML-Series card does not set the proposal flag and starts the forward-delay timer for the port. The new root port requires twice the forward-delay time to transition to the forwarding state.

If the superior information received on the port causes the port to become a backup or alternate port, RSTP sets the port to the blocking state but does not send the agreement message. The designated port continues sending BPDUs with the proposal flag set until the forward-delay timer expires, at which time the port transitions to the forwarding state.

Processing Inferior BPDU Information

If a designated ML-Series port receives an inferior BPDU (higher bridge ID, higher path cost, etc., than currently stored for the port) with a designated port role, it immediately replies with its own information.

Topology Changes

This section describes the differences between the RSTP and the 802.1D in handling spanning tree topology changes.

> Detection: Unlike 802.1D in which any transition between the blocking and the forwarding state causes a topology change, only transitions from the blocking to the forwarding state cause a topology change with RSTP. (Only an increase in connectivity is considered a topology change.) State changes on an edge port do not cause a topology change. When an RSTP switch detects a topology change, it flushes the learned information on all of its non-edge ports.
>
> Notification: Unlike 802.1D, which uses TCN BPDUs, the RSTP does not use them. However, for 802.1D interoperability, an RSTP switch processes and generates TCN BPDUs.
>
> Acknowledgement: When an RSTP switch receives a TCN message on a designated port from an 802.1D switch, it replies with an 802.1D configuration BPDU with the topology change acknowledgement bit set. However, if the TC-while timer (the same as the topology-change timer in 802.1D) is active on a root port connected to an 802.1D switch and a configuration BPDU with the topology change acknowledgement bit set is received, the TC-while timer is reset. This behavior is only required to support 802.1D switches. The RSTP BPDUs never have the topology change acknowledgement bit set.
>
> Propagation: When an RSTP switch receives a TC message from another switch through a designated or root port, it propagates the topology change to all of its non-edge, edge, designated ports, and root port (excluding the port on which it is received). The switch starts the TC-while timer for all such ports and flushes the information learned on them.
>
> Protocol migration: For backward compatibility with 802.1D switches, RSTP selectively sends 802.1D configuration BPDUs and TCN BPDUs on a per-port basis.

When a port is initialized, the timer is started (which specifies the minimum time during which RSTP BPDUs are sent), and RSTP BPDUs are sent. While this timer is active, the ML-Series card processes all BPDUs received on that port and ignores the protocol type.

If the ML-Series card receives an 802.1D BPDU after the port's migration-delay timer has expired, it assumes that it is connected to an 802.1D switch and starts using only 802.1D BPDUs. However, if the RSTP ML-Series card is using 802.1D BPDUs on a port and receives an RSTP BPDU after the timer has expired, it restarts the timer and starts using RSTP BPDUs on that port.

Interoperability with 802.1D STP

An ML-Series card running RSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy 802.1D switches. If this card receives a legacy 802.1D configuration BPDU (a BPDU with the protocol version set to 0), it sends only 802.1D BPDUs on that port. However, the ML-Series card does not automatically revert to the RSTP mode if it no longer receives 802.1D BPDUs, because it cannot determine whether the legacy switch has been removed from the link unless the legacy switch is the designated switch. Also, an ML-Series card might continue to assign a boundary role to a port when the card to which it is connected has joined the region.

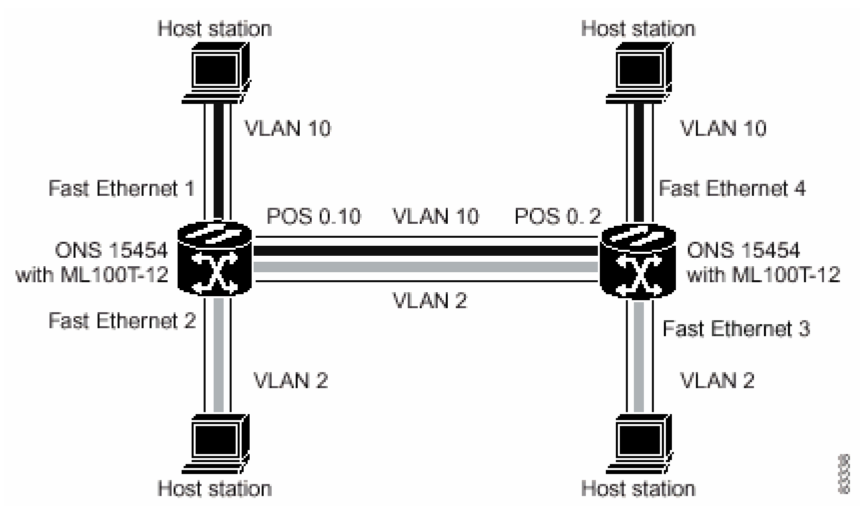
VLAN Support

ML-Series software supports port-based VLANs and VLAN trunk ports, which are ports that carry the traffic of multiple VLANs. Each frame transmitted on a trunk link is tagged as belonging to only one VLAN.

ML-Series software supports VLAN frame encapsulation through the IEEE 802.1Q standard on both the ML100T-12 and the ML1000-2. The Cisco ISL VLAN frame encapsulation is not supported. ISL frames will be broadcast at Layer 2, or dropped at Layer 3.

ML-Series switching supports up to 900 VLAN subinterfaces per card (for example, 200 VLANs on 4 interfaces uses 800 VLAN subinterfaces). A maximum of 255 logical VLANs can be bridged per card (limited by the number of bridge-groups). Each VLAN subinterface can be configured for any VLAN ID in the full 1–4095 range. Figure 5-26 shows a network topology in which two VLANs span two ONS 15454 nodes with ML-Series cards.

Figure 5-26: VLANs Spanning Devices in a Network



IEEE 802.1Q VLAN Encapsulation

On an IEEE 802.1Q trunk port, all transmitted and received frames are tagged except for those on the VLAN configured as the native VLAN for the port. Frames on the native VLAN are always transmitted untagged and are normally received untagged. You can configure VLAN encapsulation on both the ML100T-12 and the ML1000-2.

On an IEEE 802.1Q trunk port, all transmitted and received frames are tagged except for those on the VLAN configured as the native VLAN for the port. On ML-Series cards, the native VLAN is always VLAN ID 1. Frames on the native VLAN are normally transmitted untagged and are normally received untagged. Tagging of transmitted native VLAN frames can be forced by the global configuration command **vlan dot1q tag native**. VLAN encapsulation is supported on both the ML100T-12 and the ML1000-2. VLAN encapsulation is supported for routing and bridging, and is supported on Ethernet interfaces and on POS interfaces with PPP and LEX encapsulation.

IEEE 802.1Q and Layer 2 Protocol Tunneling

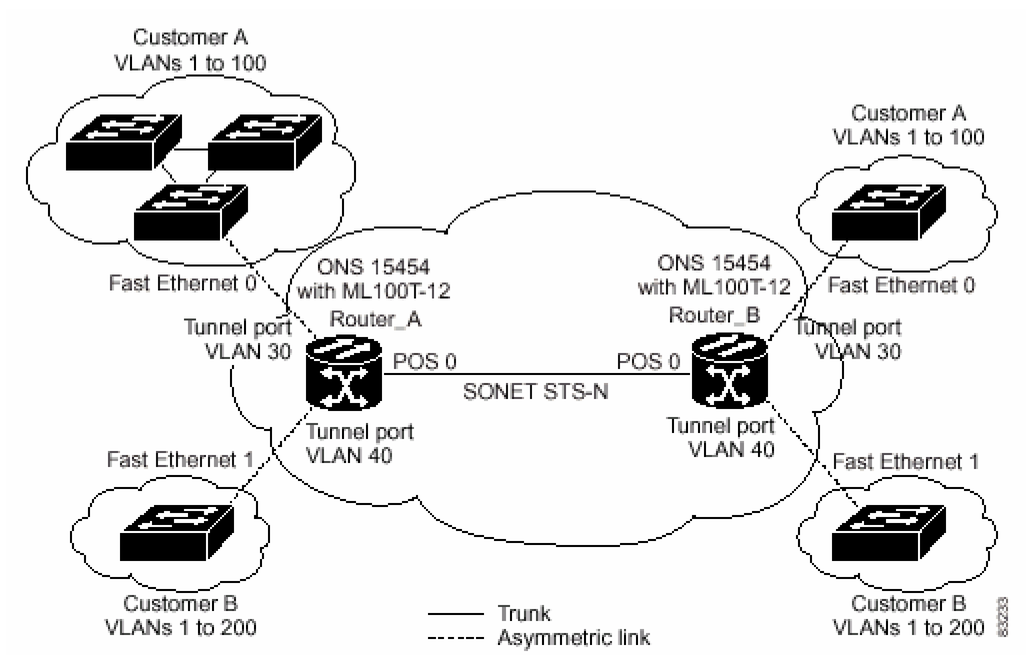
Virtual private networks (VPNs) provide enterprise-scale connectivity on a shared infrastructure, often Ethernet-based, with the same security, prioritization, reliability, and manageability requirements of private networks. Tunneling is a feature designed for service providers who carry traffic of multiple customers across their networks and are required to maintain the VLAN and Layer 2 protocol configurations of each customer without impacting the traffic of other customers. The ML-Series cards support IEEE 802.1Q tunneling and Layer 2 protocol tunneling.

Business customers of service providers often have specific requirements for VLAN IDs and the number of VLANs to be supported. The VLAN ranges required by different customers in the same service-provider network might overlap, and traffic of customers through the infrastructure might be mixed. Assigning a unique range of VLAN IDs to each customer would restrict customer configurations and could easily exceed the VLAN limit of 4096 of the IEEE 802.1Q specification.

Using the IEEE 802.1Q tunneling feature, you can use a single VLAN to support customers who have multiple VLANs. Customer VLAN IDs are preserved and traffic from different customers is segregated within the service-provider infrastructure even when they appear to be on the same VLAN. The IEEE 802.1Q tunneling expands VLAN space by using a VLAN-in-VLAN hierarchy and tagging the tagged packets. A port configured to support IEEE 802.1Q tunneling is called a tunnel port. When you configure tunneling, you assign a tunnel port to a VLAN that is dedicated to tunneling. Each customer requires a separate VLAN, but that VLAN supports all of the customer's VLANs.

Customer traffic tagged in the normal way with appropriate VLAN IDs comes from an IEEE 802.1Q trunk port on the customer device and into a tunnel port on the ML-Series card. The link between the customer device and the ML-Series card is an asymmetric link because one end is configured as an IEEE 802.1Q trunk port and the other end is configured as a tunnel port. You assign the tunnel port interface to an access VLAN ID unique to each customer. See Figure 5-27.

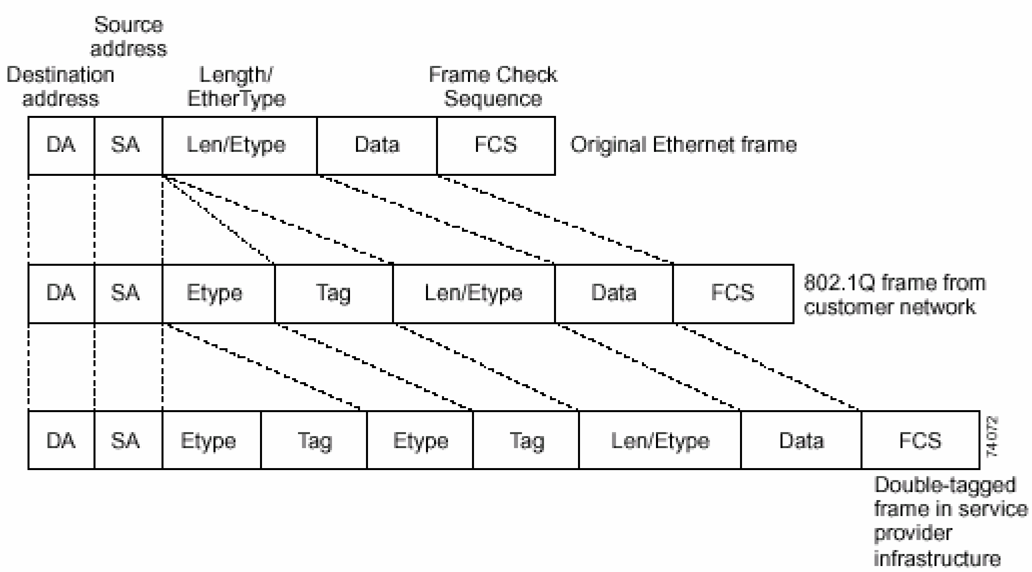
Figure 5-27: IEEE 802.1Q Tunnel Ports in a Service-Provider Network



Packets coming from the customer trunk port into the tunnel port on the ML-Series card are normally IEEE 802.1Q-tagged with appropriate VLAN ID. The tagged packets remain intact inside the ML-Series card and, when they exit the trunk port into the service provider network, are encapsulated with another layer of an IEEE 802.1Q tag (called the metro tag) that contains the VLAN ID unique to the customer. The original IEEE 802.1Q tag from the customer is preserved in the encapsulated packet. Therefore, packets entering the service-provider infrastructure are double-tagged, with the outer tag containing the customer's access VLAN ID, and the inner VLAN ID being the VLAN of the incoming traffic.

When the double-tagged packet enters another trunk port in a service provider ML-Series card, the outer tag is stripped as the packet is processed inside the switch. When the packet exits another trunk port on the same core switch, the same metro tag is again added to the packet. Figure 5-28 shows the structure of the double-tagged packet.

Figure 5-28: Normal, IEEE 802.1Q, and 802.1Q Tunneled Ethernet Packet Formats



When the packet enters the trunk port of the service-provider egress switch, the outer tag is again stripped as the packet is processed internally on the switch. However, the metro tag is not added when it is sent out the tunnel port on the edge switch into the customer network, and the packet is sent as a normal IEEE 802.1Q-tagged frame to preserve the original VLAN numbers in the customer network.

In Figure 5-27, Customer A was assigned VLAN 30, and Customer B was assigned VLAN 40. Packets entering the ML-Series card tunnel ports with IEEE 802.1Q tags are double-tagged when they enter the service-provider network, with the outer tag containing VLAN ID 30 or 40, appropriately, and the inner tag containing the original VLAN number, for example, VLAN 100. Even if both Customers A and B have VLAN 100 in their networks, the traffic remains segregated within the service-provider network because the outer tag is different. With IEEE 802.1Q tunneling, each customer controls its own VLAN numbering space, which is independent of the VLAN numbering space used by other customers and the VLAN numbering space used by the service-provider network.

At the outbound tunnel port, the original VLAN numbers on the customer's network are recovered. If the traffic coming from a customer network is not tagged (native VLAN frames), these packets are bridged or routed as if they were normal packets, and the metro tag is added (as a single-level tag) when they exit toward the service provider network.

If using the native VLAN (VLAN 1) in the service provider network as a metro tag, it is important that this tag always be added to the customer traffic, even though the native VLAN ID is not normally added to transmitted frames. If the VLAN 1 metro tag were not added on frames entering the service provider network, then the customer VLAN tag would appear to be the metro tag, with disastrous results. The global configuration command **vlan dot1q tag native** must be used to prevent this by forcing a tag to be added to VLAN 1. Avoiding the use of VLAN 1 as a metro tag transporting customer traffic is recommended to reduce the risk of misconfiguration. A best practice is to use VLAN 1 as a private management VLAN in the service provider network.

The IEEE 802.1Q class of service (COS) priority field on the added metro tag is set to zero by default, but may be modified by input or output policy maps.

ML-Series QoS

The ML-Series card incorporates QoS features to provide control over access to network bandwidth resources. This control enables providers to implement priorities specified in Service Level Agreements (SLAs) and offers tools to enable traffic engineering.

The ML-Series QoS provides the ability to classify each packet in the network based on its interface of arrival, bridge group, class of service (CoS), IP precedence, and IP differentiated services code points. When classified, further QoS functions can be applied to each packet as it traverses the network.

Policing is also provided by the ML-Series card to ensure that no attached equipment submits more than a pre-defined amount of bandwidth into the network. This feature limits the bandwidth available to a customer, and provides a mechanism to support traffic engineering.

Priority marking allows Ethernet IEEE 802.1P CoS bits to be marked, as they exit the ML-Series card. This feature operates on the outer IEEE 802.1P tag when coupled with QinQ.

Per class flow queuing is provided to enable fair access to excess network bandwidth, and low latency queuing is supported for voice traffic. It allows allocation of bandwidth to support service-level agreements and ensure applications with high network resource requirements are adequately served. Buffers are allocated to queues dynamically from a shared resource pool. The allocation process incorporates the instantaneous system load as well as the allocated bandwidth to each queue to optimize buffer allocation to each queue.

The ML-Series card uses an advanced Weighted Deficit Round Robin (WDRR) scheduling process to provide fair access to excess bandwidth as well as guaranteed throughput to each class flow.

Admission control is a process that is invoked each time that service is configured on the ML-Series card to ensure that the card's available QoS resources are not overcommitted. In particular, admission control ensures that no configurations are accepted where a sum of the committed bandwidths on an interface exceed the total bandwidth of that interface.

The QoS bandwidth allocation of Multicast and Broadcast traffic is handled separately and differently than Unicast traffic. Aggregate Multicast and Broadcast traffic are given a fixed bandwidth commit of 10% on each interface, and treated as best effort for traffic exceeding 10%. Multicast and Broadcast are supported at line-rate.

Cisco Systems

ONS 15454 Ethernet Solutions Cross-Reference Charts

ONS 15454 Ethernet Solutions	10/100 Mb/s Interface	Gig-E Interface	NEBS3E Shelf	ANSI Shelf	Minimum Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q-in-Q VLAN Tagging
E-Series	12 ports per card	2 ports per card (GBICs: SX, LX)	Yes	No	2.0	509 VLANS per DCC-connected network	Port and Circuit VLAN filtering	No (exceeds maximum frame size)
G-Series	N/A	4 ports per card (GBICs: SX, LX, ZX)	No	Yes	3.2	VLANS are tunneled (not terminated)	VLANs are tunneled (no filtering)	Yes
ML-Series	12 ports per card	2 ports per card (GBICs: SX, LX, ZX)	No	Yes	4.0	VLANS and Layer 2 protocol are tunneled	VLANs are tunneled (no filtering)	Yes

ONS 15454 Ethernet Solutions	Maximum Frame Size	Broadcast and Multicast Support	Spanning Tree	Rate Limiting capability	Layer 3 Routing	Dedicated STS Circuit Size: Point-to-Point	Shared STS Circuit Size: Multiple Ports/ Multiple Sites
E-Series	1522 bytes (802.1Q frame)	No	Yes - 8 instances	STS level rate-limiting: STS-1 to STS-12c	N/A	STS-12c	STS-6c (1.2 Gbps switch matrix enables STS sharing)
G-Series	10,000 bytes	Yes (only port-to-port circuits are supported)	No	STS level rate-limiting: STS-1 to STS-24c	N/A	STS-24c	N/A - No switch matrix
ML-Series	10,000 bytes	Yes	Yes - 255 STP and RSTP instances	Port level rate-limiting: 1 Mb/s increments	Layer 3 routing, switching, and forwarding: Up to 18,000 IP routes; Up to 20,000 IP host entries; Up to 128 IP multicast groups	STS-24c	STS-24c

ONS 15454 Ethernet Solutions	SONET Protection (Path Protection Configuration, BLSR, Linear)	Circuit Termination on E-Series Card	Circuit Termination on G-Series Card	Circuit Termination on ML-Series Card
E-Series	Yes	Yes	No	No
G-Series	Yes	No	Yes	Yes
ML-Series	Yes	No	Yes	Yes

Chapter 6 – Product Description and Specifications

Note: The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

Purpose

This chapter provides a description and hte technical specifications of the ONS 15454 system. For additional information, refer to the *Cisco ONS 15454 Reference Manual*.

Contents

The following topics are found in this chapter:

CISCO SYSTEMS

ONS 15454 Specifications

The Cisco ONS 15454 MSPP provides flexible SONET add/drop multiplexer features and offers service aggregation and high-bandwidth transport for voice and data traffic on a single platform. It is New Equipment Building System (NEBS) Level 3 compliant for Type 2, Type 4, and Class A devices and meets the applicable criteria set forth in the following requirements documents:

GR-63-CORE, Issue 1, October, 1995
GR-1089-CORE, Issue 2, with Revision 1, February, 1999
UL Standard 60950 Ed3, December 1, 2000
UL Standard 94, October 29, 1996
Requirement 1.1.4-20 of AT&T NEDS MLID #9069, December 30, 1999
SBC TP76200MP, May, 2001

Note In this chapter, the terms “ONS 15454” and “shelf assembly” are used interchangeably.

Supported Configurations

Terminal mode
Linear Add-drop multiplexer
Two-fiber Path Protection Configuration
Two- fiber BLSR
Four-fiber BLSR
Path protected mesh network (PPMN)
Regenerator mode

Physical Specifications

The ONS 15454 has the following physical characteristics (including the fan tray and mounting ears):

Height: 18.5 inches (40.7 cm)
Width: 19 or 23 inches (41.8 or 50.6 cm) with mounting ears
Depth: 12 inches (26.4 cm)
Weight: 55 lbs. empty (without plug-in cards)

Environmental Specifications

The ONS 15454 meets Telcordia’s NEBS Level 3 criteria for Type 2, Type 4, and Class A equipment, which is intended for installation in a central office (CO), controlled environmental vault (CEV), electronic equipment enclosures (EEEs), huts, and cabinets. The ONS 15454 is not designed as a Type 3 EU and has not undergone NEBS tests and evaluation for equipment directly connected to outside plant (OSP) facilities.

The fan tray assembly is required for all ONS 15454 installations.

The ONS 15454 is environmentally hardened and will function at operating temperatures of -40 to 149 degrees Fahrenheit (-40 to +65 degrees Celsius) and humidity of 5 to 95 percent (non-condensing) when configured with the following components:

- 15454-SA-ANSI Shelf
- 15454-FTA2 Fan Tray
- 15454-FTA3-T Fan Tray
- 15454-TCC+T
- 15454-TCC2
- 15454-XC-T
- 15454-XC-VT-T
- 15454-AIC-T
- 15454-AIC-I
- 15454-AEP
- 15454-DS1-14
- 15454-DS1N-14
- 15454-DS3-12-T
- 15454-DS3-12E-T
- 15454-DS3N-12E-T
- 15454-DS3XM-6-T
- 15454-EC1-12-T
- 15454-OC34IR1310-T
- 15454-OC38IR1310-T
- 15454-OC12IIR1310-T
- 15454-OC12ILR1310-T
- 15454-OC12ILR1550-T

For all other configurations, the ONS 15454 functions at operating temperatures of 32 to 131 degrees Fahrenheit (0 to +55 degrees Celsius).

When installed in an ONS 15454, all plug-in cards meet the following safety requirements:

- UL 1950
- CSA C22.2 No. 950
- EN 60950
- IEC 60950

Power Specifications

- Recommended Input Voltage: -48VDC
  - Two –48VDC power feeds (Breaker A and Breaker B)
- Acceptable Input Voltage Range: -42 to –57VDC
- Maximum Power Consumption: 1060W (System Release 3.1 or higher); 952W (System Release prior to 3.1)
- Recommended Amperage: 30A (System Release 3.1 or higher); 20A (System Release prior to 3.1)
- Power Terminals: #6 Lug

Bandwidth Capacity

- Total Capacity: 240 Gb/s
- Data Plane Bandwidth: 160 Gb/s
- SONET plane bandwidth: 80 Gb/s

Database Storage

Nonvolatile Memory (Flash): 256 MB (with TCC2)
Volatile memory (synchronous dynamic RAM): 256 MB (with TCC2)

Synchronization

Stratum 3, per Telcordia GR-253-CORE
Free-running Access: Accuracy +/−4.6 ppm
Holdover Stability: 3.7 * 10^{-7} per day including temperature (< 255 slips in first 24 hours)
References: External BITS, line, internal

BITS Interface

Two DS-1 BITS inputs
Two derived DS-1 outputs
BITS 1 and BITS 2 pins provided on backplane

Operations Interface

Local Craft Access: An EIA/TIA-232 ASCII interface (9600 baud) or 10BaseT LAN interface on the TCC faceplate.
Network/LAN Access: A 10BaseT LAN interface via the backplane. Set the LAN 10/100 Ethernet port for half-duplex.
TL1 Access: An EIA/TIA-232 ASCII interface (9600 baud) on the TCC faceplate or 10BaseT LAN interface on both the TCC faceplate and backplane.
Cisco Transport Controller (CTC): A 10BaseT LAN interface on the TCC faceplate and backplane.

Laptop PC Requirements

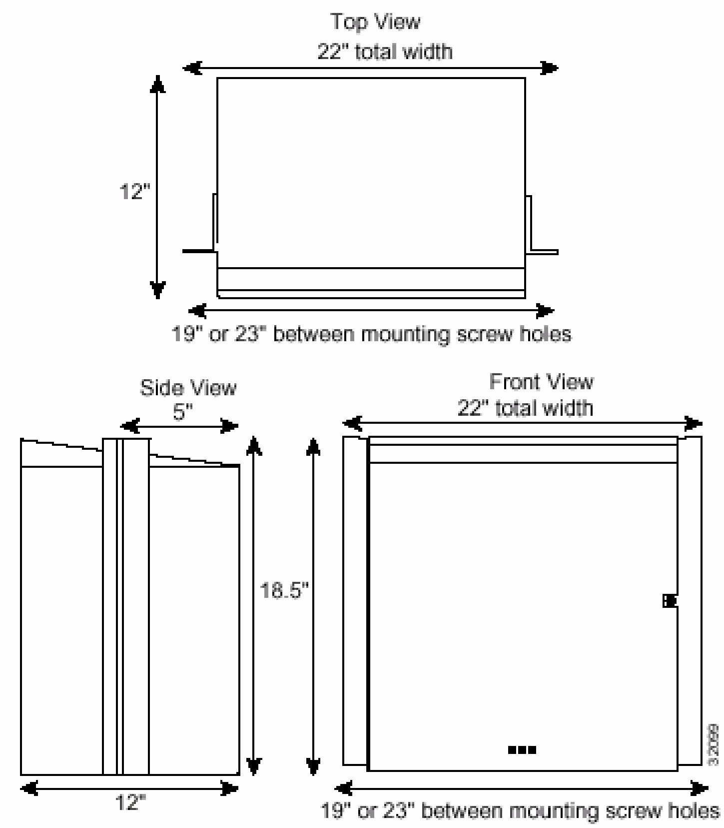
Processor: Pentium II (or higher) 300 MHz, UltraSPARC, or equivalent
RAM: 128 MB (minimum) 256 MB recommended
Hard Drive: 2 GB recommended with 50 MB vacant space available
Operating System: PC: Windows 95, Windows 98, Windows NT 4.0 with Service Pack 6, Windows 2000, or Windows XP. For Workstations: Any Solaris release
Web Browser: PC: Netscape Navigator 4.73 or higher, Internet Explorer 5.0 (service pack 2) or higher. For Workstations: Netscape Navigator 4.73 or higher. Netscape Communicator 4.73 (Windows) and 4.76 (UNIX) are installed by the CTC Installation Wizard included on the Cisco ONS 15454 software and documentation CDs.
Modem: A compatible modem must meet the following minimum requirements:

- 300, 1200, 2400, 4800, or 9600 baud
- Full duplex
- 8 data bits
- No parity bits
- 1 start bit
- 1 stop bit
- No flow control

Shelf Assembly

One person can mount the ONS 15454 in a 19- or 23-inch rack. The shelf assembly weighs approximately 55 pounds with no cards installed. It includes a front door for added security and EMI compliance, a fan tray module for cooling, and extensive cable-management space. The shelf assembly measures 18.5-inches high, 19- or 23-inches wide (depending on which way the mounting ears are attached), and 12-inches deep (see Figure 6-1).

Figure 6-1: Shelf Assembly Dimensions



Since the introduction of System Release 3.1, a new version of shelf assembly was introduced, model 15454-SA-ANSI. This updated shelf assembly has enhanced fiber management capabilities and is designed to support the 10Gb/s hardware, which includes the XC-10G cross-connect, OC48 any slot, and OC192 cards. Table 6-1 lists the shelf assemblies deployed to date, with the newest assembly available listed at the top of the table.

Table 6-1: Shelf Assembly Versions

Product Name	Part Number	Description
15454-SA-ANSI	800-19857-xx	Cisco ONS 15454 NEBS 3 ANSI 10Gb/s Shelf Assembly, NEBS 3 ANSI, Enhanced Fiber Management, Increased Power Rating (-48VDC, 30A)
15454-SA-NEBS3E	800-07149-xx	Cisco ONS 15454 NEBS 3 Compliant Shelf Assembly, Enhanced Fiber Management, Power Rating (-48VDC, 25A)
15454-SA-NEBS3	800-06741-xx	Cisco ONS 15454 NEBS 3 Compliant Shelf Assembly, Power Rating (-48VDC, 25A)
454-SA-NEBS3 (Cerent)	89-01-00018	Cerent 454 Shelf Assembly, NEBS 3 Compliant
454-SA-R1 (Cerent)	89-01-00013 89-01-00001	Cerent 454 Shelf Assembly

Assembly Shelf Specifications

Table 6-2 lists the physical dimensions and environmental specifications for the ONS 15454 assembly shelf.

Table 6-2: ONS 15454 Assembly Shelf Specifications

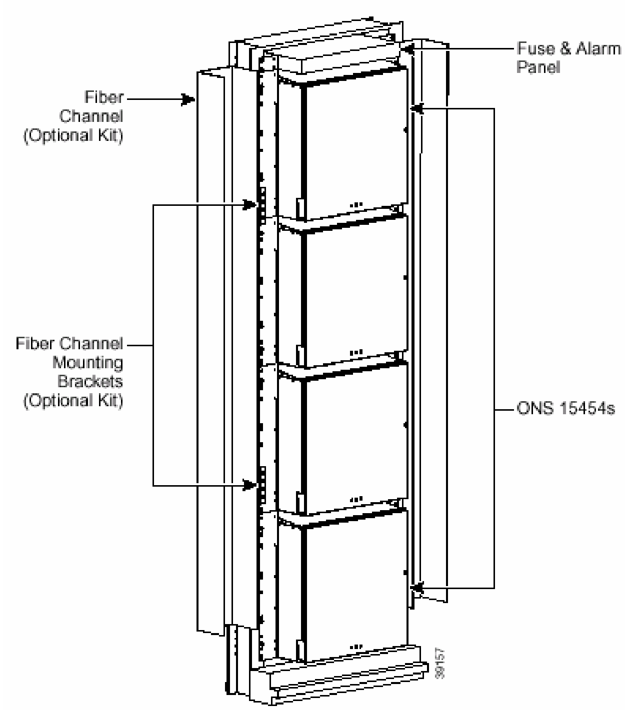
Parameter	Specifications
Physical Dimensions	
Height	18.5-inches
Width	19-inches
Depth	12-inches
Weight	55 lbs. (minimum), 165 lbs.(maximum)
Footprint	13 ft^2
Minimum Aisle Clearance Requirement	24-inches
Environmental	
Input Power Requirement	-48 VDC
Maximum Power Consumption	1060 W (maximum)
Maximum Amperage Requirement	24 A
Recommended Fuse[1]	30 A

[1] Includes 25% safety margin.

Four-Shelf Pre-Installed ONS 15454 Bay Assembly

Cisco simplifies ordering and installing the ONS 15454 because it allows you to order shelf assemblies pre-installed in a seven-foot rack. Cisco offers a pre-installed ONS 15454 Bay Assembly (OPT-BIC) that can be ordered with either three- or four-shelf pre-installed configurations in a 7-foot rack. The three-shelf configuration includes three ONS 15454 shelf assemblies, a pre-wired fuse and alarm panel, and two fiber management trays. Optional fiber channels can be ordered. The four-shelf configuration includes four ONS 15454 shelf assemblies and a pre-wired fuse and alarm panel. Optional fiber channels can be ordered. A four shelf ONS 15454 Bay Assembly is shown in Figure 6-2.

Figure 6-2: Four-Shelf Pre-Installed ONS 15454 Bay Assembly

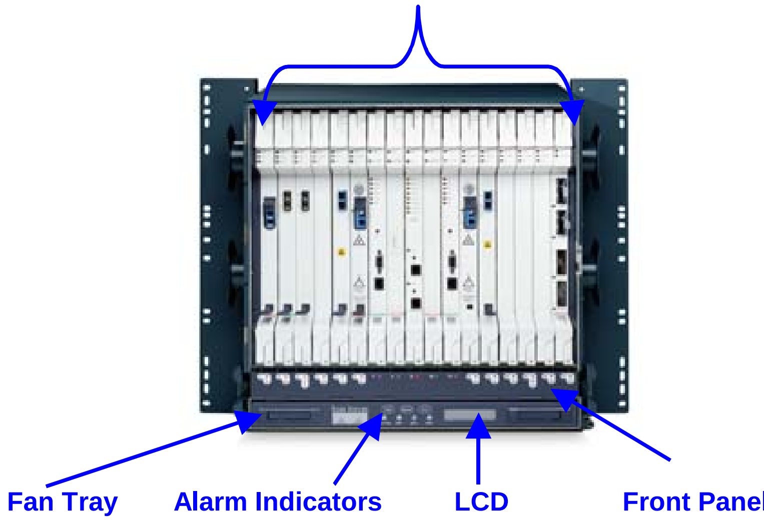


Slot Assignments

As shown in Figure 6-3, the ONS 15454 shelf assembly has 17 card slots numbered sequentially from left to right. Slots 1 to 4 and 14 to 17 are multispeed slots. They can host any ONS 15454 plug-in card, except the OC48 IR 1310, OC48 LR 1550, OC48 ELR 1550, and OC192 LR 1550 cards. Slots 5, 6, 12, and 13 are high-speed slots. They can host all ONS 15454 cards, except the OC12/STM4-4 and OC3-8 cards. You can install the OC48 IR/STM16 SH AS 1310 and the OC48 LR/STM16 LH AS 1550 cards in any multispeed or high-speed card slot.

Slots 7 and 11 are dedicated to TCC+/TCC2 cards. Slots 8 and 10 are dedicated to cross-connect (XC, XCVT, XC10G) cards. Slot 9 is reserved for the optional Alarm Interface Controller (AIC or AIC-I) card. Slots 3 and 15 can also host DS1N-14 and DS3N-12 cards that are used in 1:N protection.

Figure 6-3: ONS 15454 Shelf Assembly



Shelf assembly slots have symbols indicating the type of cards that you can install in them. Each ONS 15454 card has a corresponding symbol. The symbol on the card must match the symbol on the slot. Table 6-3 lists the slot and card symbol definitions.

Table 6-3: Slot and Card Symbol Definitions

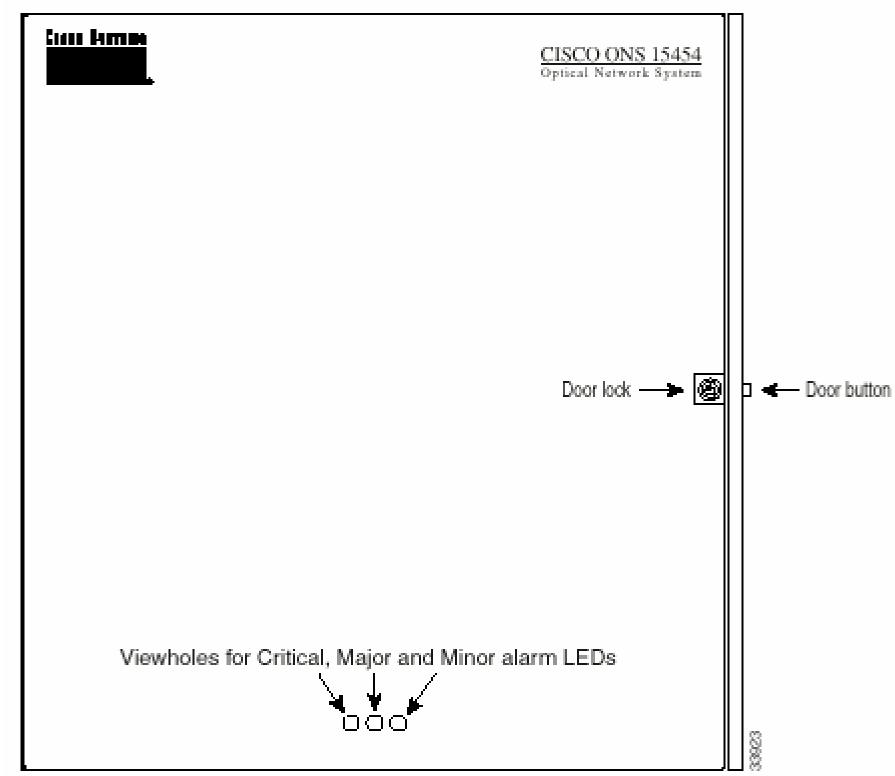
Symbol Color/Shape	Definition
Orange/Circle	Slots 1 to 6 and 12 to 17. Only install ONS 15454 cards with a circle symbol on the faceplate.
Blue/Triangle	Slots 5, 6, 12, and 13. Only install ONS 15454 cards with circle or a triangle symbol on the faceplate.
Purple/Square	TCC+/TCC2 slot, Slots 7 and 11. Only install ONS 15454 cards with a square symbol on the faceplate.
Green/Cross	Cross-connect (XC/XCVT/XC10G) slot, i.e. Slots 8 and 10. Only install ONS 15454 cards with a cross symbol on the faceplate.
Red/P	Protection slot for 1:N protection schemes.
Red/Diamond	AIC slot, that is Slot 9. Only install ONS 15454 cards with a diamond symbol on the faceplate.
Gold/Star	Slots 1 to 4 and 14 to 17. Only install ONS 15454 cards with a star symbol on the faceplate.

Filler slot cards are available for any unpopulated card slot numbered 1 to 17, a blank filler slot card, model 15454-BLANK, must be installed to maintain proper airflow and compliance with NEBS EMI and ESD requirements.

Shelf Assembly Front Door

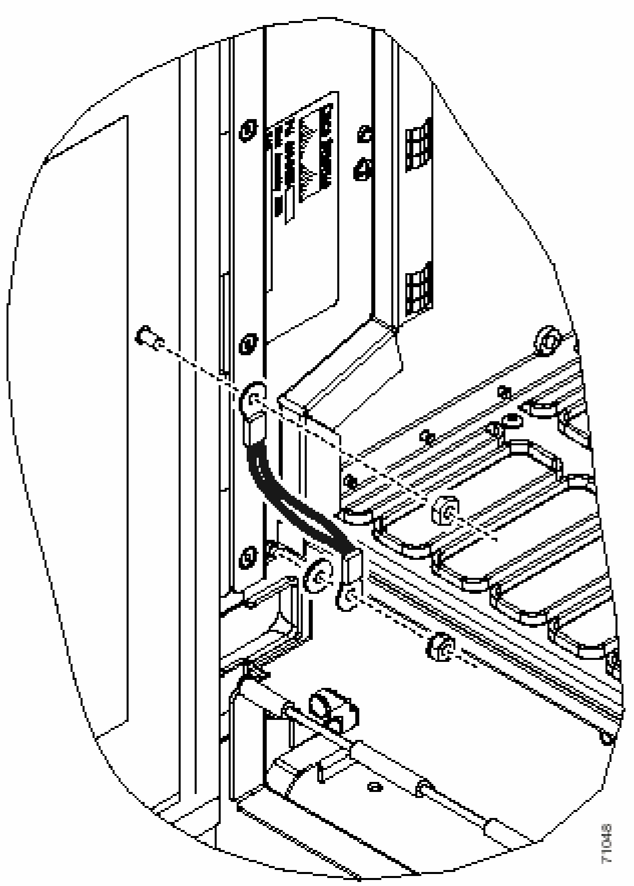
The ONS 15454 shelf assembly features a locked door to the front compartment. A pinned hex key that unlocks the front door ships with the ONS 15454. A button on the right side of the shelf assembly releases the door. The front door shown in Figure 6-4 provides access to the shelf assembly, cable-management tray, fan-tray assembly, and LCD screen.

Figure 6-4: Shelf Assembly Front Door



You can remove the front door of the shelf assembly to provide unrestricted access to the front of the card slots. Before you remove the front door, you have to remove the ground strap of the front door as shown in Figure 6-5.

Figure 6-5: Front Door Ground Strap



An erasable label shown in Figure 6-6 is pasted on the inside of the front door. You can use the label to record slot assignments, port assignments, card types, node ID, rack ID, and serial number for the ONS 15454. The label also includes the Class I and Class 1M laser warning shown in Figure 6-7.

Figure 6-6: Erasable Label Inside Front Door

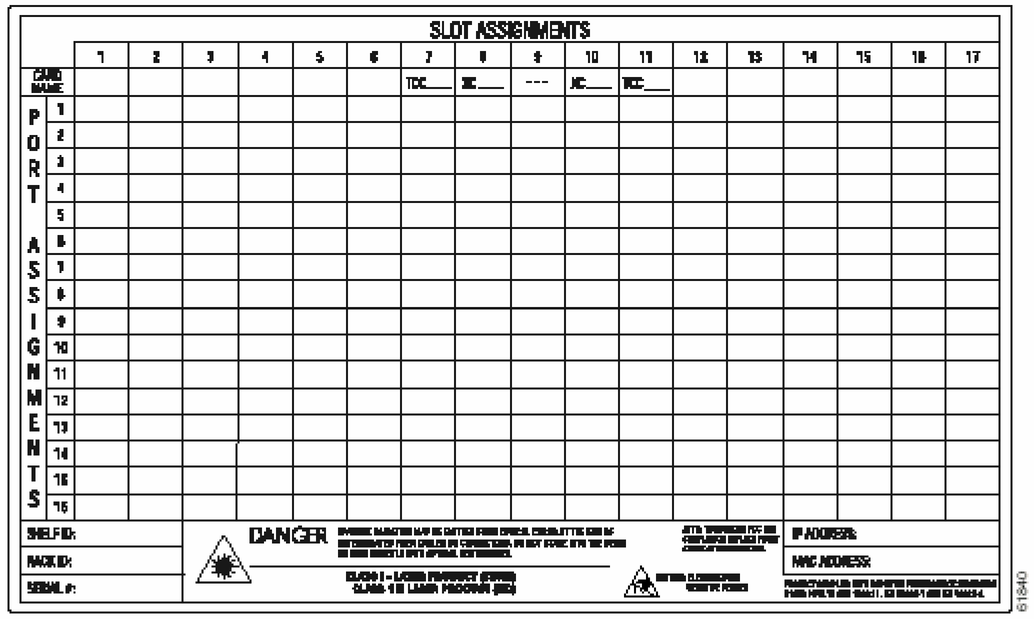
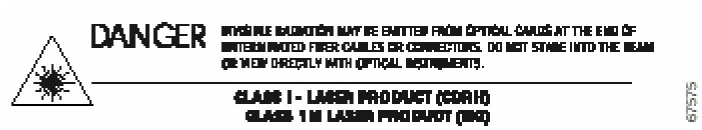


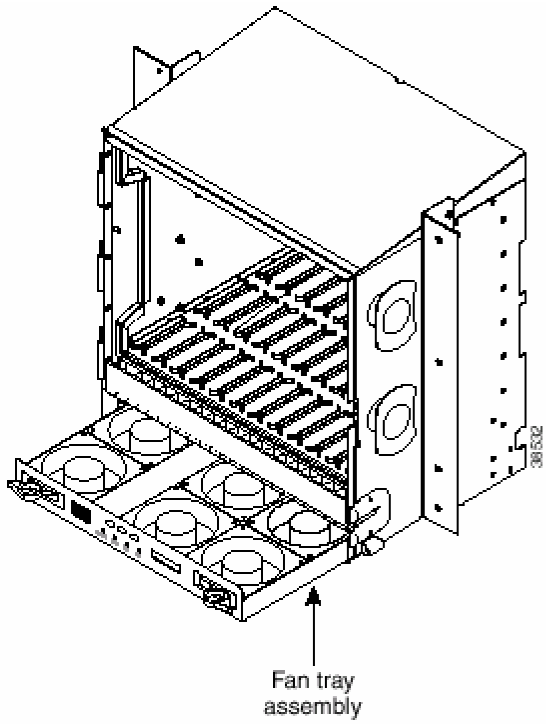
Figure 6-7: Laser Warning on the Front Door Label



Fan Tray Assembly

The fan tray assembly is located at the bottom of the ONS 15454 shelf assembly (see Figure 6-8). The fan tray is a removable drawer that holds fans and fan-control circuitry for the ONS 15454. The front door can be left in place when removing or installing the fan tray but removal is recommended. After you install the fan tray, you should only need to access it if a fan failure occurs or you need to replace or clean the fan-tray air filter.

Figure 6-8: Fan Tray Assembly



The fan tray slides into the ONS 15454, under the main card-cage (see Figure 6-8). Fan power, control, and status signals are provided by a rear connector that engages when the tray is inserted. The fans provide large volume airflow exceeding 100 linear feet per minute (LFM) across each of the plug-in cards. In addition to containing six variable-speed fans, the fan tray assembly provides a front-panel Liquid-Crystal Display, Status and Alarm LED's, and push-buttons, allowing for the quick monitoring of system status. A replaceable filter element slides in under the fan tray. The filter will function properly no matter which side faces up. This filter can be install and remove by hand. Remove and visually inspect this filter every 30 days and keep spare filters in stock.

There are presently two series of fan tray assemblies available for the ONS 15454:

1. FTA3-T high airflow assembly
2. FTA2 standard airflow assembly

The FTA3-T shown in Figure 6-8 offers the higher airflow capabilities required to support ONS 15454 systems equipped with XC-10G cross-connect cards and is rated for industrial temperature installations (-40 to +65 Celsius). The FTA3-T employs a positive stop insertion pin (see Figure 6-9) to prevent the installation of the fan tray assembly into shelf assembly versions prior to the current ANSI offering.

Figure 6-9: FTA3-T High Airflow Assembly

Front/Top View Rear/Top View

The FTA2 fan tray assembly is required for ONS 15454 System Release ≤3.1 and can be used in systems deployed for industrial temperature (I-temp) operation (-40° to +65° Celsius).

The compatibility between fan tray assemblies and shelf assemblies is outlined in Table 6-4.

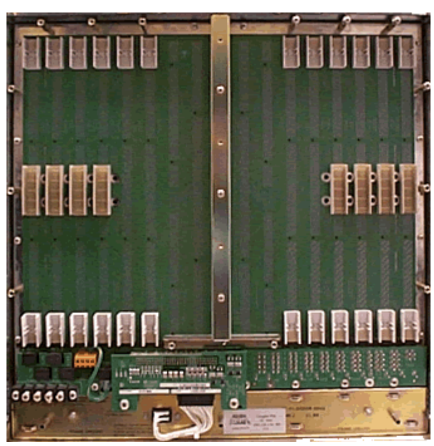
Table 6-4: Fan and Assembly Tray Compatibility Matrix

Fan Tray Assembly Product Name	Fan Tray Assembly Part Number	Shelf Assembly Product Name
15454-FTA3-T(Required for XC-10G equipped systems)	800-19858-xx	15454-SA-ANSI
15454-FTA2	800-07145-xx 800-07385-xx 800-19591-xx 800-19590-xx	15454-SA-ANSI15454-SA-NEBS3E
15454-FTA	800-06782-xx	15454-SA-NEBS3 454-SA-NEBS3 454-SA-R1 (Cerent)
454-FTA	89-01-00004	454-SA-R1 (Cerent)

Backplane

The backplane (Figure 6-10) provides access to alarm contacts, external interface contacts, power terminals, and Electrical Interface Assemblies (EIAs).

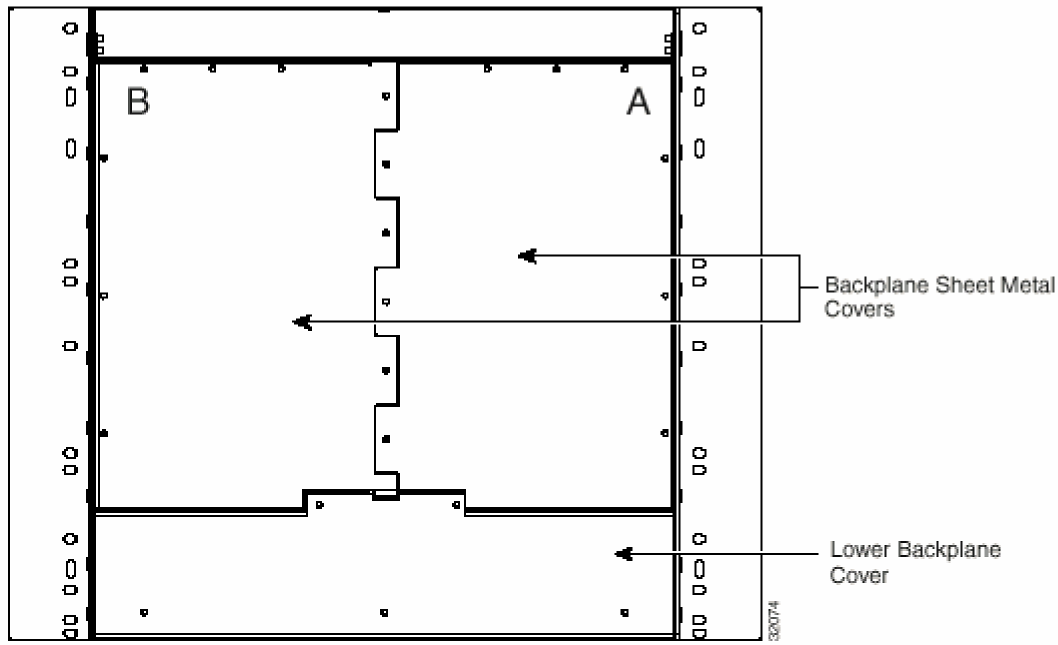
Figure 6-10: Picture of the ONS 15454 Backplane



Backplane Covers

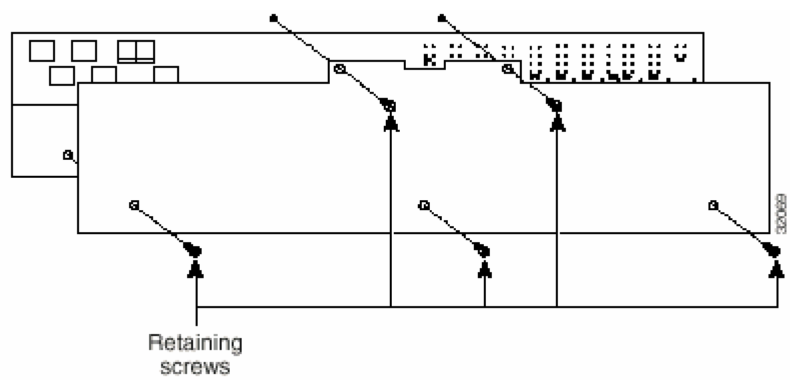
If a backplane does not have Electrical Interface Assembly (EIA) panels installed, it should have two sheet metal backplane covers (one on each side of the backplane) as illustrated in Figure 6-11. Each cover is held in place with nine 6-32 x 3/8 inch Phillips screws.

Figure 6-11: Sheet Metal Backplane Covers



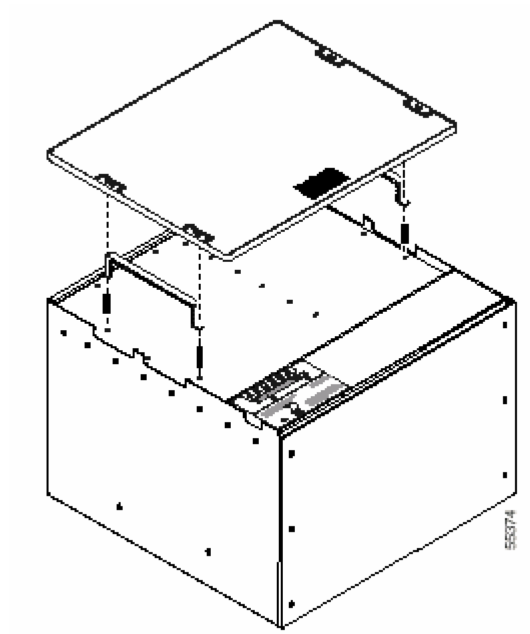
The lower section of the backplane is covered by a clear plastic protector, which is held in place by five 6-32 x 1/2 inch screws. Remove the lower backplane cover to access the alarm interface panel (AIP), alarm pin fields, frame ground, and power terminals (Figure 6-12).

Figure 6-12: Removable Lower Backplane Cover



The ONS 15454 has an optional clear plastic rear cover that can provide additional protection for the cables and connectors on the backplane. Spacers can be ordered if more space is needed between the cables and rear cover (see Figure 6-13).

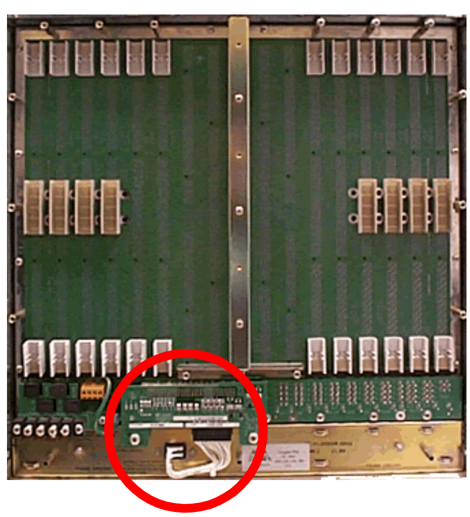
Figure 6-13: Plastic Rear Cover with Spacers



Alarm Interface Panel

The Alarm Interface Panel (AIP) is located above the alarm contacts on the lower section of the backplane (see Figure 6-14). The AIP provides surge protection for the ONS 15454. It also provides an interface from the backplane to the fan tray assembly and LCD. The AIP plugs into the backplane using a 96-pin DIN connector and is held in place with two retaining screws. The panel has a non-volatile memory chip that stores the unique node address (MAC address).

Figure 6-14: Alarm Interface Panel



Alarm Interface Panel Replacement

Note Ensure that all nodes in the affected network are running the same software version before replacing the AIP and repairing circuits. If you need to upgrade nodes to the same software version, no hardware should be changed or circuit repair performed until after the software upgrade is complete.

If the AIP fails, a MAC Fail alarm displays on the CTC Alarms menu and/or the LCD display on the fan-tray assembly will go blank. To perform an in-service replacement of the AIP, you must contact Cisco Technical Assistance Center (TAC) at 877-323-7368.

You can replace the AIP on an in-service system without affecting traffic (except Ethernet traffic on nodes running a software release earlier than Release 4.0). The circuit repair feature allows you to repair circuits affected by MAC address changes on one node at a time. Circuit repair will work when all nodes are running the same software version. Each individual AIP upgrade requires an individual circuit repair; if AIPs are replaced on two nodes, the circuit repair must be performed twice.

Caution Do not use a 2-A AIP with a 5-A fan-tray assembly; doing so will cause a blown fuse on the AIP.

Note The 5-A AIP (73-7665-XX) is required when installing the new fan-tray assembly (15454-FTA3), which comes preinstalled on the shelf assembly (15454-SA-ANSI).

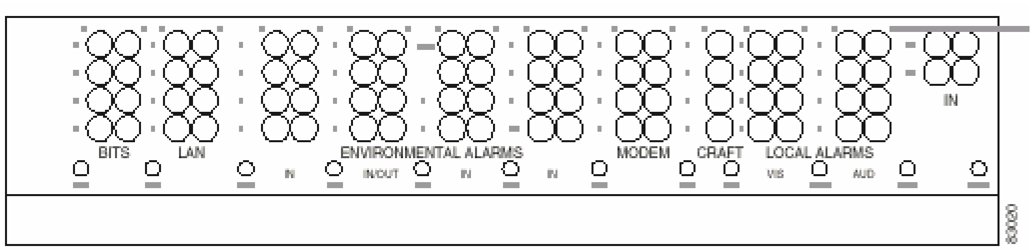
Note The MAC address identifies the nodes that support circuits. It allows CTC to determine circuit sources, destinations, and spans. The TCC+ or TCC2 cards in the ONS 15454 also use the MAC address to store the node's database.

Note A blown fuse on the AIP board can cause the LCD display to go blank.

Alarm Contacts

The ONS 15454 has a backplane pin field located at the bottom of the backplane (see Figure 6-15). The backplane pin field provides 0.045 square inch wire-wrap pins for enabling external alarms, timing input and output, and craft interface terminals.

Figure 6-15: ONS 15454 Backplane Pinouts (System Release 3.4 or higher)

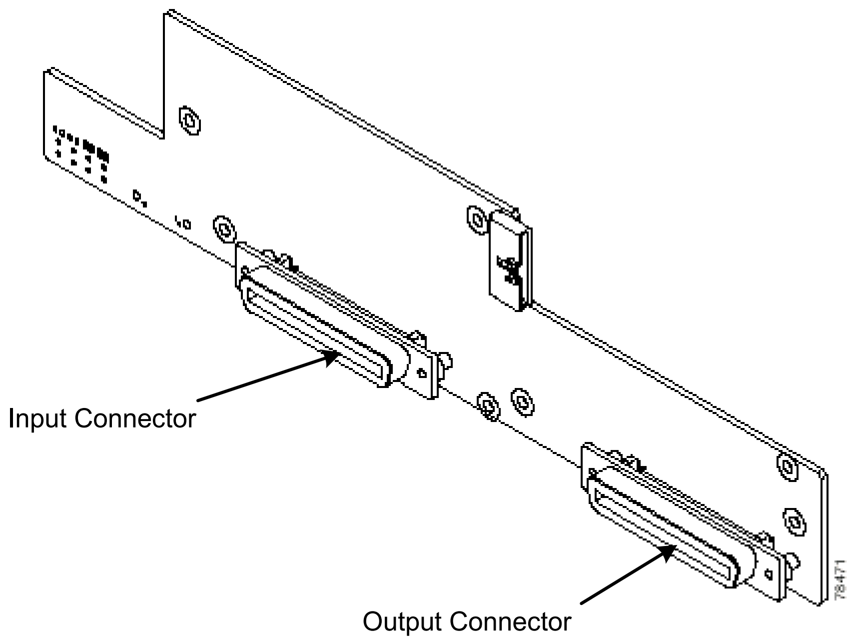


Visual and audible alarms are typically wired to trigger an alarm light or bell at a central alarm collection point when the corresponding contacts are closed. You can use the Alarm Cutoff pins to activate a remote ACO for audible alarms. You can also activate the ACO function by pressing the ACO button on the TCC+/TCC2 card faceplate. The ACO function clears all audible alarm indications. After clearing the audible alarm indication, the alarm is still present and viewable in the Alarms tab in CTC.

Alarm Expansion Panel

The optional alarm expansion panel (AEP) can be used with the enhanced Alarm Interface Controller card (AIC-I) card to provide an additional 48 dry alarm contacts, 32 of which are inputs and 16 are outputs. The AEP shown in Figure 6-11 is a printed circuit board assembly that is installed on the backplane. In Figure 6-16, the left connector is the input connector and the right connector is the output connector.

Figure 6-16: AEP Printed Circuit Board Assembly



The AIC-I without an AEP already contains direct alarm contacts. These direct AIC-I alarm contacts are routed through the backplane to wire-wrap pins accessible from the back of the shelf. If you install an AEP, you cannot use the alarm contacts on the wire-wrap pins.

Alarm inputs:
- 32 inputs
- Optocoupler isolated
- Label customer provisionable
- Severity customer provisionable
- Common 32 V output for all alarm-inputs
- Each input limited to 2 mA
- Termination: 50-pin AMP champ connector

Alarm outputs:
- 16 outputs
- Switched by opto MOS (metal oxide semiconductor)
- Triggered by definable alarm condition
- Maximum allowed open circuit voltage: 60 VDC
- Maximum allowed closed circuit current: 100 mA
- Termination: 50-pin AMP champ connector

Environmental:
- Overvoltage protection: as in ITU-T G.703 Annex B
- Operating temperature: -40 to +65 degrees Celsius
- Operating humidity: 5 to 95%, non-condensing
- Power consumption: 3.00 W max., from +5 VDC from AIC-I, 10.2 BTU/Hr. max.

Dimensions:
- Height: 20 mm (0.79 in.)
- Width: 330 mm (13.0 in.)
- Depth: 89 mm (3.5 in.)
- Weight: 0.18 kg (0.4 lb.)

Compliance:
- Installed AEP cards comply with the following standards:
  - Safety: IEC 60950, EN 60950, UL 60950, CSA C22.2 No. 60950, TS 001, AS/NZS 3260

Electrical Interface Assemblies

Electrical Interface Assemblies (EIAs) are typically pre-installed when ordered with the ONS 15454. EIAs must be ordered when using DS-1, DS-3, DS3XM-6, or EC-1 cards.

Four different EIA backplane covers are available for the ONS 15454:

1. BNC
2. High-Density BNC
3. SMB
4. AMP Champ

EIAs are attached to the shelf assembly backplane to provide electrical interface cable connections. EIAs are available with SMB and BNC connectors for DS-3 or STS-1 electrical circuits. EIAs are available with AMP Champ connectors for DS-1 circuits. You must use SMB EIAs for DS-1 twisted-pair cable installations.

You can install EIAs on one or both sides of the ONS 15454 backplane in any combination (in other words, AMP Champ on Side A and BNC on Side B or High-Density BNC on side A and SMB on side B, and so forth).

As you face the rear of the ONS 15454 shelf assembly, the right-hand side is the A side and the left-hand side is the B side. The top of the EIA connector columns are labeled with the corresponding slot number, and EIA connector pairs are marked transmit (Tx) and receive (Rx) to correspond to transmit and receive cables.

EIA Configurations

The matrix provided in Table 6-5 describes the EIA configurations available for the ONS 15454.

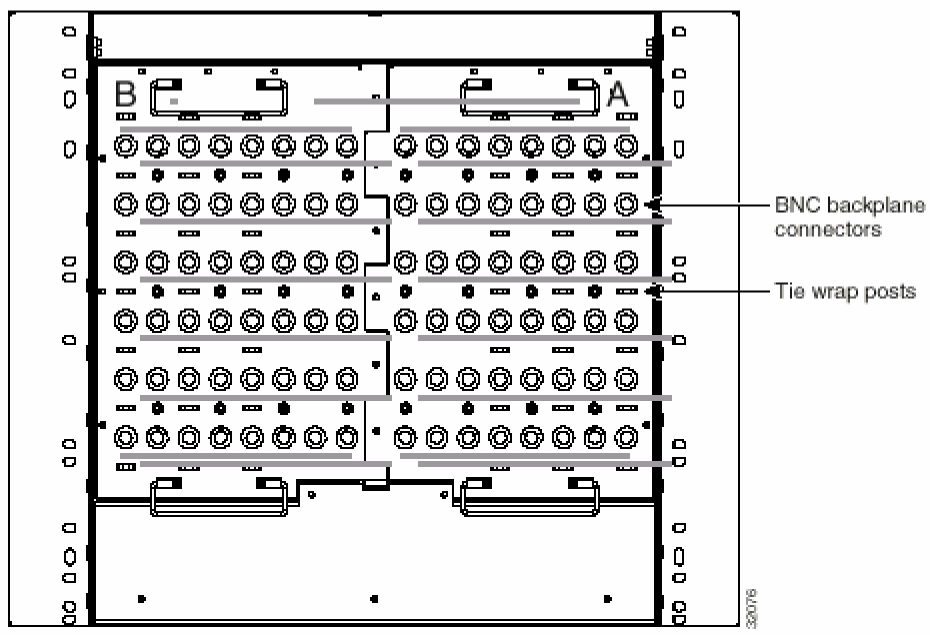
Table 6-5: Electrical Interface Assembly Configurations

EIA Type	Interface Cards Supported	A Side Capacity	A Side Connectors Map To	A Side Product Number	B Side Capacity	B Side Connectors Map To	B Side Product Number
Low-Density BNC	DS-3 DS3XM-6 EC-1	24 pairs of BNC connectors	Slot 2 and Slot 4	15454-EIA-BNC-A24	24 pairs of BNC connectors	Slot 14 and Slot 16	15454-EIA-BNC-B24
High-Density BNC	DS-3 DS3XM-6 EC-1	48 pairs of BNC connectors	Slot 1, Slot 2, Slot 4, and Slot 5	15454-EIA-BNC-A48	48 pairs of BNC connectors	Slot 13, Slot 14, Slot 16, and Slot 17	15454-EIA-BNC-B48
SMB	DS-1 DS-3 EC-1 DS3XM-6	84 pairs of SMB connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, and Slot 6	15454-EIA-SMB-A84	84 pairs of SMB connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, and Slot 17	15454-EIA-SMB-B84
AMP Champ	DS-1	6 AMP Champ connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, and Slot 6	15454-EIA-AMP-A84	6 AMP Champ connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, and Slot 17	15454-EIA-AMP-B84

Low-Density BNC EIA

You can use BNC EIAs for DS-3 and STS-1 electrical circuits. BNC EIAs are interoperate with all of Cisco's DS-3 cards (including the DS3XM-6) and the EC-1 card. The ONS 15454 low-density BNC EIA supports 24 DS-3 circuits on each side of the ONS 15454 (24 transmit and 24 receive connectors). If you install BNC EIAs on both sides of the shelf assembly, the ONS 15454 hosts up to 48 DS-3 circuits. The BNC connectors on this EIA supports Trompeter UCBJ224 (75 ohm) 4 leg connectors (King or ITT are also compatible). Right-angle mating connectors for the connecting cable are AMP 413588-2 (75 Ohm) connectors. If preferred, you can also use a straight connector of the same type. Use RG-59/U cable to connect to the ONS 15454 BNC EIA. These cables are recommended to connect to a patch panel and are designed for long runs. Figure 6-17 shows the ONS 15454 with pre-installed BNC EIAs.

Figure 6-17: Low-Density BNC EIA for use in 1:1 Protection Schemes



The EIA side marked “A” has 24 pairs of BNC connectors. The first 12 pairs of BNC connectors correspond to Ports 1 to 12 for a 12-port card and map to Slot 2 on the shelf assembly. The BNC connector pairs are marked “Tx” and “Rx” to indicate transmit and receive cables for each port. You can install an additional card in Slot 1 as a protect card for the card in Slot 2. The second 12 BNC connector pairs correspond to Ports 1 to 12 for a 12-port card and map to Slot 4 on the shelf assembly. You can install an additional card in Slot 3 as a protect card for the card in Slot 4. Slots 5 and 6 do not support DS-3 cards when the standard BNC EIA panel connectors are used.

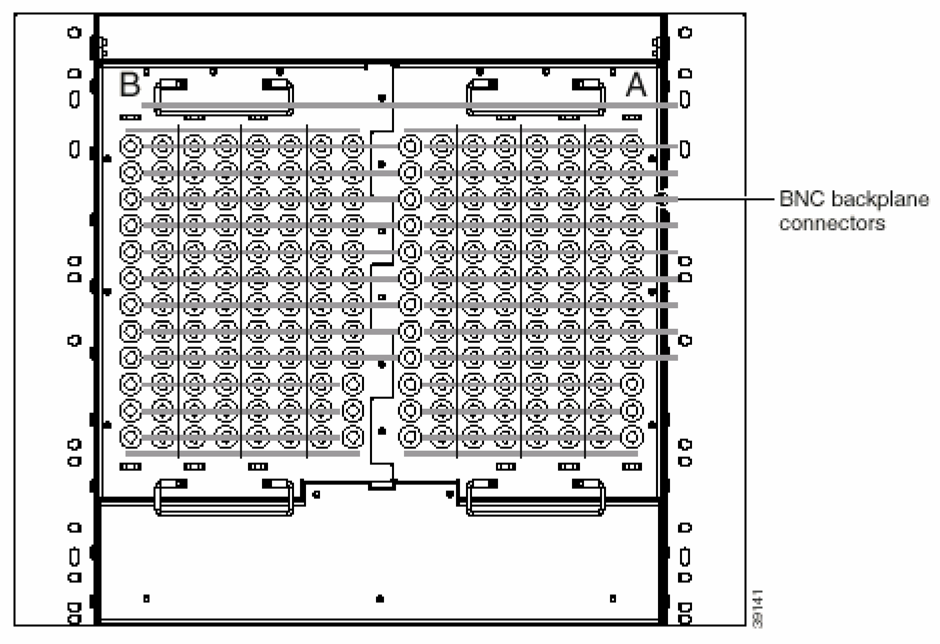
The EIA side marked “B” provides an additional 24 pairs of BNC connectors. The first 12 BNC connector pairs correspond to Ports 1 to 12 for a 12-port card and map to Slot 14 on the shelf assembly. The BNC connector pairs are marked “Tx” and “Rx” to indicate transmit and receive cables for each port. You can install an additional card in Slot 15 as a protect card for the card in Slot 14. The second 12 BNC connector pairs correspond to Ports 1 to 12 for a 12-port card and map to Slot 16 on the shelf assembly. You can install an additional card in Slot 17 as a protect card for the card in Slot 16. Slots 12 and 13 do not support DS-3 cards when the standard BNC EIA panel connectors are used.

When BNC connectors are used with a DS3N-12 card in Slot 3 or 15, the 1:N card protection extends only to the two slots adjacent to the 1:N card due to BNC wiring constraints.

High-Density BNC EIA

The ONS 15454 high-density BNC EIA supports 48 DS-3 circuits on each side of the ONS 15454 (48 transmit and 48 receive connectors). If you install BNC EIAs on both sides of the unit, the ONS 15454 hosts up to 96 circuits. The high-density BNC EIA supports Trompeter UCBJ224 (75 ohm) 4 leg connectors (King or ITT are also compatible). Use straight connectors on RG-59/U cable to connect to the high-density BNC EIA. Cisco recommends these cables for connection to a patch panel; they are designed for long runs. You can use high-density BNC EIAs for DS-3 (including the DS3XM-6) or EC-1 cards. Figure 6-18 shows the ONS 15454 with pre-installed high-density BNC EIAs.

Figure 6-18: High-Density BNC Backplane for use in 1:N Protection Schemes



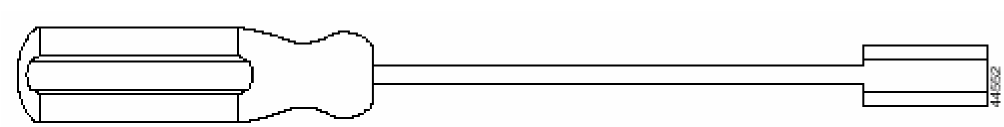
The EIA side marked "A" hosts 48 pairs of BNC connectors. Each column of connector pairs is numbered and corresponds to the slot of the same number. The first column (12 pairs) of BNC connectors corresponds to Slot 1 on the shelf assembly, the second column to Slot 2, the third column to Slot 4, and the fourth column to Slot 5. The rows of connectors correspond to Ports 1 to 12 of a 12-port card.

The EIA side marked "B" provides an additional 48 pairs of BNC connectors. The first column (12 pairs) of BNC connectors corresponds to Slot 13 on the shelf assembly, the second column to Slot 14, the third column to Slot 16, and the fourth column to Slot 17. The rows of connectors correspond to Ports 1 to 12 of a 12-port card. The BNC connector pairs are marked "Tx" and "Rx" to indicate transmit and receive cables for each port. The High-Density BNC EIA supports both 1:1 and 1:N protection across all slots except Slots 6 and 12.

BNC Insertion and Removal Tool

Due to the large number of BNC connectors on the High-Density BNC EIA, you might require a special tool for inserting and removing BNC EIAs (see Figure 6-19). This tool also helps with ONS 15454 patch panel connections.

Figure 6-19: BNC Insertion and Removal Tool



This tool can be obtained with P/N 227-T1000 from:

Amphenol USA (www.amphenol.com)
One Kennedy Drive
Danbury, CT 06810
Phone: 203-743-9272 Fax: 203-796-2032

This tool can be obtained with P/N RT-1L from:
Trompeter Electronics Inc. (www.trompeter.com)
31186 La Baya Drive
Westlake Village, CA 91362-4047
Phone: (800) 982-2629 Fax: (818) 706-1040

SMB EIA

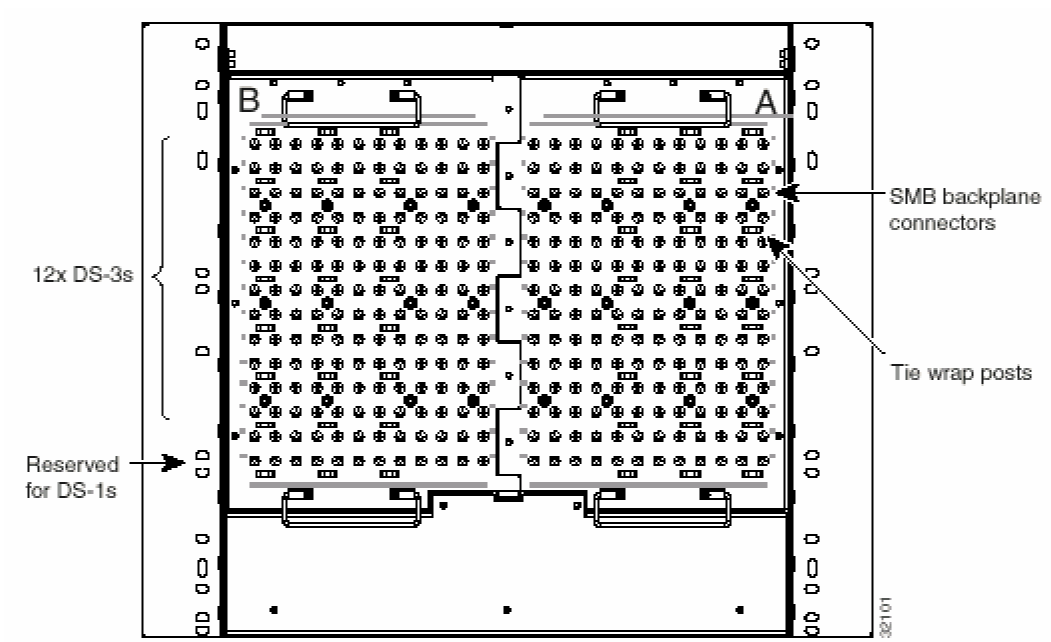
The ONS 15454 SMB EIA supports AMP 415484-1 75 ohm 4 leg connectors. Right-angle mating connectors for the connecting cable are AMP 415484-2 (75 ohm) connectors. Use RG-179/U cable to connect to the ONS 15454 EIA. Cisco recommends these cables for connection to a patch panel; they are not designed for long runs. Range does not affect loopback testing.

You can use SMB EIAs with DS-1, DS-3 (including the DS3XM-6), and EC-1 cards. If you use DS-1 cards, use the DS-1 electrical interface adapter (balun) to terminate the twisted pair DS-1 cable to the SMB EIA.

SMB EIAs support 14 ports per slot when used with a DS-1 card, 12 ports per slot when used with a DS-3 or EC-1 card, and 6 ports per slot when used with a DS3XM-6 card.

Figure 6-20 shows the ONS 15454 with pre-installed SMB EIAs and the sheet metal cover and screw locations for the EIA. The SMB connectors on the EIA are AMP 415504-3 (75 ohm) 4 leg connectors.

Figure 6-20: SMB EIA



The SMB EIA has 84 transmit and 84 receive connectors on each side of the ONS 15454 for a total of 168 SMB connectors (84 circuits).

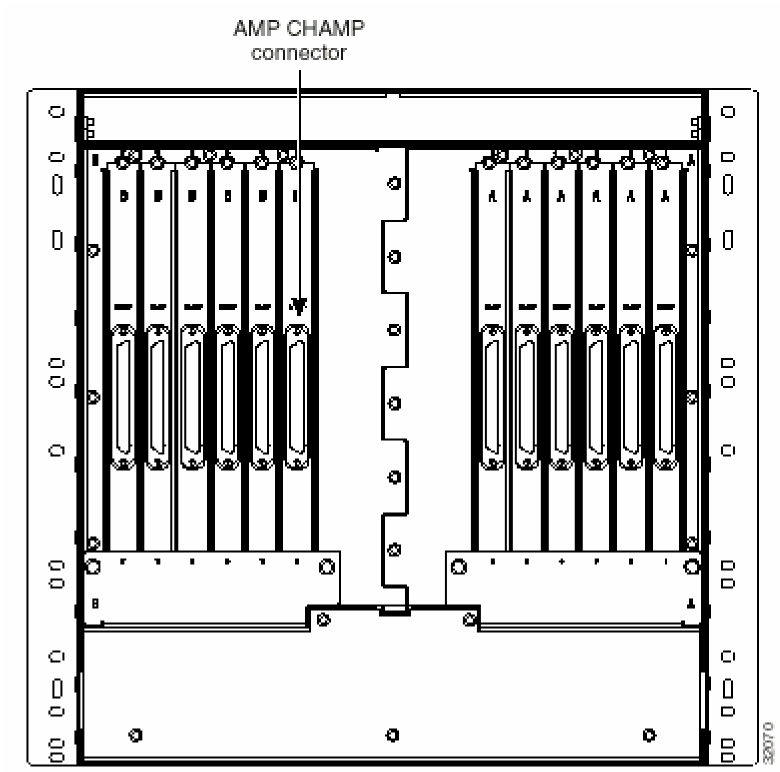
The EIA side marked “A” hosts 84 SMB connectors in six columns of 14 connectors. The “A” side columns are numbered 1 to 6 and correspond to Slots 1 to 6 on the shelf assembly. The EIA side marked “B” hosts an additional 84 SMB connectors in six columns of 14 connectors. The “B” side columns are numbered 12 to 17 and correspond to Slots 12 to 17 on the shelf assembly. The connector rows are numbered 1 to 14 and correspond to the 14 ports on a DS-1 card.

For DS-3 or EC-1, the EIA supports 72 transmit and 72 receive connectors, for a total of 144 SMB connectors (72 circuits). If you use a DS-3 or EC-1 card, only Ports 1 to 12 are active. If you use a DS3XM-6 card, only Ports 1 to 6 are active. The SMB connector pairs are marked “Tx” and “Rx” to identify transmit and receive cables for each port. If you use SMB connectors, you can install DS-1, DS-3, or EC-1 cards in any multispeed slot (Slots 1 to 4 or 14 to 17).

AMP Champ EIA

The ONS 15454 AMP Champ EIA supports 64-pin (32 pair) AMP Champ connectors for each slot on both sides of the shelf assembly where the EIA is installed. Cisco AMP Champ connectors are female AMP # 552246-1 with AMP # 552562-2 bail locks. Each AMP Champ connector supports 14 DS-1 ports. You can use AMP Champ EIAs with DS-1 cards only. Figure 6-21 shows the ONS 15454 with pre-installed AMP Champ EIAs and the corresponding sheet metal cover and screw locations for the EIA.

Figure 6-21: AMP EIA Champ Backplane



The EIA side marked “A” hosts six AMP Champ connectors. The connectors are numbered 1 to 6 for the corresponding slots on the shelf assembly. Each AMP Champ connector on the backplane supports 14 DS-1 ports for a DS1-14 card, and each connector features 28 live pairs—one transmit pair and one receive pair—for each DS-1 port.

The EIA side marked "B" hosts six AMP Champ connectors. The connectors are labeled 12 to 17 for the corresponding slots on the shelf assembly. Each AMP Champ connector on the backplane supports 14 DS-1 ports for a DS1-14 card, and each connector features 28 live pairs—one transmit pair and one receive pair—for each DS-1 port.

To install AMP Champ connector DS-1 cables, you must use 64-pin bundled cable connectors with a 64-pin male AMP Champ connector. You need an AMP Champ connector #552276-1 for the receptacle side and #1-552496-1 (for cable diameter .475in.–.540in.) or #2-552496-1 (for cable diameter .540in.–.605in.) for the right-angle shell housing (or their functional equivalent). The corresponding 64-pin female AMP Champ connector on the AMP Champ EIA supports one receive and one transmit for each DS-1 port for the corresponding card slot.

Because each DS1-14 card supports 14 DS-1 ports, only 56 pins (28 pairs) of the 64-pin connector are used. Prepare one 56-wire cable for each DS-1 facility installed.

Table 6-6 shows the pin assignments for the AMP Champ connectors on the ONS 15454

Table 6-6: AMP Champ Connector Pin Assignments

Signal/Wire	Pin	Pin	Signal/Wire	Signal/Wire	Pin	Pin	Signal/Wire
Tx Tip 1 white/blue	1	33	Tx Ring 1 blue/white	Rx Tip 1 yellow/orange	17	49	Rx Ring 1 orange/yellow
Tx Tip 2 white/orange	2	34	Tx Ring 2 orange/white	Rx Tip 2 yellow/green	18	50	Rx Ring 2 green/yellow
Tx Tip 3 white/green	3	35	Tx Ring 3 green/white	Rx Tip 3 yellow/brown	19	51	Rx Ring 3 brown/yellow
Tx Tip 4 white/brown	4	36	Tx Ring 4 brown/white	Rx Tip 4 yellow/slate	20	52	Rx Ring 4 slate/yellow
Tx Tip 5 white/slate	5	37	Tx Ring 5 slate/white	Rx Tip 5 violet/blue	21	53	Rx Ring 5 blue/violet
Tx Tip 6 red/blue	6	38	Tx Ring 6 blue/red	Rx Tip 6 violet/orange	22	54	Rx Ring 6 orange/violet
Tx Tip 7 red/orange	7	39	Tx Ring 7 orange/red	Rx Tip 7 violet/green	23	55	Rx Ring 7 green/violet
Tx Tip 8 red/green	8	40	Tx Ring 8 green/red	Rx Tip 8 violet/brown	24	56	Rx Ring 8 brown/violet
Tx Tip 9 red/brown	9	41	Tx Ring 9 brown/red	Rx Tip 9 violet/slate	25	57	Rx Ring 9 slate/violet
Tx Tip 10 red/slate	10	42	Tx Ring 10 slate/red	Rx Tip 10 white/blue	26	58	Rx Ring 10 blue/white
Tx Tip 11 black/blue	11	43	Tx Ring 11 blue/black	Rx Tip 11 white/orange	27	59	Rx Ring 11 orange/white
Tx Tip 12 black/orange	12	44	Tx Ring 12 orange/black	Rx Tip 12 white/green	28	60	Rx Ring 12 green/white
Tx Tip 13 black/green	13	45	Tx Ring 13 green/black	Rx Tip 13 white/brown	29	61	Rx Ring 13 brown/white
Tx Tip 14 black/brown	14	46	Tx Ring 14 brown/black	Rx Tip 14 white/slate	30	62	Rx Ring 14 slate/white
Tx Spare0+ N/A	15	47	Tx Spare0+ N/A	Rx Spare0+ N/A	31	63	Rx Spare0+ N/A
Tx Spare1+ N/A	16	48	Tx Spare1+ N/A	Rx Spare1+ N/A	32	64	Rx Spare1+ N/A

Table 6-7 shows the pin assignments for the AMP Champ connectors on the ONS 15454 AMP Champ EIA for a shielded DS1 cable.

Table 6-7: AMP Champ Connector Pin Assignments (Shielded DS1 Cable)

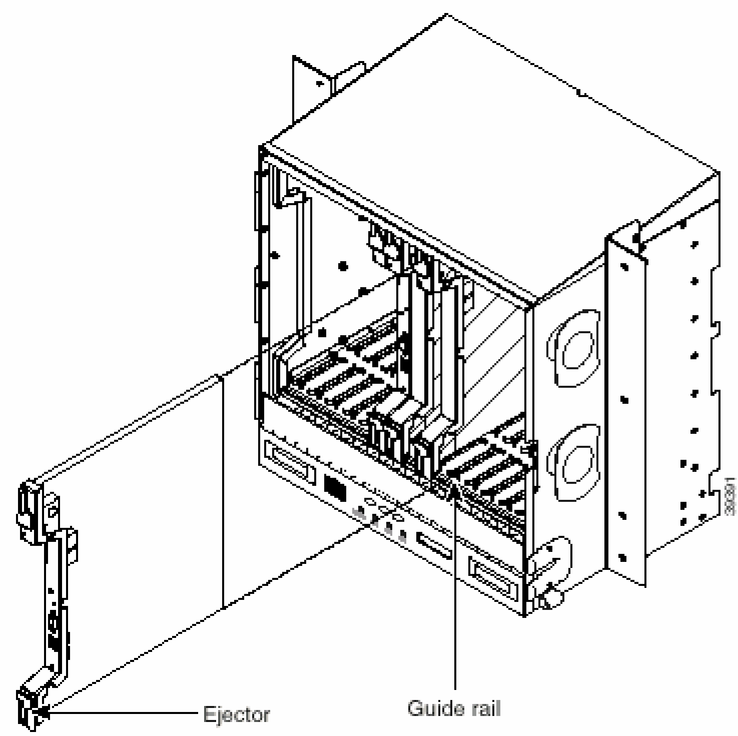
64-Pin Blue Bundle				64-Pin Orange Bundle			
Signal/Wire	**Pin**	**Pin**	**Signal/Wire**	**Signal/Wire**	**Pin**	**Pin**	**Signal/Wire**
Tx Tip 1 white/blue	1	33	Tx Ring 1 blue/white	Tx Tip 1 white/blue	17	49	Tx Ring 1 blue/white
Tx Tip 2 white/orange	2	34	Tx Ring 2 orange/white	Tx Tip 2 white/orange	18	50	Tx Ring 2 orange/white
Tx Tip 3 white/green	3	35	Tx Ring 3 green/white	Tx Tip 3 white/green	19	51	Tx Ring 3 green/white
Tx Tip 4 white/brown	4	36	Tx Ring 4 brown/white	Tx Tip 4 white/brown	20	52	Tx Ring 4 brown/white
Tx Tip 5 white/slate	5	37	Tx Ring 5 slate/white	Tx Tip 5 white/slate	21	53	Tx Ring 5 slate/white
Tx Tip 6 red/blue	6	38	Tx Ring 6 blue/red	Tx Tip 6 red/blue	22	54	Tx Ring 6 blue/red
Tx Tip 7 red/orange	7	39	Tx Ring 7 orange/red	Tx Tip 7 red/orange	23	55	Tx Ring 7 orange/red
Tx Tip 8 red/green	8	40	Tx Ring 8 green/red	Tx Tip 8 red/green	24	56	Tx Ring 8 green/red
Tx Tip 9 red/brown	9	41	Tx Ring 9 brown/red	Tx Tip 9 red/brown	25	57	Tx Ring 9 brown/red
Tx Tip 10 red/slate	10	42	Tx Ring 10 slate/red	Tx Tip 10 red/slate	26	58	Tx Ring 10 slate/red
Tx Tip 11 black/blue	11	43	Tx Ring 11 blue/black	Tx Tip 11 black/blue	27	59	Tx Ring 11 blue/black
Tx Tip 12 black/orange	12	44	Tx Ring 12 orange/black	Tx Tip 12 black/orange	28	60	Tx Ring 12 orange/black
Tx Tip 13 black/green	13	45	Tx Ring 13 green/black	Tx Tip 13 black/green	29	61	Tx Ring 13 green/black
Tx Tip 14 black/brown	14	46	Tx Ring 14 brown/black	Tx Tip 14 black/brown	30	62	Tx Ring 14 brown/black
Tx Tip 15 black/slate	15	47	Tx Tip 15 slate/black	Tx Tip 15 black/slate	31	63	Tx Tip 15 slate/black
Tx Tip 16 yellow/blue	16	48	Tx Tip 16 blue/yellow	Tx Tip 16 yellow/blue	32	64	Tx Tip 16 blue/yellow

When using DS-1 AMP Champ cables, you must equip the ONS 15454 with an AMP Champ connector EIA on each side of the backplane where DS-1 cables will terminate. Each AMP Champ connector on the EIA corresponds to a slot in the shelf assembly and is numbered accordingly. The AMP Champ connectors have screw-down tooling at each end of the connector.

Plug-in Cards

ONS 15454 plug-in cards have electrical plugs at the back that plug into electrical connectors on the shelf assembly backplane. When the ejectors are fully closed, the card plugs into the assembly backplane. Figure 6-22 shows card installation.

Figure 6-22: Installation of Plug-in Cards



Card Replacement

To replace an ONS 15454 card with another card of the same type, you do not need to make any changes to the database; remove the old card and replace it with a new card. To replace a card with a card of a different type, physically remove the card and replace it with the new card, then delete the original card from CTC. For specifics, refer to the *Cisco ONS 15454 Procedure Guide*.

Card Descriptions

This section describes the function and slot assignment for each ONS 15454 plug-in card. Each card is marked with a symbol that corresponds to a slot (or slots) on the ONS 15454 shelf assembly. The cards can only be installed into slots displaying the same symbols.

Refer to Table 6-8 for Common Card Functions and Slot Information.
Refer to Table 6-9 for Electrical Card Functions and Slot Information.
Refer to Table 6-10 for Optical Card Functions and Slot Information.
Refer to Table 6-11 for Ethernet Card Functions and Slot Information.

Table 6-8: Common Card Functions and Slot Assignments

Card	Description	Slot Assignment
TCC+	The TCC+ is the main processing center for the ONS 15454 and provides synchronization, 10 DCC terminations, system initialization, provisioning, alarm reporting, maintenance, and diagnostics.	7 and 11
TCC2	The TCC2 card requires Software Release 4.0 or later. The TCC2 performs the same functions as the TCC+, but has additional features such as A/B power supply monitoring, support for up to 84 DCC terminations, and on-card lamp test.	7 and 11
XC	The XC card contains the switch matrix for the ONS 15454. It establishes cross-connects and performs time division switching (TDS) at the STS level.	8 and 10
XC-VT	The XC-VT card performs the same functions as the XC, but can manage both STS and VT circuits up to 48c.	8 and 10
XC-10G	The XC-10G card performs the same functions as the XC-VT, but can manage STS and VT circuits up to 192c. The XC-10G has the same VT bandwidth of the XC and VT cards, but supports up to four times the STS bandwidth of these cards.	8 and 10
AIC	The AIC card provides user-defined (environmental) alarms with its 4 input and 4 output alarm contact closures. It also provides orderwire.	9
AIC-I	The AIC-I card provides user-defined (environmental) alarms with its 12 input and 4 output alarm contact closures. It also provides orderwire, user-data channels, and A/B power supply monitoring.	9
AEP	The AEP board is used with the AIC-I card to provide 48 dry alarm contacts: 32 inputs and 16 outputs.	Bottom of backplane

Note Do not operate the ONS 15454 with only one TCC+/TCC2 card and one XC/XC-VT/XC-10G card. Two TCC and cross-connect cards must always be installed for redundant operation.

Table 6-9: Electrical Card Functions and Slot Assignments

Card	Description	Slot Assignment
DS1-14	The ONS 15454 DS1-14 card provides 14 Telcordia-compliant, GR-499 DS-1 ports. Each port operates at 1.544 Mbps over a 100 ohm twisted-pair copper cable. Each DS1-14 port has DSX-level (digital signal cross-connect frame) outputs supporting distances up to 655 feet. With the proper backplane EIA and wire-wrap or AMP Champ connectors. The DS1-14 card can function as a working or protect card in 1:1 protection schemes and as a working card in 1:N protection schemes.	1-6 and 12-17
DS1N-14	The DS1N-14 card supports the same features as the DS1-14 card in addition to enhanced protection schemes. The DS1N-14 is capable of 1:N (N<5) protection with the proper backplane EIA and wire-wrap or AMP Champ connectors. The DS1N-14 card can function as a working or protect card in 1:1 or 1:N protection schemes.	1:1 protection: 1-6 and 12-17 1:N protection: 3, 15
DS3-12	The DS3-12 card provides 12 Telcordia-compliant, GR-499 DS-3 ports per card. Each port operates at 44.736 Mbps over a single 75 ohm 728A or equivalent coaxial span. Each port features DSX-level outputs supporting distances up to 450 feet (137 meters) depending on facility conditions. With the proper backplane EIA, the card supports BNC or SMB connectors. The DS3-12 card operates as a working or protect card in 1:1 protection schemes and as a working card in 1:N protection schemes.	1-6 and 12-17
DS3N-12	The DS3N-12 card supports the same features as the DS3-12 card in addition to enhanced protection schemes. The DS3N-12 is capable of 1:N (N<5) protection with the proper backplane EIA and SMB or BNC connectors. The DS3N-12 card can function as a working or protect card in 1:1 or 1:N protection schemes.	1:1 protection: 1-6 and 12-17 1:N protection: 3, 15
DS3-12E	The ONS 15454 DS3-12E card provides 12 Telcordia-compliant ports per card. Each port operates at 44.736 Mbps over a single 75 ohm 728A or equivalent coaxial span. Each port features DSX-level outputs supporting distances up to 450 feet (137 meters). With the proper backplane EIA, the card supports SMB or BNC connectors. The DS3-12E card provides enhanced performance monitoring functions.	1-6 and 12-17
DS3N-12E	The DS3N-12E card supports the same features as the DS3-12E card in addition to enhanced protection schemes. The DS3N-12 is capable of 1:N (N<5) protection with the proper backplane EIA and SMB or BNC connectors. The DS3N-12E card can function as a working or protect card in 1:1 or 1:N protection schemes.	1:1 protection: 1-6 and 12-17 1:N protection: 3, 15
DS3XM-6	The DS3XM-6 card, commonly referred to as a transmux card, provides six Telcordia-compliant, GR-499-CORE M13 multiplexing functions. The DS3XM-6 converts six framed DS-3 network connections to 28x6 or 168 VT1.5s. Each DS3XM-6 port features DSX-level outputs supporting distances up to 450 feet (137 meters) depending on facility conditions. You cannot create circuits from a DS3XM-6 card to a DS-3 card. DS3XM-6 cards operate at the VT1.5 level. The DS3XM-6 card supports 1:1 protection with the proper backplane EIA. EIAs are available with BNC or SMB connectors.	1-6 and 12-17
EC1-12	The EC1-12 card provides 12 Telcordia-compliant, GR-253 STS-1 electrical ports per card. Each port operates at 51.840 Mbps over a single 75 ohm 728A or equivalent coaxial span. Each EC1-12 interface features DSX-level (digital signal cross-connect frame) outputs supporting distances up to 450 feet (137 meters) depending on facility conditions. An EC1-12 card can be 1:1 protected with another EC1-12 card but cannot protect more than one EC1-12 card. You must install the EC1-12 in an even-numbered slot to serve as a working card and in an odd-numbered slot to serve as a protect card.	1-6 and 12-17

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Table 6-10: Optical Card Functions and Slot Assignments

Card	Description	Slot Assignment
OC3-IR-4/STM1-SH-1310 nm	The OC3 IR 4/STM1 SH 1310 card provides four intermediate or short range SONET/SDH OC-3 ports compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. Each port operates at 155.52 Mb/s over a single-mode fiber span. The card supports VT and nonconcatenated or concatenated payloads at the STS-1 or STS-3c signal levels. The OC3 IR 4/STM1 SH 1310 card supports 1+1 unidirectional or bi-directional protection switching. You can provision protection on a per port basis. The card uses SC connectors.	1-6 and 12-17
OC3-IR-8/STM1-SH-1310 nm	The OC3IR/STM1SH 1310-8 card provides eight intermediate or short range SONET/SDH OC-3 ports compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. Each port operates at 155.52 Mb/s over a single-mode fiber span. The card supports the same payloads and protection schemes as the four port OC3 card. (labeled) on the card faceplate. The card uses LC connectors on the faceplate, angled downward 12.5 degrees.	1-4 and 14-17
OC12-IR/STM4-SH-1310 nm	The OC12 IR/STM4 SH 1310 card provides one intermediate or short range SONET/SDH OC-12 port compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The port operates at 622.08 Mb/s over a single-mode fiber span. The card supports VT and nonconcatenated or concatenated payloads at STS-1, STS-3c, STS-6c or STS-12c signal levels. The OC12 IR/STM4 SH 1310 card supports 1+1 unidirectional or bi-directional protection switching. You can provision protection on a per port basis. The card uses SC connectors.	1-6 and 12-17
OC12-LR/STM4-LH-1310 nm	The OC12 LR/STM4 LH 1310 card provides one long-range SONET OC-12 port per card compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The port operates at 622.08 Mb/s over a single-mode fiber span. The card supports the same payloads and protection schemes as the OC12 IR/STM4 SH 1310 card. The OC12 LR/STM4 LH 1310 uses SC connectors.	1-6 and 12-17
OC12-LR/STM4-LH-1550 nm	The OC12 LR/STM4 LH 1550 card provides one long-range SONET/SDH OC-12 port compliant with the ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The port operates at 622.08 Mb/s over a single-mode fiber span. The card supports the same payloads and protection schemes as the OC12 IR/STM4 SH 1310 card. The OC12 LR/STM4 LH 1550 card uses SC connectors.	1-6 and 12-17
OC12-IR-4/STM4-SH-1310 nm	The OC12 IR/STM4 SH 1310-4 card provides four intermediate or short range SONET/SDH OC-12/STM-4 ports compliant with the ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. Each port operates at 622.08 Mb/s over a single-mode fiber span. The card supports VT and nonconcatenated or concatenated payloads at the STS-1, STS-3c, STS-6c, or STS-12c signal levels. The OC12 IR/STM4 SH 1310-4 card supports 1+1 unidirectional or bi-directional protection switching. You can provision protection on a per port basis. The OC12 IR/STM4 SH 1310-4 card uses SC connectors.	1-4 and 14-17[1]
OC48-IR-1310 nm	The OC48 IR 1310 card provides one intermediate-range, SONET OC-48 port per card, compliant with Telcordia GR-253-CORE. Each port operates at 2.49 Gb/s over a single-mode fiber span. The card supports VT and nonconcatenated, or concatenated payloads at STS-1, STS-3c, STS-6c, STS-12c, or STS-48c signal levels. The OC48 IR 1310 card supports 1+1 unidirectional or bi-directional protection switching. The OC48 IR 1310 card uses SC connectors.	5, 6, 12, and 13

Card	Description	Slot Assignment
OC48-LR-1550 nm	The OC48 LR 1550 card provides one long-range, SONET OC-48 port per card, compliant with Telcordia GR-253-CORE. Each port operates at 2.49 Gb/s over a single-mode fiber span. The card supports VT, nonconcatenated or concatenated payloads at STS-1, STS-3c, STS-6c STS-12c or STS-48c signal levels. The OC48 LR 1550 card supports 1+1 unidirectional or bi-directional protection switching. The OC48 LR 1550 card uses SC connectors.	5, 6, 12, and 13
OC48-IR/STM16-SH-AS-1310 nm	The OC48 IR/STM16 SH AS 1310 card provides one intermediate-range SONET/SDH OC-48 port compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The port operates at 2.49 Gb/s over a single-mode fiber span. The card supports VT and nonconcatenated or concatenated payloads at STS-1, STS-3c, STS-6c, STS-12c, or STS-48c signal levels. The card supports 1+1 unidirectional or bi-directional protection switching and uses SC connectors.	1-6 and 12-17
OC48-LR/STM16-LH-AS-1550 nm	The OC48 LR/STM16 LH AS 1550 card provides one long-range SONET/SDH OC-48 port compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The OC48 LR/STM16 LH AS 1550 and OC48 IR/STM16 SH AS 1310 cards are functionally the same.	1-6 and 12-17
OC48-ELR/STM16-EH-ITU-100GHz	Thirty-seven distinct OC48 ELR/STM16 EH 100 GHz cards provide the ONS 15454 DWDM channel plan. Nineteen of the cards operate in the blue band with spacing of 100 GHz on the ITU grid (1528.77 nm, 1530.33 nm, 1531.12 nm, 1531.90 nm, 1532.68 nm, 1533.47 nm, 1534.25 nm, 1535.04 nm, 1535.82 nm, 1536.61 nm, 1538.19 nm, 1538.98 nm, 1539.77 nm, 1540.56 nm, 1541.35 nm, 1542.14 nm, 1542.94 nm, 1543.73 nm, 1544.53 nm). ITU spacing conforms to ITU-T G.692 and Telcordia GR-2918-CORE, issue 2. The other eighteen cards operate in the red band with spacing of 100 GHz on the ITU grid (1546.12 nm, 1546.92 nm, 1547.72 nm, 1548.51 nm,1549.32 nm, 1550.12 nm, 1550.92 nm, 1551.72 nm, 1552.52 nm, 1554.13 nm, 1554.94 nm, 1555.75 nm, 1556.55 nm, 1557.36 nm, 1558.17 nm, 1558.98 nm, 1559.79 nm, 1560.61 nm). These cards are also designed to interoperate with the Cisco ONS 15216 DWDM solution. Each OC48 ELR/STM16 EH 100 GHz card has one SONET OC-48/SDH STM-16 port that complies with Telcordia GR-253-CORE, ITU-T G.692, and ITU-T G.958. The port operates at 2.49 Gb/s over a single-mode fiber span. The card carries VT, concatenated, and nonconcatenated payloads at STS-1, STS-3c, STS-6c, STS-12c, or STS-48c signal levels. Each card supports 1+1 unidirectional or bi-directional protection switching and uses SC connectors.	5, 6, 12, and 13

Card	Description	Slot Assignment
OC48-ELR/STM16-EH-ITU-200GHz	Eighteen distinct OC48 ELR 200 GHz cards provide the ONS 15454 DWDM channel plan. Nine of the cards operate in the blue band with spacing of 200 GHz on the ITU grid (1530.33 nm, 1531.90 nm, 1533.47 nm, 1535.04 nm, 1536.61 nm, 1538.19 nm, 1539.77 nm, 1541.35 nm, 1542.94 nm). The other nine cards operate in the red band with spacing of 200 GHz on the ITU grid (1547.72 nm, 1549.32 nm, 1550.92 nm, 1552.52 nm, 1554.13 nm, 1555.75 nm, 1557.36 nm, 1558.98 nm, 1560.61 nm). These cards are also designed to interoperate with the Cisco ONS 15216 DWDM solution. The OC48 ELR 200 GHz and OC48 ELR/STM16 EH 100 GHz cards are functionally the same.	5, 6, 12, and 13
OC192-SR/STM64-IO-1310 nm	The OC192 SR/STM64 IO 1310 card provides one intra-office (IO) reach SONET/SDH OC-192 port in the 1310-nm wavelength range, compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The port operates at 9.95328 Gb/s and supports VT and nonconcatenated or concatenated payloads. The OC192 SR/STM64 IO 1310 card supports 1+1 unidirectional or bi-directional protection switching and uses SC connectors.	5, 6, 12, and 13
OC192-IR/STM64-SH-1310 nm	The OC192 IR/STM64 SH 1550 card provides one intermediate reach SONET/SDH OC-192 port in the 1550-nm wavelength range, compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The port operates at 9.95328 Gb/s and supports VT and nonconcatenated or concatenated payloads. The OC192 IR/STM64 SH 1550 card supports 1+1 unidirectional or bi-directional protection switching and uses SC connectors.	5, 6, 12, and 13
OC192-LR/STM64-LH-1550 nm	The OC192 LR/STM64 LH 1550 card provides one long-range SONET/SDH OC-192 port compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The OC192 LR/STM64 LH 1550 and OC192 IR/STM64 SH 1550 cards are functionally the same.	5, 6, 12, and 13
OC192-LR/STM64-LH-ITU-100GHz	Sixteen distinct OC-192/STM-64 ITU 100 GHz DWDM cards comprise the ONS 15454 DWDM channel plan.[2] Eight of the cards operate in the blue band with a spacing of 100 GHz in the ITU grid (1534.25 nm, 1535.04 nm, 1535.82 nm, 1536.61 nm, 1538.19 nm, 1538.98 nm, 1539.77 nm, and 1540.56 nm). The other eight cards operate in the red band with a spacing of 100 GHz in the ITU grid (1550.12 nm, 1550.92 nm, 1551.72 nm, 1552.52 nm, 1554.13 nm, 1554.94 nm, 1555.75 nm, and 1556.55 nm). The OC192 LR/STM64 LH ITU card provides one long-reach STM-64/OC-192 port per card, compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE . The port operates at 9.95328 Gb/s and supports VT and nonconcatenated or concatenated payloads. Each card supports 1+1 unidirectional or bi-directional protection switching and uses SC connectors.	5, 6, 12, and 13

Card	Description	Slot Assignment
MXP_2.5G_10G[3]	The MXP_2.5G_10G (Muxponder) card multiplexes and demultiplexes four 2.5-Gb/s signals (client side) into one 10-Gb/s, 100-GHz DWDM signal (trunk side). It provides one extended long-range STM-64/OC-192 port per card on the trunk side (compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE) and four intermediate or short-range OC48/STM-16 ports per card on the client side. The port operates at 9.95328 Gb/s. The MXP_2.5G_10G card is tunable over two neighboring wavelengths in the 1550-nm, ITU 100-GHz range. It is available in four different versions, covering eight different wavelengths in the 1550-nm range. The port can also operate at 10.70923 Gb/s in ITU-T G.709 Digital Wrapper/FEC mode. Protection is done using the Y-cable. The MXP_2.5G_10G card uses SC connectors.	1-6 and 12-17
TXP_MR_10G[3]	The TXP_MR_10G card (Transponder multirate 10G) processes one 10-Gb/s signal (client side) into one 10-Gb/s, 100-GHz DWDM signal (trunk side). It provides one extended long-range STM-64/OC-192 port per card, compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The TXP_MR_10G card is tunable over two neighboring wavelengths in the 1550-nm, ITU 100-GHz range. It is available in four different versions, covering eight different wavelengths in the 1550-nm range. The port operates at 9.95328 Gb/s (or 10.70923 Gb/s with ITU-T G.709 Digital Wrapper/FEC). Protection is done using the Y-cable. The TXP_MR_10G card uses SC connectors.	1-6 and 12-17

[1] If you ever expect to upgrade an OC-12/STM-4 ring to a higher bit rate, you should not put an OC12 IR/STM4 SH 1310-4 in that ring. The four-port card is not upgradable to a single-port card. The reason is that four different spans, possibly going to four different nodes, cannot be merged to a single span.

[2] Of the sixteen OC-192/STM-64 ITU 100 GHz DWDM cards, the following eight cards are available with System Release 4.0: 1534.25 nm, 1535.04 nm, 1535.82 nm, 1536.61 nm, 1550.12 nm, 1550.92 nm, 1551.72 nm, and 1552.52 nm.

[3] This card is planned to be available in Release 4.5.

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Table 6-11: Ethernet Card Functions and Slot Assignments

Card	Description	Slot Assignment
E100T-12	Use the E100T-12 with the XC or XC-VT cards. The E100T-12 card provides 12 switched, IEEE 802.3-compliant, 10/100BaseT Ethernet ports that can independently detect the speed of an attached device (autosense) and automatically connect at the appropriate speed. The ports autoconfigure to operate at either half or full duplex and determine whether to enable or disable flow control. You can also configure Ethernet ports manually. Each E100T-12 card supports standards-based, wire-speed, Layer 2 Ethernet switching between its Ethernet interfaces. The IEEE 802.1Q tag logically isolates traffic (typically subscribers). IEEE 802.1Q also supports multiple classes of service. The E100T-12 ports use RJ-45 interfaces.	1-4 and 14-17
E1000-2	Use the E1000-2 with the XC or XC-VT cards. Do not use the E1000-2 when the XC-10G card is in use. The E1000-2 card provides two IEEE 802.3 compliant 1000 Mb/s ports for high-capacity customer LAN interconnections. Each port supports full-duplex operation. Each E1000-2 card supports standards-based, Layer 2 Ethernet switching between its Ethernet interfaces and SONET interfaces on the ONS 15454. The IEEE 802.1Q VLAN tag logically isolates traffic (typically subscribers). The E1000-2 card uses GBIC modular receptacles for the optical interfaces.	1-4 and 14-17
E100T-G	The E100T-G is the functional equivalent of the E100T-12, but will interoperate with the XC-10G cross-connect. The E100T-G ports use RJ-45 interfaces.	1-4 and 14-17
E1000-2-G	The E1000-2-G is the functional equivalent of the E1000-2, but will interoperate with the XC-10G cross-connect.	1-4 and 14-17
G1000-4	Use the G1000-4 card with the XC-10G card. The G1000-4 card provides four ports of IEEE 802.3 compliant 1000-Mb/s interfaces. Each port supports full-duplex operation for a maximum bandwidth of OC-48 on each card. The circuit sizes supported are STS-1, STS-3c, STS-6c, STS-9c, STS-24c, STS-48c. The G1000-4 card uses GBIC modular receptacles for the optical interfaces.	1-4 and 14-17
G1K-4	The G1K-4 card provides four ports of IEEE 802.3 compliant 1000-Mb/s interfaces. Each interface supports full-duplex operation for a maximum bandwidth of 1 Gb/s or 2 Gb/s bi-directional per port, and 2.5 Gb/s or 5 Gb/s bi-directional per card. Each port autonegotiates for full duplex and 802.3x flow control. The circuit sizes supported are STS-1, STS-3c, STS-6c, STS-9c, STS-24c, STS-48c. The G1K-4 card uses GBIC modular receptacles for the optical interfaces.	1-4 and 14-17
ML100T-12	The ML100T-12 card provides 12 ports of IEEE 802.3 compliant 10/100 interfaces. Each card supports standards-based, wire-speed, Layer 2 Ethernet switching between its Ethernet ports. The IEEE 802.1Q tag and port-based VLANs logically isolate traffic (typically subscribers). Priority queuing is also supported to provide multiple classes of service. Each interface supports full-duplex operation for a maximum bandwidth of 200 Mb/s per port and 2.488 Gb/s per card. Each port independently detects the speed of an attached device (autosenses) and automatically connects at the appropriate speed. The ports autoconfigure to operate at either half or full duplex and can determine whether to enable or disable flow control. The circuit sizes supported are STS-1, STS-3c, STS-6c, STS-9c, STS-24c, STS-48c. The ML100T-12 card uses RJ-45 interfaces.	1-6 and 12-17 with the XC-10G or 5, 6, 12, and 13 with the XC or XC-VT
ML1000-2	The ML1000-2 card provides two ports of IEEE 802.3 compliant 1000-Mb/s interfaces. Each interface supports full-duplex operation for a maximum bandwidth of 2 Gbps per port and 4 Gbps per card. Each port autoconfigures for full duplex and IEEE 802.3x flow control. Each ML1000-2 card supports standards-based, Layer 2 Ethernet switching between its Ethernet ports and any other Ethernet or SONET trunk interfaces on the ONS 15454. The IEEE 802.1Q tag and port-based VLANS logically isolate traffic (typically subscribers). Priority queuing is also supported to provide multiple classes of service. Two queues are provided on card. Queue level is provisionable from 0 to 7. 0 to 3 map, and 4 to 7 map. The circuit sizes supported are STS-1, STS-3c, STS-6c, STS-9c, STS-24c, STS-48c. The ML1000-2 card interfaces to Small Form Factor Pluggable (SFP) slots supporting SX and LS GBICs.	1-6 and 12-17 with the XC-10G or 5, 6, 12, and 13 with the XC or XC-VT

LED Indicators

TCC+ and TCC2 Cards

The TCC+ and TCC2 (TCC) cards have the following LED indicators on the faceplates:

Card-Level Indicators:

Red FAIL LED - This LED is lit during reset. The FAIL LED flashes during the boot and write process. Replace the card if the FAIL LED persists.

ACT/STBY LED - The ACT/STBY (Active/Standby) LED indicates the TCC is in active mode when the LED is green, and in standby mode when it is yellow. The ACT/STBY LED also provides the timing reference and shelf control. When the active TCC is writing to its database to the standby TCC database, the card LEDs blink. To avoid memory corruption, do not remove the TCC when the active or standby LED is blinking.

Network-Level Indicators:

Red CRIT LED - Indicates critical alarms in the network at the local terminal.

Red MAJ LED - Indicates major alarms in the network at the local terminal.

Yellow MIN LED - Indicates a minor alarm in the network at the local terminal.

Red REM LED - Provides first-level alarm isolation. The remote (REM) LED turns red when an alarm is present in one or several of the remote terminals.

Green SYNC LED - Indicates that node timing is synchronized to an external reference.

Green ACO LED - After pressing the alarm cutoff (ACO) button, the green ACO LED illuminates. The ACO button opens the audible alarm closure on the backplane. ACO state is stopped if a new alarm occurs. After the originating alarm is extinguished, the ACO LED and audible alarm control are reset.

XC, XC-VT, and XC-10G Cards

The XC, XC-VT, and XC-10G (cross-connect) cards have the following card-level LED indicators on the faceplates:

Red FAIL LED - The red FAIL LED indicates that the card's processor is not ready. If the FAIL LED persists, replace the card.

ACT/STBY LED - The ACT/STBY (Active/Standby) LED turns green when the XC card is active and carrying traffic and amber when it is in the standby mode as a protect card.

Electrical and Optical Cards

The electrical and optical cards have the following card-level LED indicators:

Red FAIL LED - The red FAIL LED indicates that the card's processor is not ready. If the FAIL LED persists, replace the card.

ACT/STBY LED - The ACT/STBY (Active/Standby) LED turns green when the card is active and carrying traffic and amber when it is in the standby mode as a protect card.

Amber SF LED - The amber SF LED indicates a signal failure or condition such as port LOS, LOF, AIS, or high BERs. The amber SF LED also illuminates when the transmit and receive fibers are incorrectly connected. When the fibers are properly connected, the light turns off.

You can find the status of the ports using the LCD screen on the ONS 15454 fan-tray assembly. Use the LCD to quickly view the status of any port or card slot; the screen displays the number and severity of alarms for a given port or slot.

Ethernet Cards

The Ethernet cards have the following card-level LED indicators:

Card-Level Indicators:

Red FAIL LED - The red FAIL LED indicates the card's processor is not ready or a catastrophic software failure occurred on the Ethernet card. As part of the boot sequence, the FAIL LED is turned on, and it turns off when the software is deemed operational.

ACT/STBY LED – ACT/STBY LED provides the operational status of the card. When the LED is green it indicates that the Ethernet card is active and the software is operational. The LED is amber when the card is in the standby mode.

Port-Level Indicators:

LED Off - No link exists to the Ethernet port.

Steady Amber LED - A link exists to the Ethernet port, but traffic flow is inhibited. For example, an unconfigured circuit, an error on line, or a non-enabled port may inhibit traffic flow.

Solid Green LED - A link exists to the Ethernet port, but no traffic is carried on the port.

Flashing Green LED - A link exists to the Ethernet port and traffic is being carried on the port. The LED flash rate reflects the traffic rate for the port.

Card Port and Connector Information

Table 6-12: Card Port and Connector Information

Plug-in Card	Number of Ports	Compliant Standard	Line Rate	Connector Type	Connector Location
DS1-14	14	GR-499-CORE	1.544 Mb/s	SMB with Balun adapter or AMP Champ	Backplane EIA
DS1N-14	14	GR-499-CORE	1.544 Mb/s	SMB with Balun or AMP Champ[1]	NA
DS3-12	12	GR-499-CORE	44.736 Mb/s	SMB or BNC[1]	Backplane EIA
DS3N-12	12	GR-499-CORE	44.736 Mb/s	SMB or BNC[1]	NA
DS3-12E	12	GR-499-CORE	44.736 Mb/s	SMB or BNC[1]	Backplane EIA
DS3N-12E	12	GR-499-CORE	44.736 Mb/s	SMB or BNC[1]	
DS3XM-6	6	GR-499-CORE M13	44.736 Mb/s	SMB or BNC[1]	Backplane EIA
EC1-12	12	GR-253-CORE	51.84 Mb/s	SMB or BNC[1]	Backplane EIA
OC3-4/STM1 (All)	4	GR-253-CORE	155.52 Mb/s	SC	Faceplate
OC3-8/STM1	8	GR-253-CORE	155.52 Mb/s	LC	Faceplate
OC12/STM4	1	GR-253-CORE	622.08 Mb/s	SC	Faceplate
OC12-4/STM4	4	GR-253-CORE	622.08 Mb/s	SC	Faceplate
OC48/STM16 (All versions)	1	GR-253-CORE	2488.32 Mb/s	SC	Faceplate
OC48/STM16-AS	1	GR-253-CORE	2488.32 Mb/s	SC	
OC48/STM16-ITU (100 GHz & 200 GHz)	1	GR-253-CORE ITU-T G.692 ITU-T G.958	2488.32 Mb/s	SC	Faceplate
OC-192/STM64[2] (All versions)	1	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	SC	Faceplate
OC-192/STM64-ITU[2] (100 GHz)	1	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	SC	Faceplate
MXP-2.5-10G[2]	4-Client 1-Trunk	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	Client: LC-SFP Trunk: SC	Faceplate
TXP-MR-10G[2]	1-Client 1-Trunk	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	Client: SC Trunk: SC	Faceplate
E100T-12	12	IEEE 802.3	100 Mb/s	RJ-45	Faceplate
E1000-2	2	IEEE 802.3	1000 Mb/s	GBIC-SC	Faceplate
E100T-G	12	IEEE 802.3	100 Mb/s	RJ-45	Faceplate
E1000-2-G	2	IEEE 802.3	1000 Mb/s	GBIC-SC	Faceplate
G1000-4	4	IEEE 802.3	1000 Mb/s	GBIC-SC	Faceplate
G1K-4	4	IEEE 802.3	1000 Mb/s	GBIC-SC	Faceplate
ML100T-12	12	IEEE 802.3	100 Mb/s	RJ-45	Faceplate
ML1000-2	2	IEEE 802.3	1000 Mb/s	LC-SFP	Faceplate

[1] When used as a protect card, the card does not have a physical external connection. The protect card connects to the working card(s) through the backplane and becomes active when the working card fails. The protect card then uses the physical connection of the failed card.

[2] **Warning: Class 1 (21 CFR 1040.10 and 1040.11) and Class 1M (IEC 60825-1 2001-01) laser products. Invisible laser radiation may be emitted from the end of the unterminated fiber cable or connector. Do not stare into the beam or view directly with optical instruments. Viewing the laser output with certain optical instruments (for example, eye loupes, magnifiers, and microscopes) within a distance of 100 mm may pose an eye hazard. Use of controls or adjustments, or performance of procedures other than those specified may result in hazardous radiation exposure.**

Card Power Requirements

Table 6-13 lists the power requirements for ONS 15454 cards.

Table 6-12: Card Power Requirements

Card	Watts	Amps	BTU/Hr.
TCC+	9.82	0.20	33.53
TCC2	26.00	0.54	88.80
XC	29.00	0.60	99.00
XC-VT	34.00	0.72	117.46
XC-10G	78.60	1.64	268.4
AIC	6.01	0.12	20.52
AIC-I	8.00	0.17	27.30
AEP	3.00	-	10.20
DS1-14	12.60	0.26	43.02
DS1N-14	12.60	0.26	43.02
DS3-12	38.20	0.79	130.43
DS3N-12	38.20	0.79	130.43
DS3-12E	26.80	0.56	91.51
DS3N-12E	26.80	0.56	91.51
DS3XM-6	20.00	0.42	68.00
EC1-12	36.60	0.76	124.97
OC3-4	19.20	0.40	65.56
OC3-8	23.00	0.48	78.50
OC12-1	10.90	0.23	37.22
OC12-4	28.00	0.58	100.00
OC48	26.80	0.56	91.50
OC48-AS	37.20	0.77	127.01
OC48-ITU-T (100 GHz & 200 GHz)	31.20	0.65	106.53
OC-192	72.20	1.50	246.52
OC-192-ITU-T (100 GHz)	52.00	1.08	177.60
MXP_2.5_10G	50.00	1.04	170.70
TXP_MR_10G	35.00	0.73	119.50
E100T-12	65.00	1.35	221.93
E1000-2	53.50	1.11	182.67
E100T-G	65.00	1.35	221.93
E1000-2-G	53.50	1.11	182.67
G1000-4	63.00	1.31	215.11
G1K-4	63.00	1.31	215.10
ML100T-12	53.00	1.10	181.00
ML1000-2	49.00	1.02	167.30

Common Card Specifications

Table 6-14 and Table 6-15 lists the specifications for the TCC and cross-connect cards.

Table 6-14: TCC Specifications

Specification	TCC+	TCC2
Memory	32 MB	256 MB
Operating Software	VxWorks	VxWorks
Number of DCCs	10	84[1]
Operations Interfaces:		
LAN	10BaseT on faceplate and backplane wire wrap pins	10BaseT on faceplate and backplane wire wrap pins
Craft Access	LAN and EIA/TIA-232 DB9 type connector on faceplate	LAN and EIA/TIA-232 DB9 type connector on faceplate
TL1	LAN and EIA/TIA-232 DB9 type connector on faceplate	LAN and EIA/TIA-232 DB9 type connector on faceplate
Number of Users	500	500
Synchronization	- Stratum 3, per Telcordia GR-253-CORE - Free running access: accuracy 4.6 ppm - Holdover stability: 3.7 $x10^{-7}$ ppm/day including temperature (< 255 slips in first 24 hours) - Reference: External BITS, line, internal	- Stratum 3, per Telcordia GR-253-CORE - Free running access: accuracy 4.6 ppm - Holdover stability: 3.7 $x10^{-7}$ ppm/day including temperature (< 255 slips in first 24 hours) - Reference: External BITS, line, internal
Environmental:		
Operating Temperature	- C-Temp (15454-TCC+): 32 to 131 degrees Fahrenheit (0 to +55 degrees Celsius) - I-Temp (15454-TCC+T): –40 to 149 degrees Fahrenheit (–40 to +65 degrees Celsius)	- C-Temp (15454-TCC+): 32 to 131 degrees Fahrenheit (0 to +55 degrees Celsius) - I-Temp (15454-TCC+T): –40 to 149 degrees Fahrenheit (–40 to +65 degrees Celsius)
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing
Power Consumption	9.82 W, 0.20 A at –48 V, 33.53 BTU/hr	26.00 W, 0.54 A at –48 V, 88.8 BTU/hr
Physical Characteristics:		
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	1.5 lb (0.7 kg)	1.5 lb (0.7 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001
Predicted MTBF (Years)[2]	27	27

[1] Software Release 4.0 supports 32 of the 84 DCCs.
[2] Markov modeling was used to calculate the predicted MTBF.

Table 6-15: Cross-connect Specifications

Specification	XC	XC-VT	XC-10G
Number of Bi-directional STS Ports	288	288	1152
Number of Bi-directional STS Cross-connects	144	144	576
Number of Bi-directional VT Ports	NA	672	672
Number of Bi-directional VT Cross-connects	NA	336	336
Connection Setup Time	5 ms	5 ms	5 ms
Latency	270 ns	270 ns	270 ns
Environmental:			
Operating Temperature	- C-Temp (15454-XC): 32 to 131 degrees Fahrenheit (0 to +55 degrees Celsius) - I-Temp (15454-XC-T):–40 to 149 degrees Fahrenheit (–40 to +65 degrees Celsius)	- C-Temp (15454-XC-VT): 32 to 131 degrees Fahrenheit (0 to +55 degrees Celsius) - I-Temp (15454-XC-VT-T):–40 to 149 degrees Fahrenheit (–40 to +65 degrees Celsius)	C-Temp (15454-XC-10G): 32 to 131 degrees Fahrenheit (0 to +55 degrees Celsius)
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 85%, noncondensing
Power Consumption	29 W, 0.6 A, 99 BTU/hr	34.40 W, 0.72 A, 117.46 BTU/hr	78.6 W, 1.64 A, 268.4 BTU/hr
Physical Characteristics:			
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	1.5 lb (0.7 kg)	1.9 lb (0.8 kg)	1.5 lb (0.7 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001
Predicted MTBF (Years)[1]	65	53	30

[1] Markov modeling was used to calculate the predicted MTBF.

AIC and AIC-I Card Specifications

Table 6-16 lists the physical characteristics and environmental specifications for the AIC and AIC-I cards.

Table 6-16: AIC and AIC-I Card Specifications

Specification	AIC	AIC-I
Alarm inputs	4 without AEP – Opto coupler isolated – Label customer provisionable – Severity customer provisionable – Common 32 V output for all alarm inputs – Each input limited to 2 mA – Termination: Wire-wrap on backplane without AEP, on AEP connectors with AEP	12 without AEP, 32 with AEP – Opto coupler isolated – Label customer provisionable – Severity customer provisionable – Common 32 V output for all alarm inputs – Each input limited to 2 mA – Termination: Wire-wrap on backplane without AEP, on AEP connectors with AEP
Alarm outputs	4 (user configurable as inputs) – Switched by opto MOS (metal oxide semiconductor) – Triggered by definable alarm condition – Maximum allowed open circuit voltage: 60 VDC – Maximum allowed closed circuit current: 100 mA – Termination: Wire-wrap on backplane without AEP, on AEP connectors with AEP	4 (user configurable as inputs) without AEP, 16 with AEP – Switched by opto MOS (metal oxide semiconductor) – Triggered by definable alarm condition – Maximum allowed open circuit voltage: 60 VDC – Maximum allowed closed circuit current: 100 mA – Termination: Wire-wrap on backplane without AEP, on AEP connectors with AEP
Orderwire	Extended and Local Orderwire supported	Extended and Local Orderwire supported
UDC	– Bit rate: 64 kb/s, co-directional – ITU-T G.703 – Input/output impedance: 120 ohm – Termination: RJ-11 connectors	– Bit rate: 64 kb/s, co-directional – ITU-T G.703 – Input/output impedance: 120 ohm – Termination: RJ-11 connectors
DCC/GCC	– Bit rate: 576 kb/s – EIA/TIA-485/V11 – Input/output impedance: 120 ohm – Termination: RJ-45 connectors	– Bit rate: 576 kb/s – EIA/TIA-485/V11 – Input/output impedance: 120 ohm – Termination: RJ-45 connectors
Optional AEP	No	Yes
Power Monitoring Alarming States	NA	– Power failure (0 to –38 VDC) – Undervoltage (–38 to–40.5 VDC) – Overvoltage (beyond –56.7 VDC)
Environmental:		
Operating Temperature	- C-Temp (15454-AIC): 32 to 131 degrees Fahrenheit (0 to +55 degrees Celsius) - I-Temp (15454-AIC-I-T):–40 to 149 degrees Fahrenheit (–40 to +65 degrees Celsius)	–40 to 149 degrees Fahrenheit (–40 to +65 degrees Celsius)
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing
Power Consumption (including AEP, if used)	6.01 W, 0.12 A, 20.52 BTU/hr	8.00 W, 0.17 A, 27.3 BTU/hr
Physical Characteristics:		
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	1.8 lb (0.82 kg)	1.8 lb (0.82 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001
Predicted MTBF (Years)[1]	42	22

[1] Markov modeling was used to calculate the predicted MTBF.

CISCO SYSTEMS

Interface Card Specifications

Table 6-17 to 6 23 lists the physical characteristics and environmental specifications for the electrical, optical, and Ethernet interface cards.

Table 6-17: Electrical Interface Card Specifications

Specification	DS1-14/DS1N-14	DS3-12/DS3N-12	DS3-12E/DS3N-12E	DS3XM-6	EC1-12
Input:					
Bit Rate	1.544 Mb/s +/- 32 ppm	44.736 Mb/s +/- 20 ppm	44.736 Mb/s +/- 20 ppm	44.736 Mb/s +/- 20 ppm	51.84 Mbps +/- 20 ppm
Frame Format	Off, SF (D4), ESF	DS-3 ANSI T1.107-1988	DS-3 ANSI T1.107-1988	DS-3 ANSI T1.107-1988	SONET
Line Code	AMI, B8ZS	B3ZS	B3ZS	B3ZS	B3ZS
Termination	Wire-wrap, AMP Champ	Unbalanced coaxial cable	Unbalanced coaxial cable	Unbalanced coaxial cable	Unbalanced coaxial cable
Input Impedance	100 ohms	75 ohms +/-5%	75 ohms +/-5%	75 ohms +/-5%	75 ohms +/-5%
Cable Loss	Max 655 ft. ABAM #22 AWG	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179
AIS	TR-TSY-000191-compliant	TR-TSY-000191-compliant	TR-TSY-000191-compliant	TR-TSY-000191-compliant	TR-TSY-000191-compliant
Output:					
Bit Rate	1.544 Mbps +/- 32 ppm	44.736 Mb/s +/- 20 ppm	44.736 Mb/s +/- 20 ppm	44.736 Mb/s +/- 20 ppm	51.84 Mbps +/- 20 ppm
Frame Format	Off, SF (D4), ESF	DS-3 ANSI T1.107-1988	DS-3 ANSI T1.107-1988	DS-3 ANSI T1.107-1988	SONET
Line Code	AMI, B8ZS	B3ZS	B3ZS	B3ZS	B3ZS
Termination	Wire-wrap, AMP Champ	Unbalanced coaxial cable	Unbalanced coaxial cable	Unbalanced coaxial cable	Unbalanced coaxial cable
Input Impedance	100 ohms	75 ohms +/-5%	75 ohms +/-5%	75 ohms +/-5%	75 ohms +/-5%
Cable Loss	Max 655 ft. ABAM #22 AWG	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179	Max 450 ft. 734A, RG-59, 728A/Max 79 ft. RG-179
AIS	TR-TSY-000191-compliant	TR-TSY-000191-compliant	TR-TSY-000191-compliant	TR-TSY-000191-compliant	TR-TSY-000191-compliant
Line Build Out (LBO)	NA	0-225 ft., 226-450 ft.	0-225 ft., 226-450 ft.	0-225 ft., 226-450 ft.	NA
Power Level	12.5 to 17.9 dBm centered @ 772 KHz, -16.4 to -11.1 dBm centered at 1544 KHz	-1.8 - +5.7 dBm at a center frequency of 22.368 MHz	-1.8 - +5.7 dBm at a center frequency of 22.368 MHz	-1.8 - +5.7 dBm at a center frequency of 22.368 MHz	-1.8 - +5.7 dBm at a center frequency of 22.368 MHz
Pulse Shape	GR-499-CORE Figure 9-5	ANSI T1.102-1988 Figure 8	ANSI T1.102-1988 Figure 8	ANSI T1.102-1988 Figure 8	ANSI T1.102-1988 Figure 8
Pulse Amplitude	2.4- 3.6 V peak-to-peak	0.36 - 0.85 V peak-to-peak	0.36 - 0.85 V peak-to-peak	0.36 - 0.85 V peak-to-peak	0.36 - 0.85 V peak-to-peak
Loopback Modes	Terminal and Facility	Terminal and Facility	Terminal and Facility	Terminal and Facility	Terminal and Facility
EIA Interface	BNC or SMB	BNC or SMB	BNC or SMB	BNC or SMB	BNC or SMB
Surge Protection	GR-1089-CORE	GR-1089-CORE	GR-1089-CORE	GR-1089-CORE	GR-1089-CORE

Specification	DS1-14/DS1N-14	DS3-12/DS3N-12	DS3-12E/DS3N-12E	DS3XM-6	EC1-12
Environmental:					
Operating Temperature	- C-Temp (15454-DS1-14 and 15454-DS1N-14): 0 to +55 degrees Celsius - I-Temp (15454-DS1-14-T and 15454-DS1N-14-T): -40 to +65 degrees Celsius	- C-Temp (15454-DS3-12 and 15454-DS3N-12): 0 to +55 degrees Celsius - I-Temp (15454-DS3-12-T and 15454-DS3N-12-T): -40 to +65 degrees Celsius	- C-Temp (15454-DS3-12E and 15454-DS3N-12E): 0 to +55 degrees Celsius - I-Temp (15454-DS3-12E-T and 15454-DS3N-12E-T): -40 to +65 degrees Celsius	- C-Temp (15454-DS3XM-6): 0 to +55 degrees Celsius - I-Temp (15454-DS3XM-6-T): -40 to +65 degrees Celsius	- C-Temp (15454-EC1-12): 0 to +55 degrees Celsius - I-Temp (15454-EC1-12-T): -40 to +65 degrees Celsius
Operating Humidity	5 - 95%, non-condensing	5 - 95%, non-condensing	5 - 95%, non-condensing	5 - 95%, non-condensing	5 - 95%, non-condensing
Power Consumption	12.60 W, 0.26 amps, 43.02 BTU/Hr.	38.20 W, 0.79 amps, 130.43 BTU/Hr.	26.80 W, 0.56 amps, 91.51 BTU/Hr.	20 W, 0.42 amps, 68 BTU/Hr.	36.60 W, 0.76 amps, 124.97 BTU/Hr.
Physical Characteristics:					
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	1.8 lbs, 0.8 kg	1.7 lbs, 0.7 kg/ 1.8 lbs, 0.8 kg	1.8 lbs, 0.8 kg/ 1.9 lbs, 0.8 kg	1.8 lbs, 0.8 kg	2.0 lbs, 0.9 kg
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001
Predicted MTBF (Years)[1]	33/21	35/23	42/33	34	33

[1] Markov modeling was used to calculate the predicted MTBF.

Table 6-18: OC3 to OC12 Interface Specifications

Specification	OC-3 IR/STM-1 SH,1310 4-Port/8-Port	OC-12 IR/STM-4 SH, 1310	OC-12 IR/STM-4 SH, 1310 4-Port	OC-12 LR/STM-4 LH, 1310	OC-12 LR/STM-4 LH, 1550
Line:					
Bit Rate	155.52 Mb/s	622.08 Mb/s	622.08 Mb/s	622.08 Mb/s	622.08 Mb/s
Code	Scrambled non-return to zero (NRZ)	Scrambled non-return to zero (NRZ)	Scrambled non-return to zero (NRZ)	Scrambled non-return to zero (NRZ)	Scrambled non-return to zero (NRZ)
Fiber	1310 nm single-mode	1310 nm single-mode	1310 nm single-mode	1310 nm single-mode	1310 nm single-mode
Loopback Modes	Terminal and Facility	Terminal and Facility	Terminal and Facility	Terminal and Facility	Terminal and Facility
Connector	SC	SC	SC	SC	SC
Compliance	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957
Transmitter:					
Max Output Power	–8 dBm	–8 dBm	–8 dBm	+2 dBm	+2 dBm
Min Output Power	–15 dBm	–15 dBm	–15 dBm	–3 dBm	–3 dBm
Center Wavelength	1274 nm to 1356 nm	1274 nm to 1356 nm	1274 nm to 1356 nm	1280 nm to 1335 nm	1480 nm to 1580 nm
Nominal Wavelength	1310 nm	1310 nm	1310 nm	1310 nm	1550 nm
Transmitter	Fabry Perot laser	Fabry Perot laser	Fabry Perot laser	Distributed feedback (DFB) laser	Distributed feedback (DFB) laser
Extinction Ratio	8.2 dB	8.2 dB	8.2 dB	10 dB	10 dB
Dispersion Tolerance	96 ps/nm	96 ps/nm	74 ps/nm	190 ps/nm	190 ps/nm
Receiver:					
Max Rcvr Level	–8 dBm	–8 dBm	–8 dBm	–8 dBm	–8 dBm
Min Rcvr Level	–28 dBm	–28 dBm	–30 dBm	–30 dBm	–30 dBm
Receiver	InGaAs/InP photodetector	InGaAs/InP photodetector	InGaAs/InP photodetector	InGaAs/InP photodetector	InGaAs/InP photodetector
Link Loss Budget	13 dB	13 dB	15 dB	25 dB	25 dB
Operating Wavelengths	1274 nm to 1356 nm	1274 nm to 1356 nm	1274 nm to 1356 nm	1280 nm to 1335 nm	1480 nm to 1580 nm
Front End	APD	APD	APD	APD	APD
Jitter Tolerance	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant

Specification	OC-3 IR/STM-1 SH,1310 4-Port/8-Port	OC-12 IR/STM-4 SH, 1310	OC-12 IR/STM-4 SH, 1310 4-Port	OC-12 LR/STM-4 LH, 1310	OC-12 LR/STM-4 LH, 1550
Environmental:					
Operating Temperature	- C-Temp (15454-OC34IR1310): –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit) - I-Temp (15454-OC34I13-T): –40 to +65 degrees Celsius (–40 to +149 degrees Fahrenheit)	- C-Temp (15454-OC121IR1310): –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit) - I-Temp (15454-OC121I13-T): –40 to +65 degrees Celsius (–40 to +149 degrees Fahrenheit)	C-Temp: –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)	- C-Temp (15454-OC121LR1310): –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit) - I-Temp (15454-OC121L13-T): –40 to +65 degrees Celsius (–40 to +149 degrees Fahrenheit)	- C-Temp (15454-OC121LR1550): –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit) - I-Temp (15454-OC121L15-T): –40 to +65 degrees Celsius (–40 to +149 degrees Fahrenheit)
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing
Power Consumption	19.20 W, 0.40 A, 65.56 BTU/hr/ 23.00 W, 0.48 A at –48 V, 78.5 BTU/hr	10.90 W, 0.23 A, 37.22 BTU/hr	28 W, 0.58 A, 100 BTU/hr	9.28 W, 0.25 A, 41BTU/hr	9.28 W, 0.19 A, 31.68 BTU/hr
Physical Characteristics:					
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	1.8 lbs, 0.8 kg/ 1.0 lb (0.4 kg)	1.4 lb (0.6 kg)	1.0 lb (0.4 kg)	1.4 lb (0.6 kg)	1.4 lb (0.6 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1
Predicted MTBF (Years)[1]	48/35	35	70	70	64

[1] Markov modeling was used to calculate the predicted MTBF.

CISCO SYSTEMS

Table 6-19: OC48 Interface Specifications

Specification	OC-48 IR/STM-16 SH, 1310/1310-AS	OC-48 LR/STM-16 LH, 1550/1550-AS	OC-48 ELR/STM-16 ELH ITU 100GHz	OC-48 ELR/STM-16 ELH ITU 200GHz
Line:				
Bit Rate	2.49 Gb/s	2.49 Gb/s	2.49 Gb/s	2.49 Gb/s
Code	Scrambled NRZ	Scrambled NRZ	Scrambled NRZ	Scrambled NRZ
Fiber	1310 nm single-mode	1550 nm single-mode	1550 nm single-mode	1550 nm single-mode
Loopback Modes	Terminal and Facility	Terminal and Facility	Terminal and Facility	Terminal and Facility
Connector	SC	SC	SC	SC
Compliance	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.692, ITU-T G.958	Telcordia GR-253-CORE, ITU-T G.692, ITU-T G.958
Transmitter:				
Max Output Power	0 dBm	+3 dBm	0 dBm	0 dBm
Min Output Power	–5 dBm	–2 dBm	–2 dBm	–2 dBm
Center Wavelength	1280 nm to 1350 nm	1520 nm to 1580 nm	15xx.xx nm +/- .25 nm	15xx.xx nm +/- .25 nm
Nominal Wavelength	1310 nm	1550 nm	Dependant on card	Dependant on card
Transmitter	Uncooled direct modulated DFB	DFB laser	Electro-absorption laser	Electro-absorption laser
Extinction Ratio	8.2 dB	8.2 dB	8.2 dB	8.2 dB
Dispersion Tolerance	96 ps/nm	1440 ps/nm	3600 ps/nm[2]	5400 ps/nm[2]
Receiver:				
Max Rcvr Level	0 dBm	–8 dBm	–9 dBm	–8 dBm
Min Rcvr Level	–18 dBm	–28 dBm	–27 dBm at10^{-12} BER	–28 dBm
Receiver	InGaAs InP photodetector	InGaAs InP photodetector	InGaAs APD photodetector	InGaAs APD photodetector
Link Loss Budget	13 dB minimum	26 dB minimum, with 1 dB dispersion penalty	25 dB minimum at 10^{-12} BER, (not including the 2 dB dispersion penalty)	26 dB minimum, with 1 dB dispersion penalty
Operating Wavelengths	1280 nm to 1350 nm	1520 nm to 1580 nm	1520 nm to 1580 nm	1520 nm to 1580 nm
Front End	APD	APD	APD	APD
Jitter Tolerance	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant
Environmental:				
Operating Temperature	C-Temp (15454-OC481IR1310): –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)	C-Temp (15454-OC481LR1550A): –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)	C-Temp: –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)	C-Temp: –5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing
Power Consumption	32.20 W, 0.67 A, 109.94 BTU/hr/ 37.20 W, 0.77 A, 127.01 BTU/hr	26.80 W, 0.56 A, 91.50 BTU/hr/ 37.20 W, 0.77 A, 127.01 BTU/hr	31.20 W, 0.65 A, 106.53 BTU/hr	31.20 W, 0.65 A, 106.53 BTU/hr

Specification	OC-48 IR/STM-16 SH, 1310/1310-AS	OC-48 LR/STM-16 LH, 1550/1550-AS	OC-48 ELR/STM-16 ELH ITU 100GHz	OC-48 ELR/STM-16 ELH ITU 200GHz
Physical Characteristics:				
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	1.8 lbs, 0.8 kg/ 2.2 lb (0.9 kg)	1.8 lb (0.8 kg)/ 2.2 lb (0.9 kg)	2.4 lb (1.1 kg)	2.9 lb (1.3 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1
Predicted MTBF (Years)[1]	37/37	29/29	35	35

1 Markov modeling was used to calculate the predicted MTBF.
2 2 dB for a dispersion of up to 5400 ps/nm.

Table 6-20: OC192 Interface Specifications

Specification	OC-192 SR/STM-64 IO, 1310	OC-192 IR/STM-64 SH, 1550[2]	OC-192 LR/STM-64 LH, 1550	OC-192 LR/STM-64 ELH ITU 100GHz
Line:				
Bit Rate	9.95328 Gb/s	9.95328 Gb/s	9.95328 Gb/s	9.95328 Gb/s
Code	Scrambled NRZ	Scrambled NRZ	Scrambled NRZ	Scrambled NRZ
Fiber	1310 nm single-mode	1550 nm single-mode	1550 nm single-mode	1550 nm single-mode
Loopback Modes	Terminal and Facility	Terminal and Facility	Terminal and Facility	Terminal and Facility
Connector	SC	SC	SC	SC
Compliance	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957, ITU-T G.691	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957
Transmitter:				
Max Output Power	–1 dBm	+2 dBm	+10 dBm	+6 dBm
Min Output Power	–6 dBm	–1 dBm	+7 dBm	+3 dBm
Center Wavelength	1290 nm to 1330 nm	1530 nm to 1565 nm	1530 nm to 1565 nm	Dependant on card
Nominal Wavelength	1310 nm	1550 nm	1550 nm	1550 nm
Transmitter	DFB/Directly modulated (DM) laser	Cooled EA modulated laser	LN (Lithium Niobate) external modulator transmitter	LN (Lithium Niobate) external modulator transmitter
Extinction Ratio	6 dB	8.2 dB	10 dB	10 dB
Spectral Range	40 nm	15 nm	13 nm	0.080 nm
Dispersion Tolerance	6.6 ps/nm	800 ps/nm	1500 ps/nm	- In deployments with DCU: +/- 1000 ps/nm, with ONSR of 19 dB (0.5 nm RBW) - In deployments without DCU: +/- 1200 ps/nm, with ONSR of 23 dB (0.5 nm RBW)
PMD Tolerance	10 ps/nm	10 ps/nm	10 ps/nm	10 ps/nm
Receiver:				
Max Rcvr Level	–1 dBm at 10^{-12} BER	–1 dBm at 10^{-12} BER	–10 dBm	–9 dBm at 10^{-12} BER
Min Rcvr Level	–11 dBm at 10^{-12} BER	–14 dBm at 10^{-12} BER	–19 dBm	–22 dBm at 10^{-12} BER
Receiver	PIN diode	PIN diode	APD/TIA	APD
Link Loss Budget	5 dB minimum, plus 1 dB dispersion penalty at 10^{-12} BER including dispersion	13 dB minimum, plus 2 dB dispersion penalty at 10^{-12} BER including dispersion	24 dB minimum, with no dispersion or 22 dB optical path loss at 10^{-12} BER including dispersion	25 dB minimum, plus 2 dB dispersion penalty at 10^{-12} BER including dispersion
Operating Wavelengths	1290 nm to 1330 nm	1530 nm to 1565 nm	1530 nm to 1565 nm	1529 nm to 1565 nm
Jitter Tolerance	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant	GR-253-CORE, ITU G.823 Compliant

Specification	OC-192 SR/STM-64 IO, 1310	OC-192 IR/STM-64 SH, 1550[2]	OC-192 LR/STM-64 LH, 1550	OC-192 LR/STM-64 ELH ITU 100GHz
Environmental:				
Operating Temperature	–5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)	–5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)	–5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)	–5 to +55 degrees Celsius (+23 to +131 degrees Fahrenheit)
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing
Power Consumption	47.00 W, 0.98 A at –48 V, 160.5 BTU/hr	50.00 W, 1.04 A at –48 V, 170.7 BTU/hr	72.20 W, 1.50 A, 246.52 BTU/hr	52.00 W, 1.08 A at –48 V, 177.6 BTU/hr
Physical Characteristics:				
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	3.1 lb (1.3 kg)	3.1 lb (1.3 kg)	3.1 lb (1.3 kg)	3.1 lb (1.3 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001, Class 1, ISO 9001
Predicted MTBF (Years)[1]	24	24	17	17

1 Markov modeling was used to calculate the predicted MTBF.

2 You must use a 3 to 15 dB fiber attenuator (5 dB recommended) when working with the OC192 IR/STM64 SH 1550 card in a loopback. Do not use fiber loopbacks with the OC192 IR/STM64 SH 1550 card. Using fiber loopbacks can cause irreparable damage to the OC192 IR/STM64 SH 1550 card.

Table 6-21: MXP_2.5G_10G and TXP_MR_10G Specifications (Future Release)

Specification	MXP_2.5G_10G	XP_MR_10G
Line (trunk side):		
Bit Rate	9.95328 Gbps for OC-192/STM-64 or 10.70923 Gbps with ITU-T G.709 Digital Wrapper/FEC	9.95328 Gbps for OC-192/STM-64 or 10.70923 Gbps with ITU-T G.709 Digital Wrapper/FEC
Code	Scrambled NRZ	Scrambled NRZ
Fiber	1550 nm single-mode	1550 nm single-mode
Loopback Modes	Terminal and Facility	Terminal and Facility
Connector	LC	LC
Compliance	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957
Transmitter 9trunk side):		
Max Output Power	+3 dBm	+3 dBm
Min Output Power	–16 dBm (The optical output power on the trunk side is configurable from –16 to +3 dBm with an accuracy of +/–0.5 dB.)	–16 dBm (The optical output power on the trunk side is configurable from –16 to +3 dBm with an accuracy of +/–0.5 dB.)
Center Wavelength	Dependant on card	Dependant on card
Nominal Wavelength	1550 nm	1550 nm
Transmitter	LN (Lithium Niobate) external modulator transmitter	LN (Lithium Niobate) external modulator transmitter
Dispersion Tolerance	6000 ps/nm	6000 ps/nm
Operating Wavelengths::		
Blue Band	– 1542.14 to 1542.94 nm, 10M-L1-42.1 – 1543.73 to 1544.53 nm, 10M-L1-43.7	– 1538.19 to 1538.98 nm, 10T-L1-38.1 – 1539.77 to 1540.56 nm, 10T-L1-39.7
Red Band	– 1558.17 to 1558.98 nm, 10M-L1-58.1 – 1559.79 to 1560.61 nm, 10M-L1-59.7	– 1554.13 to 1554.94 nm, 10T-L1-54.1 – 1555.75 to 1556.55 nm, 10T-L1-55.7
Receiver (trunk side):		
Receiver Input Power (no FEC, unamplified, BER 10^{-12})	–8 to –24 dBm	–8 to –24 dBm
Receiver Input Power (FEC, unamplified, BER 10^{-6})	–8 to –26 dBm	–8 to –26 dBm
Receiver Input Power (no FEC, amplified, BER 10^{-12})	–8 to –22 dBm	–8 to –22 dBm
Receiver Input Power (FEC, amplified, BER 10^{-6})	–8 to –18 dBm	–8 to –18 dBm
Receiver	APD	APD
Link Loss Budget	24 dB minimum, with no dispersion or 22 dB optical path loss at BER = 1 * 10 exp – 12 including dispersion	24 dB minimum, with no dispersion or 22 dB optical path loss at BER = 1 * 10 exp – 12 including dispersion
Receiver Input Wavelength Range	1290 nm to 1605 nm	1290 nm to 1605 nm
Line (client side):		
Bit rate	2.48832 Gb/s	9.95328 Gbps
Code	Scrambled NRZ	Scrambled NRZ
Fiber	1550 nm single-mode	1550 nm single-mode
Maximum Chromatic Dispersion Allowance	1600 ps/nm	1600 ps/nm
Loopback Modes	Terminal and Facility	Terminal and Facility
Connectors	SFF	LC
Compliance	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957	Telcordia GR-253-CORE, ITU-T G.707, ITU-T G.957
Transmitter (client side):		
Maximum transmitter output power	Depends on SFP that is used	–1 dBm
Minimum transmitter output power	Depends on SFP that is used	–6 dBm
Center wavelength	Depends on SFP that is used	1290 nm to 1330 nm
Nominal wavelength	Depends on SFP that is used	1310 nm
Transmitter	Depends on SFP that is used	DFB laser

Specification	**MXP_2.5G_10G**	**XP_MR_10G**
Receiver (client side):		
Maximum receiver level	Depends on SFP that is used	–1 dBm at BER = 10^{-12}
Minimum receiver level	Depends on SFP that is used	–14 dBm at BER = 10^{-12}
Receiver: APD	APD	APD
Link loss budget	Depends on SFP that is used	8 dB minimum, at BER = 10^{-12}
Receiver input wavelength range	Depends on SFP that is used	1290 nm to 1605 nm
Environmental:		
Operating temperature	–5 to +55 degrees Celsius (+23 to +113 degrees Fahrenheit)	–5 to +55 degrees Celsius (+23 to +113 degrees Fahrenheit)
Operating humidity	5 to 95%, noncondensing	5 to 95%, noncondensing
Power consumption	50.00 W, 1.04 A at –48 V, 170.7 BTU/hr	35.00 W, 0.73 A at –48 V, 119.5 BTU/hr
Physical Characteristics:		
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	3.1 lb (1.3 kg)	3.1 lb (1.3 kg)
Compliance	IEC 60950, EN 60950, UL 60950, CSA C22.2 No. 60950, TS 001, AS/NZS 3260, IEC 60825-1, IEC 60825-2, 21 CFR 1040-10, and 21 CFR 1040.11 Class 1M (IEC 60825-1 2001.01) and Class 1 (21 CFR 1040.10 and 1040.11) laser product, ISO 9001	IEC 60950, EN 60950, UL 60950, CSA C22.2 No. 60950, TS 001, AS/NZS 3260, IEC 60825-1, IEC 60825-2, 21 CFR 1040-10, and 21 CFR 1040.11 Class 1M (IEC 60825-1 2001.01) and Class 1 (21 CFR 1040.10 and 1040.11) laser product, ISO 9001

Table 6-22: E-Series Ethernet Specifications

Specification	E100T-12	E100T-G	E1000-2	E1000-2-G
Environmental:				
Operating Temperature	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing
Power Consumption	63.00 W, 1.31 A, 215.11 BTU/hr	65 W, 1.35 A, 221.93 BTU/hr	53.50 W, 1.11 A, 182.67 BTU/hr	53.50 W, 1.11 A, 182.67 BTU/hr
Physical Characteristics:				
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	2.1 lb (0.9 kg)	2.3 lb (1.0 kg)	2.1 lb (0.9 kg)	2.1 lb (0.9 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, Class 1 (21 CFR 1040.10 and 1040.11) and Class 1M (IEC 60825-1 2001-01) laser products, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, Class 1 (21 CFR 1040.10 and 1040.11) and Class 1M (IEC 60825-1 2001-01) laser products, ISO 9001
Predicted MTBF (Years)[1]	32	32	34	34

[1] Markov modeling was used to calculate the predicted MTBF.

Table 6-23: G and ML-Series Ethernet Specifications

Specification	G1000-4	G1K-4	ML100T-12	ML1000-2
Environmental:				
Operating Temperature	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius	C-Temp (15454-G1000-4): 0 to +55 degrees Celsius
Operating Humidity	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing	5 to 95%, noncondensing
Power Consumption	63.00 W, 1.31 A, 215.11 BTU/hr	63.00 W, 1.31 A at –48 V, 215.1 BTU/hr	53.00 W, 1.10 A at –48 V, 181.0 BTU/hr	49.00 W, 1.02 A at –48 V, 167.3 BTU/hr
Physical Characteristics:				
Height	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)	12.650 in. (321.3 mm)
Width	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)	0.716 in. (18.2 mm)
Depth	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)	9.000 in. (228.6 mm)
Weight	2.1 lb (0.9 kg)	2.1 lb (0.9 kg)	2.3 lb (1.0 kg)	2.1 lb (0.9 kg)
Compliance	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, Class 1 (21 CFR 1040.10 and 1040.11) and Class 1M (IEC 60825-1 2001-01) laser products, ISO 9001	UL 1950, CSA C22.2 No. 950, EN 60950, IEC 60950, Class 1 (21 CFR 1040.10 and 1040.11) and Class 1M (IEC 60825-1 2001-01) laser products, ISO 9001
Predicted MTBF (Years)[1]	32	32	34	34

Card Compatibility

Table 6-24 to Table 6-27 on list ONS 15454 cards, compatible software versions, and compatible cross-connect cards. Read each card description for detailed information about the card. In the tables below, “Yes” means cards are compatible with the listed software versions and cross-connect cards. Table cells with dashes mean cards are not compatible with the listed software versions or cross-connect cards.

Table 6-24: Common Card Software and Hardware Compatibility

Card	R2.2.1	R2.2.2	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	XC	XC-VT	XC10G
TCC+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TCC2	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes
XC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
XC-VT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
XC10G	-	-	-	Yes	Yes	Yes	Yes	Yes	-	-	Yes[1]
AIC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AIC-I	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes
AEP	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes

[1] Use the XC10G card, the TCC+/TCC2 card, Software R3.1 or later and the new 15454-SA-ANSI shelf assembly to enable the OC48 IR/STM16 SH AS 1310, OC48 LR/STM16 LH AS 1550, and the OC192 LR/STM64 LH 1550 cards.

Table 6-25: Electrical Card Software and Cross-Connect Card Compatibility

Card	R2.2.1	R2.2.2	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	XC	XC-VT	XC10G
EC1-12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS1-14	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS1N-14	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS3-12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS3N-12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS3-12E	-	Yes[1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS3N-12E	-	Yes[1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS3XM-6	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1] Use Software R3.0 or later to enable all enhanced performance monitoring functions on the DS-3E cards. With Software R2.2.2, the DS-3E cards operate as the older DS-3 cards without enhanced performance monitoring.

Table 6-26: Optical Card Software and Cross-Connect Card Compatibility

Card	R2.2.1	R2.2.2	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	XC	XCVT	XC10G
OC3-IR-4/STM1-SH-1310	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC-3-IR-8/STM1-SH-1310	-	-	-	-	-	-	-	Yes	-	-	Yes
OC12-IR/STM4-SH-1310	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC12-LR/STM4-LH-1310	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC12-LR/STM4-LH-1550	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC12-IR-4/STM4-SH-1310	-	-	-	-	-	Yes	Yes	Yes	-	-	Yes
OC48-IR-1310	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC48-LR-1550	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC48-IR/STM16-SH-AS-1310	-	-	-	Yes[1]	Yes	Yes	Yes	Yes	Yes, in slots 5, 6, 12, and 13	Yes, in slots 5, 6, 12, and 13	Yes[1]
OC48-LR/STM16-LH-AS-1550	-	-	-	Yes[1]	Yes	Yes	Yes	Yes	Yes, in slots 5, 6, 12, and 13	Yes, in slots 5, 6, 12, and 13	Yes[1]
OC48-ELR/STM16-EH-100GHz	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC48-ELR-200GHz	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC192-SR/STM64-IO-1310	-	-	-	-	-	-	-	Yes	-	-	Yes[1]
OC192-IR/STM64-SH-1550	-	-	-	-	-	-	-	Yes	-	-	Yes[1]
OC192-LR/STM64-LH-1550	-	-	-	Yes[1]	Yes	Yes	Yes	Yes	-	-	Yes[1]
OC192-LR/STM64-LH-ITU	-	-	-	-	-	-	-	Yes	-	-	Yes[1]
MXP-2.5G-10G	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes
TXP-2.5G-10G	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes

[1] Use the XC10G card, the TCC+/TCC2 card, Software R3.1 or later and the new 15454-SA-ANSI shelf assembly to enable the OC48 IR/STM16 SH AS 1310, OC48 LR/STM16 LH AS 1550, and the OC192 LR/STM64 LH 1550 cards.

Table 6-27: Ethernet Card Software and Cross-Connect Card Compatibility

Card	R2.2.1	R2.2.2	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	XC	XC-VT	XC10G
E100T-12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	-
E1000-2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	
E100T-G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes[1]
E1000-2-G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes[1]
G1000-4	-	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes[1]
G1K-4	-	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ML100T-12	-	-	-	-	-	-	-	-	Yes, in slots 5, 6, 12, and 13	Yes, in slots 5, 6, 12, and 13	Yes
ML1000-2	-	-	-	-	-	-	-	-	Yes, in slots 5, 6, 12, and 13	Yes, in slots 5, 6, 12, and 13	Yes

[1] To use Ethernet cards with the XC10G, select either the E100T-G card, the E1000-2-G card, or the G1000-4 card. Do not use the E100T-12 card or E1000-2 card with the XC10G.

Gigabit Interface Converters (GBICs)

E- and G-Series Gigabit Ethernet cards use standard Cisco gigabit interface converter (GBIC) modular receptacles for the optical ports. GBICs are hot-swappable input/output devices that plug into a Gigabit Ethernet port to link the port to the fiber-optic network. Cisco offers the following three GBIC modules as separate orderable products for maximum flexibility:

1. IEEE 1000BaseSX compliant, 850-nm, optical module.
2. IEEE 1000BaseLX compliant, 1300-nm, optical module.
3. IEEE 1000BaseZX compliant, 1550-nm, optical module

The technical specifications for these GBICs are listed in Table 6-28.

Table 6-28: GBIC Specifications

Specifications	**1000BaseSX**	**1000BaseLX**	**1000BaseZX**
General:			
Connector	SC	SC	SC
Wavelength	850 nm	1300 nm	1550 nm
Minimum Cable Distance	2 m	2 m	2 m
Maximum Cable Distance	1,804 ft (550 m)	32,810 ft. (10 km)	262,480 ft. (80 km)
Port Cabling			
Wavelength	850 nm	1300 nm	1550 nm
Fiber Type	MMF	SMF	SMF
Core Size (microns)	62.5	62.5	Not Conditional
Modal Bandwidth	160 MHz/km	500 MHz/km	NA
Maximum Distance	220 m	550 m	80 km
Fiber Loss Budgets:			
Transmit Minimum	-9.5 dBm	-9.5 dBm	0 dBm
Transmit Maximum	-4 dBm	-3 dBm	4.77 dBm
Receive Minimum	-17 dBm	-20 dBm	-23 dBm
Receive Maximum	0 dBm	3 dBm	0 dBm
Dimensions:			
Height	0.39-inches	0.39-inches	0.39-inches
Width	1.18-inches	1.18-inches	1.18-inches
Depth	2.56-inches	2.56-inches	2.56-inches

The ML-series Gigabit Ethernet cards use standard Cisco small form-factor pluggable connectors (SFP) for the optical ports. SFPs are hot-swappable input/output devices that plug into a Gigabit Ethernet port to link the port to the fiber-optic network. Cisco offers the SFP modules listed in Table 6-29 as separate orderable products.

Table 6-29: Cisco SFP Connectors

Card	Usable GBICs
ML1000-2	IEEE 1000BaseSX compliant 850-nm SFP IEEE 1000BaseLX compliant 1300-nm SFP (for a future release)

The IEEE 1000BaseSX compliant, 850-nm optical module is designed for multimode fiber and distances of up to 722 feet (220 meters) on 62.5 micron fiber and up to 1804 feet (550 meters) on 50 micron fiber.

The IEEE 1000BaseLX-compliant, 1300-nm optical module (for a future release) is designed for single-mode fiber and distances of up to 6.2 miles (10 kilometers). When using an LX SFP with 62.5-micron diameter MMF cable, you must install a mode-conditioning patch cord (CAB-GELX-625 or equivalent) between the SFP and the MMF cable on both the transmit and receive ends of the link. The mode-conditioning patch cord is required for link distances less than 328 feet (100 m) or greater than 984 feet (300 m). The mode-conditioning patch cord prevents overdriving the receiver for short lengths of MMF and reduces differential mode delay for long lengths of MMF.

Network Element Defaults and Performance Monitoring Thresholds

The following tables lists the provisionable settings for the ONS 15454 node and threshold range for monitored parameters. The default settings are in brackets. You can disable any monitored threshold by setting its value to zero. For a description of performance monitoring (PM) parameters, see the *Cisco ONS 15454 Reference Manual*.

Table 6-30: Node Parameters

Field	Parameter	Settable Range [Default]
Circuits	Create Like TL1	TRUE – FALSE [FALSE]
Circuits-Path Protection Configuration	Reversion Time (minutes)	0.5 – 12.0 [5.0]
	Revertive	TRUE – FALSE [FALSE]
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E7]
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]
	Switch on PDIP	TRUE – FALSE [FALSE]
General	Craft Access Only	TRUE – FALSE [FALSE]
	CTC LP Display Suppression	TRUE – FALSE [FALSE]
	Defaults Description	HTML Text [Factory Defaults]
	Enable Firewall	TRUE – FALSE [FALSE]
	Enable Proxy	TRUE – FALSE [FALSE]
	IIOP Listener Port	Variable [57790]
	LCD LP Setting	Allow Configuration – Disallow Configuration [Allow Configuration]
	Login Warning Message	HTML Text [This system is restricted to authorized users for business purposes. Unauthorized access is a violation of the law. This service may be monitored for administrative and security reasons. By proceeding, you consent to this monitoring.]
	NTP SNTP Server	Variable [0.0.0.0]
	Time Zone	EST, CST, PST [PST]
	USE Daylight Savings Time (DST)	TRUE – FALSE [TRUE]
	Use NTP SNTP Server	TRUE – FALSE [FALSE]
Protection-1+1	Bi-directional Switching	TRUE – FALSE [FALSE]
	Reversion Time (minutes)	0.5 – 12.0 [5.0]
	Revertive	TRUE – FALSE [FALSE]
Protection-BLSR	Ring Reversion Time (minutes)	0.5 – 12.0 [5.0]
	Ring Revertive	TRUE – FALSE [TRUE]
	Span Reversion Time (minutes)	0.5 – 12.0 [5.0]
	Span Revertive	TRUE – FALSE [TRUE]
Protection-Ycable	Bi-directional Switching	TRUE – FALSE [FALSE]
	Reversion Time (minutes)	0.5 – 12.0 [5.0]
	Revertive	TRUE – FALSE [FALSE]
Security-Policy	Failed Logins Before Lockout	0 –10 [5]
	Idle User Timeout Policy Maintenance	0 – 999 [60]
	Idle User Timeout Policy Provisioning (minutes)	0 – 999 [30]
	Idle User Timeout Policy Retrieve (minutes)	0 – 999 [0]
	Idle User Timeout Policy Superuser (minutes)	0 – 999 [15]
	Lockout Duration (min:sec)	00:00 – 10:00 [00:30]
	Manual Unlock by Superuser	TRUE – FALSE [FALSE]
	Password Reuse Threshold	0 – 10 [1]
	Password Reuse Timeout (days)	20 –95 [20]
	Single Session per User	TRUE – FALSE [FALSE]
Timing-BITS-1	Alarm Indication Signal (AIS) Threshold	PRS – RES [SMC]
	Coding	B8ZS – AMI [B8ZS]
	Framing	ESF – SF(D4) [ESF]
	Line Build Out (LBO) in feet	0 –655 [0-133]
	State	IS – OOS [IS]

Field	Parameter	Settable Range [Default]
Timing-BITS-2	Alarm Indication Signal (AIS) Threshold	PRS – RES [SMC]
	Coding	B8ZS – AMI [B8ZS]
	Framing	ESF – SF(D4) [ESF]
	Line Build Out (LBO) in feet	0 –655 [0-133]
	State	IS – OOS [IS]
Timing-General	Mode	Line, External, Mixed [External]
	Quality of RES	PRS<RES – RES=DUS [RES=DUS]
	Reversion Time (minutes)	0.5 – 12.0 [5.0]
	Revertive	TRUE – FALSE [FALSE]
	SSM Message Set	Generation 1 – Generation 2 [Generation 1]

Table 6-31: DS-1 Parameters

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Line Coding	AMI – B8ZS [AMI]	
	Line Length (feet)	0 – 655 [0-131]	
	Line Type	D4, ESF, Unframed [D4]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Line – Near End	Coding Violations (CV) [BPV count]	1-137700 [13340]	1-13219200 [133400]
	Errored Seconds (ES)	1-900 [65]	1-86400 [648]
	Loss of Signal Seconds (LOSS)	1-900 [10]	1-86400 [10]
	Severely Errored Seconds (SES)	1-900 [10]	1-86400 [100]
Line – Far End	Errored Seconds (ES)	1-900 [65]	1-86400 [648]
Path – Near End	AIS Seconds (AISS)	1-900 [10]	1-86400 [10]
	Coding Violations (CV) [BIP count]	1-2160000 [13296]	1-13219200 [132960]
	Errored Seconds (ES)	1-900 [65]	1-86400 [648]
	Severely Errored Seconds Alarm Signal (SAS)	1-900 [2]	1-86400 [17]
	Severely Errored Seconds (SES)	1-900 [10]	1-86400 [100]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Path – Far End	Controlled Slip Seconds (CSS)	1-900 [25]	1-86400 [25]
	Coding Violations (CV) [BIP count]	1-2160000 [13296]	1-13219200 [132960]
	Errored Seconds (ES)	1-900 [65]	1-86400 [648]
	Errored Seconds-A (ESA) sent by the NE	1-900 [25]	1-86400 [648]
	Errored Seconds-B (ESB) sent by CPE	1-900 [25]	1-86400 [648]
	Severely Errored Framed Seconds (SEFS)	1-900 [25]	1-86400 [25]
	Severely Errored Seconds (SES)	1-900 [10]	1-86400 [100]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
VT – Near End	Coding Violations (CV) [BIP8 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [10]
	Unavailable Seconds (UAS)	1-900 [7]	1-86400 [10]
VT – Far End	Coding Violations (CV) [BIP8 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
STS – Far End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Table 6-32: DS-3/DS-3E Parameters

Field	Parameter	Threshold Range [Default] 15 Minutes	1 Day
Configuration	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Far End Inhibit Loopback (DS-3E only)	TRUE – FALSE [FALSE]	
	Line Length (feet)	0 – 450 [0-225]	
	Line Type (DS-3E only)	M13, CBIT, Unframed, Auto Provision [Unframed]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Line – Near End	Coding Violations (CV) [BPV count]	1-137700 [387]	1-13219200 [3865]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Loss of Signal Seconds (LOSS)	1-900 [10]	1-86400 [10]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
STS – Far End	Coding Violations (CV) [G1 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
Pbit Path – Near End	AIS Seconds (AISS)	1-900 [10]	1-86400 [10]
	Coding Violations (CV) [BIP count]	1-2160000 [382]	1-13219200 [3820]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	1-900 [2]	1-86400 [8]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
Cbit Path – Near End	AIS Seconds (AISS)	1-900 [10]	1-86400 [10]
	Coding Violations (CV) [BIP count]	1-2160000 [382]	1-13219200 [3820]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	1-900 [2]	1-86400 [8]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
Cbit Path – Far End	AIS Seconds (AISS)	1-900 [10]	1-86400 [10]
	Coding Violations (CV) [BIP count]	1-2160000 [382]	1-13219200 [3820]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	1-900 [2]	1-86400 [8]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Cisco Systems

Table 6-33 DS3XM Parameters

Field	Parameter	Threshold Range [Default] 15 Minutes	Threshold Range [Default] 1 Day
Configuration	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Far End Inhibit Loopback	TRUE – FALSE [FALSE]	
	Line Length (feet)	0 – 450 [0-225]	
	Line Type	M13, CBIT [M13]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Line – Near End	Coding Violations (CV) [BPV count]	1-137700 [387]	1-13219200 [3865]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Loss of Signal Seconds (LOSS)	1-900 [10]	1-86400 [10]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
STS – Far End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
Pbit Path – Near End	AIS Seconds (AISS)	1-900 [10]	1-86400 [10]
	Coding Violations (CV) [BIP count]	1-2160000 [382]	1-13219200 [3820]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	1-900 [2]	1-86400 [8]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
Cbit Path – Near End	AIS Seconds (AISS)	1-900 [10]	1-86400 [10]
	Coding Violations (CV) [BIP count]	1-2160000 [382]	1-13219200 [3820]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	1-900 [2]	1-86400 [8]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
Cbit Path – Far End	AIS Seconds (AISS)	1-900 [10]	1-86400 [10]
	Coding Violations (CV) [BIP count]	1-2160000 [382]	1-13219200 [3820]
	Errored Seconds (ES)	1-900 [25]	1-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	1-900 [2]	1-86400 [8]
	Severely Errored Seconds (SES)	1-900 [4]	1-86400 [40]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
VT – Near End	Coding Violations (CV) [BIP8 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]
VT – Far End	Coding Violations (CV) [BIP8 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Table 6-34: EC-1 Parameters

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration – Line	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Line Length (feet)	0 – 450 [0-225]	
	Pointer Justification (PJ) STS Monitor #	0, 1 [0]	
	Rx Equalization	TRUE – FALSE [TRUE]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Configuration – STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE – FALSE [FALSE]	
Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [1312]	1-13219200 [13120]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Protection Switching Count (PSC)	1-600 [1]	1-57600 [5]
	Protection Switching Duration (PSD) seconds	1-600 [300]	1-57600 [600]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Line – Far End	Coding Violations (CV) [B2 count]	1-137,700 [1312]	1-13219200 [13120]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Section – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Table 6-35: OC-3 Parameters

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration – Line	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Enable Synch Messaging	TRUE – FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0, 1 [0]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Send Do Not Use (DUS)	TRUE – FALSE [FALSE]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Configuration – STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE – FALSE [FALSE]	
Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [1312]	1-13219200 [13120]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Protection Switching Count (PSC)	1-600 [1]	1-57600 [5]
	Protection Switching Duration (PSD) seconds	1-600 [300]	1-57600 [600]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [1312]	1-13219200 [13120]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Section – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Table 6-36: OC-12 Parameters

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration – Line	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Enable Synch Messaging	TRUE – FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0, 1 [0]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Send Do Not Use (DUS)	TRUE – FALSE [FALSE]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Configuration – STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE – FALSE [FALSE]	
Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [5315]	1-13219200 [53150]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Protection Switching Count (PSC)	1-600 [1]	1-57600 [5]
	Protection Switching Count (PSC) - Working	1-600 [1]	1-57600 [5]
	Protection Switching Duration (PSD) seconds	1-600 [300]	1-57600 [600]
	Protection Switching Duration (PSD) seconds - Working	1-600 [300]	1-57600 [600]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [5315]	1-13219200 [53150]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Section – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Table 6-37: OC-48 Parameters

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration – Line	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Enable Synch Messaging	TRUE – FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0, 1 [0]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Send Do Not Use (DUS)	TRUE – FALSE [FALSE]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Configuration – STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE – FALSE [FALSE]	
Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [21260]	1-13219200 [212600]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Protection Switching Count (PSC)	1-600 [1]	1-57600 [5]
	Protection Switching Count (PSC) - Ring	1-600 [1]	1-57600 [5]
	Protection Switching Count (PSC) - Span	1-600 [1]	1-57600 [5]
	Protection Switching Count (PSC) - Working	1-600 [1]	1-57600 [5]
	Protection Switching Duration (PSD) seconds	1-600 [300]	1-57600 [600]
	Protection Switching Duration (PSD) seconds - Ring	1-600 [300]	1-57600 [600]
	Protection Switching Duration (PSD) seconds - Span	1-600 [300]	1-57600 [600]
	Protection Switching Duration (PSD) seconds - Working	1-600 [300]	1-57600 [600]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [21260]	1-13219200 [212600]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Section – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Table 6-38: OC-192 Parameters

Field	Parameter	Threshold Range [Default] 15 Minutes	Threshold Range [Default] 1 Day
Configuration – Line	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	Enable Synch Messaging	TRUE – FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0, 1 [0]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Send Do Not Use (DUS)	TRUE – FALSE [FALSE]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Configuration – STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE – FALSE [FALSE]	
Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Protection Switching Count (PSC)	1-600 [1]	1-57600 [5]
	Protection Switching Count (PSC) - Ring	1-600 [1]	1-57600 [5]
	Protection Switching Count (PSC) - Span	1-600 [1]	1-57600 [5]
	Protection Switching Count (PSC) - Working	1-600 [1]	1-57600 [5]
	Protection Switching Duration (PSD) seconds	1-600 [300]	1-57600 [600]
	Protection Switching Duration (PSD) seconds - Ring	1-600 [300]	1-57600 [600]
	Protection Switching Duration (PSD) seconds - Span	1-600 [300]	1-57600 [600]
	Protection Switching Duration (PSD) seconds - Working	1-600 [300]	1-57600 [600]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [21260]	1-13219200 [212600]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
Section – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
STS – Near End	Coding Violations (CV) [B3 count]	1-72 [15]	1-6912 [125]
	Errored Seconds (ES)	1-900 [12]	1-86400 [100]
	Failure Count (FC)	1-72 [10]	1-6912 [10]
	Severely Errored Seconds (SES)	1-900 [3]	1-86400 [7]
	Unavailable Seconds (UAS)	1-900 [10]	1-86400 [10]

Table 6-39: MXP_2_5G_10G Parameters (Future Release)

Field	Parameter	Threshold Range [Default] 15 Minutes	1 Day
Configuration	Payload Type	SONET, SDH [SONET]	
	Termination Mode	TRANSPARENT, SECTION, LINE [TRANSPARENT]	
Configuration – Line	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	AIS Mode	Disabled, Automatic Restart, Manual Restart, Manual Restart for Test [Disabled]	
	AIS Recovery Interval (seconds)	[100]	
	AIS Recovery Pulse Width (seconds)	2.0 – 100.0 [2.0]	
	Route D1-D3	TRUE – FALSE [FALSE]	
	Route D4-D12	TRUE – FALSE [FALSE]	
	Route E1	TRUE – FALSE [FALSE]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Configuration – Payload	Enable Synch Messaging	TRUE – FALSE [TRUE]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Send Do Not Use (DUS)	TRUE – FALSE [FALSE]	
Configuration – Trunk	Forward Error Correction (FEC)	TRUE – FALSE [TRUE]	
	G709 OTN	TRUE – FALSE [TRUE]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Tx Power (dBm)	-40.0 – 20.0 [2.0]	
Optical Thresholds-Client – Warning	High Laser Bias (percent)	33.0 – 100.0 [81.0]	31.5 – 100.0 [85.5]
	High Laser Temperature (degrees C)	0.0 – 256.0 [167.5]	0.0 – 256.0 [171.25]
	High Rx Power (dBm)	-19.9 – 30.0 [1.8]	-20.9 – 30.0 [1.9]
	High Rx Temperature (degrees C)	0.0 – 256.0 [225.0]	0.0 – 256.0 [225.0]
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	0.0 – 10000 [10000]
	High Tx Power (dBm)	-19.9 – 30.0 [1.8]	-10.5 – 30.0 [1.9]
	Low Laser Bias (percent)	0.0 – 81.0 [33.0]	0.0 – 85.5 [31.5]
	Low Laser Temperature (degrees C)	0.0 – 256.0 [91.0]	0.0 – 256.0 [90.5]
	Low Rx Power (dBm)	-40.0 – 1.8 [-19.8]	-40.0 – 1.9 [-20.9]
	Low Rx Temperature (degrees C)	0.0 – 256.0 [60.0]	0.0 – 256.0 [60.0]
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	0.0 – 10000 [0.0]
	Low Tx Power (dBm)	-40.0 – 1.8 [-9.9]	-40.0 – 10.5 [-10.5]
Optical Thresholds-Client – Alarm	High Laser Bias (percent)	33.0 – 100.0 [90.0]	
	High Laser Temperature (degrees C)	0.0 – 256.0 [175.0]	
	High Rx Power (dBm)	-19.9 – 30.0 [2.0]	
	High Rx Temperature (degrees C)	0.0 – 256.0 [225.0]	
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	
	High Tx Power (dBm)	-11.0 – 30.0 [2.0]	
	Low Laser Bias (percent)	0.0 – 90.0 [30.0]	
	Low Laser Temperature (degrees C)	0.0 – 256.0 [90.0]	
	Low Rx Power (dBm)	-40.0 – 2.0 [-22.0]	
	Low Rx Temperature (degrees C)	0.00 – 256.00 [60.0]	
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	
	Low Tx Power (dBm)	-40.0 – 2.0 [-11.0]	
Optical Thresholds-Trunk – Warning	High Laser Bias (percent)	33.0 – 100.0 [81.0]	31.5 – 100.0 [85.5]
	High Laser Temperature (degrees C)	0.0 – 256.0 [140.0]	0.00 – 256.00 [142.75]
	High Rx Power (dBm)	-25.2 – 30.0 [-3.3]	-26.6 – 30.0 [-3.2]
	High Rx Temperature (degrees C)	0.0 – 256.0 [181.0]	0.00 – 256.00 [185.5]
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	0.0 – 10000 [10000]
	High Tx Power (dBm)	-22.5 – 30.0 [3.1]	-23.8 – 30.0 [3.3]
	Low Laser Bias (percent)	0.0 – 81.0 [33.0]	0.0 – 85.5 [31.5]
	Low Laser Temperature (degrees C)	0.0 – 256.0 [105.0]	0.00 – 256.00 [105.25]
	Low Rx Power (dBm)	-40.0 – -3.3 [-25.2]	-40.0 – -3.2 [-26.6]
	Low Rx Temperature (degrees C)	0.0 – 256.0 [95.5]	0.00 – 256.00 [95.25]
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	0.0 – 10000 [0.0]
	Low Tx Power (dBm)	-40.0 – 3.1 [-22.5]	-40.0 – -23.8 [-23.8]

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Optical Thresholds-Trunk – Alarm	High Laser Bias (percent)	30.0 – 100.0 [90.0]	
	High Laser Temperature (degrees C)	0.0 – 256.0 [145.0]	
	High Rx Power (dBm)	-28.0 – 30.0 [-3.0]	
	High Rx Temperature (degrees C)	0.0 – 256.0 [190.0]	
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	
	High Tx Power (dBm)	-25.0 – 30.0 [3.5]	
	Low Laser Bias (percent)	0.0 – 90.0 [30.0]	
	Low Laser Temperature (degrees C)	0.0 – 256.0 [105.0]	
	Low Rx Power (dBm)	-40.0 – -3.0 [-28.0]	
	Low Rx Temperature (degrees C)	0.0 – 256.0 [95.0]	
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	
	Low Tx Power (dBm)	-40.0 – 3.5 [-25.0]	
PM Thresholds-Client-Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [21260]	1-13219200 [212600]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Client-Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [21260]	1-13219200 [212600]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Client-Section – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
PM Thresholds-Trunk-Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Trunk-Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Trunk-Section Monitoring (SM) – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
OTN Thresholds-Trunk-Section Monitoring (SM) – Near End	Background Block Errors (BBE)	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
	Unavailable Seconds (UAS)	1-900 [500]	1-86400 [10]

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
OTN Thresholds-Trunk-Section Monitoring (SM) – Far End	Background Block Errors (BBE)	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
	Unavailable Seconds (UAS)	1-900 [500]	1-86400 [10]
OTN Thresholds-Trunk-Path Monitoring (PM) – Near End	Background Block Errors (BBE)	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
OTN Thresholds-Trunk-Path Monitoring (PM) – Far End	Background Block Errors (BBE)	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
FEC Thresholds – Trunk	Bit Errors Corrected	0-900 [903330]	1-86400 [8671968]
	Byte Errors Corrected	0-900 [0]	1-86400 [0]
	One Bit Errors Detected	0-900 [0]	1-86400 [0]
	Uncorrectable Words	0-900 [5]	1-86400 [480]
	Zero Bit Errors Detected	0-900 [0]	1-86400 [0]

Table 6-40: TXP_MR_10G Parameters (Future Release)

Field	Parameter	Threshold Range [Default] 15 Minutes	1 Day
Configuration	Payload Type	SONET/10GigEWANPhy, SDH, 10GigELANPhy [SONET/10GigEWANPhy]	
	Termination Mode	TRANSPARENT, SECTION, LINE [TRANSPARENT]	
Configuration – Line	AINS Soak Time (hrs:min)	00:00 – 48:00 [08:00]	
	AIS Mode	Disabled, Automatic Restart, Manual Restart, Manual Restart for Test [Disabled]	
	AIS Recovery Interval (seconds)	[100]	
	AIS Recovery Pulse Width (seconds)	2.0 – 100.0 [2.0]	
	Route D1-D3	TRUE – FALSE [FALSE]	
	Route D4-D12	TRUE – FALSE [FALSE]	
	Route E1	TRUE – FALSE [FALSE]	
	State	IS, OOS, OOS_AINS, OOS_MT [OOS]	
Configuration – Payload	Enable Synch Messaging	TRUE – FALSE [TRUE]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Send Do Not Use (DUS)	TRUE – FALSE [FALSE]	
Configuration – Trunk	Forward Error Correction (FEC)	TRUE – FALSE [TRUE]	
	G709 OTN	TRUE – FALSE [TRUE]	
	Signal Degrade (SD) BER	1E-5 – 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 – 1E-5 [1E-4]	
	Tx Power (dBm)	-40.0 – 20.0 [2.0]	
Optical Thresholds-Client – Warning	High Laser Bias (percent)	33.0 – 100.0 [81.0]	31.5 – 100.0 [85.5]
	High Laser Temperature (degrees C)	0.0 – 256.0 [167.5]	0.0 – 256.0 [171.25]
	High Rx Power (dBm)	-19.9 – 30.0 [1.8]	-20.9 – 30.0 [1.9]
	High Rx Temperature (degrees C)	0.0 – 256.0 [225.0]	0.0 – 256.0 [225.0]
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	0.0 – 10000 [10000]
	High Tx Power (dBm)	-19.9 – 30.0 [1.8]	-10.5 – 30.0 [1.9]
	Low Laser Bias (percent)	0.0 – 81.0 [33.0]	0.0 – 85.5 [31.5]
	Low Laser Temperature (degrees C)	0.0 – 256.0 [95.5]	0.00 – 256.00 [95.25]
	Low Rx Power (dBm)	-40.0 – 1.8 [-14.4]	-40.0 – 1.9 [-15.2]
	Low Rx Temperature (degrees C)	0.0 – 256.0 [60.0]	0.0 – 256.0 [60.0]
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	0.0 – 10000 [0.0]
	Low Tx Power (dBm)	-40.0 – 1.8 [-7.2]	-40.0 – 7.6 [-7.6]
Optical Thresholds-Client – Alarm	High Laser Bias (percent)	33.0 – 100.0 [90.0]	
	High Laser Temperature (degrees C)	0.0 – 256.0 [175.0]	
	High Rx Power (dBm)	-19.9 – 30.0 [2.0]	
	High Rx Temperature (degrees C)	0.0 – 256.0 [225.0]	
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	
	High Tx Power (dBm)	-11.0 – 30.0 [2.0]	
	Low Laser Bias (percent)	0.0 – 90.0 [30.0]	
	Low Laser Temperature (degrees C)	0.0 – 256.0 [95.0]	
	Low Rx Power (dBm)	-40.0 – 2.0 [-16.0]	
	Low Rx Temperature (degrees C)	0.00 – 256.00 [60.0]	
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	
	Low Tx Power (dBm)	-40.0 – 2.0 [-8.0]	
Optical Thresholds-Trunk – Warning	High Laser Bias (percent)	33.0 – 100.0 [81.0]	31.5 – 100.0 [85.5]
	High Laser Temperature (degrees C)	0.0 – 256.0 [140.5]	0.00 – 256.00 [142.75]
	High Rx Power (dBm)	-25.2 – 30.0 [-3.3]	-26.6 – 30.0 [-3.2]
	High Rx Temperature (degrees C)	0.0 – 256.0 [181.0]	0.00 – 256.00 [185.5]
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	0.0 – 10000 [10000]
	High Tx Power (dBm)	-22.5 – 30.0 [3.1]	-23.8 – 30.0 [3.3]
	Low Laser Bias (percent)	0.0 – 81.0 [33.0]	0.0 – 85.5 [31.5]
	Low Laser Temperature (degrees C)	0.0 – 256.0 [105.5]	0.00 – 256.00 [105.25]
	Low Rx Power (dBm)	-40.0 – -3.3 [-25.2]	-40.0 – -3.2 [-26.6]
	Low Rx Temperature (degrees C)	0.0 – 256.0 [95.5]	0.00 – 256.00 [95.25]
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	0.0 – 10000 [0.0]
	Low Tx Power (dBm)	-40.0 – 3.1 [-22.5]	-40.0 – -23.8 [-23.8]

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Optical Thresholds-Trunk – Alarm	High Laser Bias (percent)	30.0 – 100.0 [90.0]	
	High Laser Temperature (degrees C)	0.0 – 256.0 [145.0]	
	High Rx Power (dBm)	-28.0 – 30.0 [-3.0]	
	High Rx Temperature (degrees C)	0.0 – 256.0 [190.0]	
	High Transceiver Voltage (mV)	0.0 – 10000 [10000]	
	High Tx Power (dBm)	-25.0 – 30.0 [3.5]	
	Low Laser Bias (percent)	0.0 – 90.0 [30.0]	
	Low Laser Temperature (degrees C)	0.0 – 256.0 [105.0]	
	Low Rx Power (dBm)	-40.0 – -3.0 [-28.0]	
	Low Rx Temperature (degrees C)	0.0 – 256.0 [95.0]	
	Low Transceiver Voltage (mV)	0.0 – 10000 [0.0]	
	Low Tx Power (dBm)	-40.0 – 3.5 [-25.0]	
PM Thresholds-Client-Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [21260]	1-13219200 [212600]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Client-Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [21260]	1-13219200 [212600]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Client-Section – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
PM Thresholds-Trunk-Line – Near End	Coding Violations (CV) [B2 count]	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Negative Pointer Justification Count – Path Detected (NPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Negative Pointer Justification Count – Path Generated (NPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Detected (PPJC-Pdet)	1-600 [60]	1-57600 [5760]
	Positive Pointer Justification Count – Path Generated (PPJC-Pgen)	1-600 [60]	1-57600 [5760]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Trunk-Line – Far End	Coding Violations (CV) [B2 count]	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
PM Thresholds-Trunk-Section Monitoring (SM) – Near End	Coding Violations (CV) [B1 count]	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	1-900 [500]	1-86400 [5000]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
OTN Thresholds-Trunk-Section Monitoring (SM) – Near End	Background Block Errors (BBE)	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
	Unavailable Seconds (UAS)	1-900 [500]	1-86400 [10]

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
OTN Thresholds-Trunk-Section Monitoring (SM) – Far End	Background Block Errors (BBE)	1-138600 [10000]	1-13219200 [100000]
	Errored Seconds (ES)	1-900 [500]	1-86400 [5000]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [500]	1-86400 [5000]
	Unavailable Seconds (UAS)	1-900 [500]	1-86400 [10]
OTN Thresholds-Trunk-Path Monitoring (PM) – Near End	Background Block Errors (BBE)	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
OTN Thresholds-Trunk-Path Monitoring (PM) – Far End	Background Block Errors (BBE)	1-137700 [85040]	1-13219200 [850400]
	Errored Seconds (ES)	1-900 [87]	1-86400 [864]
	Failure Count (FC)	1-72 [10]	1-6912 [40]
	Severely Errored Seconds (SES)	1-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	1-900 [3]	1-86400 [10]
FEC Thresholds – Trunk	Bit Errors Corrected	0-900 [903330]	1-86400 [8671968]
	Byte Errors Corrected	0-900 [0]	1-86400 [0]
	One Bit Errors Detected	0-900 [0]	1-86400 [0]
	Uncorrectable Words	0-900 [5]	1-86400 [480]
	Zero Bit Errors Detected	0-900 [0]	1-86400 [0]

Chapter 7 – Systems Planning and Engineering

Note: The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

Purpose

This chapter provides the basic planning and engineering information required to configure an ONS 15454 MSPP for deployment.

Contents

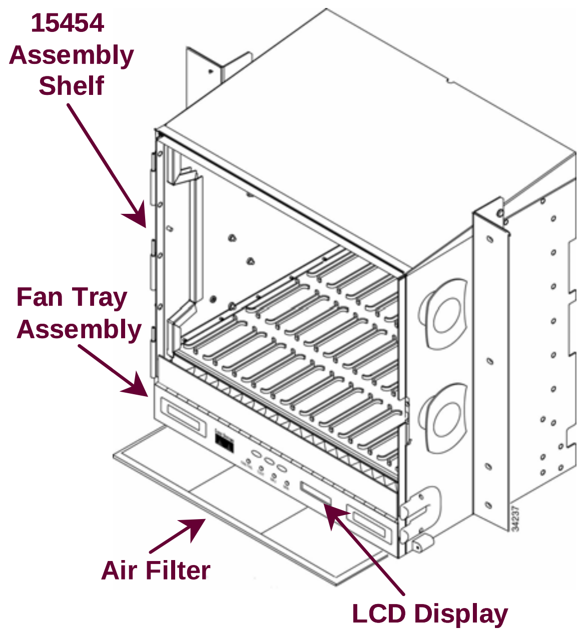
The following topics are included in this chapter:

Note The terms ONS 15454, shelf, and node shall mean a single ONS 15454 assembly shelf in this chapter.

Assembly Shelf

The ONS 15454 is a compact single-shelf multiplexer that houses the fan tray, 5 common and 12 service cards, as well as physical contacts for redundant power feeds, grounding, system timing, LAN interface, and alarm contacts.

Figure 7-1: ONS 15454 Assembly Shelf Design



The shelf assembly has 17 card slots. The card slots, referring to Figure 7-2, are numbered with slot #1 starting at the far left. Each shelf slot is also labeled with an ICON that can be matched with a plug-in card's faceplate ICON, enabling easy identification of card to slot compatibility. Five card slots, slots 7 – 11 indicated in white, are dedicated to system operations, also known as common cards, and twelve card slots, slots 1 – 6 and 12 – 17 indicated in yellow and gray, are for multi-service interface cards. A further breakout is outlined below:

Common Control Equipment – Slots 7 and 11 support the Timing, Communications and Control card, commonly referred to as the TCC. The shelf assembly should be equipped with two TCC cards allowing protected operation.

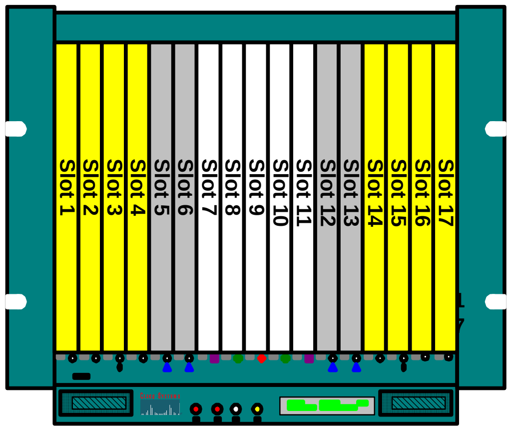
Cross-connect Matrix – Slots 8 and 10 support the Cross-Connect card. The shelf assembly should be equipped with two cross-connect cards, of matching variety, to allow protected operation.

Alarm Monitoring – Slot 9 supports an optional hardware component, the Alarm Interface Controller card. This is an optional card that provides environmental alarm inputs and output controls, orderwire, and user data channel capabilities.

Service Modules - Slots 1 through 6 and slots 12 through 17 are compatible with a wide variety of interface cards. Depending on the cross-connect card selected, these slots will be compatible with different interface cards. The gray card slots, slots 5, 6, 12, and 13 in Figure 7-2, are considered the high-speed slots, and the yellow card slots, slots 1 through 4 and 14 through 17, are the low-speed card slots. Depending on the cross-connect card selected, XC, XC-VT, or XC-10G, the high-speed slots support up to STS-192 bandwidth and the low-speed slots support up to STS-48 bandwidth. Service interface cards can be operated in protected and unprotected pairs or groups.

Shelf Slot Filler Cards – For any unpopulated card slot numbered 1 to 17, a blank filter slot card, model 15454-BLANK, must be installed to maintain proper airflow and compliance to EMI and ESD regulations outlined in Telcordia NEBS documents.

Figure 7-2: Shelf Assembly Slots



Shelf Selection

Table 7-1 lists the shelf assembly versions deployed to date. For systems running Software R3.1 or higher, use the 15454-SA-ANSI shelf.

Table 7-1: Shelf Assembly Versions

Product Name	Model Number	Description
15454-SA-ANSI	800-19857	Cisco NEBS Level 3 compliant shelf with enhanced fiber management and increased power rating
15454-SA-NEBS3E	800-07149	Cisco NEBS Level 3 compliant shelf with enhanced fiber management
15454-SA-NEBS3	800-06741	Cisco NEBS Level 3 compliant shelf
454-SA-NEBS3 (Cerent)	89-01-00018	Cerent NEBS Level 3 compliant shelf
454-SA-R1 (Cerent)	89-01-00013	Cerent 454 shelf

The 15454-SA-ANSI shelf is required for 10 Gb/s transport. It has enhanced fiber management capabilities and an increased power rating over previous shelf versions. The ANSI shelf meets NEBS Level 3 specifications for Type 2 and Type 4 equipment, which is intended for installation in restricted access areas. The physical and environmental specifications for the ONS 15454 ANSI shelf is listed in Table 7-2.

Table 7-2: ONS 15454 ANSI Shelf Specifications

Assembly Shelf Requirements	Specification
Dimensions:	
Height	18.5-inches
Width	19- or 23-inches
Depth	12-inches
Footprint	13 $ft.^2$
Minimum Aisle Clearance Requirement	24-inches
Environmental:	
Total Weight	165 lbs.
Input Power	-48VDC
Maximum Power Consumption	1060W
Maximum Amperage	24A
Minimum Fuse Recommendation (includes safety margin)	30A
Compliance	NEBS Level 3

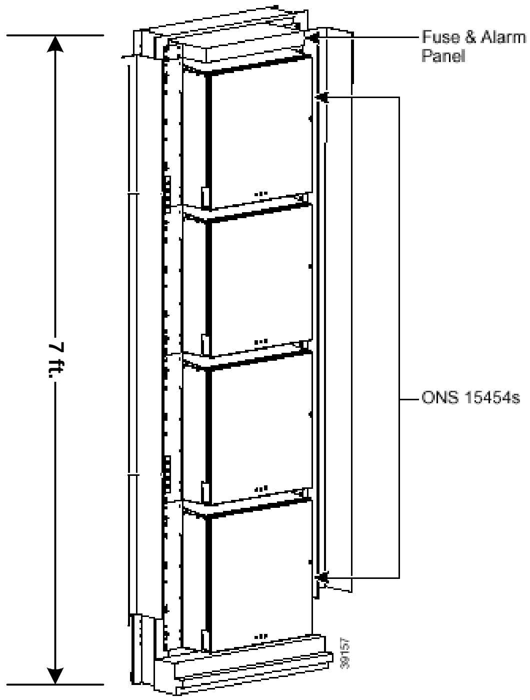
Shelf Installation

Warning To prevent the equipment from overheating, do not operate it in an area that exceeds the maximum recommended ambient temperature of 131°F (55°C) unless configured for industrial temperature (I-temp). All I-temp rated components are –40°C to +65°C. To prevent airflow restriction, allow at least 1 inch (25.4 mm) of clearance around the ventilation openings.

The ONS 15454 is typically mounted in a 19- or 23-inch equipment rack as shown in Figure 7-3. The shelf assembly projects five inches (127 mm) from the front of the rack. It mounts in both EIA-standard and Telcordia-standard racks. The shelf assembly is a total of 17 inches (431.8 mm) wide with no mounting ears attached. Ring runs are not provided by Cisco and may hinder side-by-side installation of shelves where space is limited.

The ONS 15454 ANSI shelf measures 18.5 inches (469.9 mm) high, 19- or 23-inches (482.6 or 584.2 mm) wide (depending on which way the mounting ears are attached), and 12-inches (304.8 mm) deep. It weighs approximately 55 pounds empty. One person can install an ONS 15454 ANSI shelf in an equipment frame using the temporary set screws included. You can install up to four ONS 15454 shelves in a seven-foot (2133.6 mm) equipment rack. The ONS 15454 must have one inch (25.4 mm) of airspace below the installed shelf assembly to allow air flow to the fan intake. If a second ONS 15454 is installed underneath the shelf assembly, the air ramp on top of the lower shelf assembly provides the air spacing needed and should not be modified in any way.

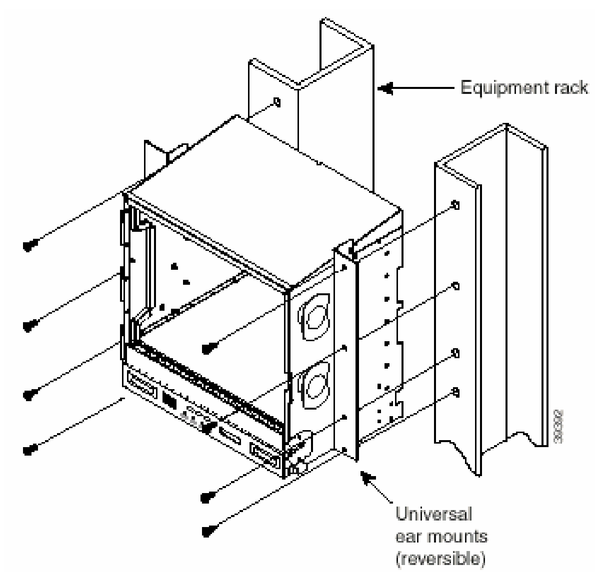
Figure 7-3: Typical Equipment Rack Arrangement



Mounting a Single Node

Mounting the ONS 15454 in a rack requires a minimum of 18.5 inches (469.9 mm) of vertical rack space and one additional inch (25.4 mm) for air flow. To ensure the mounting is secure, use two to four #12-24 mounting screws for each side of the shelf assembly. Figure 7-4 shows the rack mounting position for the ONS 15454.

Figure 7-4: Mounting an ONS 15454 in a Rack



If incremental shelves are to be installed, Cisco recommends that they be installed from the bottom of the equipment rack to the top to simplify cabling. However, shelves may be added in any position so long as proper bay cabling is selected.

Incremental ONS 15454 shelves can be installed by local technicians. Most standard seven-foot racks can hold four ONS 15454 shelves and a fuse and alarm panel. However, unequal flange racks are limited to three ONS 15454 shelves and a fuse and alarm panel or four ONS 15454 shelves and a fuse and alarm panel from an adjacent rack.

If you plan to use the external (bottom) brackets to install the fan-tray air filter, you can install three shelf assemblies in a standard seven-foot rack. If you do not use the external (bottom) brackets, you can install four shelf assemblies in a rack. The advantage to using the bottom brackets is that you can replace the filter without removing the fan tray.

Fan-Tray Assembly

Caution Do not operate an ONS 15454 without the mandatory fan-tray air filter.

The fan-tray assembly is located at the bottom of the ONS 15454 fan-tray assembly. The fan tray is a removable drawer that holds fans and fan-control circuitry for the ONS 15454. The front door can be left in place or removed before installing the fan-tray assembly. After you install the fan tray, you should only need to access it if a fan failure occurs or you need to replace or clean the fan-tray air filter.

The front of the fan-tray assembly has an LCD screen that provides slot and port-level information for all ONS 15454 card slots, including the number of Critical, Major, and Minor alarms. The LCD also tells you whether the software load is SONET or SDH and the software version number.

Release 4.0 allows you to modify parameters and control the following displayed information:

Suppression of LCD IP display
Display of the NE defaults name
Alarm output one-button toggle (alarm counts and alarm summary in the LCD are displayed alternately)

You can also modify display parameters to prohibit configuration changes via the LCD display touchpad.

The fan-tray assembly features an air filter at the bottom of the tray that you can install and remove by hand. Remove and visually inspect this filter every 30 days and keep spare filters in stock. Refer to the Cisco ONS 15454 Troubleshooting Guide for information about cleaning and maintaining the fan-tray air filter.

Fan-Tray Selection

There are presently two series of fan tray assemblies available for the ONS 15454: the FTA3-T high airflow assembly and the FTA2 standard airflow assembly. The FTA3-T should be used for all new installations and offers higher airflow capabilities required to support systems equipped with XC-10G cross-connect cards and is rated for industrial temperature installations (-40 to +65 Celsius). The FTA3-T employs a positive stop insertion pin to prevent the installation of the fan tray assembly into shelf assembly versions prior to the current ANSI offering. Use Table 7-3 to select the fan-tray assembly that is compatible with the version of shelf assembly you plan to use.

Table 7-3: Fan Tray Assembly Compatibility

Fan-Tray Product Name	Model Number	Compatible Shelf Assemblies Product Name	Model Number
15454-FTA3-T (required for XC-10G equipped systems)	800-21448	15454-SA-ANSI	800-19857
15454-FTA2 (required for I-temp)	800-07145 800-07385 800-19591 800-19590	15454-SA-ANSI 15454-SA-NEBS3E 15454-SA-NEBS3E 15454-SA-NEBS3E	800-19857 800-07149 800-07149 800-07149

Power requirements for the FTA3-T and FTA2 fan-tray assemblies are listed in Table 7-4.

Table 7-4: Fan Tray Assembly Power Requirements

Fan Tray Assembly	Watts	Amps	BTU/Hr.
15454-FTA3-T	86.4	1.8	295
15454-FTA2	53	1.21	198

If one or more fans fail on the fan-tray assembly, replace the entire assembly. You cannot replace individual fans. The red Fan Fail LED on the front of the fan tray illuminates when one or more fans fail. For fan tray replacement instructions, refer to the *Cisco ONS 15454 Troubleshooting Guide*. The red Fan Fail LED clears after you install a working fan tray.

Air Filter

The ONS 15454 contains a reusable air filter; Model 15454-FTF2, that is installed either beneath the fan-tray assembly or in the optional external filter brackets. Earlier versions of the ONS 15454 used a disposable air filter that is installed beneath the fan-tray assembly only. However, the reusable air filter is backward compatible.

Power Supply Requirements

For proper operation, the ONS 15454 must be powered from a power source that can provide sufficient wattage at a specific voltage. These two factors, in addition to how they relate to amperage, must be taken into consideration when choosing a power source for the ONS 15454. Table 7-5 lists the power requirements for the ONS 15454.

Table 7-5: ONS 15454 Power Supply Requirements

Item	Requirement
Acceptable Input DC Voltage Range	-42 to -57VDC
Recommended Input DC Voltage (two power feeds: A and B)	-48VDC (power feed A and power feed B)
Circuit Breakers (two per shelf)	30A (breaker A and breaker B)

Watts

The maximum wattage that can be drawn by the 15454-SA-ANSI shelf (System Release 3.1 and higher) based upon selecting system components with the highest power draw is 1060 watts. Maximum wattage that can be drawn by the 15454-SA-NEBS3E shelf (prior to Release 3.1) is 952 watts.

Amps

Maximum amperage required by the 15454-SA-ANSI shelf is approximately 24A. However, to ensure a sufficient operational safety margin, Cisco recommends that the ANSI shelf be fused at 30A. The nominal maximum amperage required by the 15454-SA-NEBS3E shelf is approximately 20A. However, to ensure a sufficient operational margin, Cisco recommends that the NEBS3E shelf be fused at 25A.

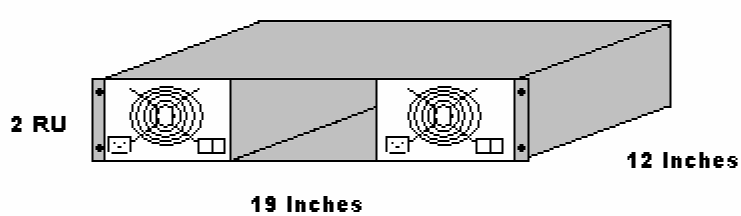
Power Solutions

The power solution required for proper operation of a Cisco ONS 15454 is dependent on the your specific needs and shelf configuration. To power a single shelf, a 3- to 5-rack unit (RU) AC-to-DC rectifier will typically suffice. For configurations that call for redundant power feeds to the shelf through the A and B battery terminals, two rectifiers will be necessary. To power several Cisco ONS 15454 shelves, a larger solution requiring a full equipment bay may be more appropriate. Additionally, you should consider using an uninterrupted power system (UPS) with integrated battery back-up, to enable a Cisco ONS 15454 node to operate if AC power is lost.

For configurations that require less than 1050 watts, Cisco offers an AC-DC power rectifier (part number 15540-PWR-AC) that can be rack mounted along with the ONS 15454. This redundant rectifier solution can provide up to 1050 watts to both the BAT 1 and BAT 2 power connectors on the back of the ONS 15454.

The Cisco AC-DC Power Rectifier offers up to 1050 watts while supplying -52VDC. The rectifier takes input from a standard 120 V electrical outlet into the 15A keyed IEC 320 AC connector, and places the output -52VDC on a Molex PN: 42820 two-pin terminal block connector. The product is shipped in a redundant configuration consisting of one rack mount and two power rectifiers, as illustrated in Figure 7-5.

Figure 7-5: Cisco AC-DC Power Rectifier



For node configurations that require more than 1050 watts or for configurations with multiple shelves, a third party vendor should be consulted. To help compare power solutions, please note that vendors will typically state the product's capabilities as a specific amperage at a specific voltage (for example, 50A @ 48V).

Cisco does not endorse any specific vendor and recommends considering solutions from as many vendors as appropriate. Vendors listed below are a sampling of companies providing power solutions suitable for the Cisco ONS 15454. Information regarding these vendor's products can be found on their respective Web sites.

APC	www.apc.com
Hendry	www.hendry.com
Eltek	www.eltek.no
Sorensen	www.sorensen.com

Power Feeds

The ONS 15454 has redundant -48VDC #8 power feeds on the shelf assembly backplane. Power terminals (shown in Figure 7-6) are labeled BAT1, RET1, BAT2, and RET2 and are located on the lower section of the backplane behind a clear plastic cover.

Figure 7-6: Dielectric Power Block

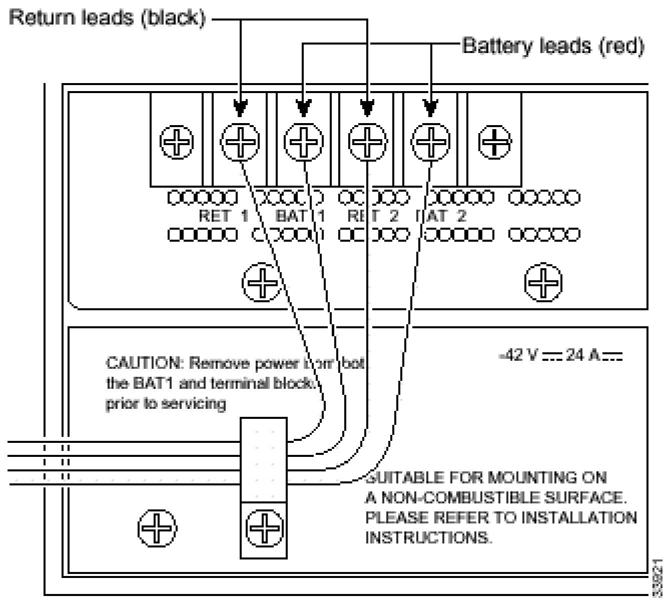
The black piece of plastic is dielectric and has been increased in length to better isolate the A and B power feeds. This design better protects against voltage spikes and accidental shorting.

The redundant –48VDC is distributed through the backplane to each of the 17 card slots. Every ONS 15454 card contains O-Ring diodes to isolate the battery feeds, inrush-limiting and filtering circuitry, and local switching regulation. Wire-wrap pins on the backplane provide frame grounds to minimize any transient voltage or current disruptions to the system when a card is inserted in the shelf.

To install redundant power feeds, use four power cables and one ground cable (#10 AWG, copper conductor, 194°F [90°C]) and one ground cable (#6 AWG). Cisco recommends the following wiring conventions illustrated in Figure 7-7:

Red wire for battery connections (–48 VDC)
Black wire for battery return connections (0 VDC)

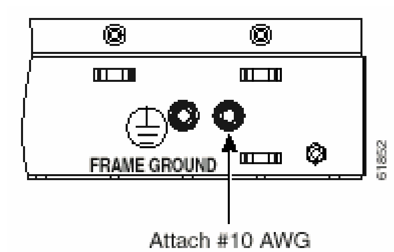
Figure 7-7: Power Feed Connections



Grounding Requirements

The existing ground post is a #10-32 bolt. The nut provided for a field connection is also a #10 AWG (2.588 mm²), with an integral lock washer. The lug must be a dual-hole type and rated to accept the #6 AWG (4.115 mm²) cable. Two posts are provided on the Cisco ONS 15454 to accommodate the dual-hole lug. Figure 7-8 shows the location of the ground posts.

Figure 7-8: Ground Posts on the ONS 15454 Backplane



Ground only one cable to ground the shelf assembly. Terminate the other end of the ground cable to ground according to local site practice. Connect a ground terminal for the frame ground (FGND) terminal according to local site practice.

External Alarms and Control

For environmental alarms and power monitoring, use the AIC card with ONS 15454 systems running software prior to R3.4, or use the AIC-I card for systems running Software Release 3.4 and higher. The ONS 15454 shelf assembly supports the termination of multiple environmental alarms. Table 7-6 details the alarm termination capacities of the AIC and AIC-I cards based upon the equipment configuration. LEDs on the front panel of the AIC and AIC-I cards indicate the status of the alarm lines, one LED representing all the inputs and one LED representing all the outputs. The physical connections are made using the backplane wire-wrap pins.

Table 7-6: Alarm Termination Capacity

Configuration	Termination Capacity
AIC card only	Up to 4 input and 4 output environmental alarms via rear wire-wrap pins
AIC-I card only	12 input plus 4 provisionable as input or output environmental alarms via rear wire-wrap pins
AIC-I plus optional AEP	32 input and 16 output environmental alarms via two 50-pin AMP CHAMP connectors

External alarms (input contacts) are typically used for external sensors such as open doors, temperature sensors, flood sensors, and other environmental conditions. External controls (output contacts) are typically used to drive visual or audible devices such as bells and lights, but they can control other devices such as generators, heaters, and fans.

You can program each of the input alarm contacts separately. Choices include Alarm on Closure or Alarm on Open, an alarm severity of any level (Critical, Major, Minor, Not Alarmed, Not Reported), a Service Affecting or Non-Service Affecting alarm-service level, and a 63-character alarm description for CTC display in the alarm log. You cannot assign the fan-tray abbreviation for the alarm, because the abbreviation reflects the generic name of the input contacts. The alarm condition remains raised until the external input stops driving the contact or you provision the alarm input.

The output contacts can be provisioned to close on a trigger or to close manually. The trigger can be a local alarm severity threshold, a remote alarm severity, or a virtual wire as follows:

> Local NE alarm severity: A hierarchy of non-reported, non-alarmed, minor, major or critical alarm severities that you set to cause output closure. For example, if the trigger is set to minor, a minor alarm or above is the trigger.
>
> Remote NE alarm severity: Same as the Local NE alarm severity but applies to remote alarms only.
>
> Virtual wire entities: You can provision any environmental alarm input to raise a signal on any virtual wire on external outputs 1 through 4 when the alarm input is an event. You can provision a signal on any virtual wire as a trigger for an external control output.

You can also program the output alarm contacts (external controls) separately. In addition to provisionable triggers, you can manually force each external output contact to open or close. Manual operation takes precedence over any provisioned triggers that might be present.

Alarm Contact Connections

The alarm pin field supports up to 17 alarm contacts, including four audible alarms, four visual alarms, one alarm cutoff (ACO), and four user-definable alarm input and output contacts.

Audible alarm contacts are in the LOCAL ALARM AUD pin field and visual contacts are in the LOCAL ALARM VIS pin field. Both of these alarms are in the LOCAL ALARMS category. User-definable contacts are in the ENVIR ALARM IN (external alarm) and ENVIR ALARM OUT (external control) pin fields. These alarms are in the ENVIR ALARMS category and you must have the AIC card installed to use the ENVIR ALARMS. Alarm contacts are Normally Open (N/O), meaning that the system closes the alarm contacts when the corresponding alarm conditions are present. Each alarm contact consists of two wire-wrap pins on the shelf assembly backplane. Visual and audible alarm contacts are classified as critical, major, minor, and remote.

Figure 7-9 and Figure 7-10 shows the wire-wrap pins on the backplane pin field. Figure 7-11 shows alarm pin assignments.

Figure 7-9: ONS 15454 Backplane Pinouts (System Release 3.4 and higher)

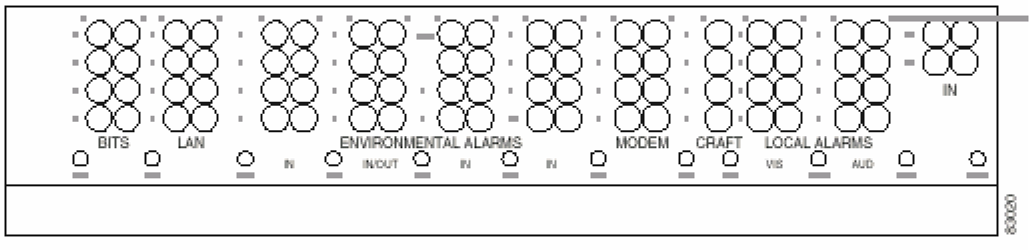


Figure 7-10: ONS 15454 Backplane Pinouts (prior to System Release 3.4)

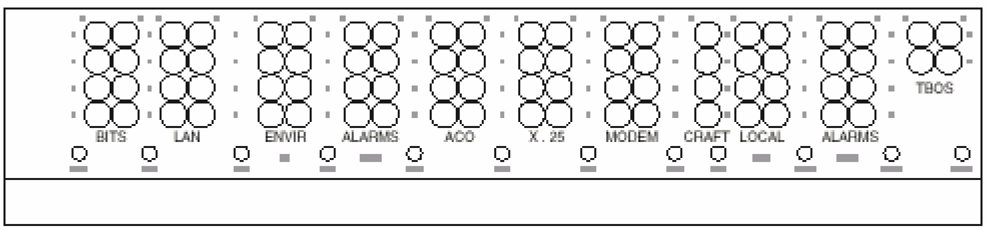


Figure 7-11: Alarm Pin Assignments

Field	Pin	Function
BITS	A1	BITS Output 2 negative (-)
	B1	BITS Output 2 positive (+)
	A2	BITS Input 2 negative (-)
	B2	BITS Input 2 positive (+)
	A3	BITS Output 1 negative (-)
	B3	BITS Output 1 positive (+)
	A4	BITS Input 1 negative (-)
	B4	BITS Input 1 positive (+)
LAN		Connecting to a hub, or switch
	A1	RJ-45 pin 6 RX-
	B1	RJ-45 pin 3 RX+
	A2	RJ-45 pin 2 TX-
	B2	RJ-45 pin 1 TX+
		Connecting to a PC/Workstation or router
	A1	RJ-45 pin 2 RX-
	B1	RJ-45 pin 1 RX+
	A2	RJ-45 pin 6 TX-
	B2	RJ-45 pin 3 TX+
ENVIR ALARMS IN	A1	Alarm input pair number 1: Reports closure on connected wires.
	B1	
	A2	Alarm input pair number 2: Reports closure on connected wires.
	B2	
	A3	Alarm input pair number 3: Reports closure on connected wires.
	B3	
	A4	Alarm input pair number 4: Reports closure on connected wires.
	B4	

Field	Pin	Function
ENVIR ALARMS OUT N/O	A1	Normally open output pair number 1
	B1	
	A2	Normally open output pair number 2
	B2	
	A3	Normally open output pair number 3
	B3	
	A4	Normally open output pair number 4
	B4	
ACO	A1	Normally open ACO pair
	B1	
CRAFT	A1	Receive (PC pin #2)
	A2	Transmit (PC pin #3)
	A3	Ground (PC pin #5)
	A4	DTR (PC pin #4)
LOCAL ALARMS AUD (Audible) N/O	A1	Alarm output pair number 1: Remote audible alarm.
	B1	
	A2	Alarm output pair number 2: Critical audible alarm.
	B2	
	A3	Alarm output pair number 3: Major audible alarm.
	B3	
	A4	Alarm output pair number 4: Minor audible alarm.
	B4	
LOCAL ALARMS VIS (Visual) N/O	A1	Alarm output pair number 1: Remote visual alarm.
	B1	
	A2	Alarm output pair number 2: Critical visual alarm.
	B2	
	A3	Alarm output pair number 3: Major visual alarm.
	B3	
	A4	Alarm output pair number 4: Minor visual alarm.
	B4	

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Visual and audible alarms are typically wired to trigger an alarm light or bell at a central alarm collection point when the corresponding contacts are closed. You can use the Alarm Cutoff pins to activate a remote ACO for audible alarms. You can also activate the ACO function by pressing the ACO button on the TCC+/TCC2 card faceplate. The ACO function clears all audible alarm indications. After clearing the audible alarm indication, the alarm is still present and viewable in the Alarms tab in CTC.

Alarm Expansion Panel

The optional ONS 15454 alarm expansion panel (AEP) can be used with the Alarm Interface Controller card (AIC-I) card to provide an additional 48 dry alarm contacts for the ONS 15454, 32 of which are inputs and 16 are outputs. The AEP is a printed circuit board assembly that is installed on the backplane.

Each AEP alarm input port has provisionable label and severity. The alarm inputs have optocoupler isolation. They have one common 32VDC output and a maximum of 2 mA per input. Each opto metal oxide semiconductor (MOS) alarm output can operate by definable alarm condition, a maximum open circuit voltage of 60 VDC, anda maximum current of 100 mA.

Table 7-7 shows the wire-wrap pins and corresponding signals on the AIC-I and AEP.

Table 7-7: AEP Wire Wrap Connections

Wire-Wrap Pin	Signal on AIC-I	Signal on AEP	P1-pins on AEP
TIP_1	GND	AEP_GND	7
TIP_2	AE_+5V	AEP_+5V	8
TIP_3	VBAT-	VBAT-	9
TIP_4	VB+	VB+	10
TIP_6	AE_CLK_P	AE_CLK_P	6
TIP_7	AE_CLK_N	AE_CLK_N	5
TIP_8	AE_DIN_P	AE_DOUT_P	4
TIP_9	AE_DIN_N	AE_DOUT_P	3
TIP_10	AE_DOUT_P	AE_DIN_P	2
TIP_11	AE_DOUT_N	AE_DIN_N	1

The connection to the external alarm sources must be done according to Table 7-8.

Table 7-8: Alarm Input Pin Association

AMP Champ Pin Number	Signal Name	AMP Champ Pin Number	Signal Name
1	ALARM_IN_1-	27	GND
2	GND	28	ALARM_IN_2-
3	ALARM_IN_3-	29	ALARM_IN_4-
4	ALARM_IN_5-	30	GND
5	GND	31	ALARM_IN_6-
6	ALARM_IN_7-	32	ALARM_IN_8-
7	ALARM_IN_9-	33	GND
8	GND	34	ALARM_IN_10-
9	ALARM_IN_11-	35	ALARM_IN_12-
10	ALARM_IN_13-	36	GND
11	GND	37	ALARM_IN_14-
12	ALARM_IN_15-	38	ALARM_IN_16-
13	ALARM_IN_17-	39	GND
14	GND	40	ALARM_IN_18-
15	ALARM_IN_19-	41	ALARM_IN_20-
16	ALARM_IN_21-	42	GND
17	GND	43	ALARM_IN_22-
18	ALARM_IN_23-	44	ALARM_IN_24-
19	ALARM_IN_25-	45	GND
20	GND	46	ALARM_IN_26-
21	ALARM_IN_27-	47	ALARM_IN_28-
22	ALARM_IN_29-	48	GND
23	GND	49	ALARM_IN_30-
24	ALARM_IN_31-	50	N.C.
25	ALARM_IN_+	51	GND1
26	ALARM_IN_0-	52	GND2

Use the pin numbers in Table 7-9 to connect to the external elements being switched by external alarms.

Table 7-9: Pin Association for Alarm Output Pins

AMP Champ Pin Number	Signal Name	AMP Champ Pin Number	Signal Name
1	N.C.	27	COM_0
2	COM_1	28	N.C.
3	NO_1	29	NO_2
4	N.C.	30	COM_2
5	COM_3	31	N.C.
6	NO_3	32	NO_4
7	N.C.	33	COM_4
8	COM_5	34	N.C.
9	NO_5	35	NO_6
10	N.C.	36	COM_6
11	COM_7	37	N.C.
12	NO_7	38	NO_8
13	N.C.	39	COM_8
14	COM_9	40	N.C.
15	NO_9	41	NO_10
16	N.C.	42	COM_10
17	COM_11	43	N.C.
18	NO_11	44	NO_12
19	N.C.	45	COM_12
20	COM_13	46	N.C.
21	NO_13	47	NO_14
22	N.C.	48	COM_14
23	COM_15	49	N.C.
24	NO_15	50	N.C.
25	N.C.	51	GND1
26	NO_0	52	GND2

Power Monitoring

The AIC-I card provides a power monitoring circuit that monitors the supply voltage of –48 VDC for presence, undervoltage, or overvoltage.

The TCC2 also monitors both A and B supply voltage inputs of the assembly shelf. It Overrides the AIC-I card and will force the AIC-I LEDs to match Power Monitor LEDs on the TCC2. The TCC2 is capable of detecting a blown fuse based on shared knowledge between the active and standby TCC2s. An alarm will be generated if one of the supply voltage inputs has a voltage out of the specified range of -42 to -57VDC.

Timing Connections

The ONS 15454 backplane supports two Building Integrated Timing Supply (BITS) clock pin fields. The first four BITS pins, rows 3 and 4, support output and input from the first external timing device. The last four BITS pins, rows 1 and 2, perform the identical functions for the second external timing device. Table 7-10 lists the pin assignments for the BITS timing pin fields.

Table 7-10: BITS External Timing Pin Assignments

External Device	Contact	Tip and Ring	Function
First external device	A3 (BITS 1 Out)	Primary ring (–)	Output to external device
	B3 (BITS 1 Out)	Primary tip (+)	Output to external device
	A4 (BITS 1 In)	Secondary ring (–)	Input from external device
	B4 (BITS 1 In)	Secondary tip (+)	Input from external device
Second external device	A1 (BITS 2 Out)	Primary ring (–)	Output to external device
	B1 (BITS 2 Out)	Primary tip (+)	Output to external device
	A2 (BITS 2 In)	Secondary ring (–)	Input from external device
	B2 (BITS 2 In)	Secondary tip (+)	Input from external device

LAN Connections

Use the LAN pins on the ONS 15454 backplane to connect the ONS 15454 to a workstation or Ethernet LAN, or to a LAN modem for remote access to the node. You can also use the LAN port on the TCC+/TCC2 faceplate to connect a workstation or to connect the ONS 15454 to the network. Table 7-11 shows the LAN pin assignments.

Note Before you can connect an ONS 15454 to other ONS 15454s or to a LAN, you must change the default IP address that is shipped with each ONS 15454 (192.1.0.2).

Table 7-11: ONS 15454 LAN Pin Assignments

Pin Field	Backplane Pins	RJ-45 Pins
LAN 1 Connecting to data circuit-terminating equipment (DCE[1]) such as a hub or switch	B2	1
	A2	2
	B1	3
	A1	6
LAN 1 Connecting to data terminal equipment (DTE) such as a PC, workstation or router	B1	1
	A1	2
	B2	3
	A2	6

[1] The Cisco ONS 15454 is DCE.

Card Slot Assignment Rules

The ONS 15454 supports 5 types of cards: common, Alarm Interface Controller (AIC), electrical, optical, and Ethernet. The common cards include the Timing Control Cards (TCC+ and TCC2) and cross-connect cards (XC, XC-VT, and XC-10G). Table 7-12 lists the compatibility of common cards to software releases.

Table 7-12: Common Card Software and Hardware Compatibility

Card	R2.2.1	R2.2.2	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	XC	XC-VT	XC10G
TCC+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TCC2	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes
XC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
XC-VT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
XC10G	-	-	-	Yes	Yes	Yes	Yes	Yes	-	-	Yes
AIC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AIC-I	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes
AEP	-	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes

Timing Control Card Selection

For systems running Software R4.0 or higher, use the TCC2 card. For all other software releases, use the TCC+ card.

To enable OC-192 and OC-48 any-slot card operation, use the XC-10G card, the TCC+ or TCC2 card, Software R3.1 to R3.4, and the new 15454-SA-ANSI shelf assembly. Do not pair an XC or XC-VT with an XC-10G card.

To enable OC-192 and OC-48 any-slot card operation on systems running Software R4.0 and higher, use TCC2 card with the XC-10G card, and the new 15454-SA-ANSI shelf assembly. Do not pair an XC or XC-VT with an XC-10G card.

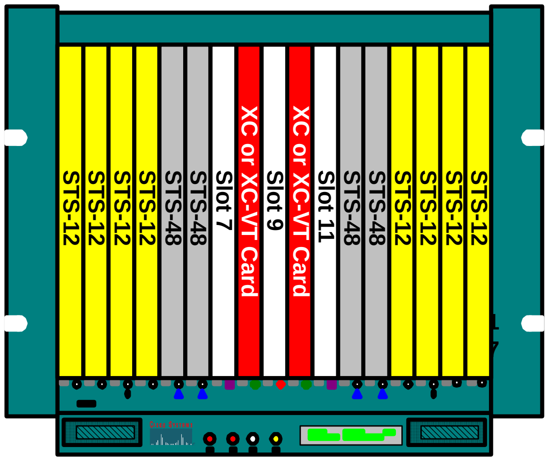
Cisco does not support operation of the ONS 15454 with only one TCC+ or TCC2 card. For full functionality and to safeguard your system, always operate in a redundant configuration. You can have a network of ONS 15454 nodes with mixed TCC+ and TCC2 cards, but you cannot mix these two cards in the same node.

The TCC+ and TCC2 cards can be installed in slots 7 and 11 only.

Cross-connect Card Selection

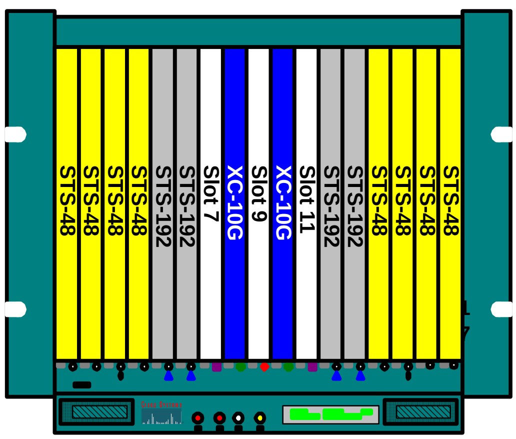
The selection of the proper cross-connect card is critical, as the cross-connect card is the "bandwidth enabling" device for the shelf assembly. As depicted in Figure 7-12, an ONS 15454 equipped with the XC or XC-VT cross-connect card can in slots 8 and 10 support up to 2.49 Gb/s (STS-48) bandwidth in card slots 5, 6, 12, and 13, and up to 622 Mb/s (STS-12) bandwidth in card slots 1-4 and 14-17.

Figure 7-12: Per Slot Bandwidth Available with the XC and XC-VT Cross-connect Cards



Equipped with the XC-10G cross-connect card, card slots 5, 6, 12, and 13 can support up to 10Gb/s (STS-192) bandwidth and up to 2.5Gb/s (STS-48) bandwidth in card slots 1-4 and 14-17, as shown in Figure 7-13.

Figure 7-13: Per Slot Bandwidth Available with the XC-10G Cross-connect Card



Card and System Compatibility

When configuring an ONS 15454 node, use Table 7-13 to determine the compatibility between common control cards, interface cards, slot assignments, shelf assemblies, and software.

Table 7-13: Card-to-Card System Compatibility

Card	Slot Assignment	TCC Card	Cross-connect Card	Shelf Assembly	Fan-Tray Assembly	Software
TCC+	7 and 11	-	All	All	All	R2.2 – R4.0
TCC2	7 and 11	-	All	All	All	≥ R4.0
XC	8 and 10	All TCC2	-	All	All	≥ R2.0 – R4.0 ≥ R4.0
XC-VT	8 and 10	All TCC2	-	All	All	≥ R2.2 – R4.0 ≥ R4.0
XC-10G	8 and 10	All TCC2	-	SA-ANSI	FTA3-T	≥ R3.1 – R4.0 ≥ R4.0
AIC	9	All TCC2	All	All	All	≥ R2.2 – R4.0 ≥ R4.0
AIC-I	9	All TCC2	All	All	All	≥ R3.4 – R4.0 ≥ R4.0
AEP	Backplane	All TCC2	All	All	All	≥ R3.4 – R4.0 ≥ R4.0
DS1-14	1-6 and 12-17	All TCC2	All	All	All	≥ R2.2 – R4.0 ≥ R4.0
DS1N-14	1:1 protection: 1-6 and 12-17 1:N protection: 3, 5	All TCC2	All	All	All	≥ R2.2 – R4.0 ≥ R4.0
DS3-12	1-6 and 12-17	All TCC2	All	All	All	≥ R2.2 – R4.0 ≥ R4.0
DS3N-12	1:1 protection: 1-6 and 12-17 1:N protection: 3, 5	All TCC2	All	All	All	≥ R2.2 – R4.0 ≥ R4.0
DS3-12E	1-6 and 12-17	All TCC2	All	All	All	≥ R3.0 – R4.0 ≥ R4.0
DS3N-12E	1:1 protection: 1-6 and 12-17 1:N protection: 3, 5	All TCC2	All	All	All	≥ R3.0 – R4.0 ≥ R4.0
DS3XM-6	1-6 and 12-17	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
EC1-12	1-6 and 12-17	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
OC3-4IR1310	1-6 and 12-17	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
OC38I-1310	1-4 and 14-17	All TCC2	All	SA-ANSI	FTA3-T	R4.0 ≥ R4.0
OC12IR1310	1-6 and 12-17	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
OC12LR1310	1-6 and 12-17	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
OC12LR1550	1-6 and 12-17	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
OC12I4-1310	1-4 and 14-17	All TCC2	XC-10G	SA-ANSI	FTA3-T	R3.3 – R4.0 ≥ R4.0
OC48IR1310	5, 6, 12, 13	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
OC48LR1550	5, 6, 12, 13	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0

Card	Slot Assignment	TCC Card	Cross-connect Card	Shelf Assembly	Fan-Tray Assembly	Software
OC48IR1310A (any slot)	1-6 and 12-17	All TCC2	All	All	All	R3.2 – R4.0 ≥ R4.0
OC48LR1550A (any slot)	1-6 and 12-17	All TCC2	All	All	All	R3.2 – R4.0 ≥ R4.0
OC48ELR-100GHz	5, 6, 12, 13	All TCC2	All	All	All	R3.3 – R4.0 ≥ R4.0
OC48ELR-200GHz	5, 6, 12, 13	All TCC2	All	All	All	R2.2 – R4.0 ≥ R4.0
OC192SR1310	5, 6, 12, 13	TCC+ TCC2	XC-10G	SA-ANSI	FTA3-T	R4.0 ≥ R4.0
OC192IR1550	5, 6, 12, 13	TCC+ TCC2	XC-10G	SA-ANSI	FTA3-T	R4.0 ≥ R4.0
OC192LR1550	5, 6, 12, 13	TCC+ TCC2	XC-10G	SA-ANSI	FTA3-T	R3.1 – R4.0 ≥ R4.0
OC192LR-100GHz	5, 6, 12, 13	TCC+ TCC2	XC-10G	SA-ANSI	FTA3-T	R4.0 ≥ R4.0
MXP_2.5G_10G	1-6 and 12-17	TCC2	XC-10G	SA-ANSI	FTA3-T	TBD
TXP_MR_10G	1-6 and 12-17	TCC2	XC-10G	SA-ANSI	FTA3-T	TBD
E100T-12 E100T-G	1-4 and 14-17	All TCC2	XC, XC-VT	All	All	≥ R2.2 – R4.0 ≥ R4.0
E1000-2 E1000-2-G	1-4 and 14-17	TCC+ TCC2	All	All	All	≥ R2.2 – R4.0 ≥ R4.0
G1000-4	1-4 and 14-17	TCC+ TCC2	XC-10G	SA-ANSI	FTA3-T	R3.2 – R3.4 ≥ R4.0
G1K-4	1-4 and 14-17	TCC+ TCC2	XC-10G All	SA-ANSI All	FTA3-T	R3.2 – R3.4 ≥ R4.0
ML100T-12	5, 6, 12, 13 1-6 and 12-17	All TCC2	XC, XC-VT XC-10G	All	All	R4.0 ≥ R4.0
ML1000-2	5, 6, 12, 13 1-6 and 12-17	All TCC2	XC, XC-VT XC-10G	All	All	R4.0 ≥ R4.0

CISCO SYSTEMS

Electrical Interface Adapters

The ONS 15454 supports a wide range of service types, each requiring a particular mechanical interface, whether fiber, coax or twisted pair. Optical and Ethernet service interface cards have card mounted, front faceplate connections. This enables physical termination directly on the card itself. The electrical cards, including DS1, DS3, and EC1, all require rear access connections to the backplane. The mechanical interfaces for the electrical cards are terminated on the rear of the shelf assembly using an Electrical Interface Adapter (EIA). The ONS 15454 shelf assembly supports two EIAs. Side A interoperates with card slots 1 to 6 and Side B interoperates with card slots 12 to 17. Select an EIA from the available configurations found in Table 7-14.

Table 7-14: Available EIA Configurations

EIA Type	Interface Cards Supported	A Side Capacity	A Side Connectors Map To	A Side Product Number	B Side Capacity	B Side Connectors Map To	B Side Product Number
Low-Density BNC	DS-3 DS3XM-6 EC-1	24 pairs of BNC connectors	Slot 2 and Slot 4	15454-EIA-BNC-A24	24 pairs of BNC connectors	Slot 14 and Slot 16	15454-EIA-BNC-B24
High-Density BNC	DS-3 DS3XM-6 EC-1	48 pairs of BNC connectors	Slot 1, Slot 2, Slot 4, and Slot 5	15454-EIA-BNC-A48	48 pairs of BNC connectors	Slot 13, Slot 14, Slot 16, and Slot 17	15454-EIA-BNC-B48
SMB	DS-1 DS-3 EC-1 DS3XM-6	84 pairs of SMB connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, and Slot 6	15454-EIA-SMB-A84	84 pairs of SMB connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, and Slot 17	15454-EIA-SMB-B84
AMP Champ	DS-1	6 AMP Champ connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, and Slot 6	15454-EIA-AMP-A84	6 AMP Champ connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, and Slot 17	15454-EIA-AMP-B84

EIAs can be mixed or matched on an ONS 15454 assembly shelf, allowing flexibility for terminating different electrical interfaces on a single shelf. Any EIA can be installed on any version of ONS 15454 shelf assembly.

Gigabit Interface Converters (GBICs)

When working with ONS 15454 Gigabit Ethernet cards, choose the appropriate GBIC from Table 7-15.

Table 7-15: Cisco GBIC Options

Card	Usable GBIC
E1000-2	IEEE 1000BaseSX compliant 850-nm GBIC IEEE 1000BaseLX compliant 1300-nm GBIC
E1000-2-G	IEEE 1000BaseSX compliant 850-nm GBIC IEEE 1000BaseLX compliant 1300-nm GBIC
G1000-4	IEEE 1000BaseSX compliant 850-nm GBIC IEEE 1000BaseLX compliant 1300-nm GBIC IEEE 1000BaseZX compliant 1550-nm GBIC
G1K-4	IEEE 1000BaseSX compliant 850-nm GBIC IEEE 1000BaseLX compliant 1300-nm GBIC IEEE 1000BaseZX compliant 1550-nm GBIC
ML1000-2	IEEE 1000BaseSX compliant 850-nm SFP IEEE 1000BaseLX compliant 1300-nm SFP (for a future release)

Cabling

Cables are not included with the ONS 15454 and must be ordered separately. Optical and electrical cables can be ordered from the following third party vendors:

Amphenol RF
Amphenol Fiber Optic Products
Fibersource International/Suncall
Senko Advanced Components
Seiko Instruments
Seikoh Geiken
Molex
ADC Telecommunications
AFOP(Alliance Fiber Optic Products)
UConn
Diamond
Westek Electronics

Table 7-16 lists the cable assemblies that can be ordered through Cisco for use on the ONS 15454.

Table 7-16: Cisco ONS 15454 Cable Assemblies

Part Number	Description	Cable Length
15454-SMB-BNC-10	SMB to BNC cable assembly	10 ft.
15454-SMB-BNC-30	SMB to BNC cable assembly	30 ft.
15454-SMB-BNC-50	SMB to BNC cable assembly	50 ft.
15454-SMB-BNC-70	SMB to BNC cable assembly	75 ft.
15454-AMP-WW-30	AMP Champ unterminated wire-wrap cable	30 ft.
15454-AMP-WW-50	AMP Champ unterminated wire	50 ft.
15454-AMP-WW-100	AMP Champ unterminated wire	100 ft.
15454-AMP-WW-250	AMP Champ unterminated wire	250 ft.

Table 7-17 lists the maximum length of cable you can have between the EIA and patch panel or cross-connect frame.

Table 7-17: Maximum EIA Cable Distance

EIA Interface	Impedance	Cable	Cable Length on Each Side of DSX
SMB: AMP #415504-3	75 Ohm	RG179	79 ft (24.1 m)
BNC: Trompeter #UCBJ224	75 Ohm	RG59	450 ft (137.2 m)
AMP Champ: AMP #552246-1 with #552562-2 bail locks	100 Ohm	Twisted Pair	655 ft (199.6 m)

Cable Routing and Management

The ONS 15454 cable management facilities include the following:

A cable-routing channel that runs the width of the shelf assembly.

Plastic horseshoe-shaped fiber guides at each side opening of the cable-routing channel that ensure the proper bend radius is maintained in the fibers. You can remove the fiber guide if necessary to create a larger opening (if you need to route CAT-5 Ethernet cables out the side, for example). To remove the fiber guide, take out the three screws that anchor it to the side of the shelf assembly.

A fold-down door that provides access to the cable-management tray.

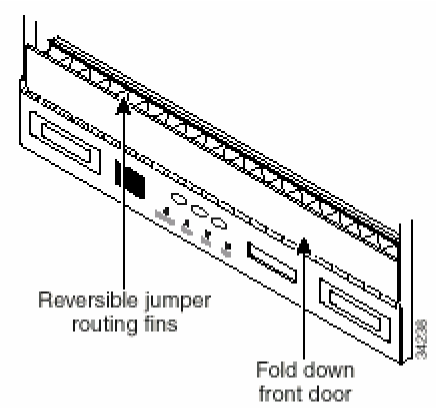
Cable tie-wrap facilities on EIAs that secure cables to the cover panel.

Reversible jumper routing fins that enable you to route cables out either side by positioning the fins as desired.

Jumper slack storage reels (2) on each side panel that reduce the amount of slack in cables that are connected to other devices. To remove the jumper slack storage reels, take out the screw in the center of each reel.

Figure 7-14 shows the cable management facilities that you can access through the fold-down front door, including the cable-routing channel and the jumper routing fins.

Figure 7-14: Cable Management Tray on the Front Panel



Coaxial Cable Management

Coaxial cables connect to EIAs on the ONS 15454 backplane using cable connectors. EIAs feature cable-management eyelets for tie wrapping or lacing cables to the cover panel.

DS-1 Twisted-Pair Cable Management

Connect twisted pair/DS-1cables to SMB EIAs on the ONS 15454 backplane using cable connectors and DS-1 electrical interface adapters (baluns).

AMP Champ Cable Management

EIAs have cable management eyelets to tie-wrap or lace cables to the cover panel. Tie-wrap or lace the AMP Champ cables according to local site practice and route the cables. If you configure the ONS 15454 for a 23-inch rack, two additional inches (50.8 mm) of cable management area is available on each side of the shelf assembly.

Synchronization

The Cisco ONS 15454 is designed to operate in a network that complies with recommendations stated in GR-253-CORE and GR-436-CORE.

1. SONET timing parameters must be set for each ONS 15454. Each ONS 15454 independently accepts its timing reference from one of three sources:

2. The BITS (building integrated timing supply) pins on the ONS 15454 backplane.

3. An OC-N card installed in the ONS 15454. The card is connected to a node that receives timing through a BITS source.

4. The internal ST3 clock on the TCC+/TCC2 card.

You can set ONS 15454 timing to one of three modes: external, line, or mixed. If timing is coming from the BITS pins, set the ONS 15454 timing to external. If the timing comes from an OC-N card, set the timing to line. Node timing for a typical ONS 15454 network would be as follows:

> One node will be set to external timing. The external node will derive its timing from a BITS source wired to the BITS backplane pins. The BITS source will derive its timing from a Primary Reference Source (PRS) such as a Stratum 1 clock or GPS signal.
>
> The other ONS 15454 nodes will be set to line. The line nodes will derive timing from the externally timed ONS 15454 node through the OC-N trunk (span) cards.

Caution Mixed timing allows you to select both external and line timing sources. However, Cisco does not recommend its use because it can create timing loops. Use this mode with caution.

You can set three timing references for each ONS 15454. The first two references are typically two BITS-level sources, or two line-level sources optically connected to a node with a BITS source. The third reference is the internal clock provided on every ONS 15454 TCC+/TCC2 card. This clock is a Stratum 3 (ST3). If an ONS 15454 becomes isolated, timing is maintained at the ST3 level.

Synchronization Status Messaging

Synchronization status messaging (SSM) is a SONET protocol that communicates information about the quality of the timing source. SSM messages are carried on the S1 byte of the SONET Line layer. They enable SONET devices to automatically select the highest quality timing reference and to avoid timing loops.

SSM messages are either Generation 1 or Generation 2. Generation 1 is the first and most widely deployed SSM message set. Generation 2 is a newer version. If you enable SSM for the ONS 15454, consult your timing reference documentation to determine which message set to use. Table 7-18 and Table 7-19 show the Generation 1 and Generation 2 message sets.

Table 7-18: SSM Generation 1 Message Set

Message	Quality	Description
PRS	1	Primary reference source – Stratum 1
STU	2	Sync traceability unknown
ST2	3	Stratum 2
ST3	4	Stratum 3
SMC	5	SONET minimum clock
ST4	6	Stratum 4
DUS	7	Do not use for timing synchronization
RES		Reserved; quality level set by user

Table 7-19: SSM Generation 2 Message Set

Message	Quality	Description
PRS	1	Primary reference source – Stratum 1
STU	2	Sync traceability unknown
ST2	3	Stratum 2
TNC	4	Transit node clock
ST3E	5	Stratum 3E
ST3	6	Stratum 3
SMC	7	SONET minimum clock
ST4	8	Stratum 4
DUS	9	Do not use for timing synchronization
RES		Reserved; quality level set by user

Common System Configurations

The ONS 15454 only requires a few components to enable turn-up of the system. The following is a list of the minimum configuration necessary to build a functional system:

Shelf Assembly (one required): Provides the card cage for the fan tray, common control and client interface cards as well as physical inputs for redundant power inputs, grounding, system timing, LAN interface, and alarm contacts.

Fan Tray Assembly (one required): Required for maintaining the proper operating temperature for the system.

Timing, Communications and Control (TCC) Card (two required): This is the brain of the system.

System Software (preloaded on the TCC): The ONS 15454 system software is typically ordered and shipped pre-installed on the TCC card. A spare version on CD/ROM is typically ordered for back-up purposes.

Cross-connect Card (two required): This card performs the cross-connection of circuits within the shelf and provides protection switching for circuits.

Equipment Rack: The ONS 15454 is rack-mounted and can be installed in either 19-inch or 23-inch frames.

Power and Grounding: The ONS 15454 system requires a nominal input voltage of –48 VDC fused at 30A. The assembly shelf should be grounded to a common building ground or to the frame.

The ONS 15454 system can be activated with only the above equipment. All that is left is for you to select the appropriate transport and tributary cards and EIAs to meet the particular application.

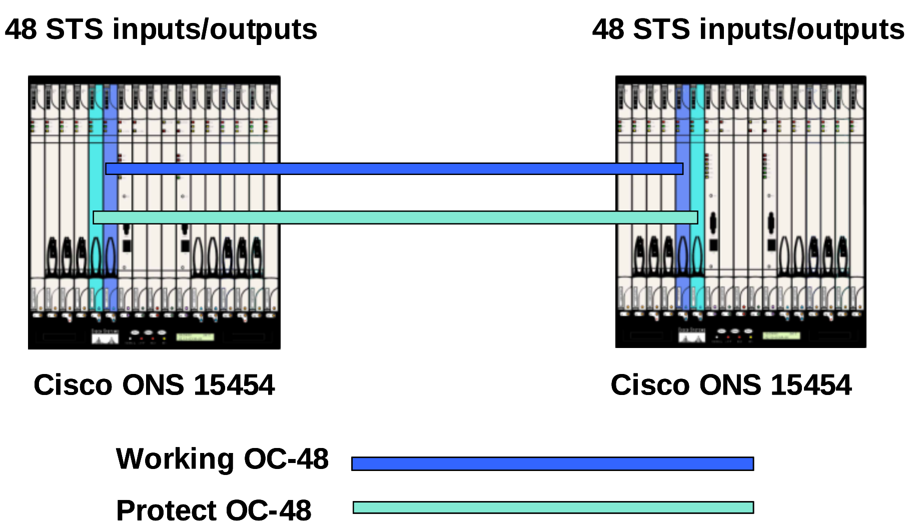
The most common ONS 15454 system configurations are:

Point-to-Point
Linear ADM
Unidirectional Path-Switched Ring Path Protection Configuration
Bi-directional Line-Switched Ring (BLSR)
Subtending Rings

Point-to-Point Configurations

Point-to-point or 1+1 protected extensions are often used to interconnect SONET subnetworks. Examples include interconnection of two access networks and interconnection between interoffice rings. ONS 15454 nodes can be configured as illustrated in Figure 7-15 to provide 1+1 protected transport directly to end users when the fiber topology warrants point-to-point connection rather than ring connection.

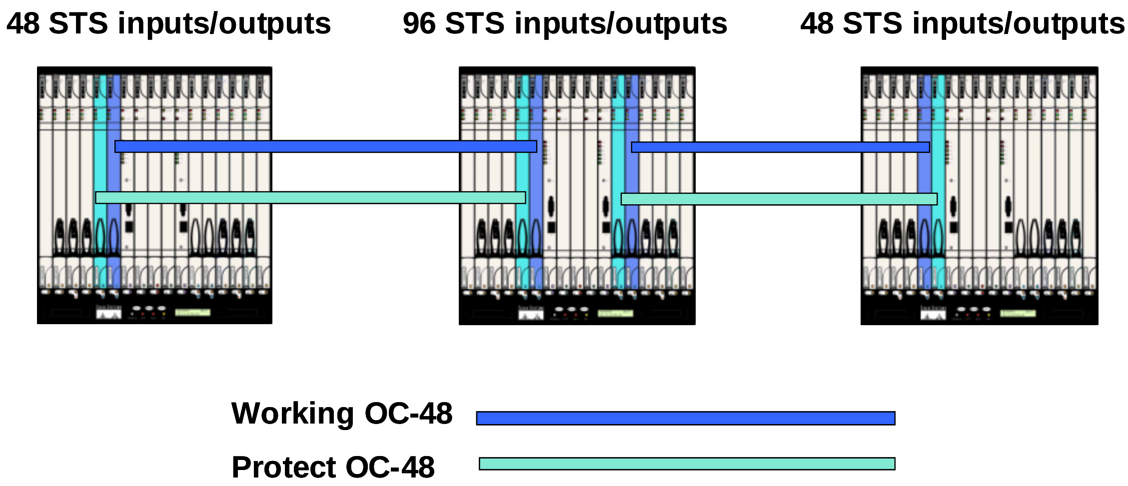
Figure 7-15: Point-to-Point 1+1 Protection Configuration



Linear ADM Configurations

You can configure ONS 15454s as a line of add/drop multiplexers (ADMs) by configuring one set of OC-N cards as the working path and a second set as the protect path. Unlike rings, linear (point-to-point) ADMs require that the OC-N cards at each node be in 1+1 protection to ensure that a break to the working line is automatically routed to the protect line. Figure 7-16 shows three ONS 15454 nodes in a linear ADM configuration.

Figure 7-16: Linear ADM Configuration



Path Protection Configurations

Path Protection Configurations provide duplicate fiber paths around the ring. Working traffic flows in one direction and protection traffic flows in the opposite direction. If a problem occurs with the working traffic path, the receiving node switches to the path coming from the opposite direction.

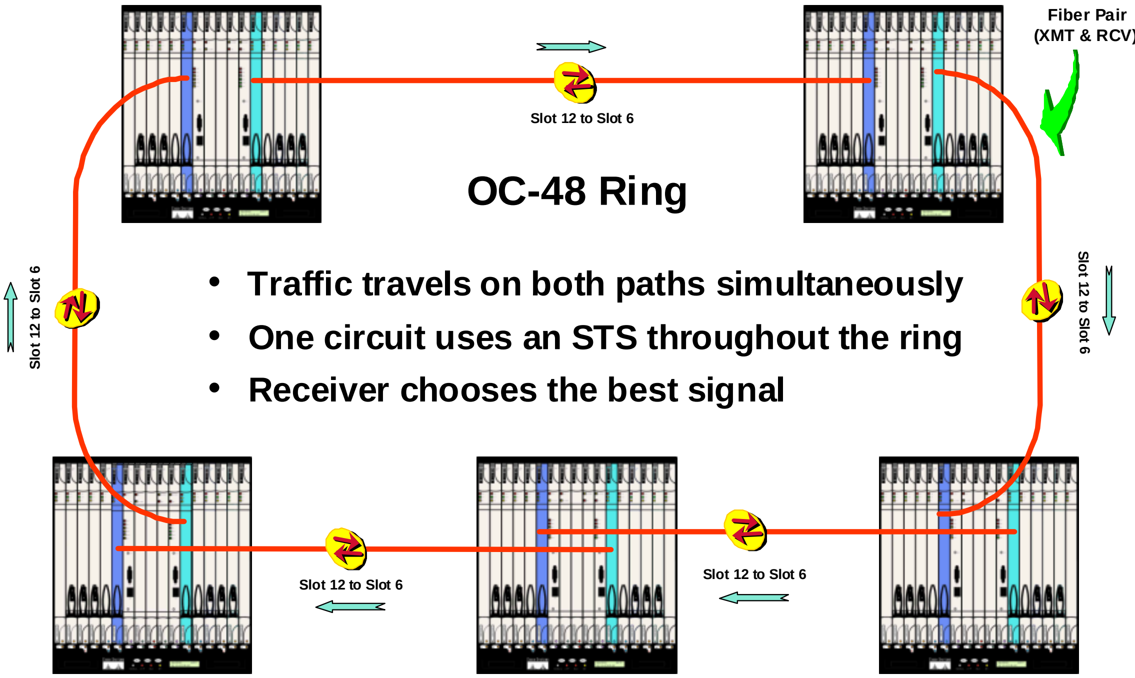
Path Protection Configuration is the default ring configuration for the ONS 15454. CTC automates the Path Protection Configuration configuration on a circuit-by-circuit basis during the circuit provisioning process. If a path-protected circuit is not defined within a 1+1 or BLSR line protection scheme and path protection is available and specified, CTC uses Path Protection Configuration as the default.

A Path Protection Configuration circuit requires two DCC-provisioned optical spans per node. Path Protection Configuration circuits can be created across these spans until their bandwidth is consumed.

If a Path Protection Configuration circuit is created manually by TL1, data communications channels (DCCs) are not needed. Therefore, Path Protection Configuration circuits are limited by the cross-connection bandwidth, or the span bandwidth, but not by the number of DCCs.

The Path Protection Configuration circuit limit is the sum of the optical bandwidth containing 10 section data communications channels (SDCCs) divided by two if you are using redundant TCC+ cards or 32 SDCCs divided by two if you are using redundant TCC2 cards. The spans can be of any bandwidth from OC-3 to OC-192. The circuits can be of any size from VT1.5 to 192c. Figure 7-17 shows a basic OC-48 Path Protection Configuration configuration.

Figure 7-17: Basic OC-48 Path Protection Configuration



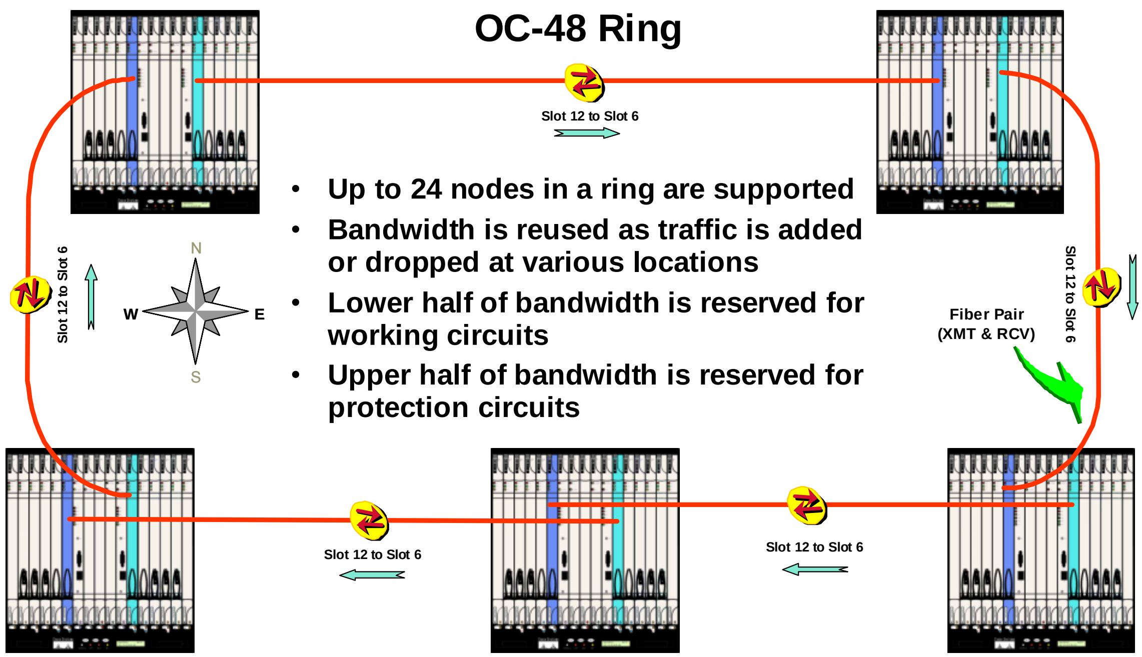
Two-Fiber BLSR Configuration

In two-fiber BLSRs, each fiber is divided into working and protect bandwidths. For example, in an OC-48 BLSR, STSs 1 through 24 carry the working traffic, and STSs 25 through 48 are reserved for protection. Working traffic (STSs 1 – 24) travels in one direction on one fiber and in the opposite direction on the second fiber. CTC circuit routing routines calculate the shortest path for circuits based on many factors, including user requirements, traffic patterns, and distance.

The SONET K1, K2, and K3 bytes carry the information that governs BLSR protection switches. Each BLSR node monitors the K bytes to determine when to switch the SONET signal to an alternate physical path. The K bytes communicate failure conditions and actions taken between nodes in the ring.

If a break occurs on one fiber, working traffic targeted for a node beyond the break switches to the protect bandwidth on the second fiber. The traffic travels in a reverse direction on the protect bandwidth until it reaches its destination node. At that point, traffic is switched back to the working bandwidth. Figure 7-18 shows a basic OC-48 BLSR configuration.

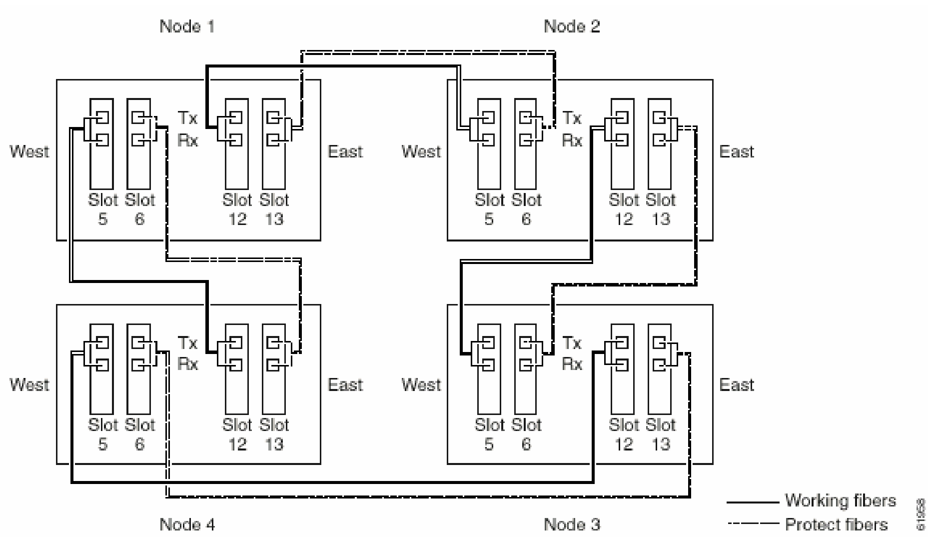
Figure 7-18: Basic OC-48 BLSR Configuration



Four-Fiber BLSR Configuration

Four-fiber BLSRs double the bandwidth of two-fiber BLSRs. Because they allow span switching as well as ring switching, four-fiber BLSRs increase the reliability and flexibility of traffic protection. Two fibers are allocated for working traffic and two fibers for protection, as shown in Figure 7-19. To implement a four-fiber BLSR, you must install four OC-48, OC-48AS, or OC-192 cards at each BLSR node. Four-fiber BLSRs provide span and ring switching.

Figure 7-19: Four-Fiber BLSR Fiber Connections



Subtending Rings and Shelves

The ONS 15454 supports up to ten SONET SDCCs with TCC+ cards and 32 SONET SDCCs with TCC2 cards. See Table 7-20 and Table 7-21 for ring and SDCC information.

Table 7-20: ONS 15454 Rings with Redundant TCC+ Cards

Ring Type	Maximum Rings per Node
2-Fiber BLSR	2
4-Fiber BLSR	1
Path Protection Configuration	5

Table 7-21: ONS 15454 Rings with Redundant TCC2 Cards

Ring Type	Maximum Rings per Node
2-Fiber BLSR	2
4-Fiber BLSR	1
Path Protection Configuration	16

Table 7-22 shows the combination of subtending ring configurations each ONS 15454 can support.

Table 7-22: Supported Subtending Ring Configurations

≤ Release 3.4	≥ Release 4.0
5 Path Protection Configurations, or	16 Path Protection Configurations, or
4 Path Protection Configurations and 1 Two-Fiber BLSR, or	15 Path Protection Configurations and 1 Two-Fiber BLSR, or
3 Path Protection Configurations and 2 Two-Fiber BLSRs, or	14 Path Protection Configurations and 2 Two-Fiber BLSRs, or
3 Path Protection Configurations and 1 Four-Fiber BLSR	14 Path Protection Configurations and 1 Four-Fiber BLSR

Subtending rings reduce the number of nodes and cards required and reduce external shelf-to-shelf cabling. Figure 7-20 shows multiple rings subtending from Node 1 inside the CO. Node 1 is part of an OC-192 BLSR (see Figure 7-21). It has an OC-192 BLSR going into the primary shelf, three OC-12 subtending Path Protection Configurations, and one 1+1 OC-48 drop to the subtending shelf. The subtending shelf contains multiple OC-3 and DS-3 drops supporting various end users.

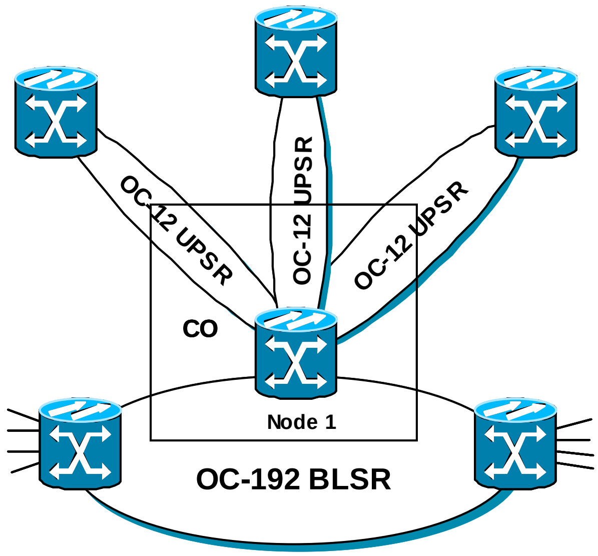


Figure 7-20: Multiple Subtending Rings

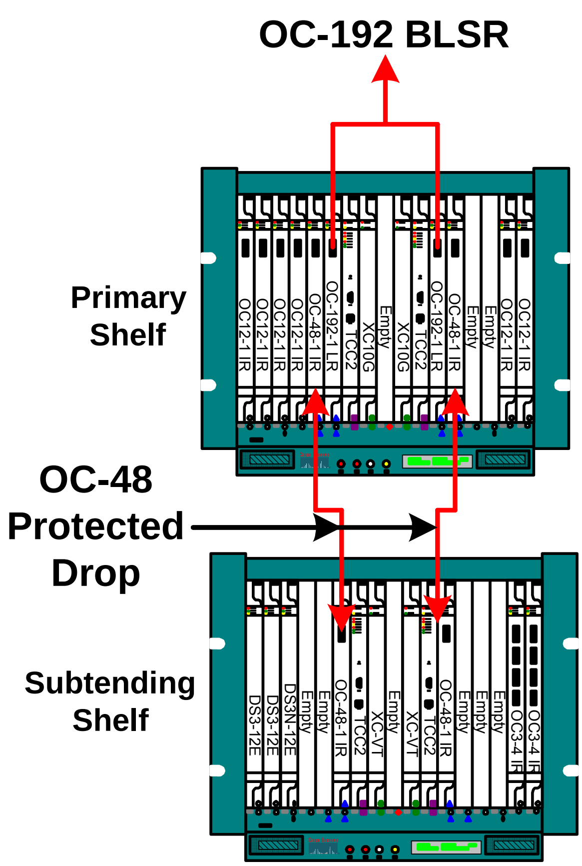


Figure 7-21: Node 1 Subtending Shelves

Maximum Shelf Capacities

Table 7-23 shows the maximum OC-192 capacity for an ONS 15454shelf with a single OC-192 feed in 1+1 protection.

Table 7-23: Maximum OC-192 Shelf Capacities

Application	Protected Ports	Unprotected Ports
DS1[1]	112[1]	140[2]
DS3[2]	96[3]	120[2]
DS3XM	24	48
EC1	48[2]	120[2]
OC-3 (4-port)	20	40
OC-3 (8-port)	40	64
OC-12	5	10
OC-12 (4-port)	16	32[4]
OC-48	2	4
OC-48 (any slot)	4	8[3]
OC-48-ITU-T	2	4
OC192	2	4
OC-192-ITU-T	2	4
E100T-12	NA[5]	120
E1000-2	NA[5]	20
E100T-G	NA[5]	120
E1000-2-G	NA[5]	20
G1000-4	NA[5]	40
G1K-4	NA[5]	40
ML100T-12	NA[5]	120
ML1000-2	NA[5]	20

1 Requires AMP Champ EIAs on side A and B of the backplane.
2 Requires SMB EIAs on side A and B of the backplane.
3 Requires BNC High-Density EIAs on side A and B of the backplane.
4 Requires two OC-192 feeds in 1+1 protection mode.
5 SONET and STP protection available only.

Protection Modes

Optical protection switching occurs automatically in response to detected faults, as well as manual requests initiated by local or remote users. The Cisco ONS 15454 supports 50 milliseconds (ms) 1+1 unidirectional or bi-directional protection switching upon detecting a signal failure or condition such as LOS, LOF, AIS-L or high BER on one or more of the optical card's ports. Revertive and nonrevertive switching options are available down to the circuit level.

The protection modes supported by the Cisco ONS 15454 are described in Table 7-24.

Table 7-24: Protection Modes

Mode	Description
Unidirectional	Each ONS 15454 node bridges it's transmit information on the working and protect lines. When traffic is switched from a bad line, only the receiving node performs a switch. The APS channel (which is carried in the K1 and K2 bytes of the signal on the protection line) is used to indicate the local switch action and the mode of operation. Path Protection Configuration is the default mode for 1+1 protection groups in the ONS 15454.
Bi-directional	Each ONS 15454 node monitors it's receive bit stream on the currently active path. When a problem is detected, both nodes transfer their transmit bit stream to the protection line. Switching of only one direction is not allowed. Head end to tail end signaling is accomplished using the APS channel. The ONS 15454 Bi-directional Path Switched Ring (BLSR) protection mode is configured by the user during initial turn up of the ring.
Revertive	In revertive mode, a failure is detected and the working line temporarily switches to the protect line using the K1/K2 bytes. When the working line is restored and meets the BER criteria, a wait-to-restore (WTR) timer is initiated in the ONS 15454 to prevent "switch bouncing." Traffic is switched back to the working line at both ONS 15454 nodes when the working line has recovered from the failure and the WTR interval has been met, or the manual switch command is cleared. Traffic will revert back to the working line again using the K1/K2 bytes. Revertive protection is illustrated in Figure 2-27.
Non-Revertive	In non-revertive mode, the ONS 15454 detects a failure and switches the working line to the protect line using the K1/K2 bytes. The protect line now becomes the working line and the previous working line will become the protect line. If the line that failed is restored, traffic will not switch back. There is no WTR setting for non-revertive switching. Traffic will not be switched back unless the current working line develops trouble. Non-revertive protection is illustrated in Figure 2-28.

The ONS 15454 provides less than 50 ms automatic path, line, and Path Protection Configuration dual ring interconnect switching as described in GR-1400-CORE and GR-253-CORE.

Electrical Card Protection

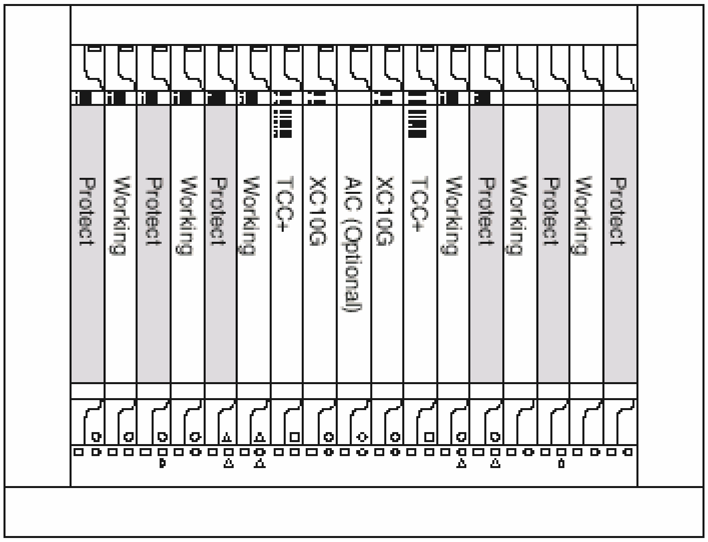
The ONS 15454 provides the following electrical card protection methods:

1:1
1:N
1x0

1:1 Protection

In 1:1 protection, a working card is paired with a protect card of the same type. If the working card fails, the traffic from the working card switches to the protect card. You can provision 1:1 to be revertive or nonrevertive. If revertive, traffic automatically reverts to the working card after the failure on the working card is resolved. Figure 7-22 shows the ONS 15454 in a 1:1 protection configuration.

Figure 7.22: 1:1 Electrical Card Protection Configuration



Each working card in an even-numbered slot is paired with a protect card in an odd-numbered slot. Slot 1 is protecting Slot 2, Slot 3 is protecting Slot 4, Slot 5 is protecting Slot 6, Slot 17 is protecting Slot 16, Slot 15 is protecting Slot 14, and Slot 13 is protecting Slot 12. The following electrical cards use a 1:1 protection scheme:

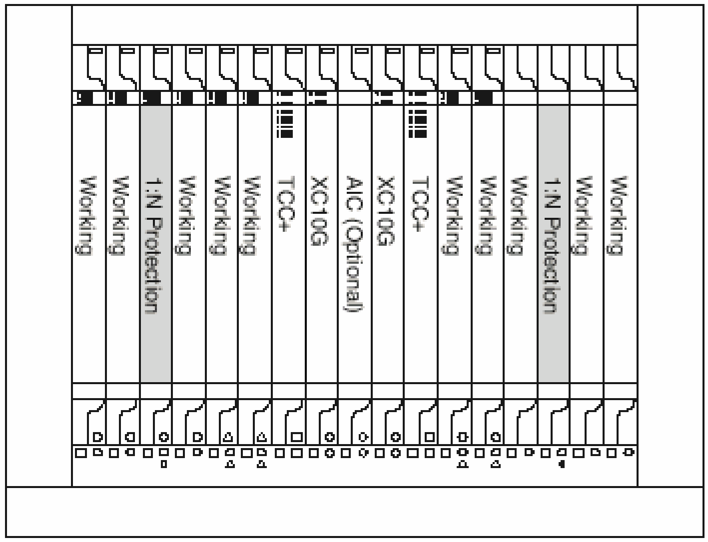
EC1-12
DS1-14
DS3-12
DS3-12E
DSCXM-6

1:N Protection

1:N protection allows a single card to protect up to five working cards of the same DS-N level. A DS1N-14 card protects DS1-14 cards, a DS3N-12 card protects DS3-12 cards, and DS3N-12E cards protect DS3-12E cards. The standard DS1-14, DS3-12, and DS3-12E cards provide 1:1 protection only. Currently, 1:N protection operates only at the DS-1 and DS-3 levels. 1:N cards have added circuitry to act as the protection card in a 1:N protection group. Otherwise, the card is identical to the standard card and can serve as a normal working card.

The physical DS-1 or DS-3 interfaces on the ONS 15454 backplane use the working card until the working card fails. When the node detects this failure, the protection card takes over the physical DS-1 or DS-3 electrical interfaces through the relays and signal bridging on the backplane. Figure 7-23 shows the ONS 15454 in a 1:N protection configuration. Each side of the shelf assembly has only one card protecting all of the cards on that side.

Figure 7-23: 1:N Electrical Card Protection Configuration



Revertive Switching

1:N protection supports revertive switching. Revertive switching sends the electrical interfaces (traffic) back to the original working card after the card comes back online. Detecting an active working card triggers the reversion process. There is a variable time period for the lag between detection and reversion, called the revertive delay, which you can set using the ONS 15454 software, CTC. To set the revertive delay, refer to the *Cisco ONS 15454 Procedure Guide*. All cards in a protection group share the same reversion settings. 1:N protection groups default to automatic reversion.

1:N Protection Guidelines

The following rules apply to 1:N protection groups in the ONS 15454:

- Working and protect card groups must reside in the same card bank (side A or side B) of the assembly shelf.
- The 1:N protect card must reside in Slot 3 for side A and Slot 15 for side B.
- Working cards may sit on either or both sides of the protect card
- The ONS 15454 supports 1:N equipment protection for all add-drop multiplexer configurations (ring, linear, and terminal), as specified by Telcordia GR-253-CORE.

The ONS 15454 automatically detects and identifies a 1:N protection card when the card is installed in Slot 3 or Slot 15. However, the slot containing the 1:N card in a protection group must be manually provisioned as a protect slot because by default all cards are working cards.

For detailed procedures on setting up DS-1 and DS-3 protection groups, refer to the *Cisco ONS 15454 Procedure Guide*.

CISCO SYSTEMS

Electrical Card Protection and the Backplane

Protection schemes for electrical cards differ slightly depending on the EIA type used on the ONS 15454 backplane. The difference is due to the varying connector size. For example, because BNC connectors are larger, fewer DS3-12 cards can be supported when using a BNC connector.

Caution When a protection switch moves traffic from the DS3-12 working/active card to the DS3-12 protect/standby card, ports on the new active/standby card cannot be taken out of service as long as traffic is switched. Lost traffic can result when a port is taken out of service even if the DS3-12 standby card no longer carries traffic.

Standard BNC Protection

When you use BNC connectors, the ONS 15454 supports 1:1 protection or 1:N protection for a total of four working DS-3 electrical cards. If you are using EC-1 electrical cards with the BNC EIA, the ONS 15454 supports 1:1 protection and a total of four working cards. Slots 2, 4, 14, and 16 are designated working slots. These slots are mapped to a set of 12 BNC connectors on the EIA. These slots can be used without protection for unprotected DS-3 access.

With 1:N or 1:1 protection, Slots 1, 3, 15 and 17 are designated for protection when BNC connectors are used. With 1:N protection, Slots 3 and 15 are also designated for protection when BNC connectors are used. Slots 5, 6, 12, and 13 do not support DS3-12 cards when you use the regular BNC EIA.

High-Density BNC Protection

When you use the high-density BNC EIA, the ONS 15454 supports 1:1 protection or 1:N protection for eight total working DS-3 electrical cards. If you are using EC-1 electrical cards with the high-density BNC EIA, the ONS 15454 supports 1:1 protection and a total of eight working cards. Slots 1, 2, 4, 5, 13, 14, 16, and 17 are designated working slots.

These slots are mapped to a set of 12 BNC type connectors on the EIA. You can use these slots without protection for unprotected DS-3 or EC-1 access. Slots 3 and 15 are designated for 1:N protection slots when you use BNC connectors with the high-density BNC EIA. Slots 6 and 12 do not support DS-3 or EC-1 cards when you use the high-density BNC EIA.

SMB Protection

When you use SMB connectors, the ONS 15454 supports 1:1 or 1:N protection for the DS-1 and the DS-3 electrical cards. If you are using EC-1 cards with the SMB EIA, the ONS 15454 supports 1:1 protection. Working and protection electrical cards are defined by card slot pairs (the same card type is used for working and protect modules; the protection of the card is defined by the slot where it is housed). Each slot maps to a set of 12 or 14 SMB connectors on the EIA depending on the number of ports on the corresponding card. Any slot can be used without protection for unprotected DS-1, DS-3, or EC-1 access.

The DS1N-14 card can be a working or protect card in 1:1 or 1:N protection schemes. When used with 1:N protection, the DS1N-14 card can protect up to five DS1-14 plug-ins using the SMB connectors with the DS-1 electrical interface adapters (baluns).

AMP Champ Protection

When you use AMP Champ connectors, the ONS 15454 supports 1:1 or 1:N protection for the DS-1 cards. The DS1N-14 card can be a working or protect card in 1:1 or 1:N protection schemes. When used with 1:N protection, the DS1N-14 card can protect up to five DS1-14 plug-ins using the AMP Champ EIA.

Optical Card Protection

With 1+1 port-to-port protection, any number of ports on the protect card can be assigned to protect the corresponding ports on the working card. The working and protect cards do not have to be placed side by side in the node. A working card must be paired with a protect card of the same type and number of ports. For example, a single-port OC12 must be paired with another single-port OC12, and a four-port OC12 must be paired with another four-port OC12. You cannot create a 1+1 protection group if one card is single-port and the other is multi-port, even if the OC-N rates are the same. The protection takes place on the port level, any number of ports on the protect card can be assigned to protect the corresponding ports on the working card.

For example, on a four-port card, you can assign one port as a protection port on the protect card (protecting the corresponding port on the working card) and leave three ports unprotected. Conversely, you can assign three ports as protection ports and leave one port unprotected.

1+1 span protection can be either revertive or nonrevertive. With nonrevertive 1+1 protection, when a failure occurs and the signal switches from the working card to the protect card, the signal stays switched to the protect card until it is manually switched back. Revertive 1+1 protection automatically switches the signal back to the working card when the working card comes back online.

You create and modify protection schemes using CTC software. For more information, refer to the *Cisco ONS 15454 Procedure Guide*.

Spanning Tree

The Ethernet cards support IEEE 802.1D Spanning Tree Protocol (STP). The ONS 15454 can operate multiple instances of STP to support VLANs in a looped topology. You can dedicate separate circuits across the SONET ring for different VLAN groups. Each circuit runs its own STP to maintain VLAN connectivity in a multi-ring environment.

You can also disable or enable STP on a circuit-by-circuit basis on single-card EtherSwitch in a point-to-point configuration. This feature allows customers to mix spanning tree protected circuits with unprotected circuits on the same card. It also allows two single-card EtherSwitch Ethernet cards on the same node to form an intra-node circuit.

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Spanning Tree Parameters

Table 7-25 shows the 802.1D STP parameters for the Ethernet cards.

Table 7-25: 802.1D Spanning Tree Parameters

Parameter	Description	Default	Range
BridgeID	ONS 15454 unique identifier that transmits the configuration bridge protocol data unit (BPDU); the bridge ID is a combination of the bridge priority and the ONS 15454 MAC address	Read Only	Read Only
Priority	Defines bridge priority	32768	0 - 65535
TopoAge	Amount of time in seconds since the last topology change	Read Only	Read Only
TopoChanges	Number of times the spanning tree topology has been changed since the node booted up	Read Only	Read Only
DesignatedRoot	Identifies the spanning tree's designated root for a particular spanning tree instance	Read Only	Read Only
RootCost	Identifies the total path cost to the designated root	Read Only	Read Only
RootPort	Port used to reach the root	Read Only	Read Only
MaxAge	Maximum time that received-protocol information is retained before it is discarded	20	6 - 40 seconds
HelloTime	Time interval, in seconds, between the transmission of configuration BPDUs by a bridge that is the spanning tree root or is attempting to become the spanning tree root	2	1 - 10 seconds
HoldTime	Minimum time period, in seconds, that elapses during the transmission of configuration information on a given port		
ForwardDelay	Time spent by a port in the listening state and the learning state	15	4 - 30 seconds

The ML-Series cards also support the 802.1T spanning tree extensions shown in Table 7-26.

Table 7-26: 802.1T Spanning Tree Extensions

Switch Priority Value				Extended System ID (Set Equal to the Bridge ID)											
Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16	Bit 16
32768	16384	8192	4096	2048	1024	512	256	128	64	43	16	8	4	2	1

Rapid Spanning Tree

The ML-Series cards support per-VLAN rapid spanning tree and a maximum of 255 rapid spanning tree (RSTP) instances per port.

SONET Protection for Ethernet Circuits

Table 7-27 lists the Ethernet topologies where SONET protection can be used for Ethernet circuits.

Table 7-27: SONET Protection for Ethernet Circuits

Topology	Path Protection Configuration	BLSR	Linear 1+1
Point-to-Point – Stitched	No protection	SONET	SONET
Point-to-Point – Unstitched	SONET	SONET	SONET
Shared Packet Ring – Stitched	SONET	SONET	SONET
Shared Packet Ring – Unstitched	STP	SONET	SONET

Chapter 8 – IP Networking

Purpose

This chapter provides an understanding of how to manage ONS 15454 nodes within a TCP/IP network environment.

Content

The following topics are included in this chapter:

IP Networking Overview

Every ONS 15454 requires a unique, valid IP address. The CTC application utilizes TCP/IP to communicate with nodes in the ONS 15454 network, which requires each node to have a unique IP address. The node's IP address is equivalent to a terminal identification (TID) number.

ONS 15454s can be connected in many different ways within an IP environment:

They can be connected to LANs through direct connections or a router.

IP subnetting can create ONS 15454 node groups, which allow you to provision non-data communications channel (DCC) connected nodes in a network.

Different IP functions and protocols can be used to achieve specific network goals. For example, Proxy Address Resolution Protocol (ARP) enables one LAN-connected ONS 15454 to serve as a gateway for ONS 15454s that are not connected to the LAN.

You can create static routes to enable connections among multiple CTC sessions with ONS 15454 nodes that reside on the same subnet but have different destination IP addresses.

If ONS 15454s are connected to Open Shortest Path First (OSPF) networks, ONS 15454 network information is automatically communicated across multiple LANs and WANs.

The ONS 15454 proxy server controls the visibility and accessibility between CTC computers and ONS 15454 element nodes.

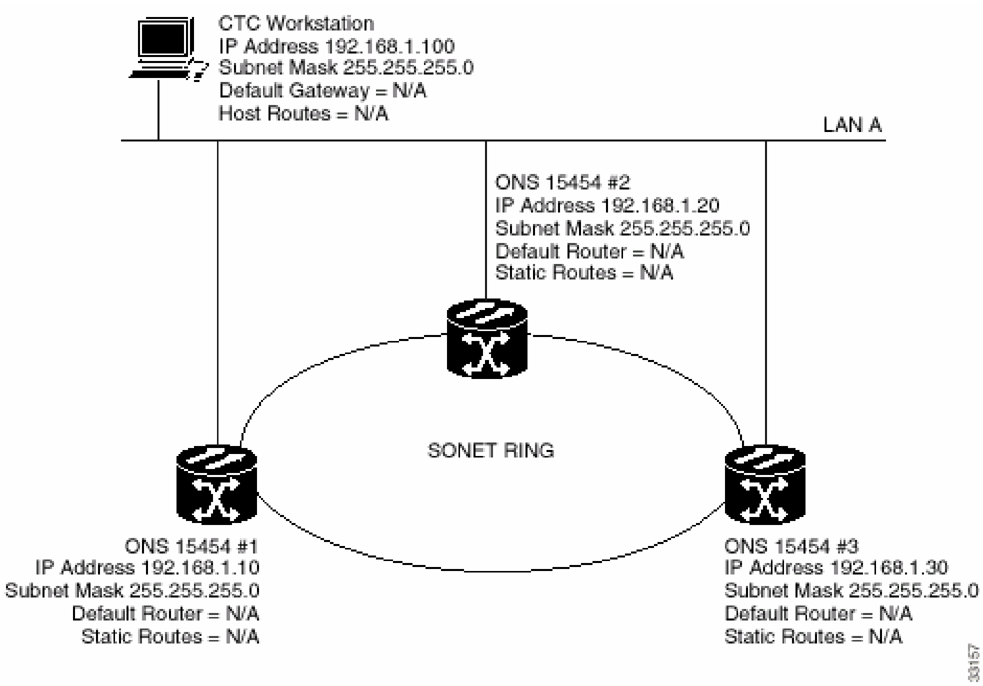
IP Addressing Scenarios

ONS 15454 IP addressing generally has seven common scenarios or configurations. Use the following scenarios as building blocks for more complex network configurations.

Scenario 1: CTC and ONS 15454 Nodes on the Same Subnet

Figure 8-1 shows a basic ONS 15454 LAN configuration. The ONS 15454 nodes and CTC computer reside on the same subnet. All ONS 15454 nodes connect to LAN A, and all ONS 15454 nodes have DCC connections.

Figure 8-1: CTC and ONS 15454 Nodes on Same Subnet

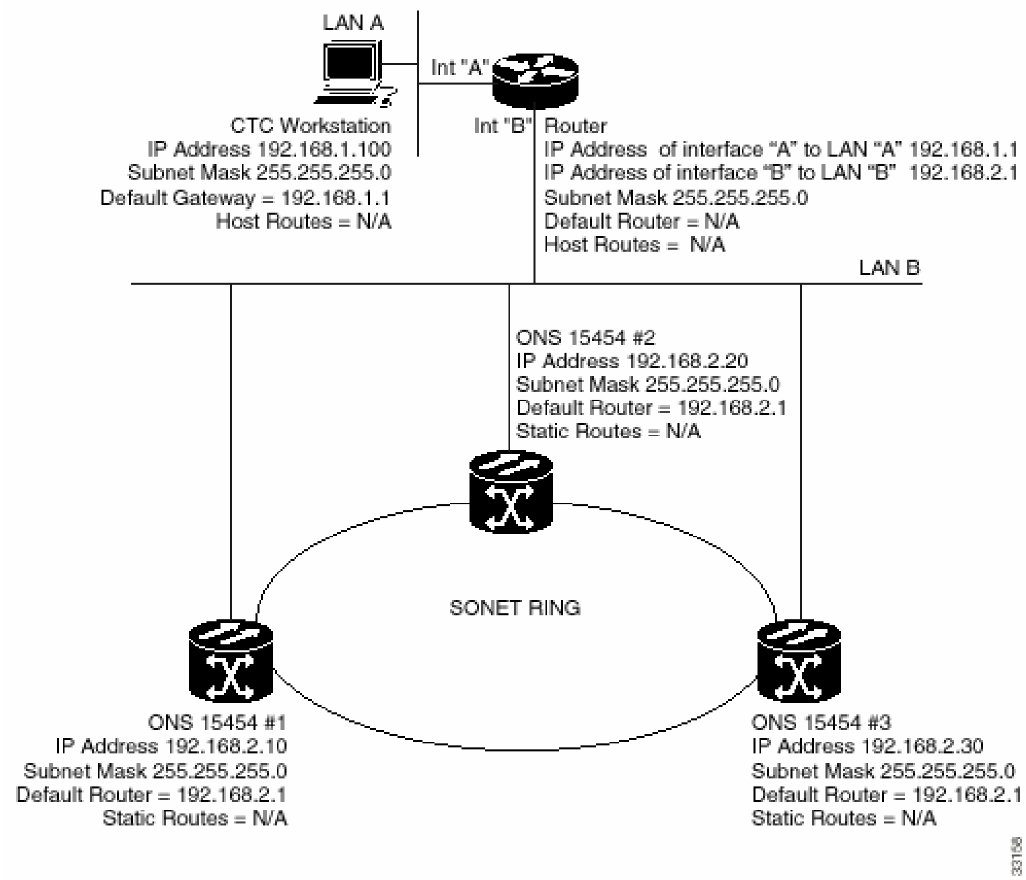


Scenario 2: CTC and ONS 15454 Nodes Connected to a Router

In Figure 8-2 the CTC computer resides on subnet 192.168.1.0 and attaches to LAN A. The ONS 15454 nodes reside on a different subnet (192.168.2.0) and attach to LAN B. A router connects LAN A to LAN B. The IP address of router interface A is set to LAN A (192.168.1.1), and the IP address of router interface B is set to LAN B (192.168.2.1).

On the CTC computer, the default gateway is set to router interface A. If the LAN uses DHCP (Dynamic Host Configuration Protocol), the default gateway and IP address are assigned automatically. In the Figure 8-2 example, a DHCP server is not available.

Figure 8-2: CTC and ONS 15454 Nodes Connected to Router

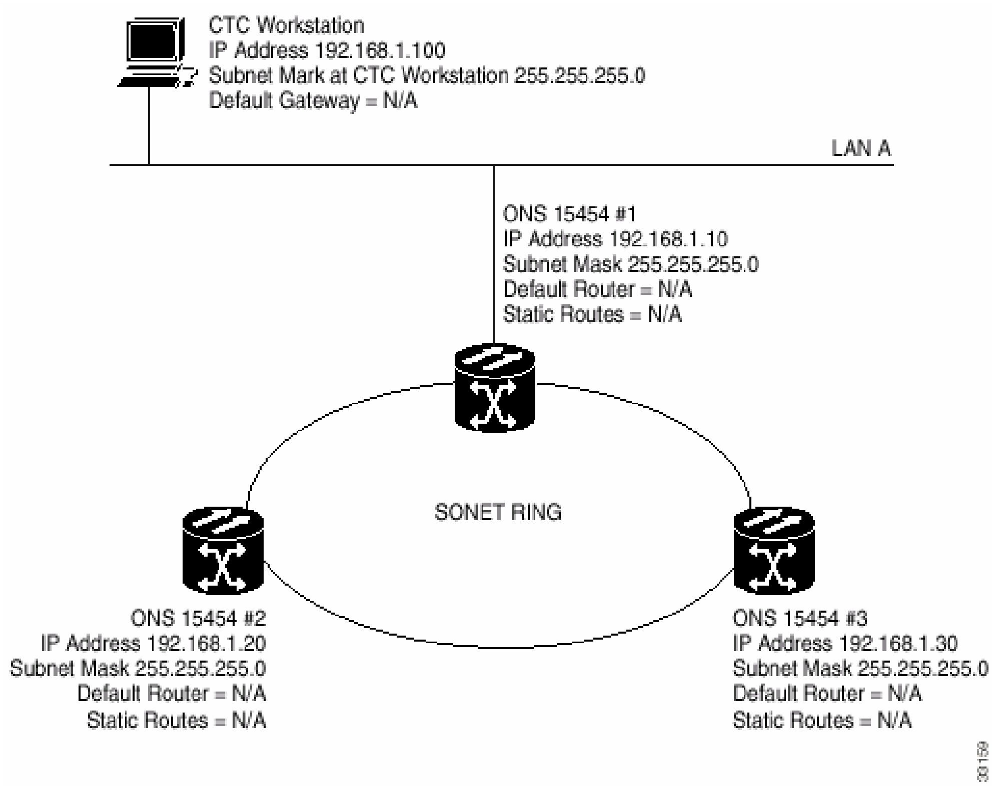


Scenario 3: Using Proxy ARP to Enable an ONS 15454 Gateway

This scenario assumes all CTC connections are to ONS 15454 #1. If you connect a laptop to either ONS 15454 #2 or #3, network partitioning will occur; neither the laptop or the CTC computer will be able to see all nodes. If you want laptops to connect directly to end network elements, you will need to create static routes (see Scenario #5) or enable the ONS 15454 Proxy Server shown in Scenario 7.

Scenario 3 is similar to Scenario 1, but only one ONS 15454 (node #1) connects to the LAN (see Figure 8-3). Two ONS 15454 nodes (#2 and #3) connect to ONS 15454 #1 through the SONET DCC. Because all three ONS 15454 nodes are on the same subnet, Proxy ARP enables ONS 15454 #1 to serve as a gateway network element (GNE) for ONS 15454s #2 and #3.

Figure 8-3: Using Proxy ARP



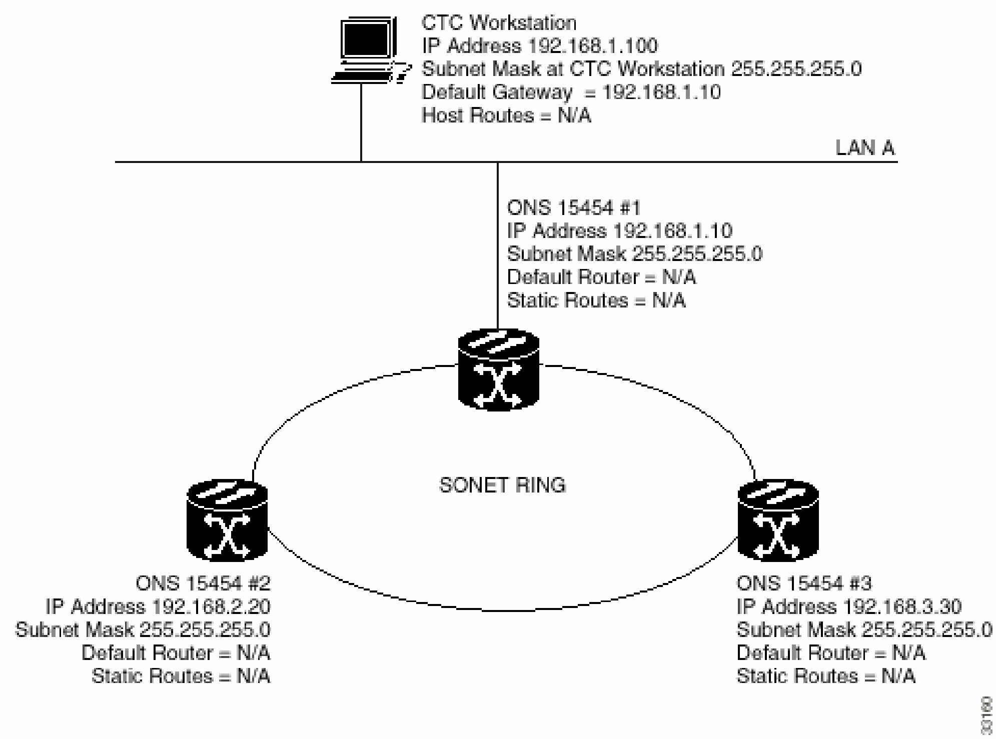
ARP matches higher-level IP addresses to the physical addresses of the destination host. It uses a lookup table (called ARP cache) to perform the translation. When the address is not found in the ARP cache, a broadcast is sent out on the network with a special format called the ARP request. If one of the machines on the network recognizes its own IP address in the request, it sends an ARP reply back to the requesting host. The reply contains the physical hardware address of the receiving host. The requesting host stores this address in its ARP cache so that all subsequent datagrams (packets) to this destination IP address can be translated to a physical address.

Proxy ARP enables one LAN-connected ONS 15454 to respond to the ARP request for ONS 15454 nodes not connected to the LAN (ONS 15454 Proxy ARP requires no user configuration). For this to occur, the DCC-connected ONS 15454 nodes must reside on the same subnet. When a LAN device sends an ARP request to an ONS 15454 that is not connected to the LAN, the gateway ONS 15454 returns its MAC address to the LAN device. The LAN device then sends the datagram for the remote ONS 15454 to the MAC address of the proxy ONS 15454. The proxy ONS 15454 uses its routing table to forward the datagram to the non-LAN ONS 15454.

Scenario 4: Default Gateway on the CTC Computer

Scenario 4 is similar to Scenario 3, but nodes #2 and #3 reside on different subnets, 192.168.2.0 and 192.168.3.0, respectively (see Figure 8-4). Node #1 and the CTC computer are on subnet 192.168.1.0. Proxy ARP is not used because the network includes different subnets. In order for the CTC computer to communicate with ONS 15454 nodes #2 and #3, ONS 15454 #1 is entered as the default gateway on the CTC computer.

Figure 8-4: Default Gateway on the CTC Computer



Scenario 5: Using Static Routes to Connect to LANs

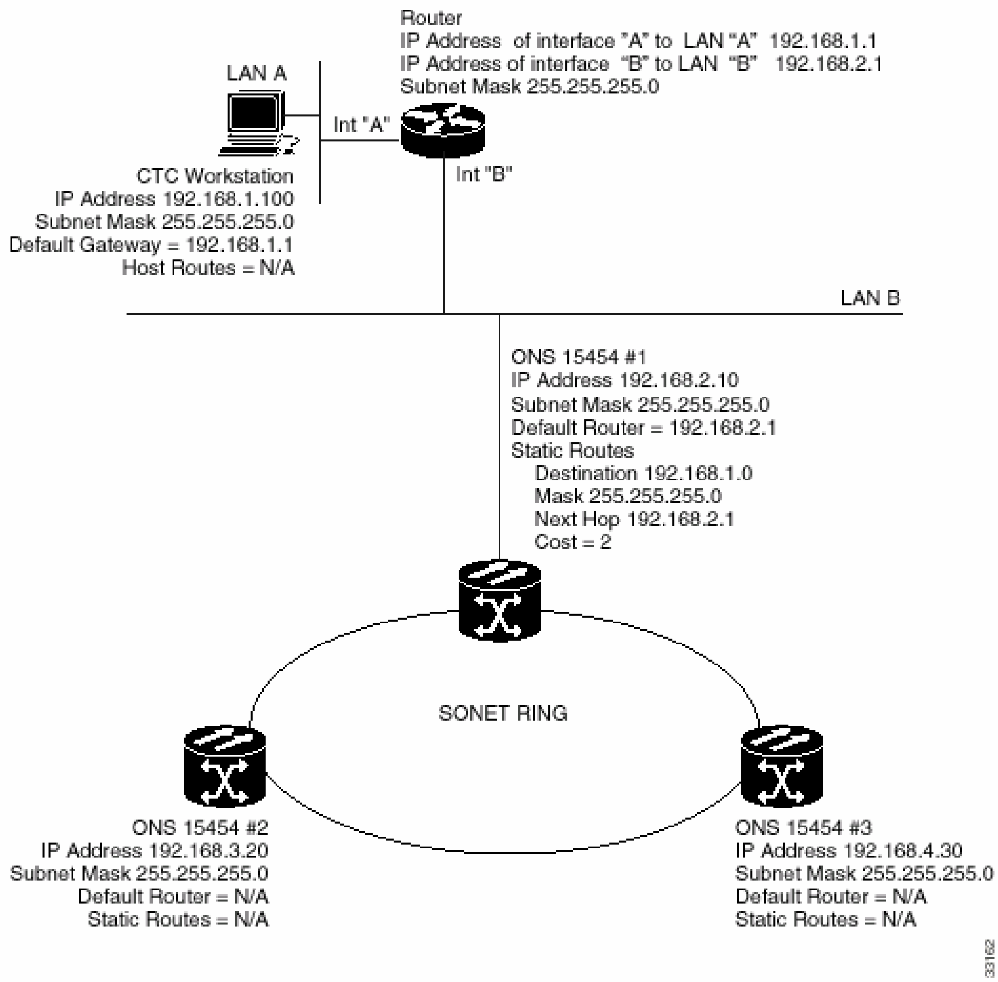
Static routes are used for two purposes:

1. To connect ONS 15454s to CTC sessions on one subnet connected by a router to ONS 15454s residing on another subnet. (These static routes are not needed if OSPF is enabled. Scenario 6 shows an OSPF example.)

2. To enable multiple CTC sessions among ONS 15454s residing on the same subnet.

In Figure 8-5, one CTC residing on subnet 192.168.1.0 connects to a router through interface A (the router is not set up with OSPF). ONS 15454 nodes residing on different subnets are connected through ONS 15454 #1 to the router through interface B. Because ONS 15454 nodes #2 and #3 are on different subnets, proxy ARP does not enable ONS 15454 #1 as a gateway. To connect to CTC computers on LAN A, a static route is created on ONS 15454 #1.

Figure 8-5: Static Route With One CTC Computer Used as a Destination



The destination and subnet mask entries control access to the ONS 15454 nodes as follows:

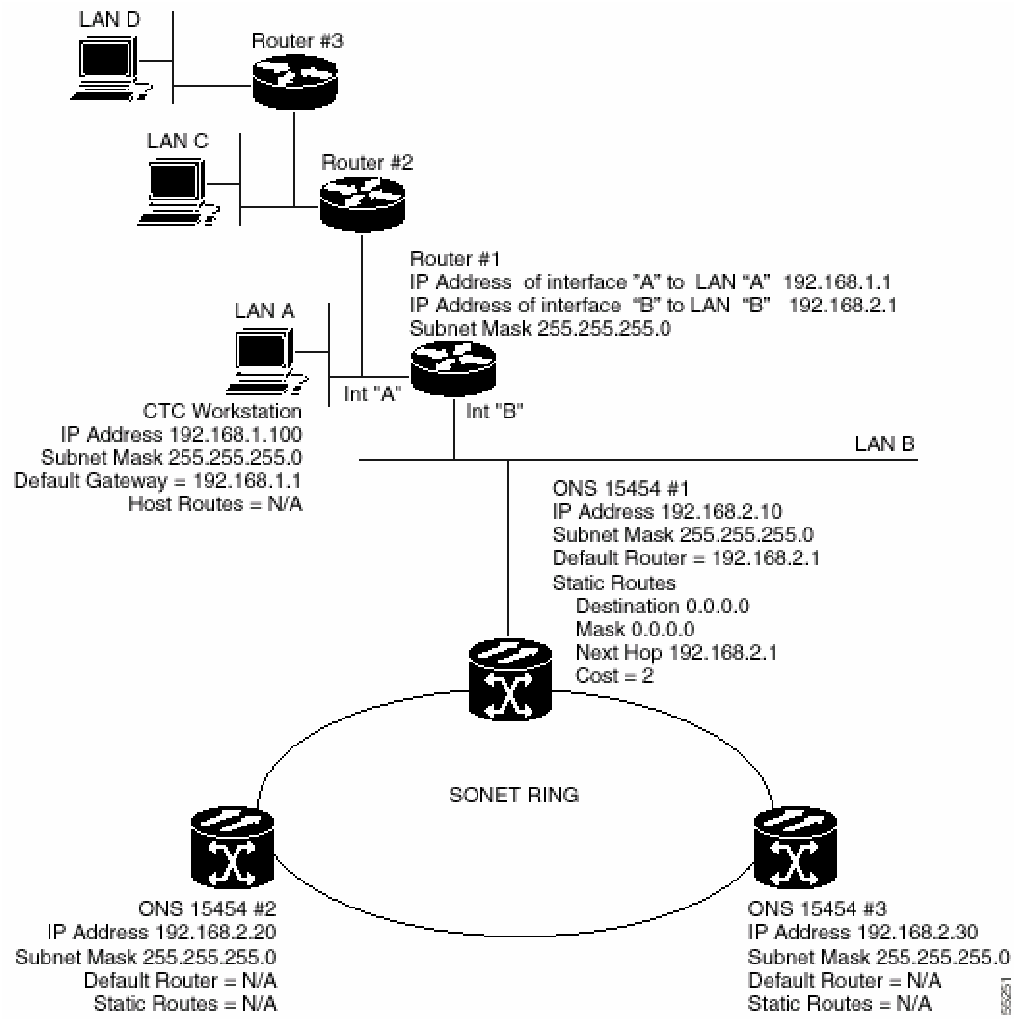
If a single CTC computer is connected to a router, enter the complete CTC "host route" IP address as the destination with a subnet mask of 255.255.255.255.

If CTC computers on a subnet are connected to a router, enter the destination subnet (in this example, 192.168.1.0) and a subnet mask of 255.255.255.0.

If all CTC computers are connected to a router, enter a destination of 0.0.0.0 and a subnet mask of 0.0.0.0. Figure 8-6 shows an example.

The IP address of router interface B is entered as the next hop, and the cost (number of hops from source to destination) is 2.

Figure 8-6: Static Route With Multiple LAN Destinations



Scenario 6: Using OSPF

Open Shortest Path First (OSPF) is a link state Internet routing protocol. Link state protocols use a "hello protocol" to monitor their links with adjacent routers and to test the status of their links to their neighbors. Link state protocols advertise their directly connected networks and their active links. Each link state router captures the link state "advertisements" and puts them together to create a topology of the entire network or area. From this database, the router calculates a routing table by constructing a shortest path tree. Routes are recalculated when topology changes occur.

ONS 15454 nodes use the OSPF protocol in internal ONS 15454 networks for node discovery, circuit routing, and node management. You can enable OSPF on the ONS 15454s so that the ONS 15454 topology is sent to OSPF routers on a LAN. Advertising the ONS 15454 network topology to LAN routers eliminates the need to manually enter static routes for ONS 15454 subnetworks. Figure 8-7 shows a network enabled for OSPF. Figure 8-8 shows the same network without OSPF. Static routes must be manually added to the router in order for CTC computers on LAN A to communicate with ONS 15454 #2 and #3 because these nodes reside on different subnets.

OSPF divides networks into smaller regions, called areas. An area is a collection of networked end systems, routers, and transmission facilities organized by traffic patterns. Each OSPF area has a unique ID number, known as the area ID, that can range from 0 to 4,294,967,295. Every OSPF network has one backbone area called "area 0." All other OSPF areas must connect to area 0.

When you enable an ONS 15454 OSPF topology for advertising to an OSPF network, you must assign an OSPF area ID in decimal format to the ONS 15454 network. Coordinate the area ID number assignment with your LAN administrator. All DCC-connected ONS 15454 nodes should be assigned the same OSPF area ID.

Figure 8-7: OSPF Enabled

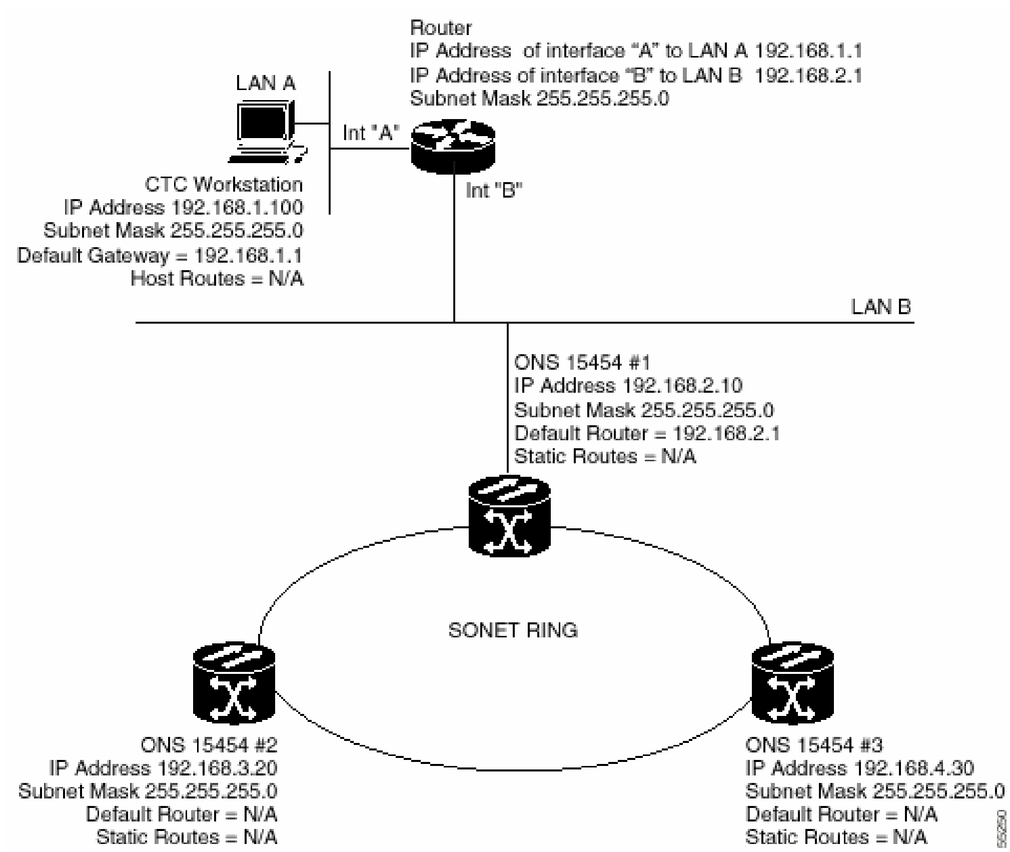
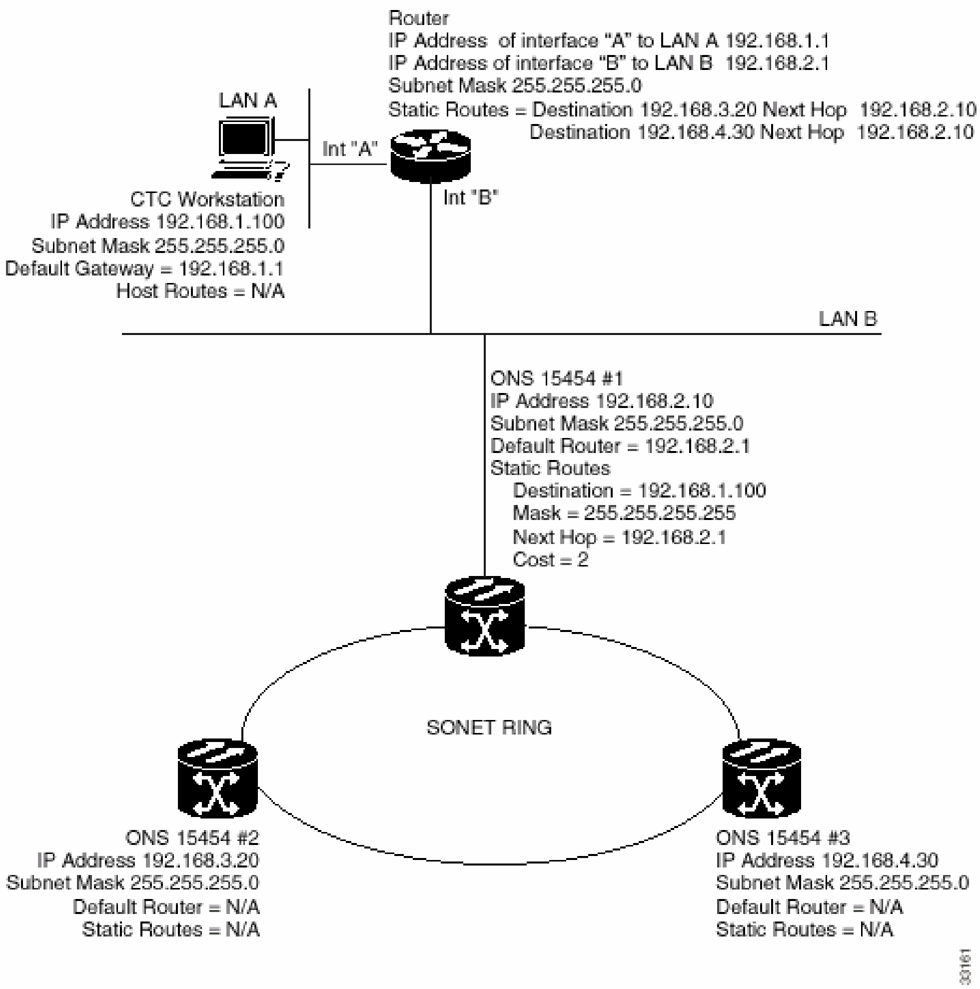


Figure 8-8: OSPF Not Enabled



Scenario 7: Provisioning the ONS 15454 Proxy Server

The ONS 15454 proxy server is a set of functions that allows you to network ONS 15454 nodes in environments where visibility and accessibility between ONS 15454 nodes and CTC computers must be restricted. For example, you can set up a network so that field technicians and network operating center (NOC) personnel can both access the same ONS 15454s while preventing the field technicians from accessing the NOC LAN. To do this, one ONS 15454 is provisioned as a gateway NE (GNE) and the other ONS 15454s are provisioned as end NEs (ENEs). The GNE ONS 15454 tunnels connections between CTC computers and ENE ONS 15454s, providing management capability while preventing access for non-ONS 15454 management purposes.

The ONS 15454 proxy server performs the following tasks:

- Isolates DCC IP traffic from Ethernet (craft port) traffic and accepts packets based on filtering rules. The filtering rules (see Table 8-3 and Table 8-4) depend on whether the packet arrives at the ONS 15454 DCC or TCC+/TCC2 Ethernet interface.

Monitors ARP request packets on its Ethernet port. If the ARP request is from an address that is not on the current subnet, the ONS 15454 creates an entry its ARP table. The ARP entry allows the ONS 15454 to reply to an address over the local Ethernet so craft technicians can connect to ONS 15454 nodes without changing the IP addresses of their computers.

Processes SNTP/NTP requests. Element ONS 15454 NEs can derive time-of-day from an SNTP/NTP LAN server through the GNE ONS 15454.

Process SNMPv1 traps. The GNE ONS 15454 receives SNMPv1 traps from the ENE ONS 15454 nodes and forwards them to all provisioned SNMPv1 trap destinations.

The ONS 15454 proxy server is provisioned using three check boxes on the Provisioning > Network >General tab (see Figure 8-9):

Enable Proxy - When enabled, the ONS 15454 serves as a proxy for connections between CTC clients and ONS 15454 nodes that are DCC-connected to the proxy ONS 15454. The CTC client establishes connections to DCC-connected nodes through the proxy node. The CTC client can connect to nodes that it cannot directly reach from the host on which it runs. If Enable Proxy is off, the node does not proxy for any CTC clients, although any established proxy connections will continue until the CTC client exits.

Note If you launch CTC against a node through a NAT/PAT router and that node does not have proxy enabled, your CTC session will start and initially appear to be fine. However CTC will never receive alarm updates and will disconnect and reconnect every two minutes. If the proxy is accidentally disabled, it is still possible to enable the proxy during a reconnect cycle and recover your ability to manage the node, even through a NAT/PAT firewall.

Craft Access Only - When enabled, the ONS 15454 neither installs nor advertises default or static routes. CTC computers can communicate with the ONS 15454 using the TCC+/TCC2 craft port, but they cannot communicate directly with any other DCC-connected ONS 15454.

Enable Firewall - If selected, the node prevents IP traffic from being routed between the DCC and the LAN port. The ONS 15454 can communicate with machines connected to the LAN port or connected through the DCC. However, the DCC-connected machines cannot communicate with the LAN-connected machines, and the LAN-connected machines cannot communicate with the DCC-connected machines. A CTC client using the LAN to connect to the firewall-enabled node can use the proxy capability to manage the DCC-connected nodes that would otherwise be unreachable. A CTC client connected to a DCC-connected node can only manage other DCC-connected nodes and the firewall itself.

Proxy Server Port Reduction

In previous releases, CTC was able to manage nodes behind routers that performed network address translation (NAT) but required that intermediate routers allow connections on many ports. Additionally, these intermediate routers needed to be configured to allow connections to be initiated from both CTC and the GNE. With Release 4.00, CTC can now manage nodes behind routers that perform NAT or port address translation (PAT). Intermediate routers need only be configured to allow connections from CTC to the GNE on ports 80 (HTTP) and 1080 (SOCKS) and packets for established connections from the GNE to CTC. The superuser can enable this functionality on the node level Provisioning > Network tab.

Figure 8-9: Proxy Server Gateway Settings

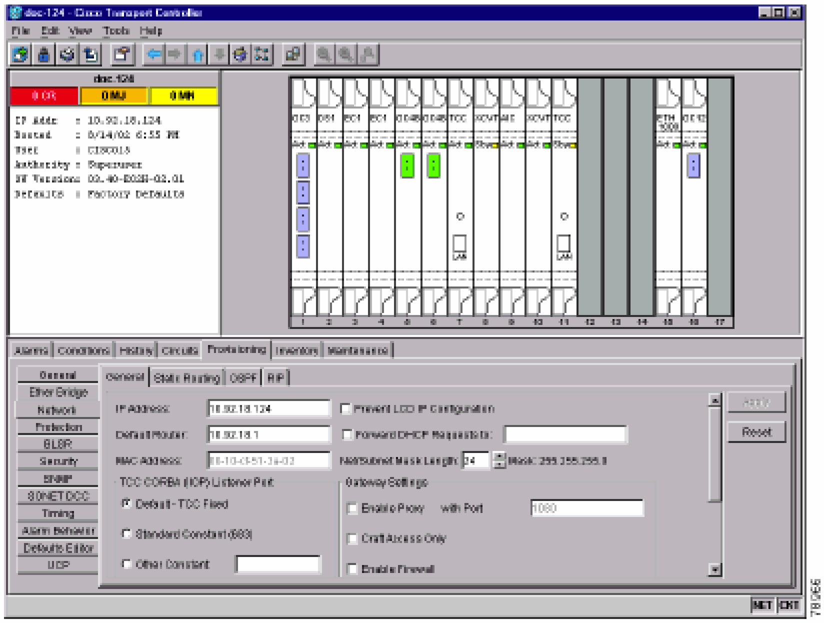


Figure 8-10 shows an ONS 15454 proxy server implementation. A GNE ONS 15454 is connected to a central office LAN and to ENE ONS 15454 nodes. The central office LAN is connected to a NOC LAN, which has CTC computers. The NOC CTC computer and craft technicians must both be able to access the ONS 15454 ENEs. However, the craft technicians must be prevented from accessing or seeing the NOC or central office LANs.

In the example, the ONS 15454 GNE is assigned an IP address within the central office LAN and is physically connected to the LAN through its LAN port. ONS 15454 ENEs are assigned IP addresses that are outside the central office LAN and given private network IP addresses. If the ONS 15454 ENEs are co-located, the craft LAN ports could be connected to a hub. However, the hub should have no other network connections.

Figure 8-10: ONS 15454 Proxy Server with GNE and ENEs on the Same Subnet

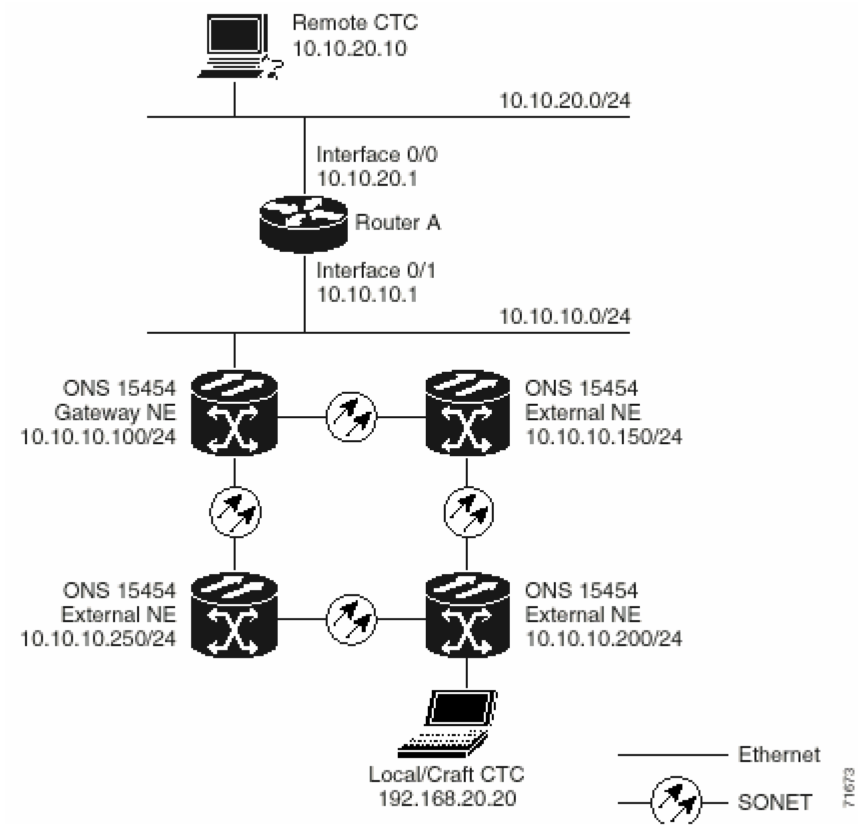


Table 8-1 shows recommended settings for ONS 15454 GNEs and ENEs in the configuration shown in Figure 8-10.

Table 8-1: ONS 15454 Gateway and Element NE Settings

Setting	ONS 15454 Gateway NE	ONS 15454 Element NE
Craft Access Only	Off	On
Enable Proxy	On	On
Enable Firewall	On	On
OSPF	Off	Off
SNTP server (if used)	SNTP server IP address	Set to ONS 15454 GNE IP address
SNMP (if used)	SNMPv1 trap destinations	Set SNMPv1 trap destinations to ONS 15454 GNE, port 391

Figure 8-11 shows the same proxy server implementation with ONS 15454 ENEs on different subnets. Figure 8-12 shows the implementation with ONS 15454 ENEs in multiple rings. In each example, ONS 15454 GNEs and ENEs are provisioned with the settings shown in Table 8-1.

Figure 8-11: ONS 15454 Proxy Server with GNE and ENEs on Different Subnets

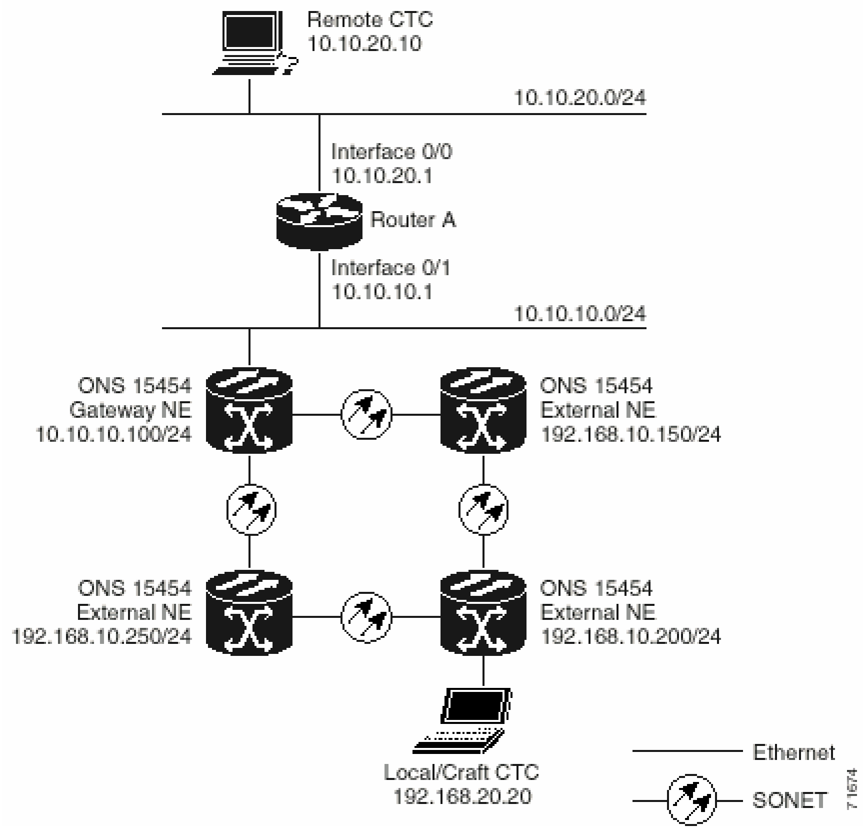


Figure 8-12: ONS 15454 Proxy Server With ENEs on Multiple Rings

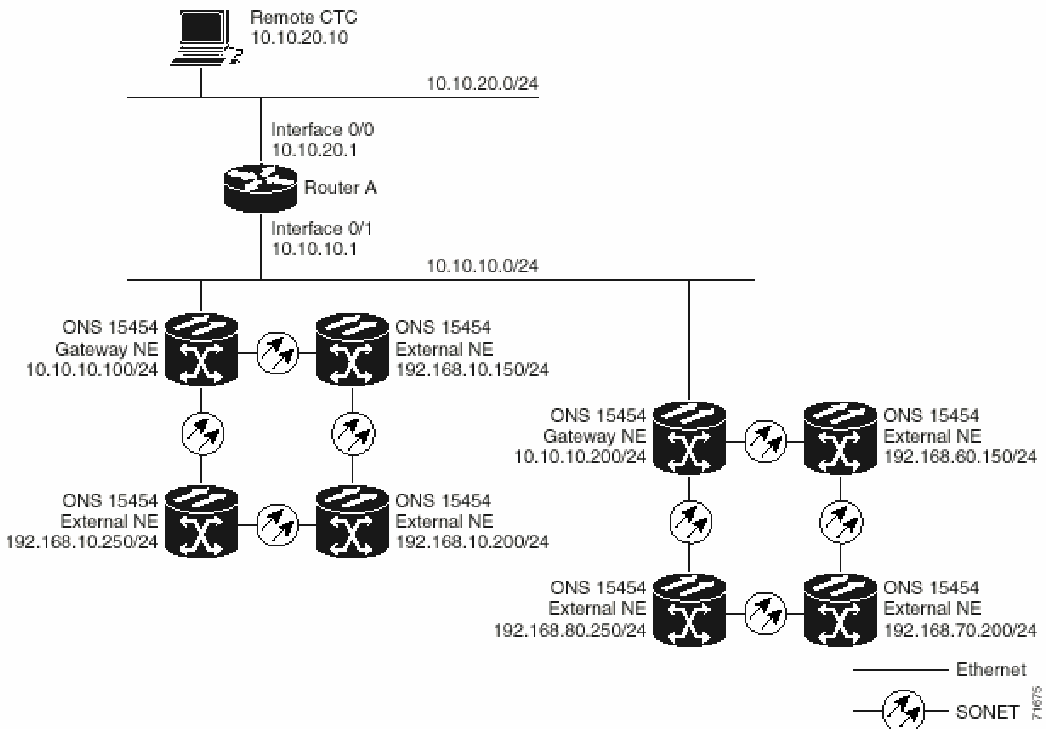


Table 8-2 shows the rules the ONS 15454 follows to filter packets when Enable Firewall is enabled. If the packet is addressed to the ONS 15454, additional rules, shown in Table 8-3, are applied. Rejected packets are silently discarded.

Table 8-2: Proxy Server Firewall Filtering Rules

Packets arriving at:	Are accepted if the IP destination address is:
TCC+ Ethernet Interface	The ONS 15454 itself. The ONS 15454's subnet broadcast address. Within the 224.0.0.0/8 network (reserved network used for standard multicast messages). Subnet mask = 255.255.255.255
DCC Interface	The ONS 15454 itself. Any destination connected through another DCC interface. Within the 224.0.0.0/8 network.

Table 8-3: Proxy Server Firewall Filtering Rules When Packet Addressed to ONS 15454

Packets Arrive At	Accepted	Rejected
TCC+ Ethernet Interface	All UDP packets except those in the Rejected column.	UDP packets addressed to the SNMP trap relay port (391).
DCC Interface	All UDP packets All TCP packets except those in the Rejected column. OSPF packets. ICMP packets.	TCP packets addressed to the telnet port. TCP packets addressed to the proxy server port. All packets other than UDP, TCP, OSPF, ICMP.

If you implement the proxy server, keep the following rules in mind:

1. All DCC-connected ONS 15454s on the same Ethernet segment must have the same Craft Access Only setting. Mixed values will produce unpredictable results, and may leave some nodes unreachable through the shared Ethernet segment.

2. All DCC-connected ONS 15454s on the same Ethernet segment must have the same Enable Firewall setting. Mixed values will produce unpredictable results. Some nodes may become unreachable.

3. If you enable Enable Firewall, always check Enable Proxy. If Enable Proxy is not enabled, CTC will not be able to see nodes on the DCC side of the ONS 15454.

4. If Craft Access Only is enabled, check Enable Proxy. If Enable Proxy is not enabled, CTC will not be able to see nodes on the DCC side of the ONS 15454.

If nodes become unreachable in cases 1, 2, and 3, correct the setting by performing one of the following:

Disconnect the craft computer from the unreachable ONS 15454. Connect to the ONS 15454
through another network ONS 15454 that has a DCC connection to the unreachable ONS 15454.

Disconnect the Ethernet cable from the unreachable ONS 15454. Connect a CTC computer directly to the ONS 15454.

Routing Table

ONS 15454 routing information is displayed on the Maintenance > Routing Table tabs (see Figure 8-13). The routing table provides the following information:

Destination - Displays the IP address of the destination network or host.

Mask - Displays the subnet mask used to reach the destination host or network.

Gateway - Displays the IP address of the gateway used to reach the destination network or host.

Usage - Shows the number of times the listed route has been used.

Interface - Shows the ONS 15454 interface used to access the destination. Values are:

cpm0 - The ONS 15454 Ethernet interface, that is, the RJ-45 jack on the TCC+/TCC2and the LAN 1 pins on the backplane.

pdcc0 - A SONET data communications channel (SDCC) interface, that is, an OC-N trunk card identified as the SDCC termination.

lo0 - A loopback interface

Figure 8-13: Viewing the ONS 15454 Routing Table

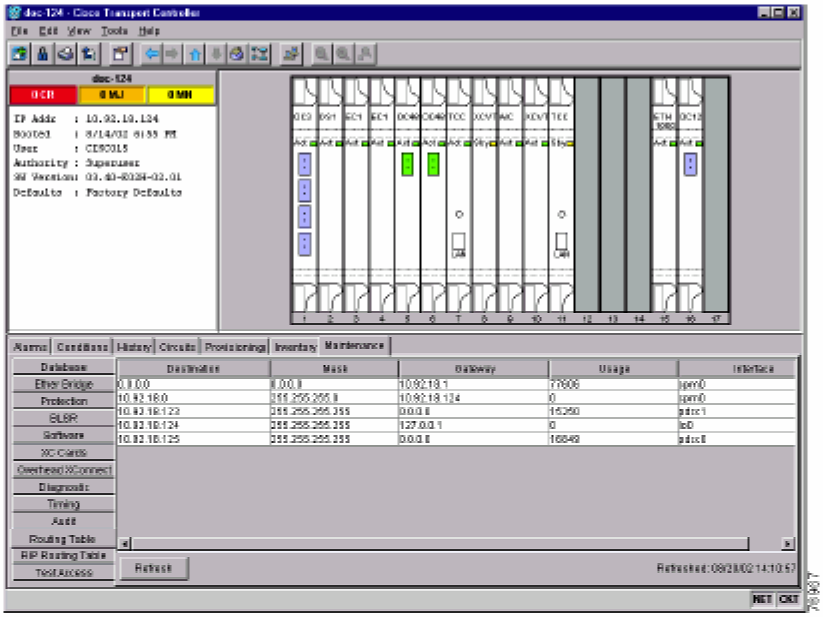


Table 8-4 shows sample routing entries for an ONS 15454.

Table 8-4: Sample Routing Table Entries

Entry	Destination	Mask	Gateway	Interface
1	0.0.0.0	0.0.0.0	172.20.214.1	cpm0
2	172.20.214.0	255.255.255.0	172.20.214.92	cpm0
3	172.20.214.92	255.255.255.255	127.0.0.1	lo0
4	172.20.214.93	255.255.255.255	0.0.0.0	pdcc0
5	172.20.214.94	255.255.255.255	172.20.214.93	pdcc0

Entry #1 shows the following:

Destination (0.0.0.0) is the default route entry. All undefined destination network or host entries on this routing table will be mapped to the default route entry.

Mask (0.0.0.0) is always 0 for the default route.

Gateway (172.20.214.1) is the default gateway address. All outbound traffic that cannot be found in this routing table or is not on the node's local subnet will be sent to this gateway.

Interface (cpm0) indicates that the ONS 15454 Ethernet interface is used to reach the gateway.

Entry #2 shows the following:

Destination (172.20.214.0) is the destination network IP address.

Mask (255.255.255.0) is a 24-bit mask, meaning all addresses within the 172.20.214.0 subnet can be a destination.

Gateway (172.20.214.92) is the gateway address. All outbound traffic belonging to this network is sent to this gateway.

Interface (cpm0) indicates that the ONS 15454 Ethernet interface is used to reach the gateway.

Entry #3 shows the following:

Destination (172.20.214.92) is the destination host IP address.

Mask (255.255.255.255) is a 32 bit mask, meaning only the 172.20.214.92 address is a destination.

Gateway (127.0.0.1) is a loopback address. The host directs network traffic to itself using this address.

Interface (lo0) indicates that the local loopback interface is used to reach the gateway.

Entry #4 shows the following:

Destination (172.20.214.93) is the destination host IP address.

Mask (255.255.255.255) is a 32 bit mask, meaning only the 172.20.214.93 address is a destination.

Gateway (0.0.0.0) means the destination host is directly attached to the node.

Interface (pdcc0) indicates that a SONET SDCC interface is used to reach the destination host.

Entry #5 shows a DCC-connected node that is accessible through a node that is not directly connected:

Destination (172.20.214.94) is the destination host IP address.

Mask (255.255.255.255) is a 32-bit mask, meaning only the 172.20.214.94 address is a destination.

Gateway (172.20.214.93) indicates that the destination host is accessed through a node with IP
address 172.20.214.93.

Interface (pdcc0) indicates that a SONET SDCC interface is used to reach the gateway.

Provisioning an External Firewall

Table 8-5 shows the ports that are used by the TCC+/TCC2.

Table 8-5: Ports Used by the TCC+/TCC2

Port	Function
0	Never used
21	FTP control
23	Telnet
80	HTTP
111	rpc (not used; but port is in use)
513	rlogin (not used; but port is in use)
≤1023	Default CTC listener ports
1080	Proxy server
2001-2017	I/O card Telnet
2018	DCC processor on active TCC+/TCC2
2361	TL1
3082	TL1
3083	TL1
5001	BLSR server port
5002	BLSR client port
7200	SNMP input port
9100	EQM port
9101	EQM port 2
9401	TCC boot port
9999	Flash manager
10240-12288	Proxy client
57790	Default TCC listener port

Access Control List Example With Proxy Server Not Enabled

The following ACL (access control list) examples shows a firewall configuration when the Proxy Server feature is not enabled. In the example, the CTC workstation's address is 192.168.10.10. and the ONS 15454 address is 10.10.10.100. The firewall is attached to the GNE CTC, so inbound is CTC to the GNE and outbound is from the GNE to CTC. The CTC CORBA Standard constant is 683 and the TCC CORBA Default is TCC Fixed (57790).

```
access-list 100 remark *** Inbound ACL, CTC -> NE ***
access-list 100 remark
access-list 100 permit tcp host 192.168.10.10 any host 10.10.10.100 eq www
access-list 100 remark *** allows initial contact with the 15454 using http (port 80) ***
access-list 100 remark
access-list 100 permit tcp host 192.168.10.10 683 host 10.10.10.100 eq 57790
access-list 100 remark *** allows CTC communication with the 15454 GNE (port 57790) ***
access-list 100 remark
access-list 100 permit tcp host 192.168.10.10 host 10.10.10.100 established
access-list 100 remark *** allows ACKs back from CTC to the 15454 GNE ***
access-list 101 remark *** Outbound ACL, NE -> CTC ***
access-list 101 remark
access-list 101 permit tcp host 10.10.10.100 any host 192.168.10.10 eq 683
access-list 101 remark *** allows alarms etc., from the 15454 (random port) to the CTC workstation (port
683) ***
access-list 100 remark
access-list 101 permit tcp host 10.10.10.100 host 192.168.10.10 established
access-list 101 remark *** allows ACKs from the 15454 GNE to CTC ***
```

Access Control List Example With Proxy Server Enabled

The following ACL (access control list) examples shows a firewall configuration when the Proxy Server feature is enabled. As with the first example, the CTC workstation address is 192.168.10.10 and the ONS 15454 address is 10.10.10.100. The firewall is attached to the GNE CTC, so inbound is CTC to the GNE and outbound is from the GNE to CTC. CTC CORBA Standard constant (683) and TCC CORBA Default is TCC Fixed (57790).

```
access-list 100 remark *** Inbound ACL, CTC -> NE ***
access-list 100 remark
access-list 100 permit tcp host 192.168.10.10 any host 10.10.10.100 eq www
access-list 100 remark *** allows initial contact with the 15454 using http (port 80) ***
access-list 100 remark
access-list 100 permit tcp host 192.168.10.10 683 host 10.10.10.100 eq 57790
access-list 100 remark *** allows CTC communication with the 15454 GNE (port 57790) ***
access-list 100 remark
access-list 100 permit tcp host 192.168.10.10 683 host 10.10.10.100 eq 1080
access-list 100 remark *** allows CTC communication with the 15454 GNE proxy server (port
1080) ***
access-list 100 remark
access-list 100 permit tcp host 192.168.10.10 host 10.10.10.100 established
access-list 100 remark *** allows ACKs from CTC to the 15454 GNE ***
access-list 101 remark *** Outbound ACL, NE -> CTC ***
access-list 101 remark
access-list 101 permit tcp host 10.10.10.100 any host 192.168.10.10 eq 683
access-list 101 remark *** allows alarms and other communications from the 15454 (random
port) to the CTC workstation (port 683) ***
access-list 100 remark
access-list 101 permit tcp host 10.10.10.100 host 192.168.10.10 established
access-list 101 remark *** allows ACKs from the 15454 GNE to CTC ***
```

Security

The ONS 15454 offers security against unauthorized access to the system. It features a locked door to the front compartment to physically protect access to the assembly shelf m cards, and cables. A pinned hex key that unlocks the front door is shipped with the ONS 15454. A button on the right side of the shelf assembly releases the door. In addition to the Craft Only and Firewall features described previously in this chapter, the DCC can be disabled to provide further protection against remote intrusion. Provisionable user idle time and log-out control is available to log out an inactive user.

User Security Levels

CISCO15 is the default user ID provided with every shipped ONS 15454 system. The password for CISCO15 is not assigned from factory. The user ID “CISCO15” is not prompted when you sign into CTC. This default user ID is provided to set up the ONS 15454 system for initial use. Once the system is set up, you can assign a password to CISCO15, or delete it if your running System Release 4.0 or higher.

Each user ID created on an ONS 15454 can be provisioned for a single or multiple occurrence. If the user ID for a node is provisioned to be active in a single occurrence, then no one else can log into that node as CISCO15 if another user is currently logged into it as CISCO15. The default setting for each ONS 15454 node is to allow multiple concurrent user ID sessions.

You can have up to 500 user IDs on one ONS 15454. Each CTC or TL1 user can be assigned one of the following security levels:

Retrieve – Users can retrieve and view CTC information but cannot set or modify parameters.

Maintenance – Users can access only the ONS 15454 maintenance options.

Provisioning – Users can access provisioning and maintenance options.

Superusers – Users can perform all of the functions of the other security levels as well as set names, passwords, and security levels for other users.

Table 8-6 shows the actions that each user level can perform.

Table 8-6: User Level Privileges

CTC Tab	Subtab	Actions	Retrieve	Maintenance	Provisioning	Superuser
Alarms		Synchronize alarms	X	X	X	X
Conditions		Retrieve	X	X	X	X
History	Session	Read only	X	X	X	X
	Node	Retrieve Alarms/Events	X	X	X	X
Circuits		Create/Edit/Delete/Filter			X	X
		Search	X	X	X	X
Provisioning	General	Edit			X	X
	EtherBridge	Spanning Trees: Edit			X	X
		Thresholds: Create/Delete			X	X
	Network	All				X
	Protection	Create/Delete/Edit			X	X
		Browse groups	X	X	X	X
	Ring	All (BLSR)			X	X
	Security	Create/Delete				X
		Change password	Same user only	Same user only	Same user only	All users
	SNMP	Create/Delete/Edit			X	X
		Browse trap destinations	X	X	X	X
	SONET DCC	Create/Delete			X	X
	Timing	Edit			X	X
	Alarm Behavior	Edit			X	X
	Defaults Editor	Edit				X
	UCP	All			X	X
Inventory		Delete			X	X
		Reset		X	X	X

CTC Tab	Subtab	Actions	Retrieve	Maintenance	Provisioning	Superuser
Maintenance	Database	Backup				X
		Restore				X
	EtherBridge	Spanning Tree (read only)	X	X	X	X
		MAC Table Retrieve	X	X	X	X
		MAC Table Clear/Clear all		X	X	X
		Trunk Utilization Refresh	X	X	X	X
	Protection	Switch/lock out operations		X	X	X
	BLSR	BLSR maintenance			X	X
	Software	Download/Upgrade				X
		Activate/Revert				X
	XC Cards	Protection switches		X	X	X
	Overhead XConnect	Read only	X	X	X	X
	Diagnostic	Retrieve				X
		Lamp test		X	X	X
	Timing	Edit		X	X	X
	Audit	Retrieve				X
	Routing Table	Read only	X	X	X	X
	RIP Routing Table	Refresh	X	X	X	X

A Superuser can perform ONS 15454 user management tasks from the network or node (default login) view. In network view you can add, edit, or delete users from multiple nodes at one time. If you perform user management tasks in node view you can only add, edit, or delete users from that node.

Each ONS 15454 CTC or TL1 user can be idle during his or her login session for a specified amount of time before the CTC window is locked. The lockouts prevent unauthorized users from making changes. Higher-level users have shorter default idle periods and lower-level users have longer or unlimited default idle periods, as shown in Table 8-7. The user idle period can be modified by a Superuser while completing the "Modify Users and Change Security" procedure in the *Cisco ONS 15454 Procedure Guide*.

Table 8-7: ONS 15454 Default User Idle Times

Security Level	Idle Time
Superuser	15 minutes
Provisioning	30 minutes
Maintenance	60 minutes
Retrieve	Unlimited

Superusers can change the user idle times and have the ability to log-out an active user. A Superuser can also retrieve a list of users logged into a specific ONS 15454 node.

The following security policies can be edited:

Password expiration and reuse settings – Superusers can provision password reuse periods and reuse intervals (the number of passwords that must be generated before a password can be reused).

Login visibility – Superusers can view real-time lists of users who are logged into CTC or TL1 user logins by node by retrieving the list of logins by node.

Invalid login attempts – Superusers can define the quantity of invalid login attempts a user can make before the user's ID is locked out. The default is five attempts.

Privilege change – Superusers can initiate privilege changes for other users while the user is logged in. The changes will be propagated to all nodes within the network and they become effective the next time the user logs in.

The ONS 15454 maintains a 640-entry-long readable audit trail of user actions such as login, logout, circuit creation or deletion, etc. You can move the log to a local workstation or network server for later review. The ONS 15454 generates an event to indicate when the audit log is 80 percent full, and another event to indicate that the oldest log entries are being overwritten.

In Release 4.0, the Audit Trail feature has been improved. To use the Audit Trail features, you must be logged on with either Provisioning or Superuser privileges.

You can now save Audit Trail records created since the last archive operation to a local file. Multiple archive files, when put together, provide a view of the node's audit travel over time with no omissions or overlap.

Two new alarms indicate when an archive of the Audit Trail is needed:

AUD-LOG-LOW is raised when the audit trail is 80% full.

AUD-LOG-LOSS is raised when the audit trail begins to overwrite records that have not yet been archived.

Both of the new alarms clear automatically when you perform an archive via CTC.

Chapter 9 – Applications and Configurations

Note: The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

Purpose

This chapter provides examples of common ONS 15454 network applications and shelf configurations. All SONET examples are shown as either ring or 1+1 protected. All DS-1 and DS-3 examples are shown either as 1:N ($N \leq 5$) protected. DS3XM (transmux) and EC1 traffic is shown as 1:1 protected. Ethernet cards are shown unprotected.

The examples shown in this chapter are designed to provide general guidance for developing node configurations to meet your service needs.

Contents

This chapter contains the following topics:

Overview

The Cisco ONS 15454 provides efficient bandwidth delivery and management in fiber optic transport networks. It is a flexible SONET add/drop multiplexer that offers service aggregation and high-bandwidth transport of voice, data, and digital video traffic on a single platform. The

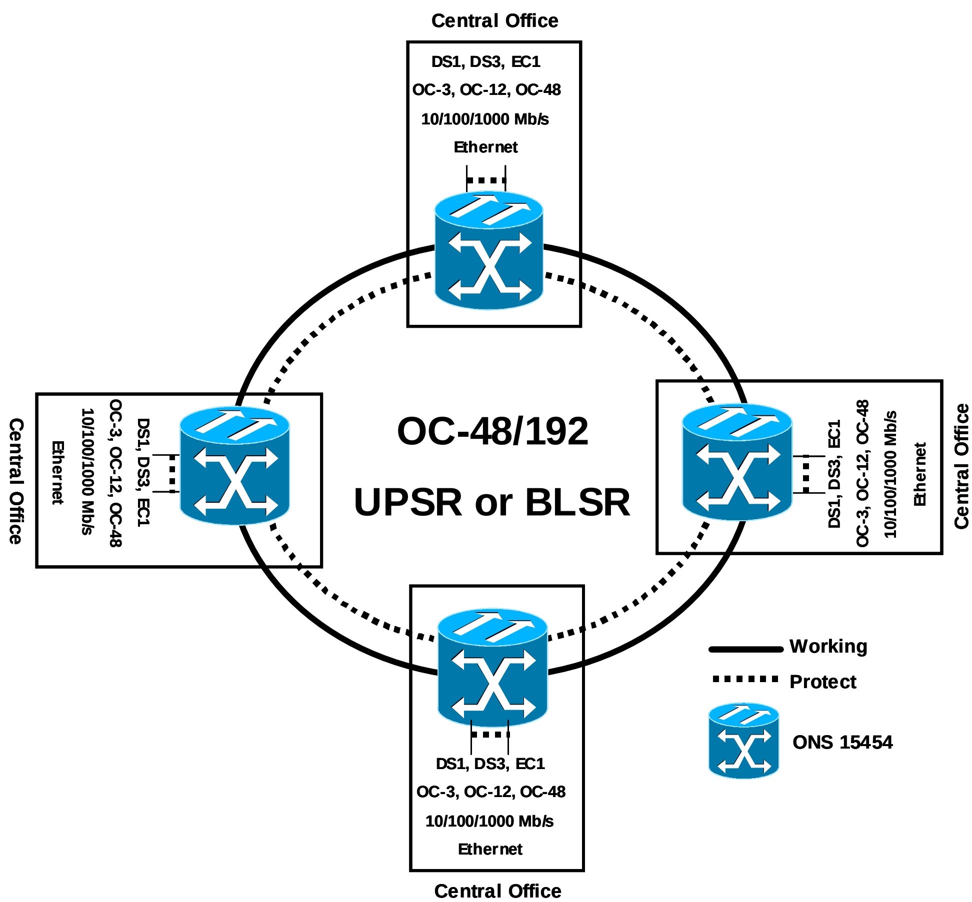
ONS 15454 allows you to easily manage services and quickly increase capacity without disrupting service.

NOC workstations or technician laptops can connect to the ONS 15454 using either direct, LAN, or firewall-compliant Ethernet connections, as well as through DCC connections for OAM&P. CTC and TL1 interfaces provide easy provisioning and troubleshooting applications.

Interoffice Transport

The ONS 15454 can be easily configured to carry TDM, ATM, data, and digital video services with Path Protection Configuration or BLSR protection. Its full range of interfaces provide incremental bandwidth increases as needed and supports DS-1, DS-3, DS-3 transmux, EC-1, OC-3, OC-12, OC-48, OC-192, 10/100 Mb/s, and Gigabit Ethernet line rates. The intermediate and long reach optics along with the ability to support any network topology makes the ONS 15454 ideal for interoffice (IOF) transport applications. Figure 9-1 shows an example of an interoffice transport in either a Path Protection Configuration or BLSR configuration.

Figure 9-1: Interoffice Transport



The ONS 15454 can groom services at the edge of the Metro Transport Network shown in Figure 9-2, packing the network with information and eliminating the need for multiple cross-connects and routers. Figure 9-3 shows the shelf layout of the ONS 15454 node located at the Interoffice Site.

Figure 9-2: Multi-Service Grooming at the Edge of the Metro Transport Network

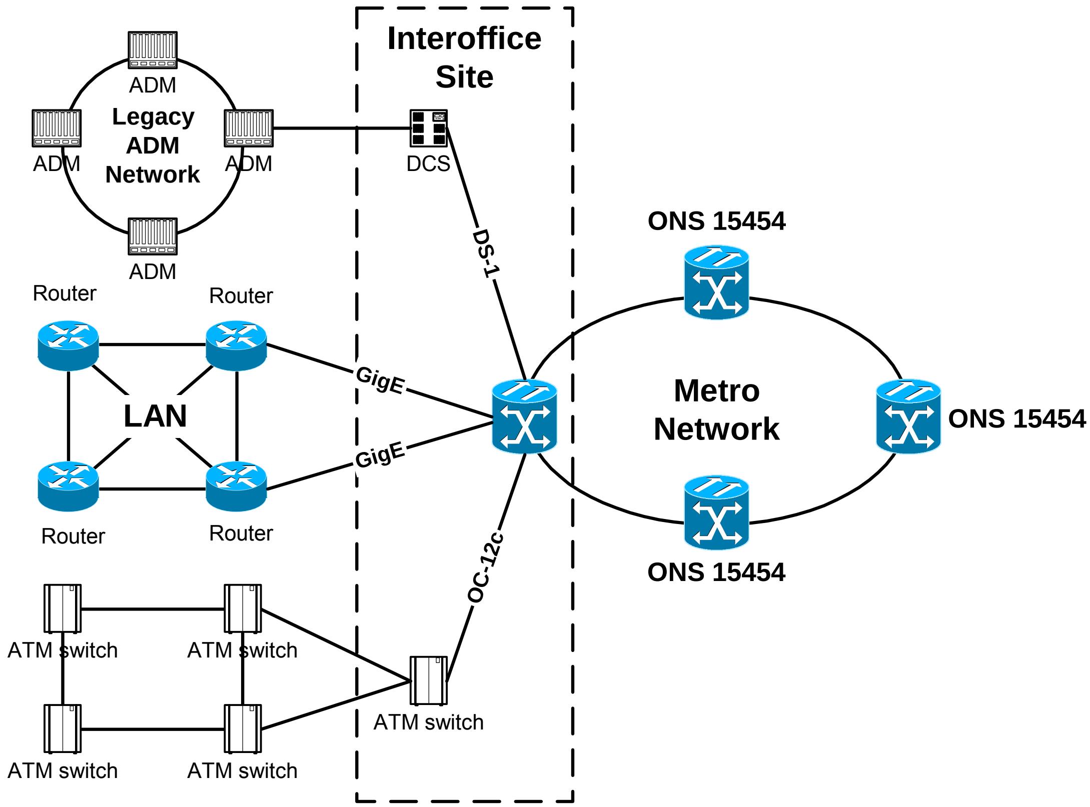
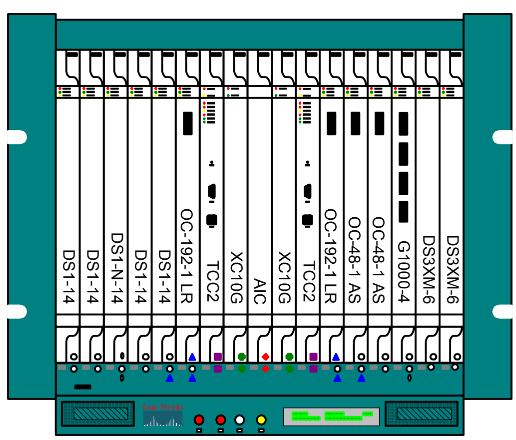


Figure 9-3: Shelf Layout of a Multi-Service Grooming Node



Two-Fiber BLSR Transport

Two-Fiber BLSR is a protected SONET architecture that survives cable cuts and node failures by providing redundant, geographically diverse paths for each fiber span. The ONS 15454 Two-Fiber BLSR solution allows each node to reuse bandwidth as traffic is added or dropped at any location on the ring.

Figure 9-4 shows multiple ONS 15454 nodes deployed in a typical 2-Fiber BLSR configuration. Because it offers bandwidth protection and flexible bandwidth distribution (allows for STS/VT1.5 reuse after traffic is dropped and protection channel access), the 2-Fiber BLSR is the preferred solution for interoffice transport where survivability is paramount.

Figure 9-4: Two-Fiber BLSR Topology

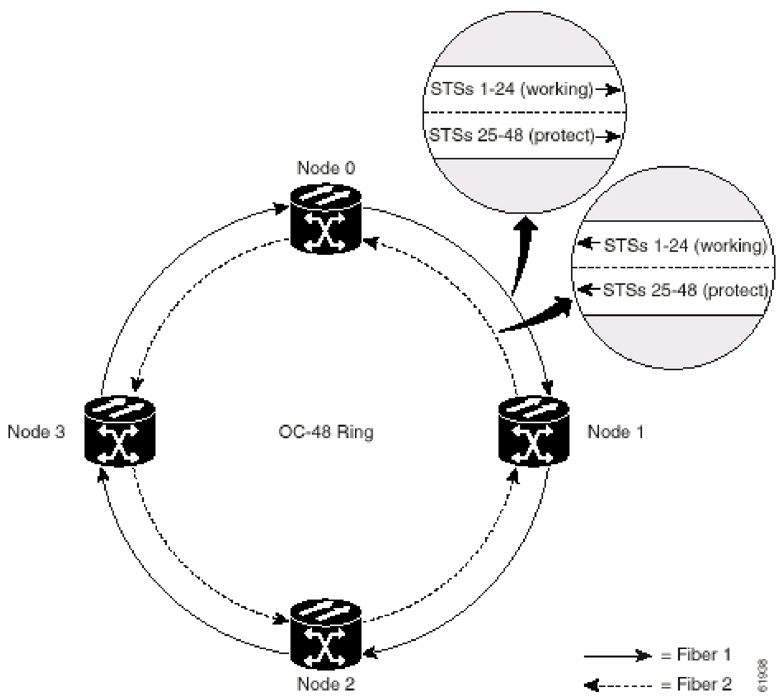
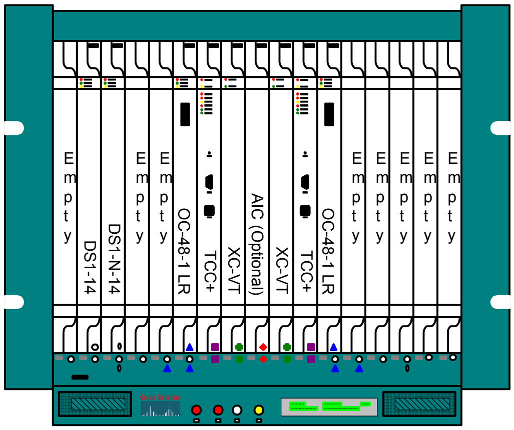


Figure 9-5 shows the shelf layout for an OC-48 Two-Fiber BLSR node with 4 DS-1s and 8 available slots for future growth.

Figure 9-5: OC-48 Two-Fiber BLSR Node with 4 DS-1s and 8 Available Slots

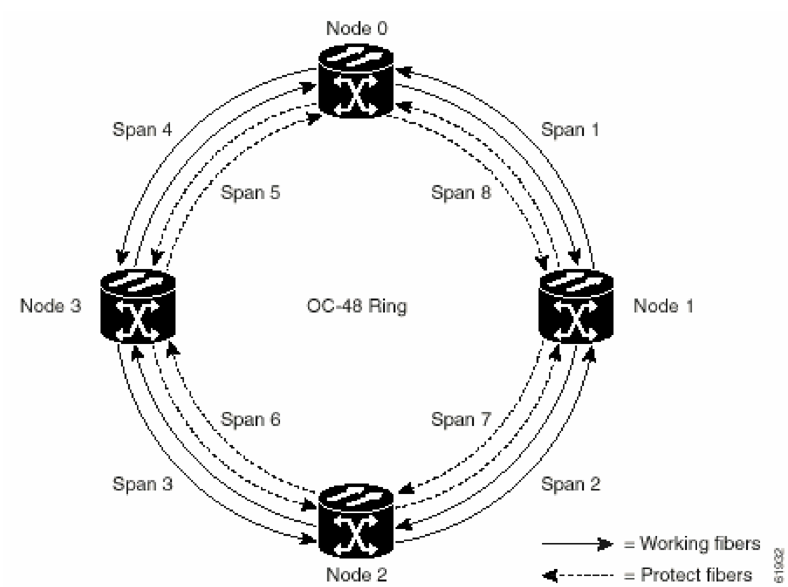


Four-Fiber BLSR Transport

Four-Fiber BLSRs double the bandwidth of 2-Fiber BLSRs. Because they allow span switching as well as ring switching, 4-fiber BLSRs increase the reliability and flexibility of traffic protection. Two fibers are allocated for working traffic and two fibers for protection, as shown in Figure 9-6. To implement a 4-Fiber BLSR, you must install four OC-48, OC-48AS, or OC-192 cards in the shelf assembly.

Because it offers bandwidth, maximum protection and flexible bandwidth distribution (allows for STS/VT1.5 reuse after traffic is dropped and protection channel access), the 4-Fiber BLSR is the preferred architecture for inter-exchange transport. However, since the 4-Fiber BLSR topology also protects against cable cuts and node failures by providing redundant, geographically diverse paths for each transport span, 4-Fiber BLSR is ideal for IOF transport applications.

Figure 9-6: Four-Fiber BLSR Topology



Two-Fiber BLSR to Four-Fiber BLSR Conversion

Two-fiber OC-48 or OC-192 BLSRs can be converted to four-fiber BLSRs. To convert the BLSR, install two OC-48 or OC-192 cards at each two-fiber BLSR node, then log into CTC and convert each node from two-fiber to four-fiber. The fibers that were divided into working and protect bandwidths for the two-fiber BLSR are now fully allocated for working BLSR traffic. See the *Cisco ONS 15454 Procedure Guide* for BLSR conversion procedures.

Access Transport

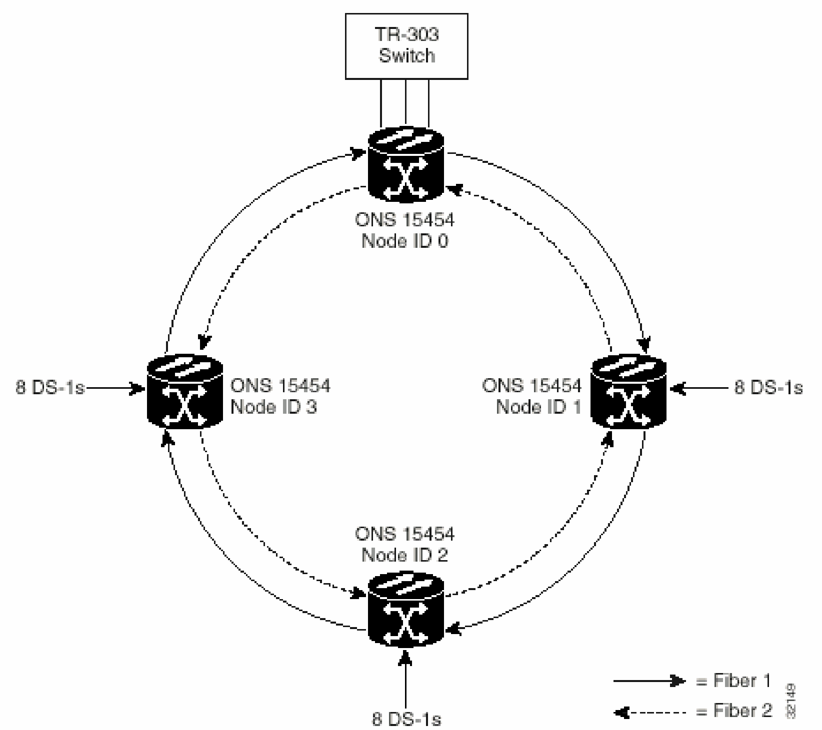
The ONS 15454 provides the flexibility required to link remote offices to a central office (CO) and to aggregate a wide range of services at the edge of the network and transport them to the core of the network.

Path Protection Configuration

The unidirectional ring is the simplest TDM ring architecture to implement and has become the access ring architecture of choice. A Path Protection Configuration circuit requires two DCC-provisioned optical spans per ONS 15454 node. In the case of a fiber cut or signal degradation, the ONS 15454 initiates a receive-end switch on the individual traffic path, restoring service very quickly. Since each traffic path is transported around the entire ring, the unidirectional ring architecture is optimized for networks where traffic homes to one or two locations. The capacity of the ring is equal to its bit rate since all traffic returns to one hub location.

Path Protection Configuration functionality is available on the OC-3, OC-12, OC-48 and OC-192 port cards. Figure 9-7 shows a common Path Protection Configuration application. OC-3 optics provide remote switch connectivity to a host Telcordia TR-303 switch. In the example, each remote switch requires eight DS-1s to return to the host switch. Figure 9-8 and Figure 9-9 show the shelf layout for each ONS 15454 node.

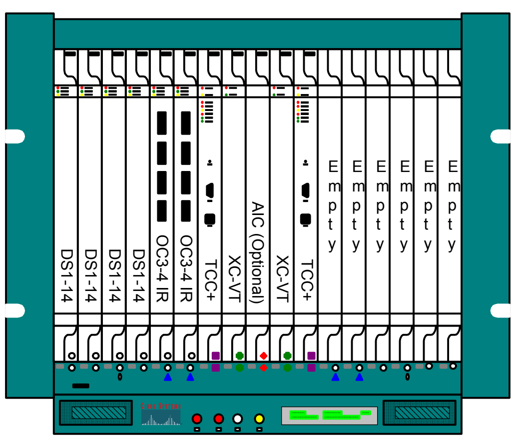
Figure 9-7: OC-3 Path Protection Configuration Transport



Node 0 has four DS1-14 cards to provide 56 active DS-1 ports. The other nodes only require two DS1-14 cards to handle the eight DS-1s to and from the remote switch. You can use the other half of each ONS 15454 shelf assembly to provide support for a second or third ring to other existing or planned remote sites.

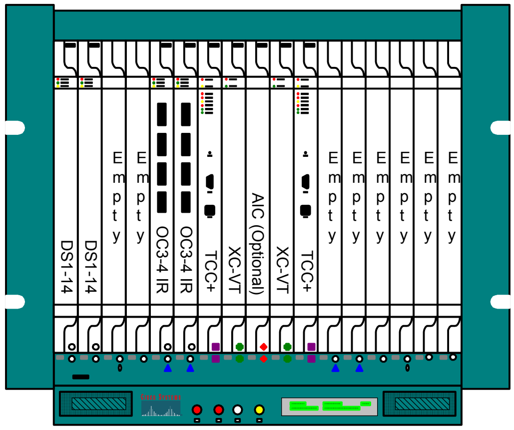
In the OC-3 Path Protection Configuration sample, Node 0 contains four DS1-14 cards and two OC3 IR 4 1310 cards. The six remaining slots can be provisioned with cards or left empty. Figure 9-8 shows the shelf setup for this node.

Figure 9-8: Layout of Node 0 in the OC-3 Path Protection Configuration Example in Figure 9-7



In the Figure 9-7 example, Nodes 1 to 3 each contain two DS1-14 cards and two OC3 IR 4 1310 cards. Eight empty slots exist. They can be provisioned with other cards or left empty. Figure 9-9 shows the shelf assembly setup for Nodes 1 to 3.

Figure 9-9: Layout of Nodes 1 to 3 in the OC-3 Path Protection Configuration Example in Figure 9-7



Path Protection Configuration Dual Ring Interconnect

The Path Protection Configuration dual ring interconnect (Path Protection Configuration DRI) topology provides an extra level of path protection between interconnected Path Protection Configurations. In DRIs traffic is dropped and continued at the interconnecting nodes to eliminate single points of failure. Two DRI topologies can be implemented on the ONS 15454. The traditional DRI uses four ONS 15454 nodes at the interconnect nodes, while the integrated DRI uses two ONS 15454 nodes. All ONS 15454 interfaces support Path Protection Configuration DRI. There can also be intermediate pass through nodes in the interconnection routes between the two Path Protection Configuration rings. Figure 9-10 shows ONS 15454 nodes in a traditional OC-48 Path Protection Configuration dual ring interconnect topology.

Figure 9-10: Traditional Path Protection Configuration DRI Topology

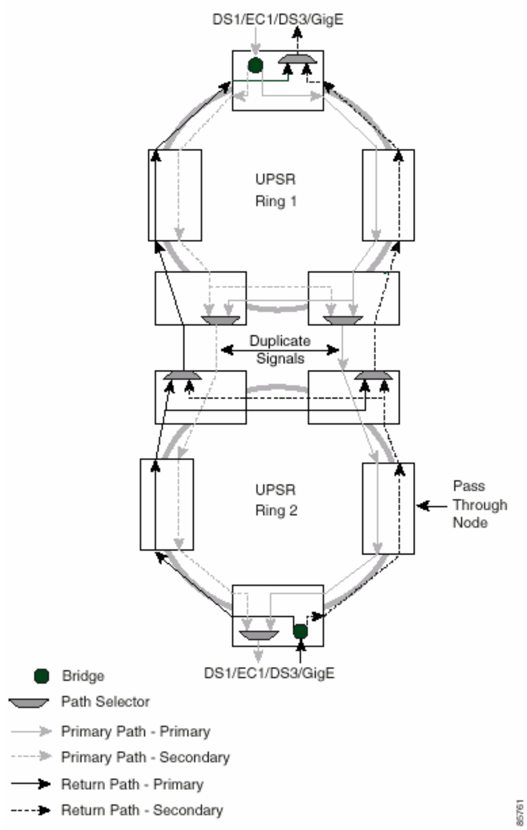


Figure 9-11 shows the shelf configuration of the four Path Protection Configuration DRI nodes. The six empty slots can be provisioned with other cards or left empty.

Figure 9-11 Shelf Layout of the Traditional Path Protection Configuration DRI Nodes

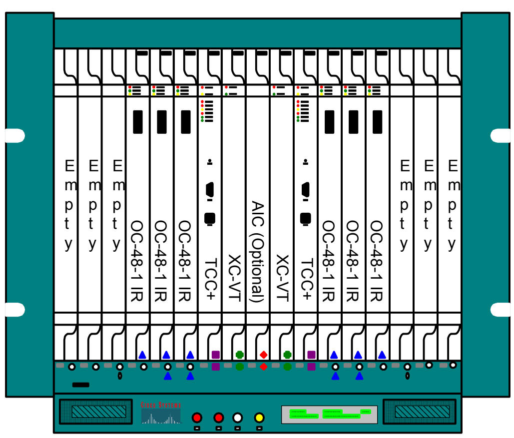


Figure 9-12 shows ONS 15454 nodes in an integrated dual ring interconnect topology. The same drop and continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an additional OC-48 trunk at the two interconnect nodes. Figure 9-13 shows the shelf layout of the two interconnect nodes.

Figure 9-12: Integrated DRI Topology

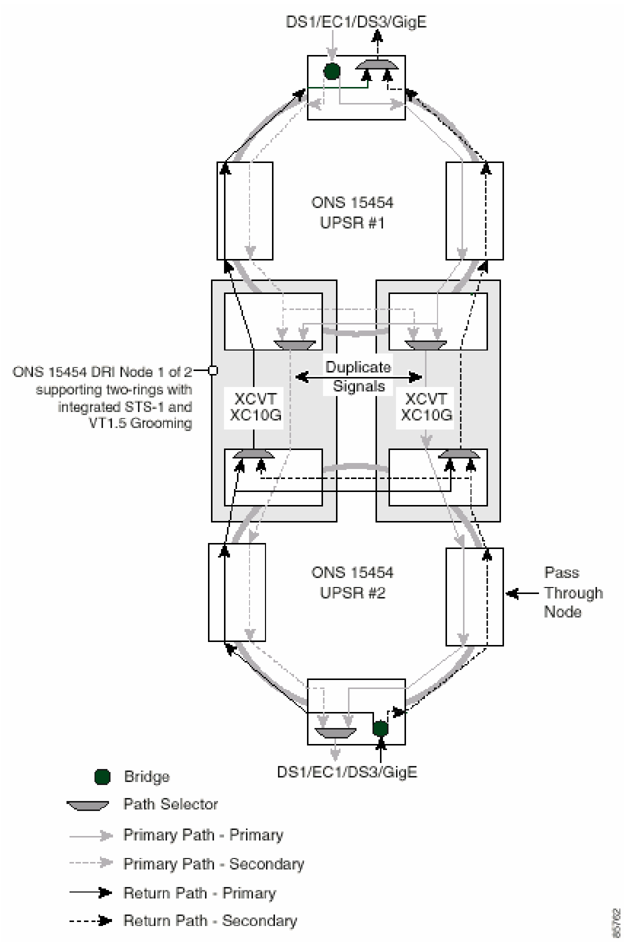
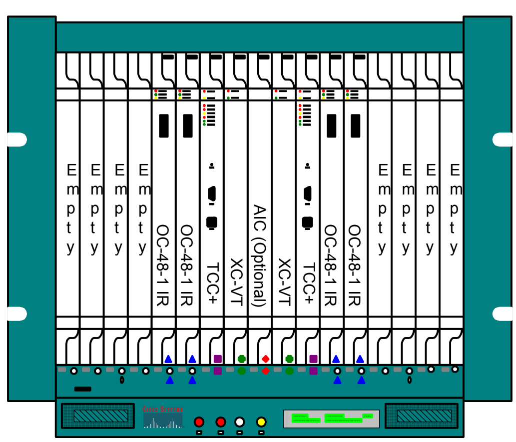


Figure 9-13: Shelf Layout of the Integrated DRI Nodes



Cisco Systems

Subtending Rings

The ONS 15454 supports up to ten SONET SDCCs with TCC+ cards and 32 SONET SDCCs with TCC2 cards. See Table 9-1 for ring and SDCC information.

Table 9-1: Maximum Number of Rings Supported per Shelf

TCC Card	2-Fiber BLSR	4-Fiber BLSR	Path Protection Configuration
TCC+	2	1	5
TCC2	2	1	16

Subtending rings reduce the number of nodes and cards required and reduce external shelf-to-shelf cabling. Figure 9-14 shows an OC-12 Path Protection Configuration subtending from an OC-48 BLSR. In this example, Node 3 is the only node serving both the BLSR and Path Protection Configuration. Node 3 has OC-48 cards in Slots 5 and 6 which serve the BLSR, and OC-12 cards in Slots 6 and 13, which serve the Path Protection Configuration (see Figure 9-15).

Figure 9-14: Path Protection Configuration Subtending from a BLSR

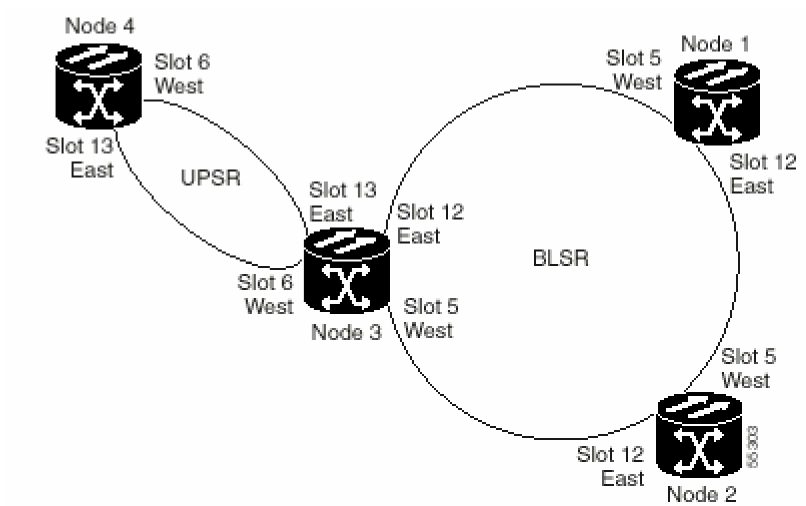
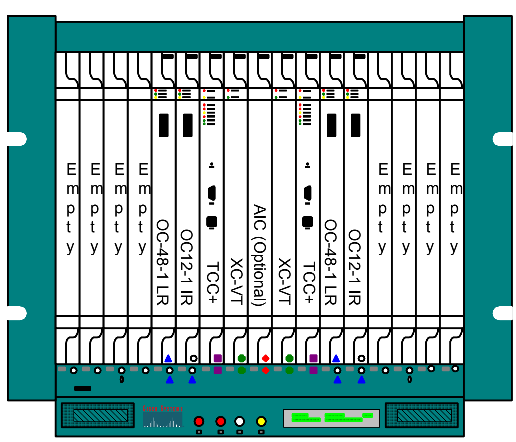


Figure 9-15: Node 3 Subtending Ring Shelf Layout



The ONS 15454 can support two 2-Fiber BLSRs or one 4-Fiber BLSR on the same shelf. This capability allows you to deploy an ONS 15454 in applications requiring SONET digital cross connect systems (DCSs) or multiple SONET add/drop multiplexers (ADMs).

Figure 9-16 shows two OC-48 BLSR rings shared by one ONS 15454 node. Ring 1 runs on Nodes 1, 2, 3, and 4. Ring 2 runs on Nodes 4, 5, 6, and 7. Two BLSR rings, Ring 1 and Ring 2, are provisioned on Node 4. Ring 1 uses cards in Slots 5 and 12, and Ring 2 uses cards in Slots 6 and 13. Figure 9-17 shows the shelf layout for Node 4.

Note Nodes in different BLSRs can have the same, or different node IDs.

Figure 9-15: BLSR Subtending from a BLSR

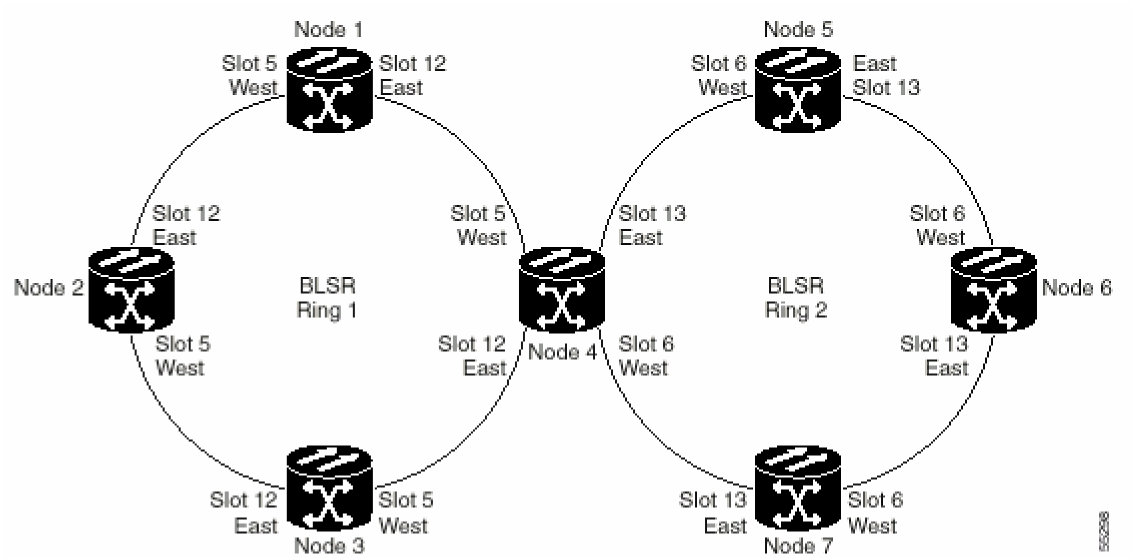
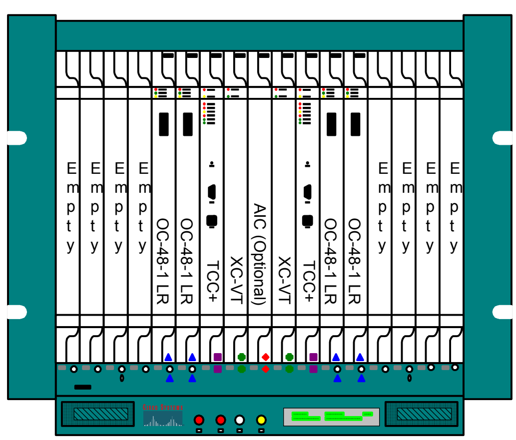


Figure 9-17: OC-48 BLSR Subtended Ring Shelf Layout



After subtending two BLSR rings, you can route circuits from nodes in one ring to nodes in the second ring. For example, in Figure 9-16 you can route a circuit from Node 1 to Node 7. The circuit would normally travel from Node 1 to Node 4 to Node 7. If fiber breaks occur, for example between Nodes 1 and 4 and Nodes 4 and 7, traffic is rerouted around each ring: in this example, Nodes 2 and 3 in Ring 1 and Nodes 5 and 6 in Ring 2.

Linear ADM Configurations

You can configure ONS 15454s as a line of add/drop multiplexers (ADMs) by configuring one set of OC-N cards as the working path and a second set as the protect path. Unlike rings, linear (point-to-point) ADMs require that the OC-N cards at each node be in 1+1 protection to ensure that a break to the working line is automatically routed to the protect line.

A common linear application is a configuration with a backbone route requiring traffic to be dropped and inserted at each site. Figure9-18 shows an OC-192 application with 10 DS-1s and 2 DS-3s dropped at each site. Four OC-192 modules are required at the two central ADM sites to handle traffic in both directions.

Figure 9-18: OC-192 Linear ADM 1+1 Protected

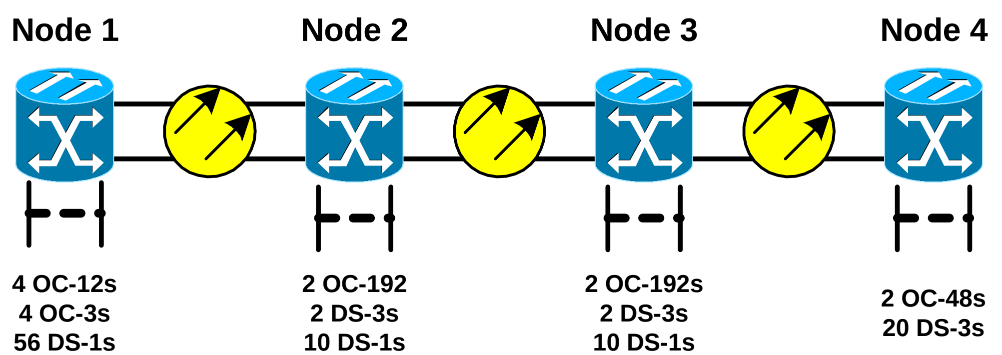
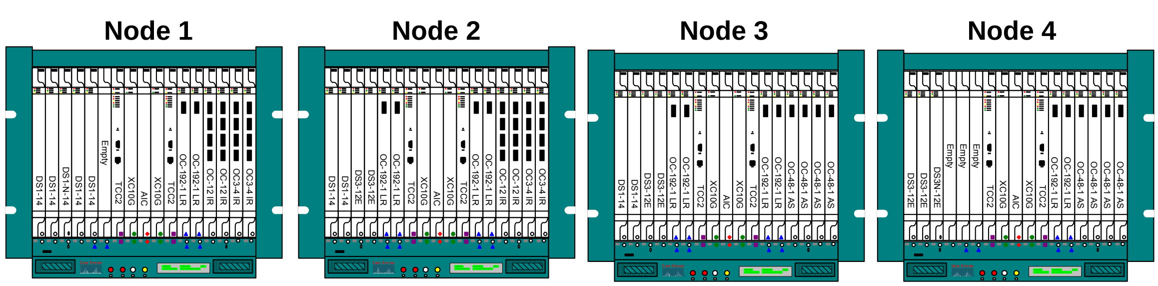


Figure 9-19 shows the shelf layouts for Nodes 1 to 4 in the above example.

Figure 9-19: OC-192 Linear ADM 1+1 Protected Shelf Layouts



The ONS 15454 also supports distributed linear networks. Figure 9-20 shows a distributed OC-48 backbone with OC-12 and EC-1 uplinks. Site A collects DS-1 traffic from the remote sites, while, Sites B, C, and D are configured in an Ethernet Virtual Private Network (VPN). Note that at Site C, an OC-12 can be dropped from the same shelf that contains an OC-48 (see Figure 9-21).

Figure 9-20: Distributed Linear Network

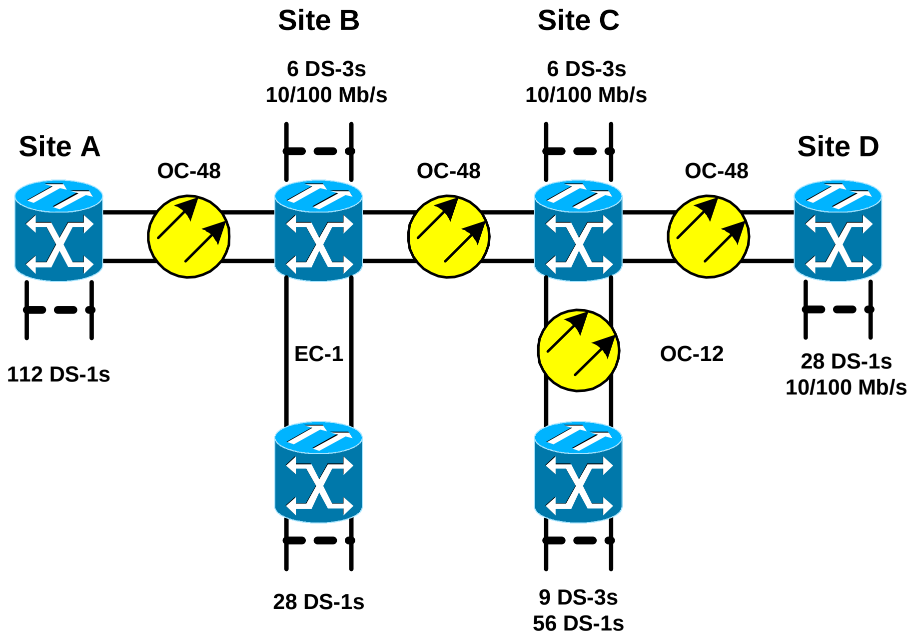
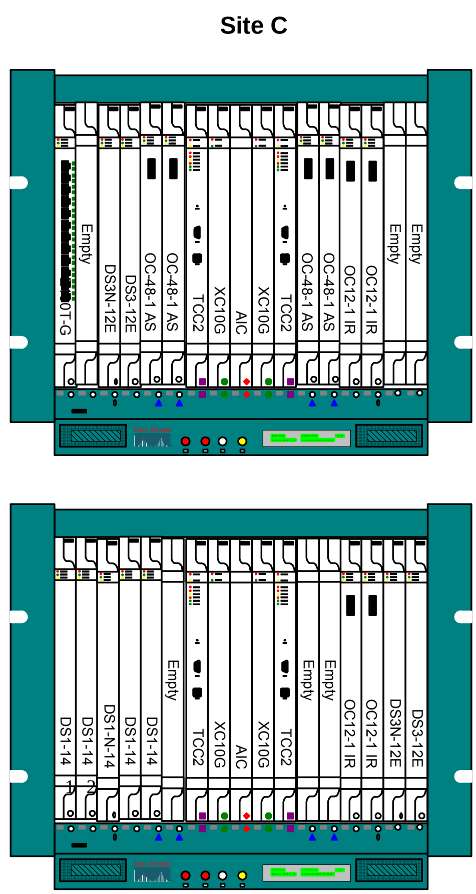


Figure 9-21: Multi-homed Linear ADM Shelf Layout

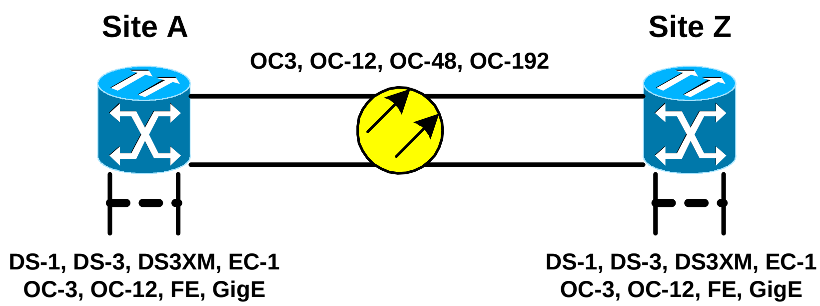


Terminal Mode

In a Terminal Mode (TM) configuration, the ONS 15454 node terminates the entire SONET payload at each end of the fiber span. TM systems are generally employed in a basic transport application calling for a single system/single route solution.

The ONS 15454 is designed to meet a wide range of capacity demands and can support TM configurations using OC-3, OC-12, OC-48 and OC-192 line rates. The ONS 15454 also supports an extensive range of mixed voice and data interfaces within the same shelf that hosts the SONET spans, making it extremely cost-effective for TM point-to-point applications shown in Figure 9-22.

Figure 9-22: Terminal Mode Point-to-Point Application



Depending on the ONS 15454 port card used for the SONET span, protection spans can be added by installing another port card, such as OC-192, or by using additional ports on a multi-port card, such as OC-3 or OC-12. Table 9-2 lists the available TM protection schemes for electrical and optical interface cards.

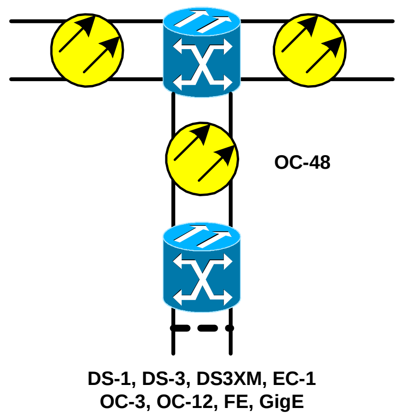
Table 9-2: Terminal Mode Protection Schemes

Protection Scheme Supported	Electrical Cards	Optical Cards
Unprotected	X	X
1:1	X	
1:N	X	
1+1		X
Path Protection Configuration		X
BLSR		X
PPMN		X

Traffic Aggregation

As an aggregator, the ONS 15454 combines the traffic from several low-speed sources for transmission across a high-speed link to another ONS 15454 node as illustrated in Figure 9-23.

Figure 9-23: Traffic Aggregation Application



Optical Hub

The multi-service flexibility and shelf capacity of the ONS 15454 enables a single shelf to act as an optical hub. As an optical hub, a single ONS 15454 can support multiple linear or ring systems. Traffic can be groomed an routed through an optical hub. Figure 9-24 shows an optical hub supporting two OC-48, four OC-12, and three OC-3 terminations.

Figure 9-24: Optical Hub Application

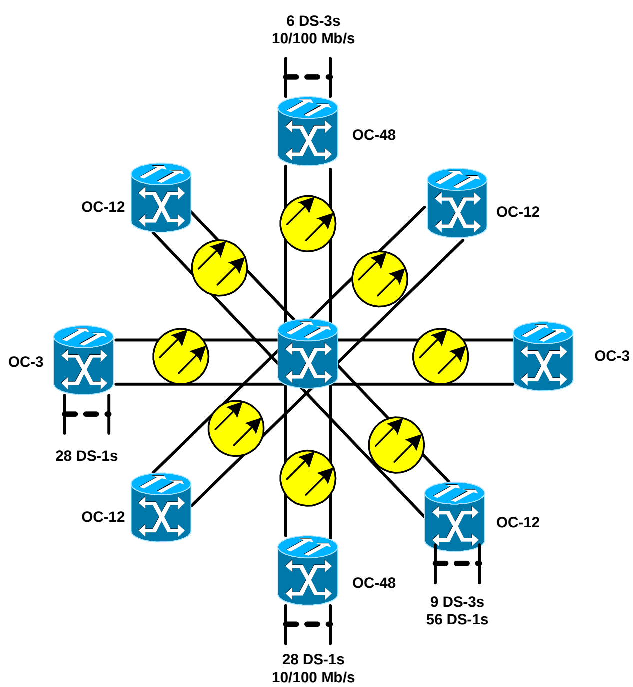
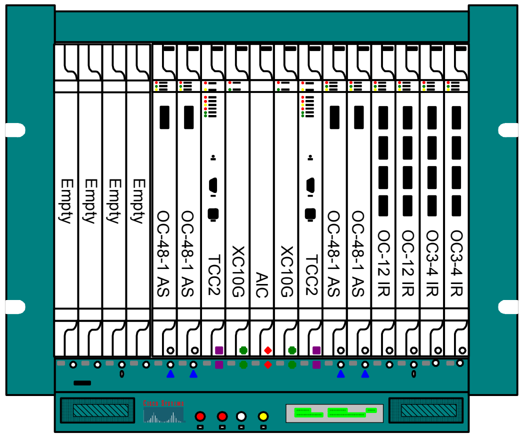


Figure 9-25 shows the shelf layout for the optical hub node in Figure 9-24.

Figure 9-25: Optical Hub Shelf Layout



Digital Cross-connect Applications

The ONS 15454 digital cross-connect system (DCS) capabilities provide full STS and VT1.5 matrices to facilitate traffic grooming and consolidation. This allows the ONS 15454 to act as a 3/1 and/or 3/3 DCS. The DCS functionality is key to traffic grooming where you take a series of partially filled STSs and consolidate them into a few tightly packed STSs.

3/1 DCS

The VT Cross-connect (XC-VT) and DS3XM (transmux) cards enable 3/1 DCS functionality. DS-1s, DS-3s and VT1.5 signals are mapped into STS circuits. The ONS 15454 can take several partially filled DS-3s and combine them into one DS-3. This ensures that the SONET ring is full of used channels, not idle channels.

The ONS 15454 also performs Time Slot Interchange (TSI) and in addition to cross-connecting. This allows signals to be groomed at the edge of the network, which can reduce or eliminate the need for expensive DCSs and fan out ports to the DCSs at a central office.

The following figures show rack and shelf layouts for 3/1 DCS applications:

Figure 9-26: Single Shelf 3/1 DCS 112 DS1 Ports and 6 DS3 Transmux Ports

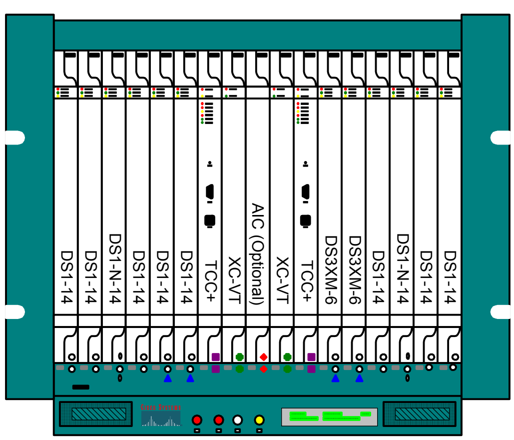


Figure 9-27: Two Shelf 3/1 DCS with 140 DS1 Ports and 18 DS3 Transmux Ports

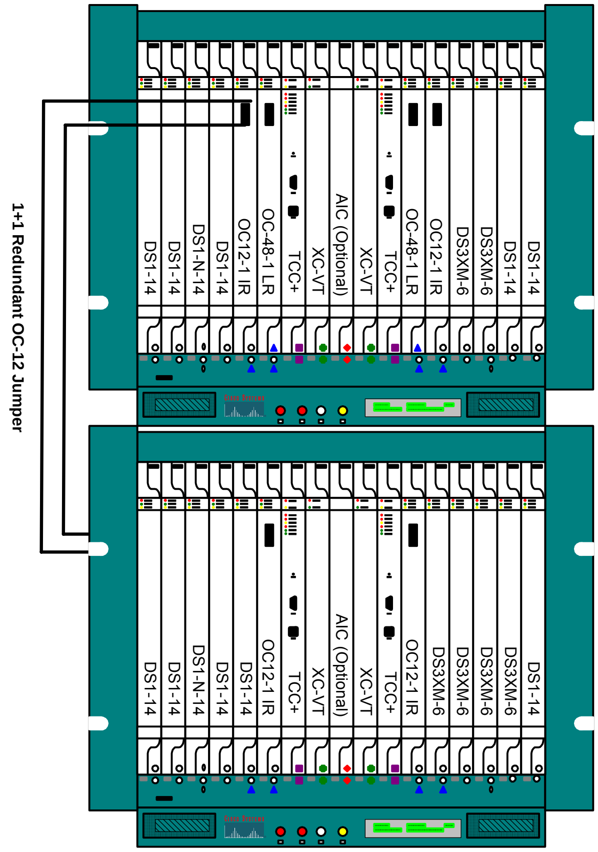


Figure 9-28: Three-shelf 3/1 DCS with 224 DS1 ports, 18 DS3 Transmux ports, and 12 STS1 ports

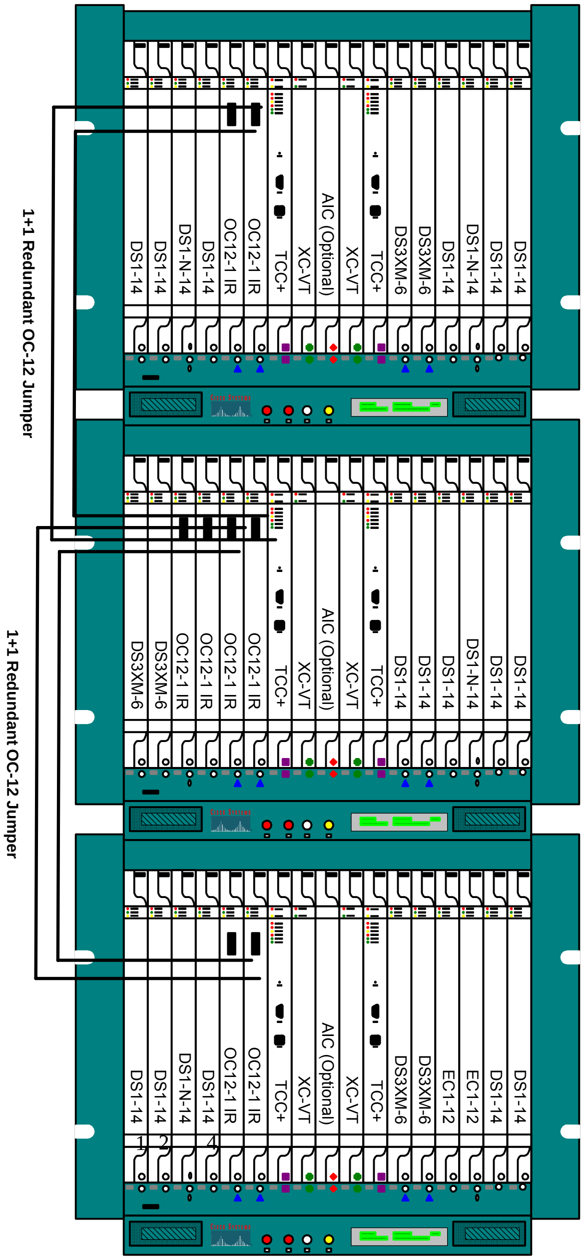
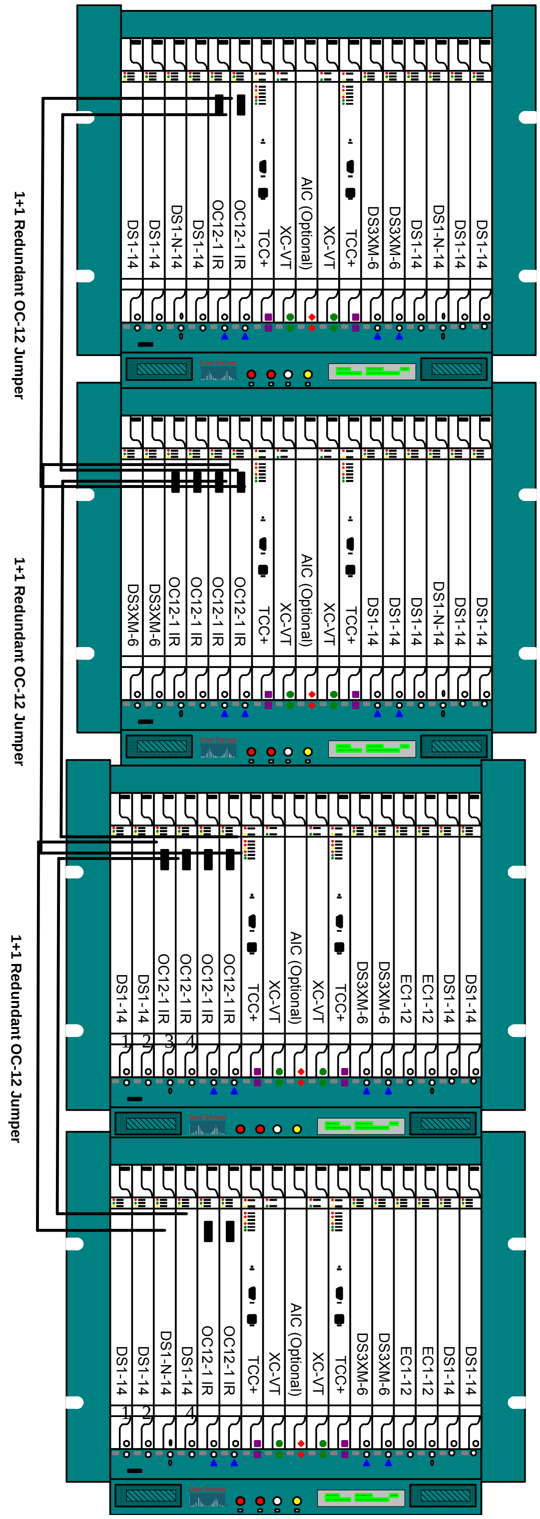


Figure 9-29: Four Shelf 3/1 DCS with 280 DS1 ports, 24 DS3 Transmux Ports, and 24 STS1 Ports



3/3 DCS

The ONS 15454 also has an integrated 3/3 cross-connect, which is ideal for grooming DS-3s and STSs prior to passing them into a core network. A typical 3/3 DCS application for the ONS 15454 is at IOF sites where local loops converge.

Table 9-3 lists the 3/3 DCS configurations supported by the ONS 15454.

Note The DS-3 capacity will be reduced if you assign OC-N modules to card slots optimized for DS-3 traffic.

Table 9-3: 3/3 DCS Configurations and Capacities

Configuration	Tributaries
120 DS-3 Ports	DS-3 or STS-1s
264 DS3 Ports	DS-3 or STS-1s
336 DS3 Ports	DS-3 or STS-1s

The following figures show the rack and shelf layouts for the 3/3 DCS applications:

Figure 9-30: 3/3 DCS Application with 120 DS-3 Ports

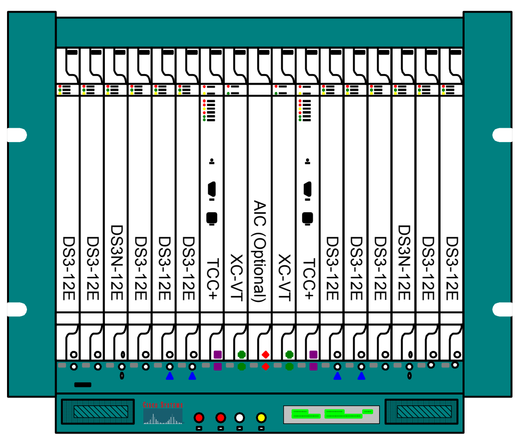


Figure 9-31: 3/3 DCS Application with 264 DS-3 Ports

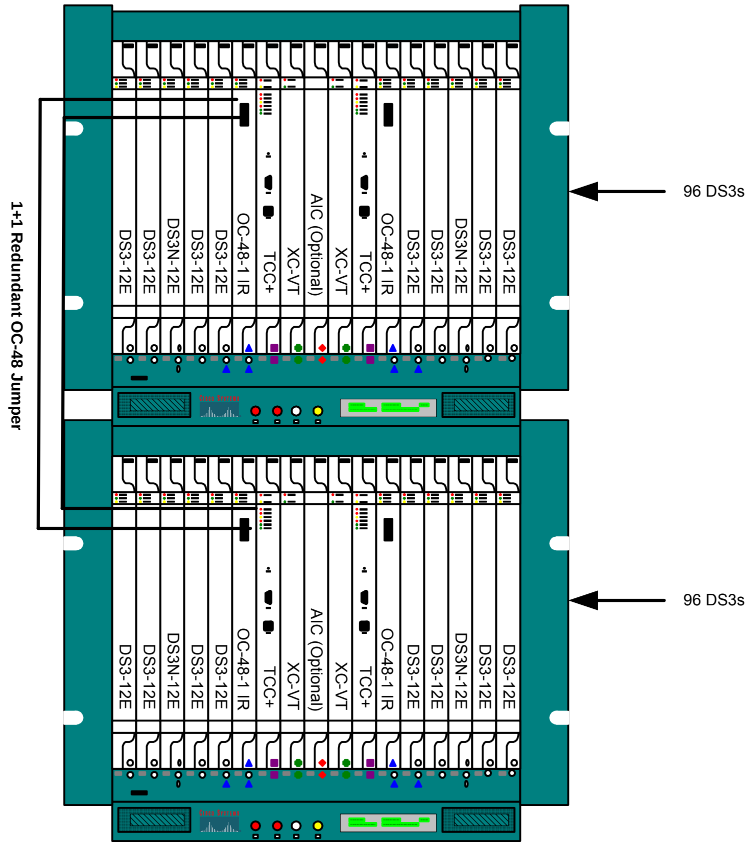
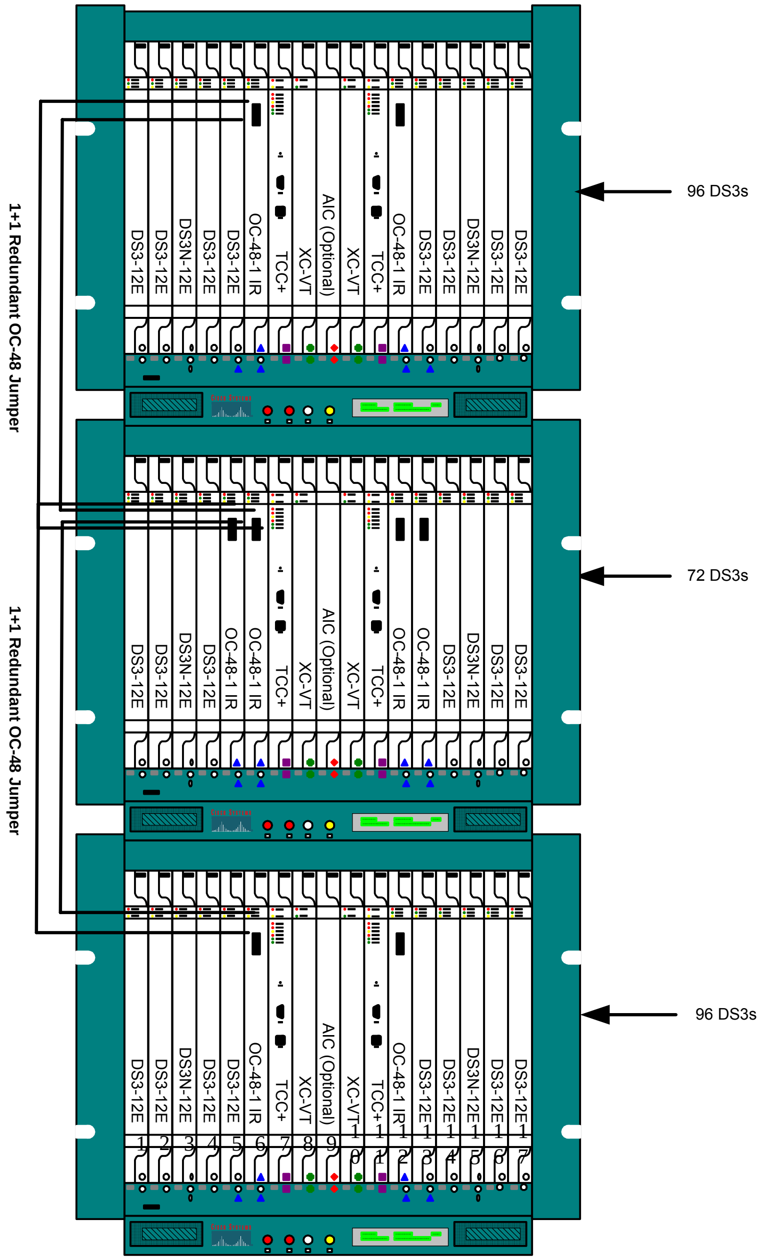


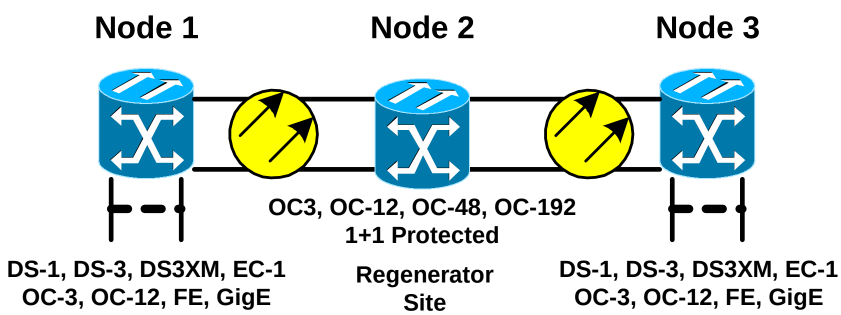
Figure 9-32: 3/3 DCS Application with 336 DS-3 Ports



Regenerator Site

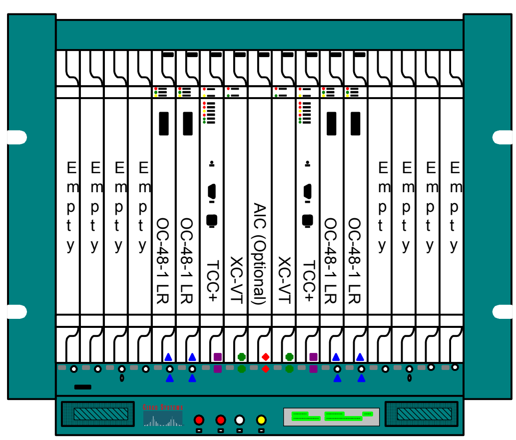
The ONS 15454 can be configured as an effective regenerator. An added benefit of this configuration is that when new services are needed at the regenerator, you simply add an interface card to the ONS 15454 to support the services. This does not require any new software or network engineering, just plug in the interface card and turn up the service. Figure 9-33 shows the ONS 15454 supporting a regenerator configuration for a linear ADM network. The ONS 15454 can also act as a regenerator for other SONET topologies including Path Protection Configuration, BLSR, and virtual rings, and PPMN meshes. Adding new interface cards and activating new services is non-service affecting.

Figure 9-33: Regenerator Application for a Linear Network



Regenerators are popular for long-haul systems where signal regeneration and future access to traffic is required. Another popular configuration is the extension of digitized video traffic to other sites to eliminate the costs of building a new headend site. However, the most exciting application is the pre-positioning of SONET terminals as future service nodes. The continuing reduction in SONET costs has made this a feasible deployment option. The ONS 15454 supports this application since an ONS 15454 can be configured to support terminal mode, ADM, ring, hub, and regenerator applications. Figure 9-34 shows the shelf layout for the ONS 15454 OC-48 regenerator node shown in Figure 9-33.

Figure 9-34: OC-48 Regenerator Node Shelf Layout



Passive DWDM Applications

The ONS 15454 supports 18 different OC48 ELR ITU-T 200 GHz or 37 OC48 ELR ITU-T 100 GHz cards to provide you with up to 80 Gb/s of bandwidth over a single fiber. Deployed where fiber routes are constrained, this fiber bandwidth leverages the installed fiber resources and reduces the need to install new fiber. Matching the ONS 15454 OC48 ELR ITU-T cards with Cisco's ONS 15216 DWDM products or DWDM products from third party vendors greatly expands the capabilities of the ONS 15454. Figure 9-35 shows a typical 7ft. x 19in. rack layout for a DWDM hub site using ONS 15454 OC48 ELR ITU-T cards and third party multiplexers and demultiplexers.

Figure 9-35: DWDM Hub Site Layout

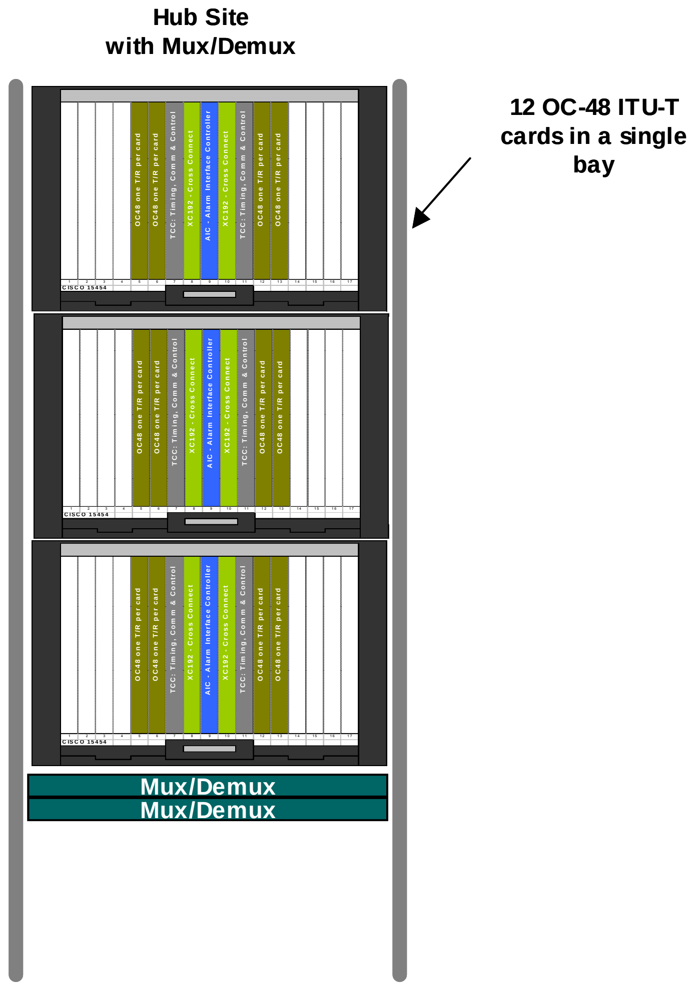
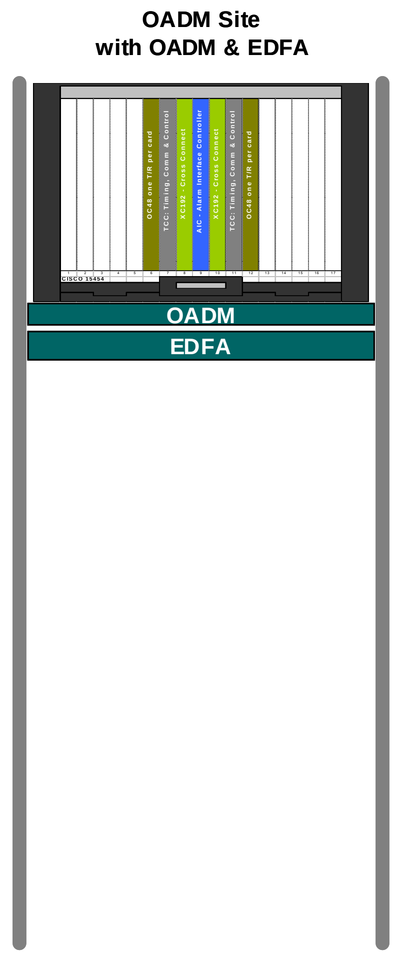


Figure 9-36 is an example of an optical add/drop multiplexer (OADM) site where multiple channels can be dropped an inserted. The 7ft. x 19in. rack is equipped with a single ONS 15454 shelf containing the ONS 15454 OC48 ELR ITU-T optics cards, OADM unit, and EDFA.

Figure 9-36: OADM Site Shelf Layout



Wavelength Multiplexer

The multi-wavelength capabilities of the ONS 15454 allow it to easily interface with passive WDM filters.

Since the WDM/DWDM systems are transparent to the ONS 15454, all of the topologies described in this document can be run over WDM/DWDM networks. This includes linear networks, rings, data meshes, PPMN and Virtual rings.

1310 nm and 1550 nm OC-48 and OC-12 cards can be passed through inexpensive passive couplers to be multiplexed over a single fiber. See Figure 9-37.

Figure 9-37: Passive DWDM Interface

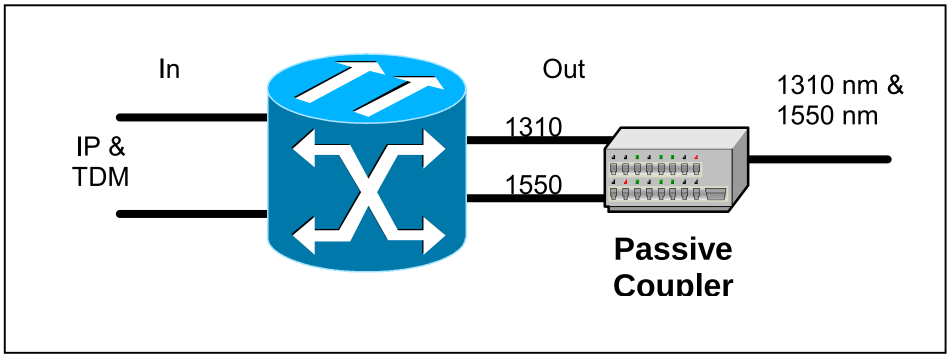
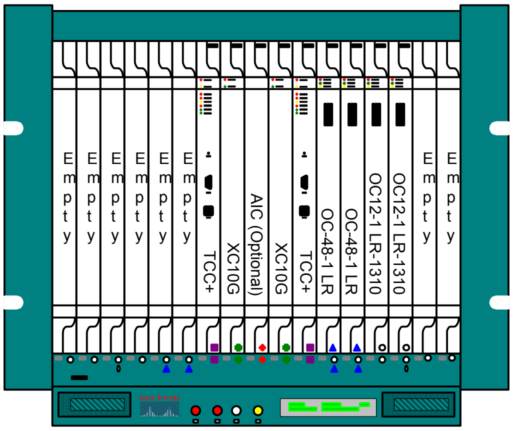


Figure 9-38 shows the shelf layout for an ONS 15454 Passive Wavelength Multiplexing node.

Figure 9-38: Passive Wavelength Multiplexing Node



Ethernet Applications

The Cisco ONS 15454 integrates Ethernet into a SONET time-division multiplexing (TDM) platform. The ONS 15454 supports E-Series, G-Series, and ML-Series Ethernet cards.

The ONS 15454 E-Series cards include the E100T-12, E100T-G, E1000-2, and E1000-2-G. An ONS 15454 supports a maximum of ten E-Series cards. You can insert these cards in any multipurpose slot. Use the E-Series cards if your application requires Layer 2 switching. These cards support point-to-point, hub and spoke, and shared packet ring topologies with a maximum circuit size of STS-12c.

The G-Series cards include the G1000-4 and G1K-4. These cards map up to four Gigabit Ethernet interfaces onto a SONET transport network. G-Series cards provide scalable and provisionable transport bandwidth at signal levels up to STS-48c per card. The G-Series cards provide line rate forwarding for all Ethernet frames (unicast, multicast, and broadcast) and can be configured to support Jumbo frames (defined as a maximum of 10,000 bytes). Use the G-Series cards if your application is for an Ethernet private line service providing transparent LAN services (TLS), line rate GigE, and high-availability transport for applications such as storage over MAN/WANs. You can independently map the four ports on the G-Series card to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, and STS-48c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-48c.

The ML-Series cards consist of the ML100T-12 and ML-1000-2. These cards integrate high-performance Ethernet transport, switching, and routing into a single card. Use the ML-Series cards if your application calls for Layer 2 bridging and/or Layer 3 routing, switching, or forwarding of data packets. ML-Series cards can be installed in any of the multipurpose slots. For a description of ML-Series software features and configuration files, see the *Cisco ONS 15454 SONET/SDH ML-Series Multilayer Ethernet Card Software Feature and Configuration Guide*.

Ethernet Solutions Matrix

The ONS 15454 is designed to be located at the edge and core of the network to provide Ethernet transport between Enterprise locations, data centers, remote sites, and Internet service providers (ISPs). Ethernet applications and features are described in Chapter 5. Use the charts below to select the Ethernet solution for your application.

ONS 15454 Ethernet Solutions	10/100 Mb/s Interface	Gig-E Interface	NEBS3E Shelf	ANSI Shelf	Minimum Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q-in-Q VLAN Tagging
E-Series	12 ports per card	2 ports per card (GBICs: SX, LX)	Yes	No	2.0	509 VLANS per DCC-connected network	Port and Circuit VLAN filtering	No (exceeds maximum frame size)
G-Series	N/A	4 ports per card (GBICs: SX, LX, ZX)	No	Yes	3.2	VLANS are tunneled (not terminated)	VLANs are tunneled (no filtering)	Yes
ML-Series	12 ports per card	2 ports per card (GBICs: SX, LX, ZX)	No	Yes	4.0	VLANS and Layer 2 protocol are tunneled	VLANs are tunneled (no filtering)	Yes

ONS 15454 Ethernet Solutions	Maximum Frame Size	Broadcast and Multicast Support	Spanning Tree	Rate Limiting capability	Layer 3 Routing	Dedicated STS Circuit Size: Point-to-Point	Shared STS Circuit Size: Multiple Ports/ Multiple Sites
E-Series	1522 bytes (802.1Q frame)	No	Yes - 8 instances	STS level rate-limiting: STS-1 to STS-12c	N/A	STS-12c	STS-6c (1.2 Gbps switch matrix enables STS sharing)
G-Series	10,000 bytes	Yes (only port-to-port circuits are supported)	No	STS level rate-limiting: STS-1 to STS-24c	N/A	STS-24c	N/A - No switch matrix
ML-Series	10,000 bytes	Yes	Yes - 255 STP and RSTP instances	Port level rate-limiting: 1 Mb/s increments	Layer 3 routing, switching, and forwarding: Up to 18,000 IP routes; Up to 20,000 IP host entries; Up to 128 IP multicast groups	STS-24c	STS-24c

ONS 15454 Ethernet Solutions	SONET Protection (Path Protection Configuration, BLSR, Linear)	Circuit Termination on E-Series Card	Circuit Termination on G-Series Card	Circuit Termination on ML-Series Card
E-Series	Yes	Yes	No	No
G-Series	Yes	No	Yes	Yes
ML-Series	Yes	No	Yes	Yes

Cable Modem Aggregation

The ONS 15454 is ideal for providing Ethernet aggregation at remote sites and them back to one central site or headend location. Aggregation can be performed via point-to-point Transparent LAN Service (TLS) shown in Figure 9-39 or over a Shared Packet Ring shown in Figure 9-40.

Figure 9-39: Point-to-Point Cable Modem Aggregation

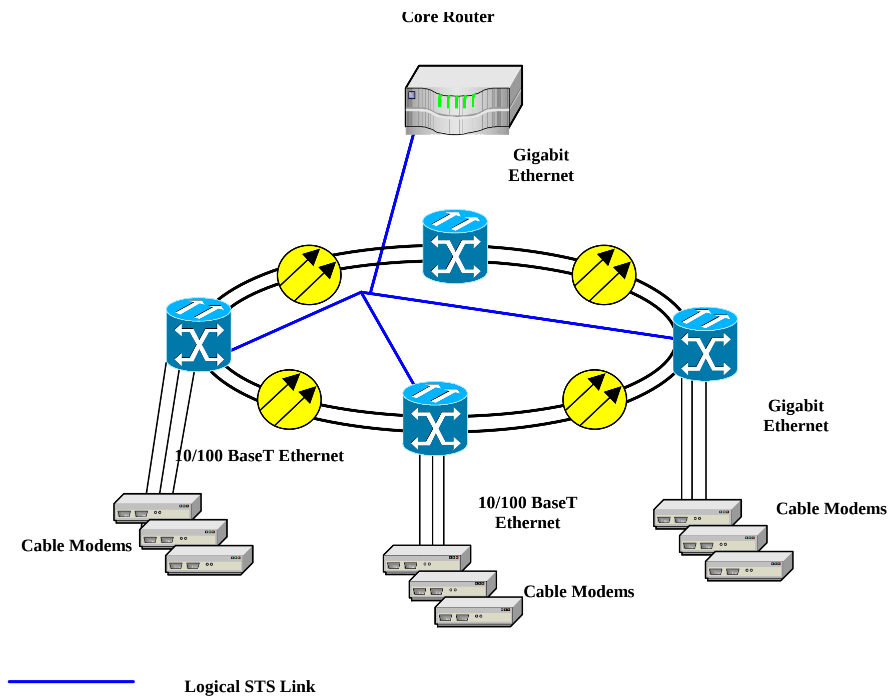
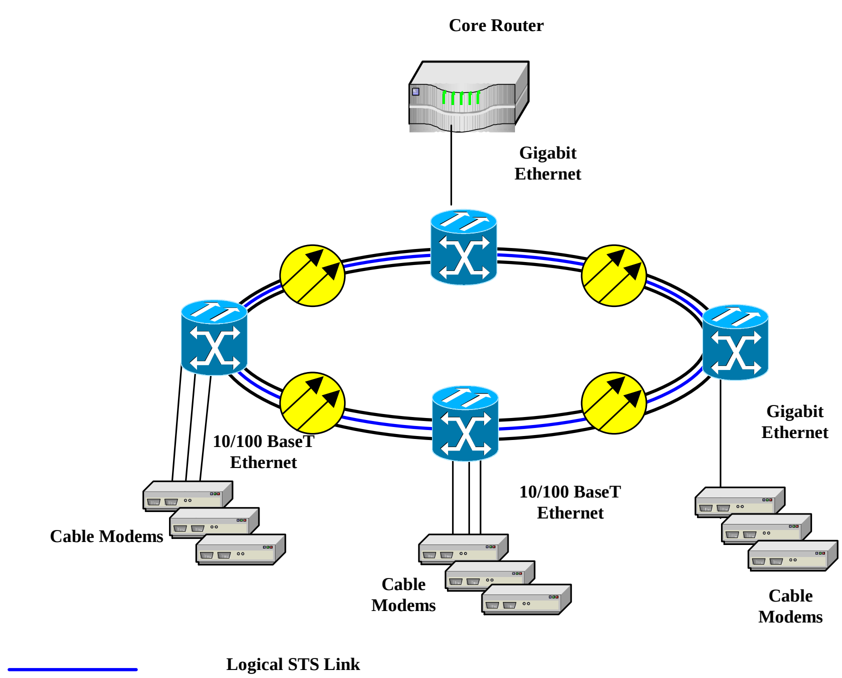


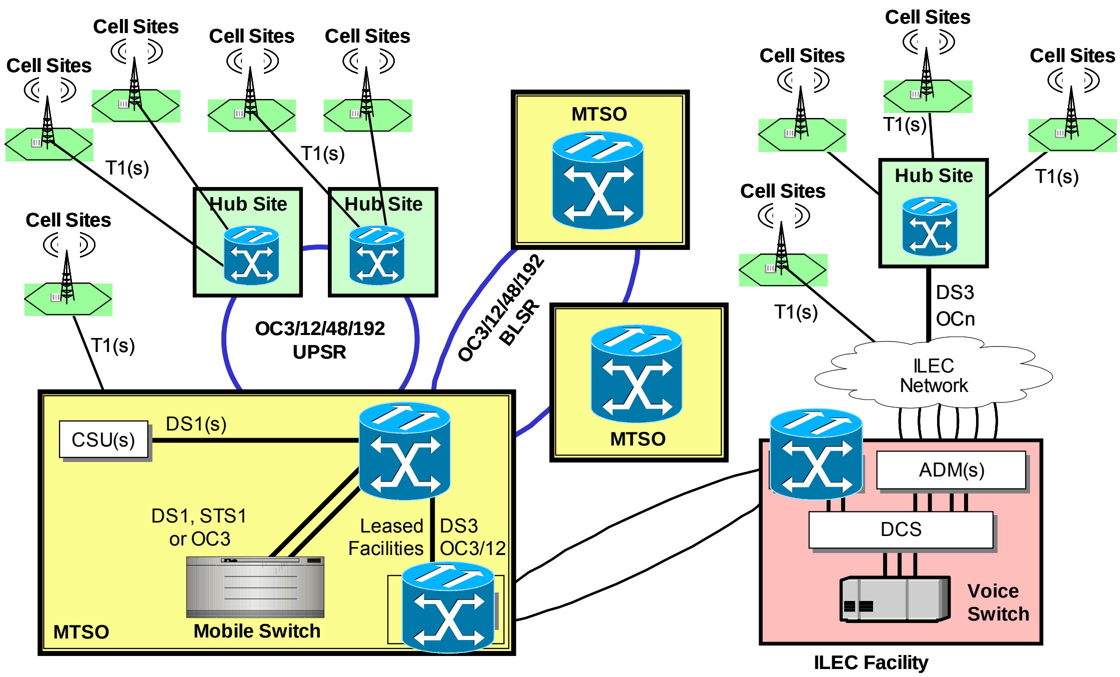
Figure 9-40: Shared Packet Ring Cable Modem Aggregation



Wireless Networking

The ONS 15454 provides cost-effective transport of services between mobile telephone switch offices (MTSOs) and hub sites. In Figure 9-41, the ONS 15454 links the hub sites to the MTSO transport network and ILEC facilities. It also provides the optical bandwidth management between each MTSO site.

Figure 9-41: Wireless Networking Optical Bandwidth Management



Video Transport

The ONS 15454 provides the flexibility required to support the next generation hybrid fiber coax (HFC) network recommended by Cable Labs. The next generation HFC network is based on the regional hub concept and includes the following attributes:

A master headend offering the ability to combine voice, data, and video into ATM cells for transmission on a SONET network to secondary headends and regional hubs.

Centralized regional hubs which allow sharing of common equipment among multiple system operators (MSOs) within the region.

Fiber rings interconnecting hubs and headends extend their reach and offers routing capabilities.

No amplifiers needed for fiber rings.

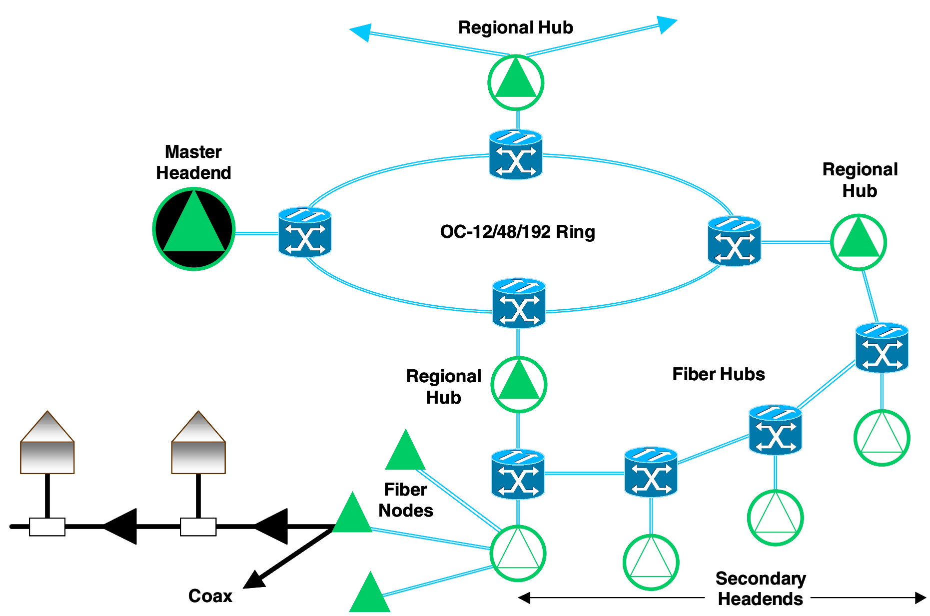
Maximum distance between furthest end user node and fiber hub of 80 km.

The ring topology may interconnect a single operator's headends or the headends of any number of MSOs operating in adjacent serving areas.

Centralization of capital-intensive investments at the regional hub allows the cable operators to spread the investments across a wider base and provides a platform for offering a common set of services to subscribers and other cable operators.

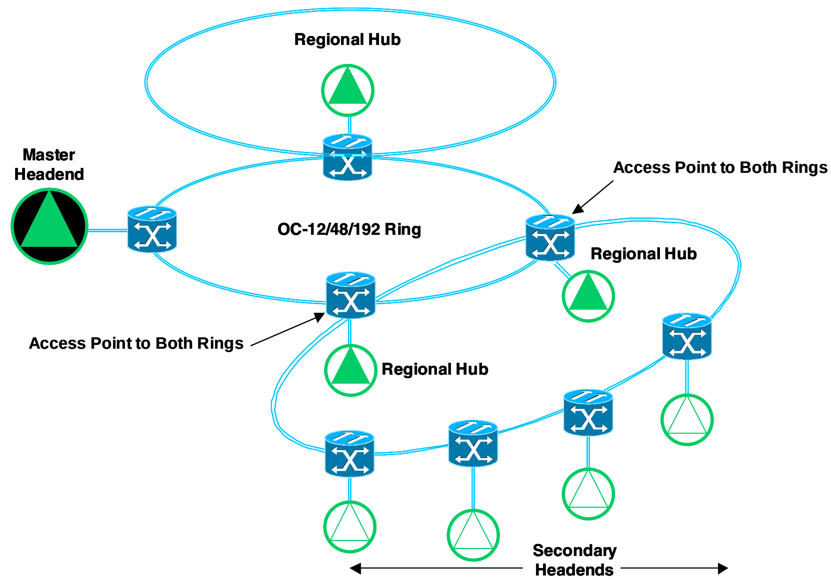
In Figure 9-42, the ONS 15454 is used to transport voice, data, and video signals from the Master Headend to all Regional Headends and Fiber Hubs over OC-12, OC-48, or OC-192 SONET rings.

Figure 9-42: Next Generation HFC Network Architecture



Redundant systems can be installed to avoid single points of failure, as shown in Figure 9-43.

Figure 9-43: Avoiding Single Points of Failure

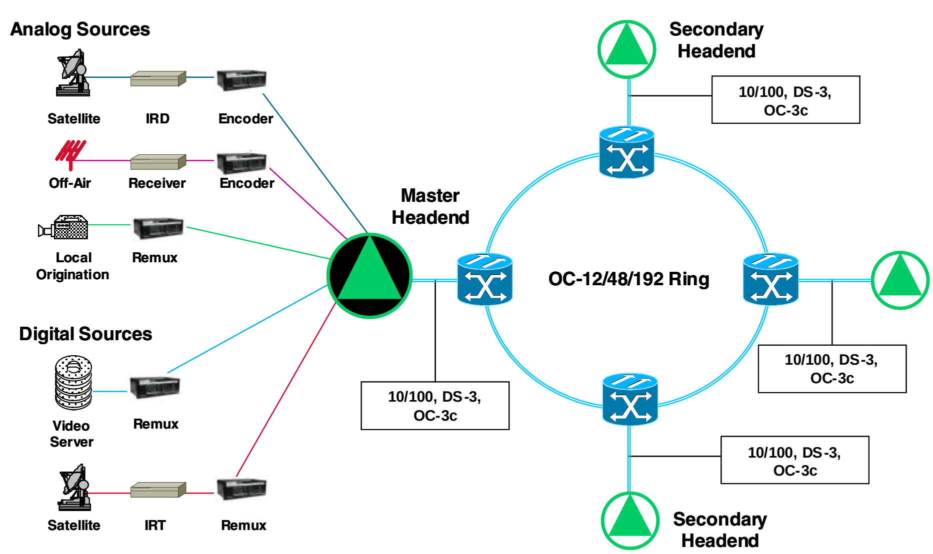


MSOs have been trading systems to create contiguous serving areas. These contiguous serving areas form a region. A region may have 10 to 20 different cable systems connected to a Regional Hub.

Contiguous serving areas allow MSOs to consolidate headends from various areas into a Master Headend. To consolidate headends, MSOs can transport their standard channel line up from the Master Headend to Secondary Headends. Localized broadcast services, advertising, and must-carry channels are added to the standard line up at the Secondary Headend.

In Figure 9-44, the ONS 15454 transports the standard channel line up over a SONET ring to each Secondary Headend through its drop and continue capability.

Figure 9-44: Headend Consolidation



Appendix A – Compliance

Note: The terms "Unidirectional Path Switched Ring" and "UPSR" may appear in Cisco literature. These terms do not refer to using Cisco ONS 15xxx products in a unidirectional path switched ring configuration. Rather, these terms, as well as "Path Protected Mesh Network" and "PPMN," refer generally to Cisco's path protection feature, which may be used in any topological network configuration. Cisco does not recommend using its path protection feature in any particular topological network configuration.

Purpose

This appendix lists ONS 15454 compliance with regulatory and industry standards relevant to Class A, Type 2 and Type 4 devices.

Contents

The following topics are included in this appendix:

CISCO SYSTEMS

Table A-1: Compliance Matrix

Discipline	Country	Specification
EMC Emissions – Class A Digital Device	Canada	ICES-003 Issue 3, 1997
		Telcordia GR-1089-CORE
	USA	Telcordia GR-1089-CORE
		FCC 47CFR15
	Japan	VCCIV3/2000.04
	Korea	CISPR22
	Mexico	EN55022
	Europe	EN 300-386-TC
EMC Immunity	Canada	Telcordia GR-1089-CORE
	USA	Telcordia GR-1089-CORE
	Japan	NA
	Korea	CISPR24
	Mexico	EN55024
	Europe	EN50082-2, EN 300-386-TC
Safety	Canada	CAN/CSA-C22.2 No. 950-95, 3rd Ed/
		Telcordia GR-1089-CORE
		Telcordia GR-63-CORE
	USA	UL 1950 3rd Ed.
		Telcordia GR-1089-CORE
		Telcordia GR-63-CORE
	Japan	EN60950 (to A4)
	Korea	EN60950 (to A4)
	Mexico	Certified
	Europe	IEC60950/EN60950, 3rd Ed.
Telecommunications	Canada	NA
	USA	NA
	Japan	Blue Book 1996, Green Book 1997
	Korea	OC-12, OC-48
	Mexico	Certified
	Europe	NA
Environmental	Canada USA	Telcordia GR-63-CORE NEBS Level 3
		Cisco Mechanical Environmental Design and Qualification Guideline ENG-3396
		AT&T Network Equipment Development Standards (NEDS)
Structural Dynamics (Mechanical)	Canada USA	Telcordia GR-63-CORE NEBS Level 3
		Cisco Mechanical Environmental Design and Qualification Guideline ENG-3396
		AT&T Network Equipment Development Standards (NEDS)
Power and Grounding	Global	SBC Local Exchange Carriers, Network Equipment Power, Grounding, Environmental, and Physical Design Requirements-TLP76200MP

The ONS 15454 cards listed in Table A-2 have received certification from Japan.

Table A-2: Japan Card Approvals

Card	Certificate Number
15454-DS1-14	L02-0014
15454-DS3E-12	L02-0013
DS3N-12	L02-0285
15454-OC3-4IR 1310	L02-0265
15454-OC312IR 1310	L02-0266
15454-OC48IR 1310	L02-0267
15454-OC48IR 1310AS	L02-0012

The ONS 15454 system received the certification listed in Table A-3 from Korea.

Table A-3: Korea Certification of Information and Communication Equipment

Model	Certification Number
ONS 15454	T-C21-00-1434

OSMINE Process

Cisco is actively involved in the OSMINE process with Telcordia to ensure compatibility with Telcordia's OSSs. The following is a summary of completion of the OSMINE process for the ONS 15454.

ONS 15454 Software Release 1.0 – Completed

TIRKS
- Inserted in Catalog
- OSIA in Release 2.0
- CLEI Codes completed
- Function Coding completed

NMA
- Not supported

Transport
- Not supported

ONS 15454 Software Release 2.0 and 2.1 – Completed

Content
- Hybrid

TIRKS (19.2)
- Final OSIA for the Release 2.0 is available
- CLEI Codes completed

NMA (9.1)
- R2.0 OSIA is available
- R2.1 OSIA is available
- System Test Report is available

Transport
- Not supported

ONS 15454 Software Release 2.2 – Not Tested

ONS 15454 Software Release 3.0 – Completed

Content
- o DS3

TIRKS (19.4)
- o Final OSIA (R3.0/R3.1 Issue 2 is available
- o CLEI Codes completed
- o Supports non-adjacent optical slot protection
- o Does not support Limited VT Matrix

NMA (10.1)
- o Final OSIA is available
- o NMA Test Plan is available)
- o Templates and M&P are available
- o System Test Report is available

Transport (2.0)
- o Test Report is available

Transport
- o Does not support non-adjacent optical slot protection until Software Release 3.3

ONS 15454 Software Release 3.1 – Completed

Content
- o OC192 LR, OC48 AS, XC10G, 10G Backplane/FTA, Limited VT Matrix

TIRKS (19.4)
- o Final OSIA (R3.0/R3.1 Issue 2) is available
- o Final OSIA (R3.0/R3.1 Issue 3) for HECIG changes (see Hybrid HECIG Issue) is available
- o Final OSIA (R3.0/R3.1 Issue 4) to correct the 1+1 protection CD (Section 7.9) and to add explanatory information to Table 6-3 is available
- o CLEI Codes completed
- o Support for Limited VT matrix for Path Protection Configuration, 1+1 and Linear Chain
- o VT Matrix Circuit Descriptions

NMA (10.1)
- o Support for Limited VT matrix for Path Protection Configuration, 1+1 and Linear Chain
- o Final OSIA is available
- o NMA Test Plan is available)
- o Templates and M&P are available
- o System Test Report is available

Transport (2.1) (2.2.1)
- o Transport R2.1 Test Report is available
- o HECIG retest in Transport 2.2.1, Release Content Letter is available
- o No support for Limited VT matrix for Path Protection Configuration, 1+1 and Linear Chain until Software Release 3.2
- o Does not support non-adjacent optical slot protection until Software Release 3.3

ONS 15454 Software Release 3.2 – Not Tested

ONS 15454 Software Release 3.3 – Completed

Content
- OC48 ITU, G1000-4, OC12-4

LFACS
- Supported in the LFACS quarterly release available 5/31/02
- Final LFACS Requirements Document for Table Changes is available

TIRKS (19.5)
- CLEI Codes completed
- Supports "Add a Hybrid Node" feature
- Final OSIA Issue 1 is available
- Final OSIA Issue 2 for STS-STS example and G10004 HECIG changes is available

NMA (11.1)
- Supports "Multi-Gateway (Dual TL1)" feature
- Final OSIA is available
- NMA Test Plan is available
- Templates and M&P are available
- System Test Report is available

Transport (2.4)
- Support for Limited VT matrix for Path Protection Configuration, 1+1 and Linear Chain
- Transport R2.4 Test Report is available

ONS 15454 Software Release 3.4 – Completed

Content
- AIC-I, PCA, FTP, TL1 Enhancements, ESM AINS, Interconnecting Rings

TIRKS (19.7) (19.7.0.3)
- Final OSIA Issue 1 (19.7) supports Limited VT Matrix BLSR GFDS and is available
- Final OSIA Issue 2 (19.7.0.3) supports 1+1 VT Matrix usage is available
- Final OSIA Issue 3 (19.7.0.3) supports Backplane EIA change and Interconnecting Rings is available

NMA (12.0)
- Final OSIA is available

NMA Test Plan is available
- System Test Report is available

Transport (2.6)
- Transport R2.6 supports FTP Software Download
- Transport R2.6 Test Report is available

Content
- OC192 SR/IR/ITU, TCC2, OC3-8, G1K, M400T-12, M4000-2, 10G to OC192 Trans, 4x2.5G to OC192 Mux, DS1 FDL, PDI-P, DRI Path Protection Configuration, Multi-shelf/Single TID, Universal Backplane

TIRKS (19.8)
- Final OSIA Issue 1 is available
- Final OSIA Issue 2 available

NMA (12.1)
- Final OSIA is available

NMA Test Plan is available
- System Test Report available

Transport (2.8)
- Transport R2.8 Test Report is scheduled to be available in July 2003

Appendix B – SONET Primer

Purpose

This appendix provides an introduction to the Synchronous Optical NETwork (SONET) standard. For additional information on SONET, refer to:

ANSI T1.105 – 1995 American National Standard for Telecommunications, Synchronous Optical Network (SONET)

ANSI T1.106-1988 American National Standard for Telecommunications – Digital Hierarchy Optical Interface Specifications, Single Mode

ITU Recommendations G.707, G.708, G.709

Telcordia GR-253-CORE – Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria

Contents

The following topics are included in this appendix:

CISCO SYSTEMS

Background of SONET

Before SONET, the first generations of fiber optic systems in the public telephone network used proprietary architectures, equipment, line codes, multiplexing formats, and maintenance procedures. The users of this equipment included the Regional Bell Operating Companies (RBOCs) and Interexchange Carriers (IXCs) in the U.S., Canada, Korea, Taiwan, and Hong Kong. These operating companies wanted an industry standard so they could mix and match equipment from different suppliers. The task of creating such a standard was taken up in 1984 by the Exchange Carriers Standards Association (ECSA) to establish a standard for connecting one fiber system to another. This standard became known as SONET, which stands for Synchronous Optical NETwork.

SONET is an ANSI standard for synchronous data transmission on optical media. SONET defines optical carrier (OC) levels and electrically equivalent synchronous transport signals (STSs) for the fiber-optic based transmission hierarchy. It was formulated by the Exchange Carriers Standards Association (ECSA) for the American National Standards Institute (ANSI), which sets industry standards in the U.S. for telecommunications and other industries. Internationally, Synchronous Digital Hierarch (SDH) is the equivalent of SONET. Together, these standards ensure that world-wide digital telecommunications networks can interconnect.

SONET defines the following standards:

Optical carrier (OC) parameters

Multiplexing schemes to map existing tributary signals (i.e., DS-1 and DS-3) into SONET payload signals

Overhead channels to support standard operation, administration, maintenance, and provisioning (OAM&P) functions

Criteria for optical line automatic protection switching (APS)

Synchronous, Asynchronous, and Plesiochronous Signals

To understand correctly the concepts and details of SONET, it’s important to be clear about the meaning of Synchronous, Asynchronous, and Plesiochronous.

In a set of Synchronous signals, the digital transitions in the signals occur at exactly the same rate. There may, however, be a phase difference between the transitions of the two signals, and this would lie within specified limits. These phase differences may be due to propagation time delays or jitter introduced into the transmission network. In a synchronous network, all the clocks are traceable to one Primary Reference Clock (PRC). The accuracy of the PRC is better than ±1 in 1011 and is derived from a cesium atomic standard.

If two digital signals are Plesiochronous, their transitions occur at “almost” the same rate, with any variation being constrained within tight limits. For example, if two networks need to interwork, their clocks may be derived from two different PRCs. Although these clocks are extremely accurate, there is a difference between one clock and the other. This is known as a plesiochronous difference.

In the case of Asynchronous signals, the transitions of the signals do not necessarily occur at the same nominal rate. Asynchronous, in this case, means that the difference between two clocks is much greater than a plesiochronous difference. For example, if two clocks are derived from free-running quartz oscillators, they could be described as asynchronous.

SONET Signal Hierarchy

SONET uses a basic transmission rate of Synchronous Transport Signal level-1 (STS-1), which is equivalent to 51.84 Mb/s. There are 8,000 STS-1 frames per second in a STS-1 signal. Higher-level signals are integer multiples of the base rate. For example, STS-3 is three times the rate of STS-1 (3 x 51.84 = 155.52 Mb/s). An STS-12 rate would be 12 x 51.84 = 622.08 Mb/s. Table B-1 shows the hierarchy of STS-1 signals.

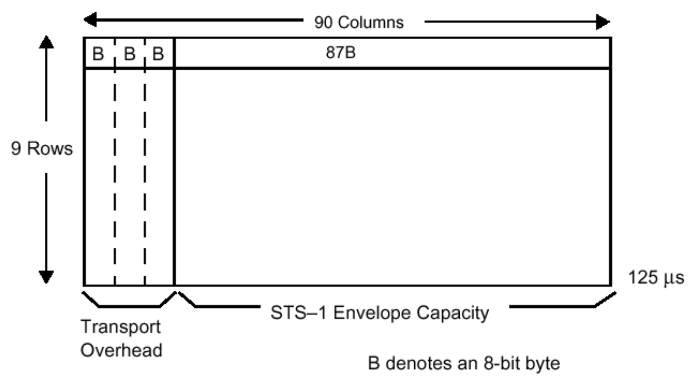
Table B-1: STS-1 Signal Hierarchy

STS-N Signal	OC-N Signal	Bit Rate	Channel Capacity
STS-1	OC-1	51.84 Mb/s	28 DS-1s or 1 DS-3
STS-3	OC-3	155.520 Mb/s	84 DS-1s or 3 DS-3s
STS-12	OC-12	622.080 Mb/s	336 DS-1s or 12 DS-3s
STS-48	OC-148	2488.320 Mb/s	1344 DS-1s or 48 DS-3s
STS-192	OC-192	9953.280 Mb/s	5376 DS-1s or 192 DS-3s

SONET Frame Structure

The frame format of the STS-1 signal is shown in Figure B-1. The STS-1 frame has a recurring rate of 8000 frames a second and a frame rate of 125 microseconds The STS-1 frame consists of 90 columns and 9 rows. In general, the frame can be divided into two main areas: Transport overhead and the STS-1 synchronous payload envelope (STS-1 SPE).

Figure B-1: STS-1 Frame Format

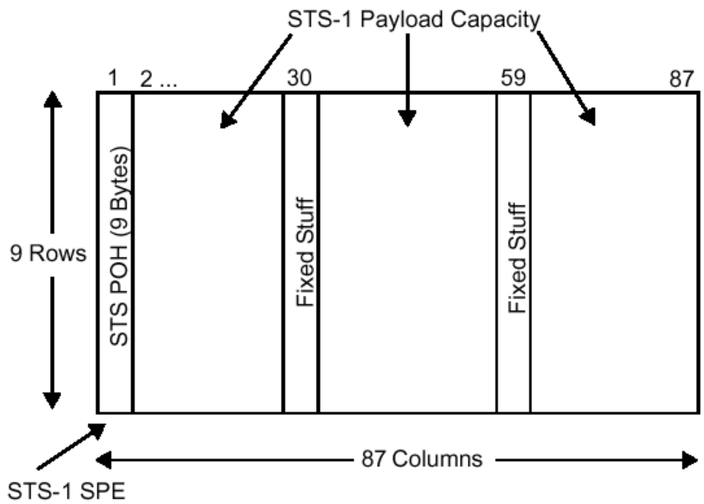


The first three columns in each of the nine rows carry the section and line overhead bytes. Collectively, these 27 bytes are referred to as Transport Overhead. Transport Overhead is composed of section overhead and line overhead. The STS-1 path overhead is part of the synchronous payload envelope. The STS-1 payload has the capacity to transport up to:

28 DS-1s
1 DS-3
21 2.048 Mb/s signals or combinations of above.

Columns 4 through 90 are reserved for payload signals (i.e., DS1 and DS3) and is referred to as the STS-1 SPE. The optical counterpart of the STS-1 is the optical carrier level 1 signal (OC-1), which is the result of a direct optical conversion after scrambling. The STS-1 SPE can be divided into two parts: STS path overhead and the payload, as shown in Figure B-2. The payload is the revenue-producing traffic being transported and routed over the SONET network. Once the payload is multiplexed into the synchronous payload envelope, it can be trans-ported and switched through SONET without having to be examined and possibly demultiplexed at intermediate nodes. Thus, SONET is said to be service-independent or transparent.

Figure B-2: STS-1 SPE Format



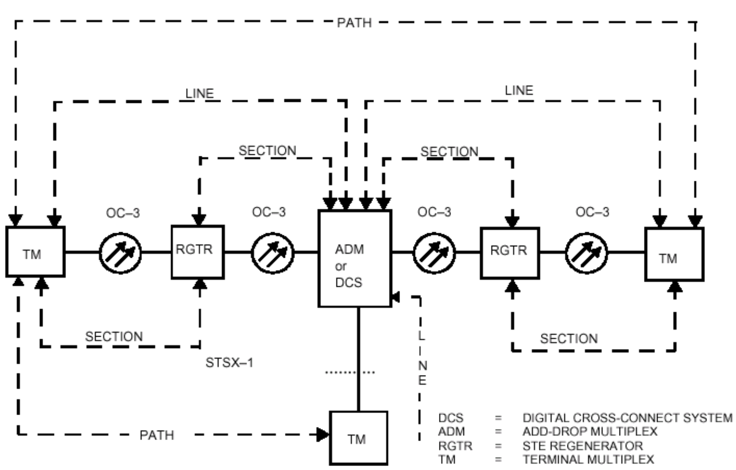
SONET Layers

SONET divides the overhead and transport functions into three layers:

Section
Line
Path

These three layers are associated with both the physical equipment that segments the network and the bytes of information that flows through the network elements. Figure B-3 shows the various layers of a typical SONET network.

Figure B-3: Section, Line and Path Network Layers



The overhead layers are described in Table B-2.

Table B-2: SONET Overhead Layers

Overhead Layer	Description
Section	Section overhead is used for communications between adjacent network elements, including regenerators.
Line	Line overhead is used for the STS-N signal between SONET equipment except regenerators.
Path	Path-level overhead is carried within the SPE from end-to-end. It is added to DS-1 signals when they are mapped into virtual tributaries (VTs) and for STS-1 payloads that travel across the path end-to-end.

Section Overhead

The Section Overhead is found in the first three rows of Columns 1 through 9 (see Figure B-4). Table B-3 lists and defines the various Section Overhead bytes.

Figure B-4: Section Overhead Bytes within Rows 1 to 3 of Transport Overhead

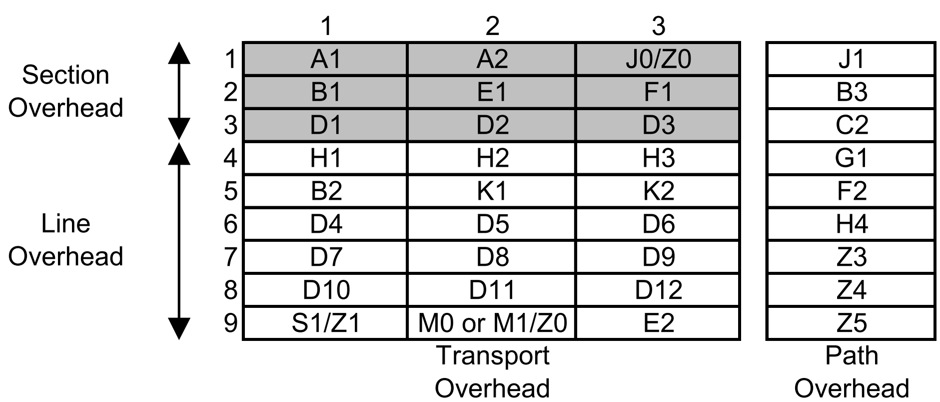


Table B-3: Description of Section Overhead Bytes

Byte	Description
A1 & A2	Framing bytes – These two bytes indicate the beginning of an STS-1 frame.
J0	Section Trace (J0)/Section Growth (Z0) – The byte in each of the N STS-1s in an STS-N that was formally defined as the STS-1 ID (C1) byte has been refined either as the Section Trace byte (in the first STS-1 of the STS-N), or as a Section Growth byte (in the second through Nth STS-1s).
B1	Section bit interleaved parity code (BIP-8) byte – This is a parity code (even parity) used to check for transmission errors over a regenerator section. Its value is calculated over all bits of the previous STS-N frame after scrambling, then placed in the B1 byte of STS-1 before scrambling. Therefore, this byte is defined only for STS-1 number 1 of an STS-N signal.
E1	Section orderwire byte – This byte is allocated to be used as a local orderwire channel for voice communication between regenerators, hubs, and remote terminal locations.
F1	Section user channel byte – This byte is set aside for users' purposes. It terminates at all section terminating equipment within a line; that is, it can be read and/or written to at each section terminating equipment in that line.
D1 to D3	Section data communications channel (DCC) bytes – Together, these three bytes form a 192 kbps message channel providing a message-based channel for Operations, Administration, Maintenance, and Provisioning (OAM&P) between pieces of section-terminating equipment. The channel is used from a central location for alarms, control, monitoring, administration, and other communication needs. It's available for internally generated, externally generated, or manufacturer-specific messages.

Line Overhead

The Line Overhead is found in Rows 4 to 9 of Columns 1 through 9 (see Figure B-5). Table B-4 lists and defines the various Line Overhead bytes.

Figure B-5: Line Overhead Bytes in Rows 4 to 9 of Transport Overhead

	Row	1	2	3	Path Overhead
Section Overhead	1	A1	A2	J0/Z0	J1
	2	B1	E1	F1	B3
	3	D1	D2	D3	C2
Line Overhead	4	H1	H2	H3	G1
	5	B2	K1	K2	F2
	6	D4	D5	D6	H4
	7	D7	D8	D9	Z3
	8	D10	D11	D12	Z4
	9	S1/Z1	M0 or M1/Z0	E2	Z5
			Transport Overhead		Path Overhead

Table B-4: Description of Line Overhead Bytes

Byte	Description
H1, H2	STS Payload Pointer (H1 and H2) – Two bytes are allocated to a pointer that indicates the offset in bytes between the pointer and the first byte of the STS SPE. The pointer bytes are used in all STS-1s within an STS-N to align the STS-1 Transport Overhead in the STS-N, and to perform frequency justification. These bytes are also used to indicate concatenation, and to detect STS Path Alarm Indication Signals (AIS-P).
H3	Pointer Action Byte (H3) – The pointer action byte is allocated for SPE frequency justification purposes. The H3 byte is used in all STS-1s within an STS-N to carry the extra SPE byte in the event of a negative pointer adjustment. The value contained in this byte when it's not used to carry the SPE byte is undefined.
B2	Line bit interleaved parity code (BIP-8) byte – This parity code byte is used to determine if a transmission error has occurred over a line. It's even parity, and is calculated over all bits of the line Overhead and STS-1 SPE of the previous STS-1 frame before scrambling. The value is placed in the B2 byte of the line Overhead before scrambling. This byte is provided in all STS-1 signals in an STS-N signal.
K1 & K2	Automatic Protection Switching (APS channel) bytes – These two bytes are used for Protection Signaling between Line Terminating entities for bi-directional automatic protection switching and for detecting alarm indication signal (AIS-L) and Remote Defect Indication (RDI) signals.
D4 to D12	Line Data Communications Channel (DCC) bytes – These nine bytes form a 576kb/s message channel from a central location for OAM&P information (alarms, control, maintenance, remote provisioning, monitoring, administration, and other communication needs) between line entities. Available for internally generated, externally generated, and manufacturer specific messages. A protocol analyzer is required to access the Line-DCC information.
S1	Synchronization Status (S1) – The S1 byte is located in the first STS-1 of an STS-N, and bits 5 through 8 of that byte are allocated to convey the synchronization status of the network element.
Z1	Growth (Z1) – The Z1 byte is located in the second through Nth STS-1s of an STS-N ($3 \le N \le 48$), and is allocated for future growth. Note that an OC-1 or STS-1 electrical signal does not contain a Z1 byte.
MO	STS-1 REI-L (M0) – The M0 byte is only defined for STS-1 in an OC-1 or STS-1 electrical signal. Bits 5 through 8 are allocated for a Line Remote Error Indication function (REI-L – formerly referred to as Line FEBE), which conveys the error count detected by an LTE (using the Line BIP-8 code) back to its peer LTE.
M1	STS-N REI-L (M1) – The M1 byte is located in the third STS-1 (in order of appearance in the byte-interleaved STS-N electrical or OC-N signal) in an STS-N ($N \ge 3$), and is used for a REI-L function.
Z2	Growth (Z2) – The Z2 byte is located in the first and second STS-1s of an STS-3, and the first, second, and fourth through Nth STS-1s of an STS-N ($12 \le N \le 48$). These bytes are allocated for future growth. Note that an OC-1 or STS-1 electrical signal does not contain a Z2 byte.

Byte	Description
E2	Orderwire byte – This orderwire byte provides a 64 kb/s channel between line entities for an express orderwire. It's a voice channel for use by technicians and will be ignored as it passes through the regenerators.

STS-1 Path Overhead

The STS-1 Path Overhead is found in Rows 1 to 9 of the first column of the STS-1 SPE (see Figure B-6). Table B-5 lists and defines the Path Overhead bytes.

Figure B-6: Path Overhead in Rows 1 to 9

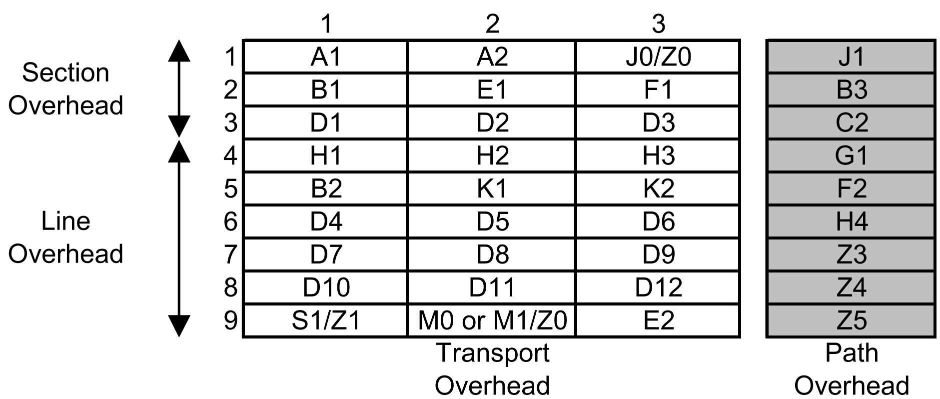


Table B-5: Description of Path Overhead Bytes

Byte	Description
J1	STS path trace byte – This user-programmable byte repetitively transmits a 64-byte, or 16-byte E.164 format string. This allows the receiving terminal in a path to verify its continued connection to the intended transmitting terminal.
B3	STS Path Bit Interleaved Parity code (Path BIP-8) byte – This is a parity code (even), used to determine if a transmission error has occurred over a path. Its value is calculated over all the bits of the previous synchronous payload envelope (SPE) before scrambling.
C2	STS Path signal label byte – This byte is used to indicate the content of the STS SPE, including the status of the mapped payloads.
G1	Path status byte – This byte is used to convey the path terminating status and performance back to the originating path terminating equipment. Therefore, the duplex path in its entirety can be monitored from either end, or from any point along the path. Bits 1 through 4 are allocated for an STS Path REI function (REI-P – formerly referred to as STS Path FEBE). Bits 5, 6, and 7 of the G1 byte are allocated for an STS Path RDI (RDI-P) signal. Bit 8 of the G1 byte is currently undefined.
F2	Path user channel byte – This byte is used for user communication between path elements.
H4	Virtual Tributary (VT) multi-frame indicator byte – This byte provides a generalized multi-frame indicator for payload containers. At present, it is used only for tributary unit structured payloads.

Note The Path Overhead Portion of the SPE remains with the payload until it is demultiplexed.

SPE Values

Table B-6 lists and describes the type of STS-1 SPE values.

Table B-6: Description of STS-1SPE Values

Hexidecimal Code	Description
00	Unequipped
01	Equipped nonspecific payload
02	VT-Structured STS-1 SPE
04	Asynchronous mapping for DS3
12	DS4NA Asynchronous mapping
13	Mapping for ATM
14	Mapping for DQDB
15	Asynchronous mapping FDDI

VT Path Overhead

VT Path Overhead (VT POH) provides communication between the point of creation of a VT SPE and its point of disassembly. Four bytes (V5, J2, Z6, and Z7) are allocated for VT POH. The first byte of a VT SPE (i.e., the byte in the location pointed to by the VT Payload Pointer) is the V5 byte, while the J2, Z6, and Z7 bytes occupy the corresponding locations in the subsequent 125 microsecond frames of the VT Super-frame.

The V5 byte provides the same functions for VT paths that the B3, C2, and G1 bytes provide for STS paths; namely error checking, signal label, and path status.

SONET Multiplexing

SONET supports two multiplexing schemes:

Asynchronous
Synchronous

Asynchronous Multiplexing

Asynchronous multiplexing uses multiple stages. Signals such as asynchronous DS-1s are multiplexed, extra bits are added (bit-stuffing) to account for the variations of each individual stream, and are combined with other bits (framing bits) to form a DS2 stream. Bit-stuffing is used again to multiplex up to DS-3. DS-3s are multiplexed up to higher rates in the same manner. At the higher asynchronous rate, they cannot be accessed without demultiplexing. When these signals are multiplexed to carry DS-3 signals, the signal consists of a combination of the following payloads:

28 DS-1s
14 DS-1s
7 DS-2s

M13 Format

M13 multiplex provides a digital interface between the DS-1 and DS-3 signal levels. M13 takes 28 DS-1 signals and combines them into a single DS-3 using a two-step process. In step one, 4 DS-1 signals are multiplexed using pulse stuffing synchronization to reach a 6.312 Mb/s DS-2 signal. Bit multiplexing is used and the bits are interleaved according to the input numbering order. The second step multiplexes 7 of the DS-2 signals using pulse stuffing synchronization to generate the DS-3 signal. Demultiplexing is also accomplished in a two-step process. In the first step, a DS-3 signal is decomposed into 7 DS-2 signals. In the second step, each of the DS-2 signals is decomposed into 4 DS-1 signals.

Synchronous Multiplexing

Synchronous multiplexing is the SONET process used when multiple lower-order path-layer signals are adapted into a higher-order path signal, or when the higher-order path signals are adapted into the Line Overhead. The multiplexing principles of SONET are:

Mapping – A process used when tributaries are adapted into Virtual Tributaries (VTs) by adding justification bits and Path Overhead (POH) information.

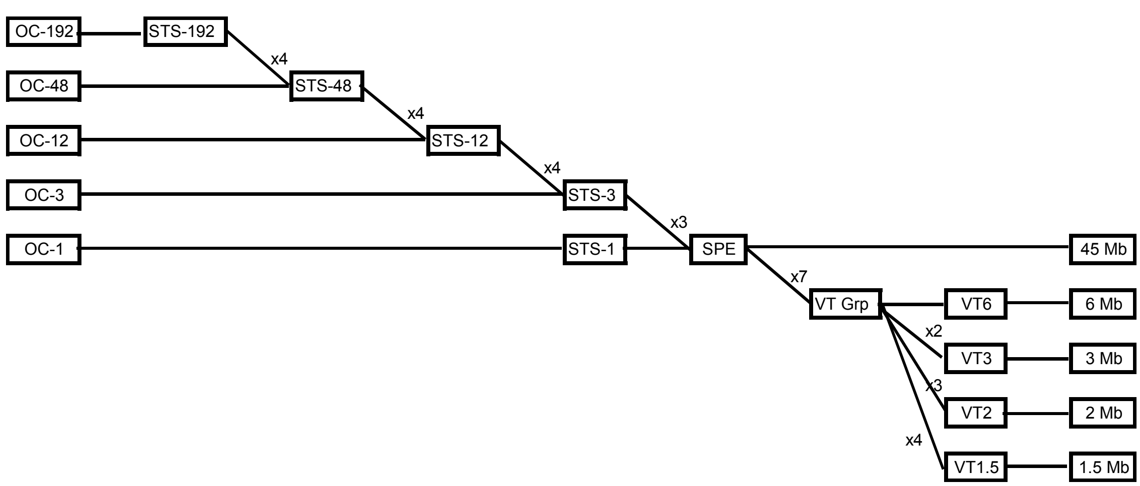
Aligning – This process takes place when a pointer is included in the STS Path or VT Path Overhead, to allow the first byte of the Virtual Tributary to be located.

Multiplexing – This process is used when multiple lower-order path-layer signals are adapted into a higher-order path signal, or when the higher-order path signals are adapted into the Line Overhead.

Stuffing – SONET has the ability to handle various input tributary rates from asynchronous signals. As the tributary signals are multiplexed and aligned, some spare capacity has been designed into the SONET frame to provide enough space for all these various tributary rates

Figure B-7 shows the basic multiplexing structure of SONET. Any type of service, ranging from voice to high-speed data and video, can be accepted by various types of service adapters. A service adapter maps the signal into the payload envelope of the STS-1 or virtual tributary (VT). New services and signals can be transported by adding new service adapters at the edge of the SONET network.

Figure B-7: SONET Multiplexing Hierarchy



Except for concatenated signals, all inputs are eventually converted to a base format of a synchronous STS-1 signal (51.84 Mb/s or higher). Lower speed inputs such as DS1s are first bit- or byte-multiplexed into virtual tributaries. Several synchronous STS-1s are then multiplexed together in either a single- or two-stage process to form an electrical STS-N signal (N = 1 or more).

STS multiplexing is performed at the Byte Interleave Synchronous Multiplexer. Basically, the bytes are interleaved together in a format such that the low-speed signals are visible. No additional signal processing occurs except a direct conversion from electrical to optical to form an OC-N signal.

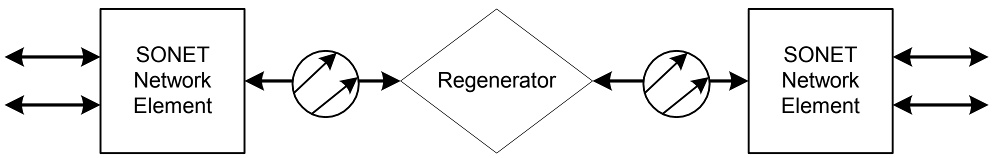
SONET Network Configurations

Point-to-Point

The SONET multiplexer acts as a concentrator of DS-1s as well as other tributaries. Its simplest deployment involves two terminal multiplexers linked by fiber with or without a regenerator in the link. This implementation represents the simplest SONET configuration.

In the configuration shown in Figure B-8, the SONET path and the Service path (DS-1 or DS-3 links end-to-end) are identical and this synchronous island can exist within an asynchronous network world. Point-to-point service path connections can span across the whole network and will always originate and terminate in a multiplexer.

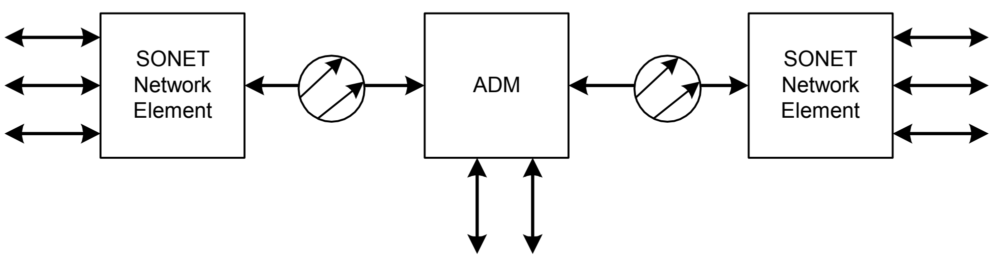
Figure B-8: Point-to-Point Network Configuration



Point-to-Multipoint

The point-to-multipoint (linear add/drop) configuration shown in Figure B-9 includes adding and drop-ping circuits along the way. The SONET add/drop multiplexer (ADM) is a unique network element specifically designed for this task. It avoids the current cumbersome network architecture of demultiplexing, cross-connecting, adding and dropping channels, and than re-multiplexing. The ADM is typically placed along a SONET link to facilitate adding and dropping tributary channels at intermediate points in the network.

Figure B-9: Point-to-Multipoint Configuration



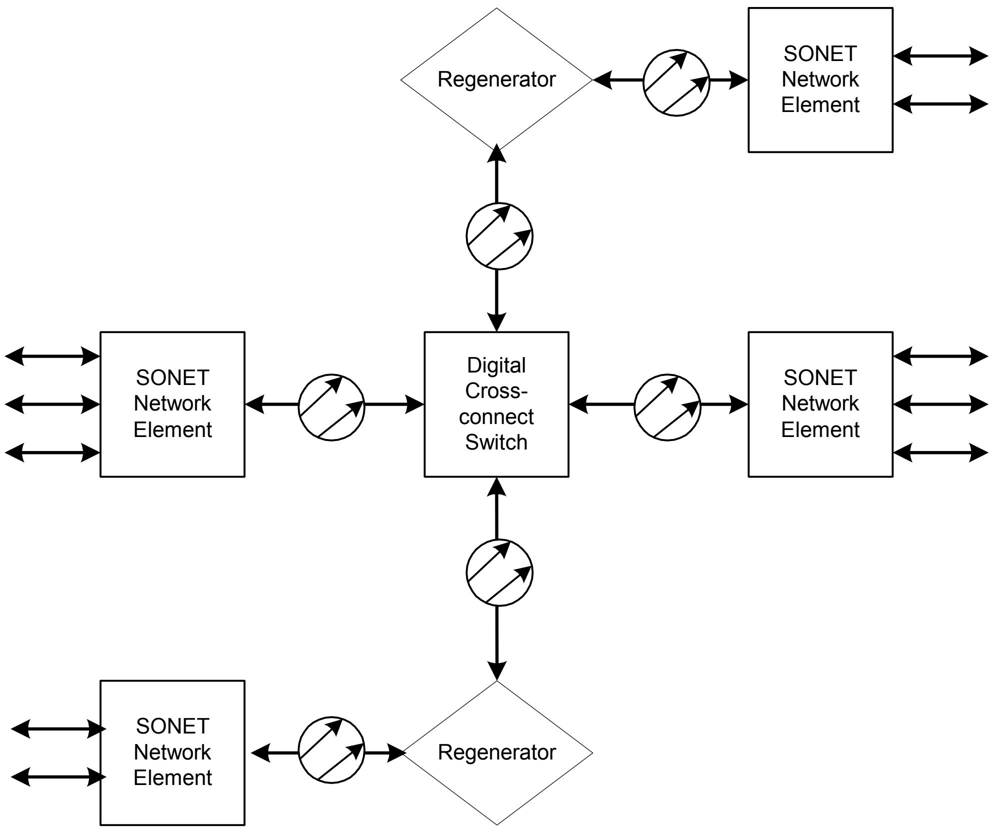
Hub

The hub configuration accommodates unexpected growth and change more easily than simple point-to-point networks. The hub configuration shown in Figure B10 concentrates traffic at a central site and allows easy re-provisioning of the circuits. There are two possible implementations of this type of network:

Using two or more ADMs, and a wideband cross-connect switch which allows cross-connecting the tributary services at the tributary level.

Using a broadband digital cross-connect switch which allows cross-connecting at both the SONET level and the tributary level.

Figure B-10: Hub Architecture

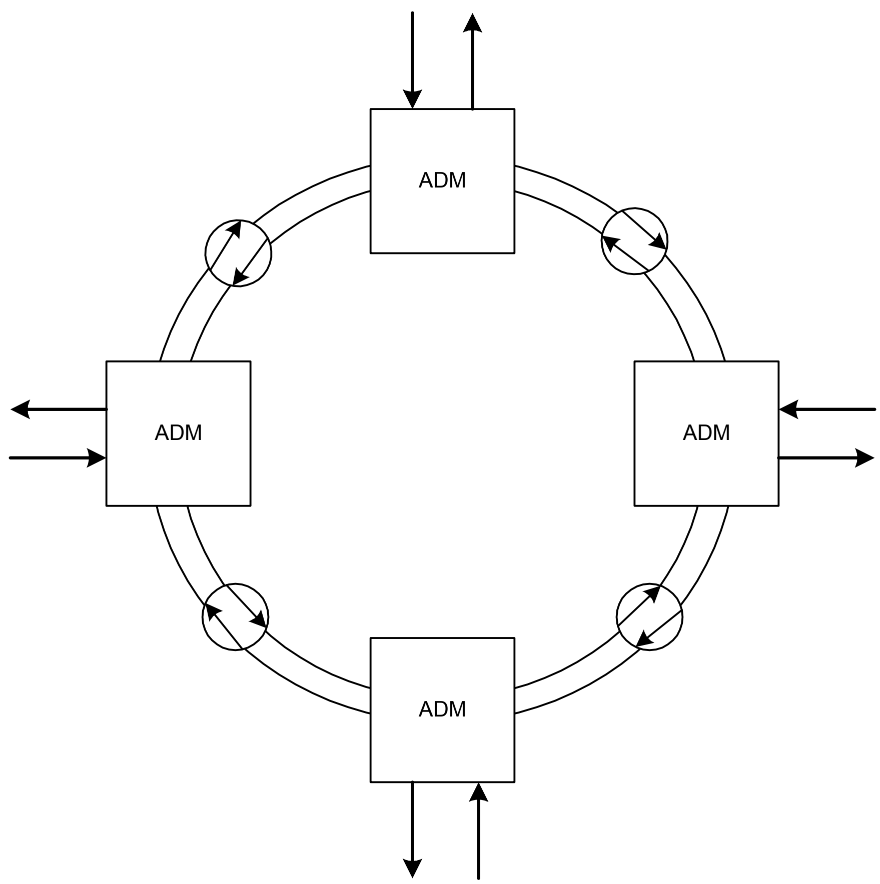


Ring

The SONET building block for a ring configuration is the ADM. Multiple ADMs can be put into a ring configuration for either bi-directional or unidirectional traffic as shown in Figure B-11. The main advantage of the ring topology is its survivability; if a fiber cable is cut, the multiplexers have the intelligence to send the services affected via an alternate path through the ring without interruption.

The demand for survivable services, diverse routing of fiber facilities, flexibility to rearrange services to alternate serving nodes, as well as automatic restoration within seconds, have made rings a popular SONET topology.

Figure B-11: Ring Architecture



Benefits of SONET

The transport network using SONET provides much more powerful networking capabilities than existing asynchronous systems. The key benefits provided by SONET include the following:

Pointers

As a result of SONET transmission, the network's clocks are referenced to a highly stable reference point. Therefore, the need to align the data streams or synchronize clocks is unnecessary. Therefore, a lower rate signal such as DS1 is accessible, and demultiplexing is not needed to access the bitstreams. Also, the signals can be stacked together without bit stuffing.

For those situations in which reference frequencies may vary, SONET uses pointers to allow the streams to "float" within the payload envelope. Synchronous clocking is the key to pointers. It allows a very flexible allocation and alignment of the payload within the transmission envelope.

Reduced Back-to-Back Multiplexing

Separate M13 multiplexers (DS-1 to DS-3) and fiber optic transmission system terminals are used to multiplex a DS-1 signal to a DS-2, DS-2 to DS-3, and then DS-3 to an optical line rate. The next stage is a mechanically integrated fiber/multiplex terminal.

In the existing asynchronous format, care must be taken when routing circuits in order to avoid multiplexing and demultiplexing too many times since electronics (and their associated capital cost) are required every time a DS-1 signal is processed. With SONET, DS-1s can be multiplexed directly to the OC-N rate. Because of synchronization, an entire optical signal doesn't have to be demultiplexed, only the VT or STS signals that need to be accessed.

Optical Interconnect

Because of different optical formats among vendors' asynchronous products, it's not possible to optically connect one vendor's fiber terminal to another. For example, one manufacturer may use 417 Mb/s line rate, another 565 Mb/s.

A major SONET value is that it allows mid-span meet with multi-vendor compatibility. Today's SONET standards contain definitions for fiber-to-fiber interfaces at the physical level. They determine the optical line rate, wavelength, power levels, pulse shapes, and coding. Current standards also fully define the frame structure, overhead, and payload mappings. Enhancements are being developed to define the messages in the overhead channels to provide increased OAM&P functionality.

SONET allows optical interconnection between network providers regardless of who makes the equipment. The network provider can purchase one vendor's equipment and conveniently interface with other vendors' SONET equipment at either the different carrier locations or customer premises sites. Users may now obtain the OC-N equipment of their choice and meet with their network provider of choice at that OC-N level.

Multipoint Configurations

The difference between point-to-point and multipoint systems was shown previously in this appendix. Most existing asynchronous systems are only suitable for point-to-point, whereas SONET supports a multipoint or hub configuration.

A hub is an intermediate site from which traffic is distributed to three or more spurs. The hub allows the four nodes or sites to communicate as a single network instead of three separate systems. Hubbing reduces requirements for back-to-back multiplexing and demultiplexing, and helps realize the benefits of traffic grooming.

Network providers no longer need to own and maintain customer-located equipment. A multi-point implementation permits OC-N interconnects or midspan meet, allowing network providers and their customers to optimize their shared use of the SONET infrastructure.

Convergence of Voice, Data, and Video

Convergence is the trend toward delivery of voice, data, and video through diverse transmission and switching systems that supply high-speed transportation over any medium to any location. With its modular, service-independent architecture, SONET provides vast capabilities in terms of service flexibility.

Grooming

Grooming refers to either consolidating or segregating traffic to make more efficient use of the facilities. Consolidation means combining traffic from different locations onto one facility.

Segregation is the separation of traffic. With existing systems, the cumbersome technique of back hauling might be used to reduce the expense of repeated multiplexing and demultiplexing.

Grooming eliminates inefficient techniques like back hauling. It's possible to groom traffic on asynchronous systems, however to do so requires expensive back-to-back configurations and manual DSX panels or electronic cross-connects. By contrast, a SONET system can segregate traffic at either an STS-1 or VT level to send it to the appropriate nodes.

Grooming can also provide segregation of services. For example, at an interconnect point, an incoming SONET line may contain different types of traffic, such as switched voice, data, or video. A SONET network can conveniently segregate the switched and non-switched traffic.

Reduced Cabling and Use of DSX Panels

Asynchronous systems are dominated by back-to-back terminals because the asynchronous Fiber optic transmission system architecture is inefficient for other than point-to-point networks. Excessive multiplexing and demultiplexing are used to transport a signal from one end to another, and many bays of DSX-1 cross-connect and DSX-3 panels are required to interconnect the systems. Associated expenses are the panel, bays, cabling, the labor installation, and the inconveniences of increased floor space and congested cable racks.

The corresponding SONET system allows a hub configuration, reducing the need for back-to-back terminals. Grooming is performed electronically so DSX panels are not used except when required to interface with existing asynchronous equipment.

Enhanced OAM&P

SONET allows integrated network OAM&P (also known as OA&M), in accordance with the philosophy of single-ended maintenance. In other words, one connection can reach all network elements (within a given architecture); separate links are not required for each network element. Remote provisioning provides centralized maintenance and reduced travel for maintenance personnel, which translates to expense savings.

Enhanced Performance Monitoring

Substantial overhead information is provided in SONET to allow quicker troubleshooting and detection of failures before they degrade to serious levels.

Convergence of SONET and SDH Hierarchies

SONET and SDH converge at SONET's 52 Mb/s base level, defined as STM-0 or "Synchronous Transport Module-0". The base level for SDH is STM-1 which is equivalent to SONET's STS-3 (3 x 51.84 Mb/s = 155.5 Mb/s). Higher SDH rates are STM-4 (622 Mb/s) and STM-16 (2.5 Gb/s). STM-64 (10 Gb/s) has also been defined.

Multiplexing is accomplished by combining (or interleaving) multiple lower-order signals (1.5 Mb/s, 2 Mb/s, etc.) into higher-speed circuits (52 Mb/s, 155 Mb/s, etc.). By changing the SONET standard from bit-interleaving to byte-interleaving, it became possible for SDH to accommodate both transmission hierarchies.

SDH

Following development of the SONET standard by ANSI, the CCITT undertook to define a synchronization standard that would address inter-working between the CCITT and ANSI transmission hierarchies. That effort culminated in 1989 with CCITT's publication of the Synchronous Digital Hierarchy (SDH) standards. Synchronous Digital Hierarchy is a world standard, and as such, SONET can be considered a subset of SDH.

Transmission standards in the U.S., Canada, Korea, Tai-wan, and Hong Kong (ANSI) and the rest of the world (ITU-T, formerly CCITT) evolved from different basic rate signals in the non-synchronous hierarchy. ANSI Time Division Multiplexing (TDM) combines twenty-four 64-kbps channels (DS0s) into one 1.54-Mb/s DS1 signal. ITU-T TDM multiplexes thirty-two 64-kbps channels (E0s) into one 2.048 Mb/s E-1 signal.

The issues between ITU-T and ANSI standards-makers involved how to efficiently accommodate both the 1.5-Mb/s and the 2-Mb/s non-synchronous hierarchies in a single synchronization standard. The agreement reached specifies a basic transmission rate of 52 Mb/s for SONET and a basic rate of 155 Mb/s for SDH.

Asynchronous and Synchronous Tributaries

SDH does away with a number of the lower multiplexing levels, allowing non-synchronous 2-Mb/s tributaries to be multiplexed to the STM-1 level in a single step. SDH recommendations define methods of subdividing the payload area of an STM-1 frame in various ways so that it can carry combinations of synchronous and asynchronous tributaries. Using this method, synchronous transmission systems can accommodate signals generated by equipment operating from various levels of the non-synchronous hierarchy.

Synchronous and non-synchronous line rates and the relationships between each are shown in Tables B-7 and B-8.

Table B-7: SONET/SDH Hierarchies

SONET Signal	Bit Rate (Mb/s)	SDH Signal	SONET Capacity	SDH Capacity
STS-1, OC-1	51.84	STM-0	28 DS1s or 1 DS3	21 E1s
STS-3, OC-3	155.520	STM-1	84 DS1s or 3 DS3s	63 E1s or 1 E4
STS-12, OC-12	622.080	STM-4	336 DS1s or 12 DS3s	252 E1s or 4 E4s
STS-48, OC-48	2488.320	STM-16	1344 DS1s or 48 DS3s	1008 E1s or 16 E4s
STS-192, OC-192	9953.280	STM-64	5376 DS1s or 192 DS3s	4032 E1s or 64 E4s

Table B-8: Non-Synchronous Hierarchies

ANSI Rate			ITU-T Rate		
Signal	**Bit Rate**	**Channels**	**Signal**	**Bit Rate**	**Channels**
DS0	64 kb/s	1 DS0	64-kbps	64 kb/s	1 64-kb/s
DS1	1.544 Mb/s	24 DS0s	E1	2.048 Mb/s	1 E1
DS2	6.312 Mb/s	96 DS0s	E2	8.45 Mb/s	4 E1s
DS3	44.7 Mb/s	28 DS1s	E3	34 Mb/s	16 E1s
Not Defined			E4	144 Mb/s	64 E1s

Appendix C – DWDM Primer

Purpose

This appendix provides an introduction into dense wave division multiplexing (DWDM) principles.

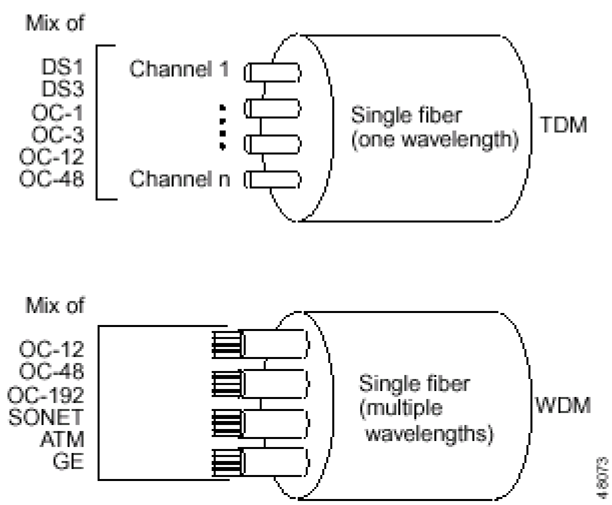
Content

The following topics are included in this appendix:

Comparison of SONET TDM and Wave Division Multiplexing (WDM)

SONET TDM takes synchronous and asynchronous signals and multiplexes them to a single higher bit rate for transmission at a single wavelength over fiber. Source signals may have to be converted from electrical to optical, or from optical to electrical and back to optical before being multiplexed. WDM takes multiple optical signals, maps them to individual wavelengths, and multiplexes the wavelengths over a single fiber. Another fundamental difference between the two technologies is that WDM can carry multiple protocols without a common signal format, while SONET cannot. Some of the key differences between TDM and WDM interfaces are graphically illustrated in Figure C-1.

Figure C-1: TDM and WDM Interfaces



Bandwidth, the chief driver in the long-haul market, is also a big driver in metropolitan area, access, and large enterprise networks. In these types of networks additional applications driving demand for bandwidth include storage area networks (SANs), which make possible the serverless office, consolidation of data centers, and real-time transaction processing backup.

Value of DWDM in the Metropolitan Area Network

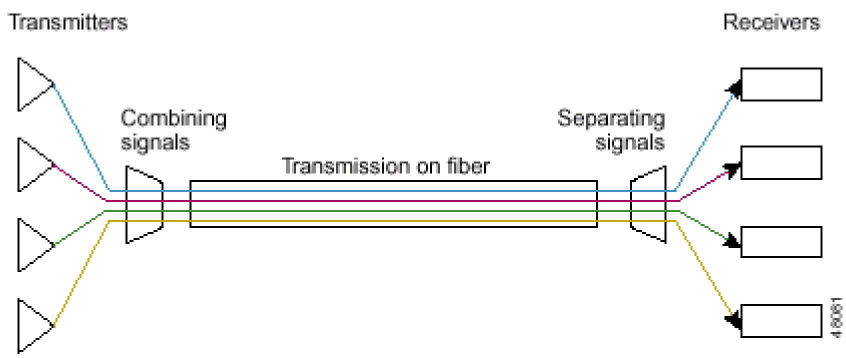
DWDM has been very successful in the backbone. It was first deployed on long-haul routes in a time of fiber scarcity. Then the equipment savings made it the solution of choice for new long-haul routes, even when ample fiber was available. While DWDM can relieve fiber exhaust in the metropolitan area, its value in this market extends beyond this single advantage. Alternatives for capacity enhancement exist, such as pulling new cable and SONET overlays, but DWDM can do more. What delivers additional value in the metropolitan market is DWDM's fast and flexible provisioning of protocol- and bit rate-transparent, data-centric, protected services, along with the ability to offer new and higher-speed services at less cost.

The need to provision services of varying types in a rapid and efficient manner in response to the changing demands of customers is a distinguishing characteristic of the metropolitan networks. With SONET, which is the foundation of the vast majority of existing MANs, service provisioning is a lengthy and complex process. Network planning and analysis, ADM provisioning, Digital Cross-connect System (DCS) reconfiguration, path and circuit verification, and service creation can take several weeks. By contrast, with DWDM equipment in place provisioning new service can be as simple as turning on another lightwave in an existing fiber pair.

DWDM System Functions

At its core, DWDM involves a small number of physical-layer functions. These are depicted in Figure C-2, which shows a DWDM schematic for four channels. Each optical channel occupies its own wavelength.

Figure C-2: DWDM Functional Schematic



The system performs the following main functions:

Generating the signal – The source, a solid-state laser, must provide stable light within a specific, narrow bandwidth that carries the digital data, modulated as an analog signal.

Combining the signals – Modern DWDM systems employ multiplexers to combine the signals. There is some inherent loss associated with multiplexing and demultiplexing. This loss is dependent upon the number of channels but can be mitigated with optical amplifiers, which boost all the wavelengths at once without electrical conversion.

Transmitting the signals – The effects of cross-talk and optical signal degradation or loss must be reckoned with in fiber optic transmission. Controlling variables such as channel spacing, wavelength tolerance, and laser power levels can minimize these effects. Over a transmission link, the signal may need to be optically amplified.

Separating the received signals – At the receiving end, the multiplexed signals must be separated out. Although this task would appear to be simply the opposite of combining the signals, it is actually more technically difficult.

Receiving the signals – The demultiplexed signal is received by a photodetector.

In addition to these functions, a DWDM system must also be equipped with client-side interfaces to receive the input signal. This function may be performed by transponders. On the DWDM side are interfaces to the optical fiber that links DWDM systems.

Cisco Systems

DWDM Components and Operation

DWDM is a core technology in an optical transport network. The essential components of DWDM can be classified by their place in the system as follows:

On the transmit side, lasers with precise, stable wavelengths

On the link, optical fiber that exhibits low loss and transmission performance in the relevant wavelength spectra, in addition to flat-gain optical amplifiers to boost the signal on longer spans

On the receive side, photodetectors and optical demultiplexers using thin film filters or diffractive elements

Optical add/drop multiplexers and optical cross-connect components

These and other components, along with their underlying technologies, are discussed in the following sections.

Optical Fibers

The main job of optical fibers is to guide lightwaves with a minimum of attenuation (loss of signal). Optical fibers are composed of fine threads of glass in layers, called the core and cladding that can transmit light at about two-thirds the speed of light in a vacuum. Though admittedly an oversimplification, the transmission of light in optical fiber is commonly explained using the principle of total internal reflection. With this phenomenon, 100 percent of light that strikes a surface is reflected. By contrast, a mirror reflects about 90 percent of the light that strikes it.

Light is either reflected (it bounces back) or refracted (its angle is altered while passing through a different medium) depending upon the angle of incidence (the angle at which light strikes the interface between an optically denser and optically thinner material).

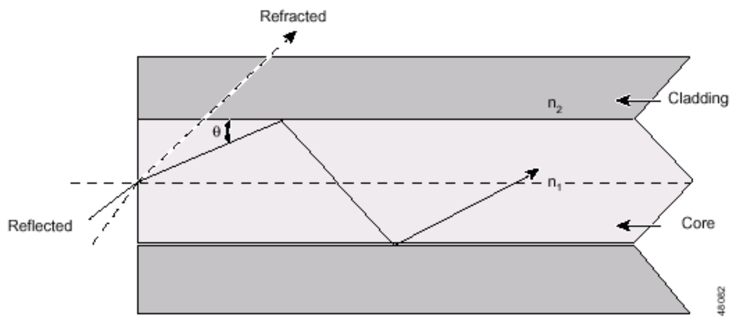
Total internal reflection happens when the following conditions are met:

Beams pass from a denser to a less dense material. The difference between the optical density of a given material and a vacuum is the material's refractive index.

The incident angle is less than the critical angle. The critical angle is the maximum angle of incidence at which light stops being refracted and is instead totally reflected.

The principle of total internal reflection within a fiber core is illustrated in Figure C-3. The core has a higher refractive index than the cladding, allowing the beam that strikes that surface at less than the critical angle to be reflected. The second beam does not meet the critical angle requirement and is refracted.

Figure C-3: Principle of Total Internal Reflection

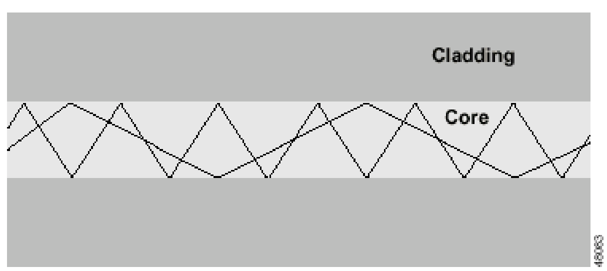


An optical fiber consists of two different types of highly pure, solid glass (silica) – the core and the cladding—that are mixed with specific elements, called dopants, to adjust their refractive indices. The difference between the refractive indices of the two materials causes most of the transmitted light to bounce off the cladding and stay within the core. The critical angle requirement is met by controlling the angle at which the light is injected into the fiber. Two or more layers of protective coating around the cladding ensure that the glass can be handled without damage.

Multimode and Single-Mode Fiber

There are two general categories of optical fiber in use today, multimode and single-mode fiber. Multimode, the first type of fiber to be commercialized, has a larger core than single-mode fiber. It gets its name from the fact that numerous modes, or light rays, can be carried simultaneously through the waveguide. Figure C-4 shows an example of light transmitted in the first type of multimode fiber, called step-index. Step-index refers to the fact that there is a uniform index of refraction throughout the core; thus there is a step in the refractive index where the core and cladding interface. Notice that the two modes must travel different distances to arrive at their destinations. This disparity between the times that the light rays arrive is called modal dispersion. This phenomenon results in poor signal quality at the receiving end and ultimately limits the transmission distance. This is why multimode fiber is not used in wide-area applications.

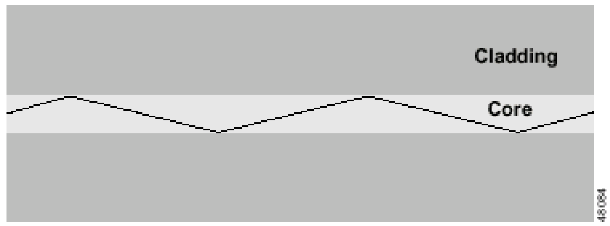
Figure C-4: Reflected Light in Step-Index Multimode Fiber



To compensate for the dispersion drawback of step-index multimode fiber, graded-index fiber was invented. Graded-index refers to the fact that the refractive index of the core is graded – it gradually decreases from the center of the core outward. The higher refraction at the center of the core slows the speed of some light rays, allowing all the rays to reach their destination at about the same time and reducing modal dispersion.

The second general type of fiber, single-mode, has a much smaller core that allows only one mode of light at a time through the core (see Figure C-5). As a result, the fidelity of the signal is better retained over longer distances, and modal dispersion is greatly reduced. These factors attribute to a higher bandwidth capacity than multimode fibers are capable of. For its large information-carrying capacity and low intrinsic loss, single-mode fibers are preferred for longer distance and higher bandwidth applications, including DWDM.

Figure C-5: Reflected Light in Single-Mode Fiber



Single-Mode Fiber Designs

Designs of single-mode fiber have evolved over several decades. The three principle types and their ITU-T specifications are:

Non-dispersion-shifted fiber (NDSF), G.652
Dispersion-shifted fiber (DSF), G.653
Non-zero dispersion-shifted fiber (NZ-DSF), G.655

As discussed earlier, there are four windows within the infrared spectrum that have been exploited for fiber transmission. The first window, near 850 nm, was used almost exclusively for short-range, multimode applications. Non-dispersion-shifted fibers, commonly called standard single-mode (SM) fibers, were designed for use in the second window, near 1310 nm. To optimize the fiber's performance in this window, the fiber was designed so that chromatic dispersion would be close to zero near the 1310-nm wavelength.

As optical fiber use became more common and the needs for greater bandwidth and distance increased, a third window, near 1550 nm, was exploited for single-mode transmission. The third window, or C band, offered two advantages: it had much lower attenuation, and its operating frequency was the same as that of the new erbium-doped fiber amplifiers (EDFAs). However, its dispersion characteristics were severely limiting. This was overcome to a certain extent by using narrower line width and higher power lasers. But because the third window had lower attenuation than the 1310-nm window, manufacturers came up with the dispersion-shifted fiber design, which moved the zero-dispersion point to the 1550-nm region. Although this solution now meant that the lowest optical attenuation and the zero-dispersion points coincided in the 1550-nm window, it turned out that there are destructive nonlinearities in optical fiber near the zero-dispersion point for which there is no effective compensation. Because of this limitation, these fibers are not suitable for DWDM applications.

The third type, non-zero dispersion-shifted fiber, is designed specifically to meet the needs of DWDM applications. The aim of this design is to make the dispersion low in the 1550-nm region, but not zero. This strategy effectively introduces a controlled amount of dispersion, which counters nonlinear effects such as four-wave mixing that can hinder the performance of DWDM systems.

Table C-1 provides dispersion ratings for five commonly used fiber types.

Table C-1: Fiber Dispersion Characteristics

Fiber Type	**Manufacturer**	**Chromatic Dispersion [ps/(nm x km)]**	**PMD (ps/km$^{1/2}$)**
SMF-28	Corning	17.0	<0.2 (0.1 typical)
LEAF	Corning	2.0 – 6.0 (1530 – 1565)	<0.1 (0.04 typical)
Metrocore	Corning	-10.0 – -10.0 (1530 – 1605)	<0.2 (0.1 typical)
Allwave	Lucent	Unspecified	<0.1
TrueWave RS	Lucent	2.6 – 6.0 (1530 – 1565)	<0.1

Transmission Challenges

Transmission of light in optical fiber presents several challenges that must be dealt with. These fall into the following three broad categories:

Attenuation – decay of signal strength, or loss of light power, as the signal propagates through the Fiber.

Chromatic dispersion – spreading of light pulses as they travel down the fiber.

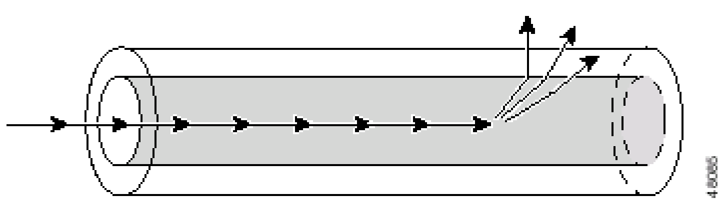
Nonlinearities – cumulative effects from the interaction of light with the material through which it travels, resulting in changes in the lightwave and interactions between lightwaves.

Each of these effects has several causes, not all of which affect DWDM. The discussion in the following sections addresses those causes that are relevant to DWDM.

Attenuation

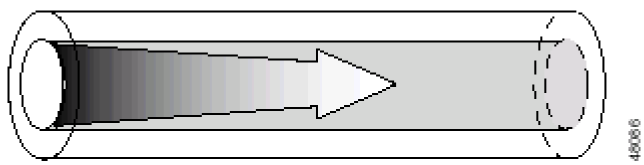
Attenuation in optical fiber is caused by intrinsic factors, primarily scattering and absorption, and by extrinsic factors, including stress from the manufacturing process, the environment, and physical bending. The most common form of scattering, Rayleigh scattering, is caused by small variations in the density of glass as it cools. These variations are smaller than the wavelengths used and therefore act as scattering objects (see Figure C-6). Scattering affects short wavelengths more than long wavelengths and limits the use of wavelengths below 800 nm.

Figure C-6: Rayleigh Scattering



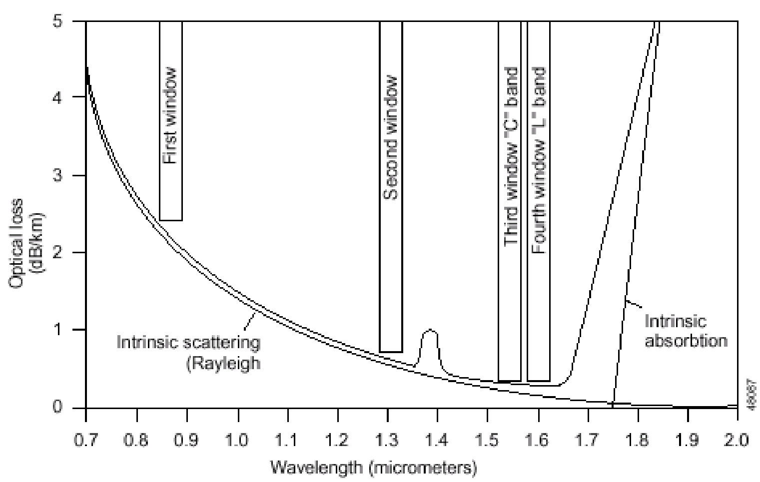
The intrinsic properties of the material itself, the impurities in the glass, and any atomic defects in the glass cause attenuation due to absorption. These impurities absorb the optical energy, causing the light to become dimmer (see Figure C-7). While Rayleigh scattering is important at shorter wavelengths, intrinsic absorption is an issue at longer wavelengths and increases dramatically above 1700 nm. However, absorption due to water peaks introduced in the fiber manufacturing process is being eliminated in some new fiber types.

Figure C-7: Absorption



The primary factors affecting attenuation in optical fibers are the length of the fiber and the wavelength of the light. Figure C-8 shows the loss in decibels per kilometer (dB/km) by wavelength from Rayleigh scattering, intrinsic absorption, and total attenuation from all causes.

Figure C-8: Total Attenuation Curve

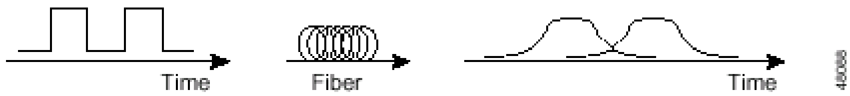


Attenuation in fiber is compensated primarily through the use of optical amplifiers.

Dispersion

Dispersion is the spreading of light pulses as they travel down optical fiber. Dispersion results in distortion of the signal (see Figure D-9), which limits the bandwidth of the fiber.

Figure D-9: Principle of Dispersion



Two general types of dispersion affect DWDM systems. One of these effects, chromatic dispersion, is linear while the other, polarization mode dispersion (PMD), is nonlinear.

Chromatic Dispersion

Chromatic dispersion occurs because different wavelengths propagate at different speeds. The effect of chromatic dispersion increases as the square of the bit rate. In single-mode fiber, chromatic dispersion has two components, material dispersion and waveguide dispersion.

Material dispersion occurs when wavelengths travel at different speeds through the material. A light source, no matter how narrow, emits several wavelengths within a range. Thus, when this range of wavelengths travels through a medium, each individual wavelength arrives at a different time.

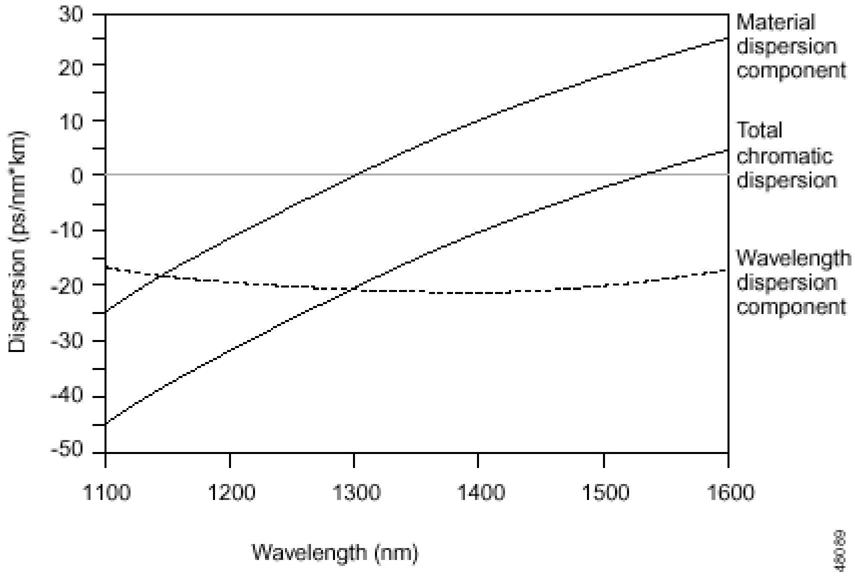
The second component of chromatic dispersion, waveguide dispersion, occurs because of the different refractive indices of the core and the cladding of fiber. The effective refractive index varies with wavelength as follows:

> At short wavelengths, the light is well confined within the core. Thus the effective refractive index is close to the refractive index of the core material.
>
> At medium wavelengths, the light spreads slightly into the cladding. This decreases the effective refractive index.
>
> At long wavelengths, much of the light spreads into the cladding. This brings the effective refractive index very close to that of the cladding.

This result of the phenomenon of waveguide dispersion is a propagation delay in one or more of the wavelengths relative to others.

Total chromatic dispersion, along with its components, is plotted by wavelength in Figure C-10 for dispersion-shifted fiber. For non-dispersion-shifted fiber, the zero dispersion wavelength is 1310 nm.

Figure C-10: Chromatic Dispersion



Though chromatic dispersion is generally not an issue at speeds below OC-48, it does increase with higher bit rates due to the spectral width required. New types of zero-dispersion-shifted fibers greatly reduce these effects. The phenomenon can also be mitigated with dispersion compensators.

Polarization Mode Dispersion

Most single-mode fibers support two perpendicular polarization modes, a vertical one and a horizontal one. Because these polarization states are not maintained, there occurs an interaction between the pulses that results is a smearing of the signal. Polarization mode dispersion (PMD) is caused by quality of the fiber shape as a result of the manufacturing process or from external stressors. Because stress can vary over time, PMD, unlike chromatic dispersion, is subject to change over time. PMD is generally not a problem at speeds below OC-192.

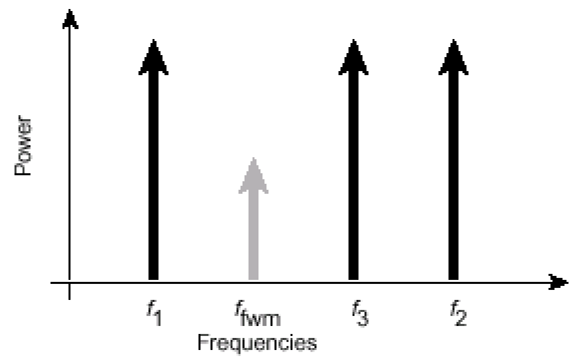
Other Nonlinear Effects

In addition to PMD, there are other nonlinear effects. Because nonlinear effects tend to manifest themselves when optical power is very high, they become important in DWDM.

Linear effects such as attenuation and dispersion can be compensated, but nonlinear effects accumulate. They are the fundamental limiting mechanisms to the amount of data that can be transmitted in optical fiber. The most important types of nonlinear effects are stimulated Brillouin scattering, stimulated Raman scattering, self-phase modulation, and four-wave mixing. In DWDM, four-wave mixing is most critical of these types.

Four-wave mixing is caused by the nonlinear nature of the refractive index of the optical fiber. Nonlinear interactions among different DWDM channels create sidebands that can cause interchannel interference. In Figure C-11 three frequencies interact to produce a fourth frequency, resulting in cross-talk and signal-to-noise degradation.

Figure C-11: Four-Wave Mixing



The effect of four-wave mixing is to limit the channel capacity of a DWDM system. Four-wave mixing cannot be filtered out, either optically or electrically, and increases with the length of the fiber. Due to its propensity for four-wave-mixing, DSF is unsuitable for WDM applications. This prompted the invention of NZ-DSF, which takes advantage of the fact that a small amount of chromatic dispersion can be used to mitigate four-wave mixing.

Light Sources and Detectors

Light emitters and light detectors are active devices at opposite ends of an optical transmission system. Light sources, or light emitters, are transmit-side devices that convert electrical signals to light pulses. The process of this conversion, or modulation, can be accomplished by externally modulating a continuous wave of light or by using a device that can generate modulated light directly. Light detectors perform the opposite function of light emitters. They are receive-side opto-electronic devices that convert light pulses into electrical signals.

Light Emitters – LEDs and Lasers

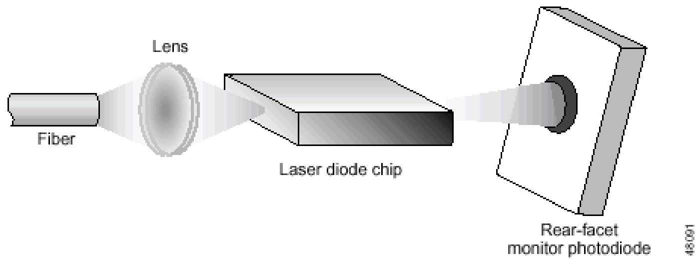
The light source used in the design of a system is an important consideration because it can be one of the most costly elements. Its characteristics are often a strong limiting factor in the final performance of the optical link. Light emitting devices used in optical transmission must be compact, monochromatic, stable, and long-lasting.

Note Monochromatic is a relative term; in practice they are only light sources within a certain range. Stability of a light source is a measure of how constant its intensity and wavelength is.

Two general types of light emitting devices are used in optical transmission, light-emitting diodes (LEDs) and laser diodes, or semiconductor lasers. LEDs are relatively slow devices, suitable for use at speeds of less than 1 Gb/s, they exhibit a relatively wide spectrum width, and they transmit light in a relatively wide cone. These inexpensive devices are often used in multimode fiber communications. Semiconductor lasers, on the other hand, have performance characteristics better suited to single-mode fiber applications.

Figure C-12 shows the general principles of launching laser light into fiber. The laser diode chip emits light in one direction to be focused by the lens onto the fiber and in the other direction onto a photodiode. The photodiode, which is angled to reduce back reflections into the laser cavity, provides a way of monitoring the output of the lasers and providing feedback so that adjustments can be made.

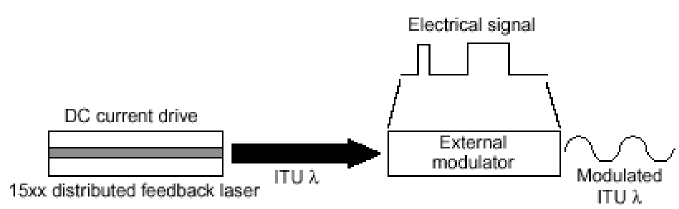
Figure C-12: Typical Laser Design



Requirements for lasers include precise wavelength, narrow spectrum width, sufficient power, and control of chirp (the change in frequency of a signal over time). Semiconductor lasers satisfy nicely the first three requirements. Chirp, however, can be affected by the means used to modulate the signal.

In directly modulated lasers, the modulation of the light to represent the digital data is done internally. With external modulation, an external device does the modulation. When semiconductor lasers are directly modulated, chirp can become a limiting factor at high bit rates (above 10 Gb/s). External modulation, on the other hand, helps to limit chirp. The external modulation scheme is depicted in Figure C-13.

Figure C-13: External Modulation of a Laser



Two types of semiconductor lasers are widely used, monolithic Fabry-Perot lasers, and distributed feedback (DFB) lasers. The latter type is particularly well suited for DWDM applications, as it emits a nearly monochromatic light, is capable of high speeds, has a favorable signal-to-noise ratio, and has superior linearity. DFB lasers also have center frequencies in the region around 1310 nm, and from 1520 to 1565 nm. The latter wavelength range is compatible with EDFAs. There are many other types and subtypes of lasers. Narrow spectrum tunable lasers are available, but their tuning range is limited to approximately 100-200 GHz. Under development are wider spectrum tunable lasers, which will be important in dynamically switched optical networks.

Light Detectors

On the receive end, it is necessary to recover the signals transmitted at different wavelengths on the fiber. Because photodetectors are by nature wideband devices, the optical signals are demultiplexed before reaching the detector.

Two types of photodetectors are widely deployed, the positive-intrinsic-negative (PIN) photodiode and the avalanche photodiode (APD). PIN photodiodes work on principles similar to, but in the reverse of, LEDs. That is, light is absorbed rather than emitted, and photons are converted to electrons in a 1:1 relationship. APDs are similar devices to PIN photodiodes, but provide gain through an amplification process: One photon acting on the device releases many electrons. PIN photodiodes have many advantages, including low cost and reliability, but APDs have higher receive sensitivity and accuracy.

However, APDs are more expensive than PIN photodiodes, they can have very high current requirements, and they are temperature sensitive.

Optical Amplifiers

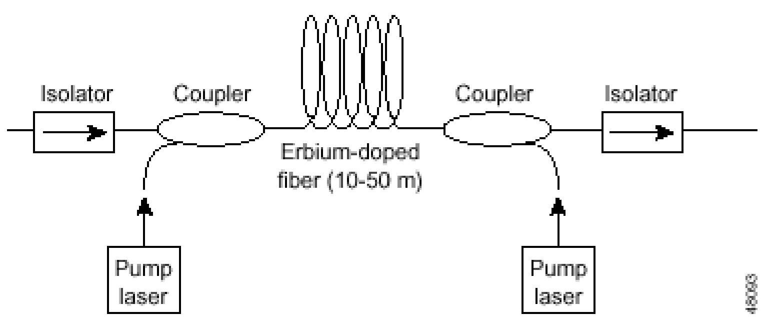
Due to attenuation, there are limits to how long a fiber segment can propagate a signal with integrity before it has to be regenerated. Before the arrival of optical amplifiers (OAs), there had to be a repeater for every signal transmitted. The OA has made it possible to amplify all the wavelengths at once and without optical-electrical-optical (OEO) conversion. Besides being used on optical links, optical amplifiers also can be used to boost signal power after multiplexing or before demultiplexing, both of which can introduce loss into the system.

Erbium-Doped Fiber Amplifier (EDFA)

By making it possible to carry the large loads that DWDM is capable of transmitting over long distances, the EDFA was a key enabling technology. At the same time, it has been a driving force in the development of other network elements and technologies.

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. Figure C-14 shows a simplified diagram of an EDFA. A weak signal enters the erbium-doped fiber, into which light at 980 nm or 1480 nm is injected 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 grows stronger. The spontaneous emissions in the EDFA also add noise to the signal; this determines the noise figure of an EDFA.

Figure C-14: Erbium-Doped 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 dB or more. The target parameters when selecting 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 an ultimate limiting factor in the number of amplifiers that can be concatenated. In general, signals can travel for up to 120 km (74 mi) between amplifiers. At longer distances of 600 to 1000 km (372 mi to 620 mi) the signal must be regenerated. That is because the optical amplifier merely amplifies the signals and does not perform the 3R functions (reshape, retime, retransmit). EDFAs are available for the C-band and the L-band.

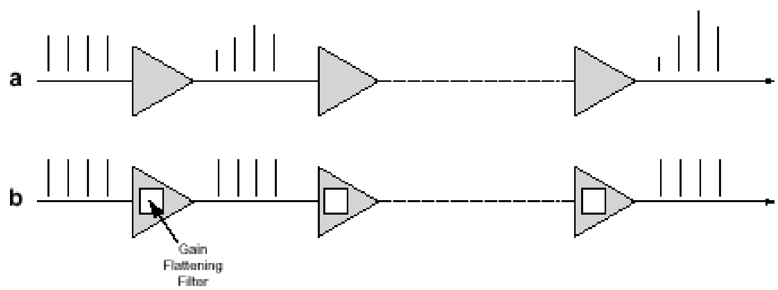
Constant Gain Mode

Constant amplification per wavelength is important for bandwidth-on-demand wavelength services. As wavelengths are added/dropped from an optical fiber, small variations in gain between channels in a span can cause large variations in the power difference between channels at the receivers. Constant gain mode is achieved using an automatic control circuit that adjusts pump power when changes in input power are detected.

Gain Flatness

Figure C-15 illustrates the importance of an EDFAs gain-flattening filter. With the first fiber (a), channels having equal power going into a cascaded network of amplifiers have vastly different powers and optical signal-to-noise ratio (SNR) at the output – without a gain flattening filter. In contrast, with the second fiber (b), the EDFAs reduce this effect by introducing a gain-flattening filter within each amplifier.

Figure C-15: Gain Flattening Filter



Transient Suppression

Transients in the performance of EDFAs are inevitable whenever the number of signals or the relative power of signals change. The amount of time required by an amplifier to recover from a change indicates the suitability of the amplifier for add/drop applications. Some EDFAs can reconfigure rapidly to ensure constant gain and gain flatness. The lower transient suppression implied on the lower transient delay makes it suitable for dynamic channel addition and subtraction (add/drop).

Low Noise

Noise increases whenever a gain occurs in an optical system. The predominant source of noise in EDFAs is Amplified Spontaneous Emission (ASE). An EDFA with a low-noise figure of < 6.0 dB ensures better OSNR performance for cascaded amplified networks.

Saturation-Protection Internal VOA

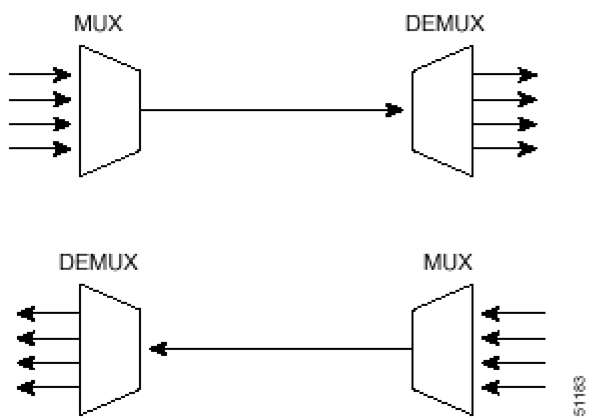
Saturation-protection internal VOA is an internal variable optical attenuator that is placed before the EDFA to attenuate the channel and composite power going into the amplifier gain block. The purpose of the VOA is to protect the EDFA from being driven into saturation. The VOA can be adjusted from 1 dB to 10 dB. Since the EDFA saturation input power is –6 dBm, the internal VOA allows a higher-power input to the amplifier with higher power (up to +4 dBm more). The VOA can be adjusted through software to control the gain block input to –6 dBm or less. For conditions where the gain block is in the normal operating region (i.e. non-saturated), some EDFAs can operate as a variable-gain amplifier.

DWDM Multiplexers and Demultiplexers

Because DWDM systems send signals from several sources over a single fiber, they must include some means to combine the incoming signals. This is done with a multiplexer, which takes optical wavelengths from multiple fibers and converges them into one beam. At the receiving end the system must be able to separate out the components of the light so that they can be discreetly detected. Demultiplexers perform this function by separating the received beam into its wavelength components and coupling them to individual fibers. Demultiplexing must be done before the light is detected, because photodetectors are inherently broadband devices that cannot selectively detect a single wavelength.

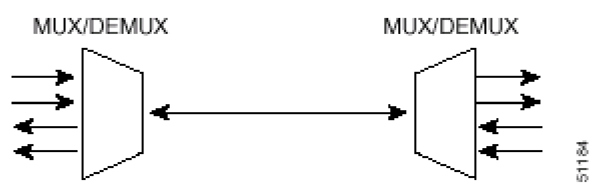
In a unidirectional system (see Figure C-16), there is a multiplexer at the sending end and a demultiplexer at the receiving end. Two systems (back-to-back terminals) would be required at each end for bi-directional communication, and two separate fibers would be needed.

Figure C-16: Multiplexing and Demultiplexing in a Unidirectional System



In a bi-directional system, there is a multiplexer/demultiplexer at each end (see Figure C-17) and communication is over a single fiber, with different wavelengths used for each direction.

Figure C-17: Multiplexing and Demultiplexing in a Bi-Directional System

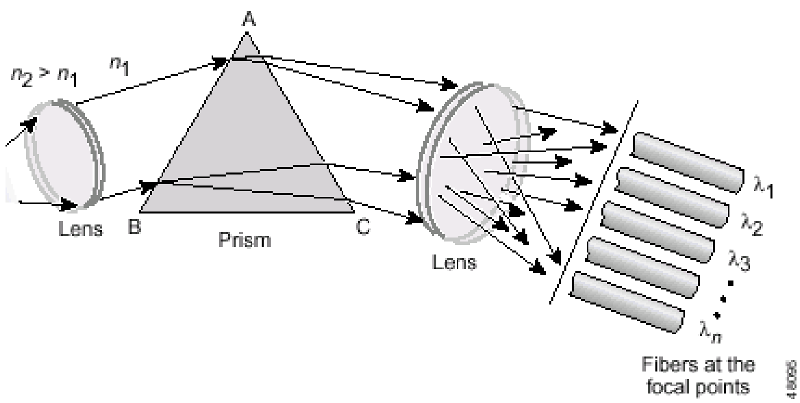


Multiplexers and demultiplexers can be either passive or active in design. Passive designs are based on prisms, diffraction gratings, or filters, while active designs combine passive devices with tunable filters. The primary challenges in these devices are to minimize cross-talk and maximize channel separation. Cross-talk is a measure of how well the channels are separated, while channel separation refers to the ability to distinguish each wavelength.

Techniques for Multiplexing and Demultiplexing

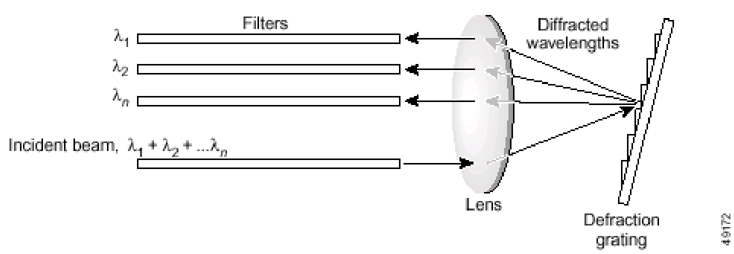
A simple form of multiplexing or demultiplexing of light can be done using a prism. Figure C-18 demonstrates the demultiplexing case. A parallel beam of polychromatic light impinges on a prism surface; each component wavelength is refracted differently. This is the "rainbow" effect. In the output light, each wavelength is separated from the next by an angle. A lens then focuses each wavelength to the point where it needs to enter a fiber. The same components can be used in reverse to multiplex different wavelengths onto one fiber.

Figure C-18: Prism Diffraction Multiplexing



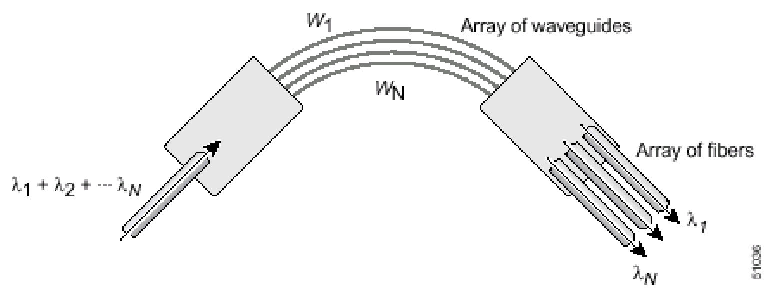
Another technology is based on the principles of diffraction and of optical interference. When a polychromatic light source impinges on a diffraction grating (see Figure C-19), each wavelength is diffracted at a different angle and therefore to a different point in space. Using a lens, these wavelengths can be focused onto individual fibers.

Figure C-19: Waveguide Grating Diffraction



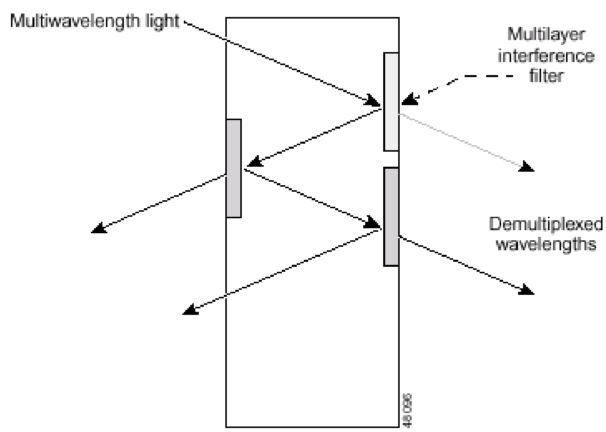
Arrayed waveguide gratings (AWGs) are also based on diffraction principles. An AWG device, sometimes called an optical waveguide router or waveguide grating router, consists of an array of curved-channel waveguides with a fixed difference in the path length between adjacent channels (see Figure C-20). The waveguides are connected to cavities at the input and output. When the light enters the input cavity, it is diffracted and enters the waveguide array. There the optical length difference of each waveguide introduces phase delays in the output cavity, where an array of fibers is coupled. The process results in different wavelengths having maximal interference at different locations, which correspond to the output ports.

Figure C-20: Arrayed Waveguide Grading



By positioning filters, consisting of thin films, in the optical path, wavelengths can be sorted out (demultiplexed). The property of each filter is such that it transmits one wavelength while reflecting others. By cascading these devices, many wavelengths can be demultiplexed (see Figure C-21).

Figure C-21: Multi-Layer Interface Filters



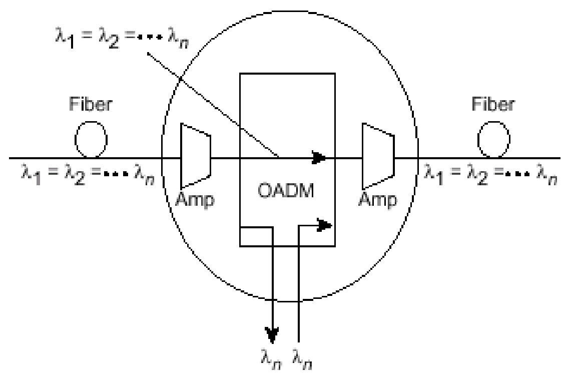
Of these designs, the AWG and thin film interference filters are gaining prominence. Filters offer good stability and isolation between channels at moderate cost, but with a high insertion loss. AWGs are polarization-dependent (which can be compensated), and they exhibit a flat spectral response and low insertion loss. A potential drawback is that they are temperature sensitive such that they may not be practical in all environments. Their big advantage is that they can be designed to perform multiplexing and demultiplexing operations simultaneously. AWGs are also better for large channel counts, where the use of cascaded thin film filters is impractical.

Optical Add/Drop Multiplexers

Between multiplexing and demultiplexing points in a DWDM system, as shown in Figure C-17, there is an area in which multiple wavelengths exist. It is often desirable to be able to remove or insert one or more wavelengths at some point along this span. An optical add/drop multiplexer (OADM) performs this function. Rather than combining or separating all wavelengths, the OADM can remove some while passing others on. OADMs are a key part of moving toward the goal of all-optical networks.

OADMs are similar in many respects to SONET ADM, except that only optical wavelengths are added and dropped, and no conversion of the signal from optical to electrical takes place. Figure C-22 is a schematic representation of the add-drop process. This example includes both pre-and post-amplification; these components that may or may not be present in an OADM, depending upon its design.

Figure C-22: Selectively Adding and Removing Wavelengths



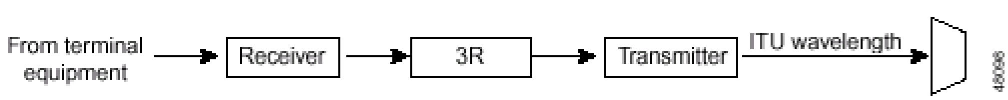
Interfaces to DWDM

Most DWDM systems support standard SONET/SDH optical interfaces to which any SONET compliant client device can attach. On the client side there can be SONET/SDH terminals or ADMs, ATM switches, or routers. Transponders are used to convert incoming optical signals into the precise ITU-standard wavelengths to be multiplexed.

Within the DWDM system a transponder converts the client optical signal back to an electrical signal and performs the 3R functions (see Figure C-23). This electrical signal is then used to drive the WDM laser. Each transponder within the system converts its client's signal to a slightly different wavelength. The wavelengths from all of the transponders in the system are then optically multiplexed.

In the receive direction of the DWDM system, the reverse process takes place. Individual wavelengths are filtered from the multiplexed fiber and fed to individual transponders, which convert the signal to electrical and drive a standard interface to the client.

Figure C-23: Transponder Functions

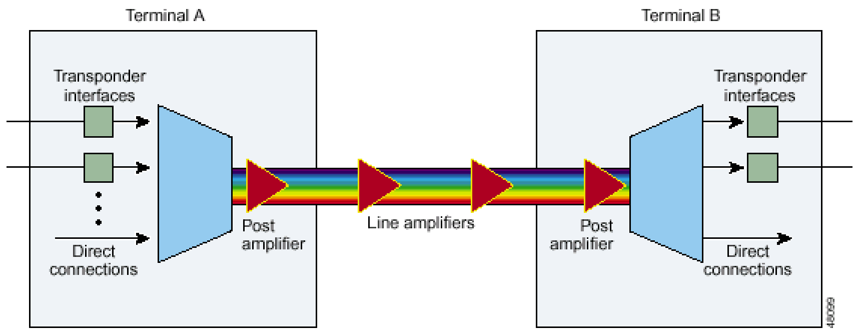


Using the ONS 15454 with its OC48ELR ITU optics cards reduces or eliminates the need for transponders. This architecture provides a cost-effective solution for Metro DWDM network applications.

Operation of a Transponder Based DWDM System

Some DWDM systems transponders are optical-electrical-optical (OEO) devices that transforms (maps) an incoming wavelength into a DWDM wavelength. Using the ONS 15454 OC48ELR ITU optical cards reduces or eliminates (based on your channel plan) the need for transponders. Figure C-24 shows a DWDM system with transponders.

Figure C-24: DWDM System with Transponders



The following steps describe the system shown in Figure C-24:

1. The transponder accepts input in the form of standard single-mode or multimode laser. The input can come from different physical media and different protocols and traffic types.
2. The wavelength of each input signal is mapped to a DWDM wavelength.
3. DWDM wavelengths from the transponder are multiplexed into a single optical signal and launched into the fiber. The system might also include the ability to accept direct optical signals to the multiplexer; such signals could come, for example, from a satellite node.
4. A post-amplifier boosts the strength of the optical signal as it leaves the system (optional).
5. Optical amplifiers are used along the fiber span as needed (optional).
6. A pre-amplifier boosts the signal before it enters the end system (optional).
7. The incoming signal is demultiplexed into individual DWDM lambdas (or wavelengths).
8. The individual DWDM lambdas are mapped to the required output type (for example, OC-48 single-mode fiber) and sent out through the transponder.

ITU Grid

For WDM system interoperability, the operating center frequency (wavelength) of channels must be the same at the transmitting and at the receiving end. The ITU-T currently recommends 81 channels in the C-band starting from 1528.77 nm, and incrementing in multiples of 50 GHz, to 1560.61 nm. Table C-2 lists the ITU frequencies and wavelengths.

Table C-2: ITU Grid

Frequency (GHz)	Wavelength (nm)	Frequency (GHz)	Wavelength (nm)	Frequency (GHz)	Wavelength (nm)	Frequency (GHz)	Wavelength (nm)
196.100	1528.77	195.050	1537.00	194.000	1545.32	192.950	1553.73
196.075	1528.97	195.025	1537.20	193.975	1545.52	192.925	1553.93
196.050	1529.16	195.000	1537.40	193.950	1545.72	192.900	1554.13
196.025	1529.36	194.975	1537.59	193.925	1545.92	192.875	1554.34
196.000	1529.55	194.950	1537.79	193.900	1546.12	192.850	1554.54
195.975	1529.75	194.925	1537.99	193.875	1546.32	192.825	1554.74
195.950	1529.94	194.900	1538.19	193.850	1546.52	192.800	1554.94
195.925	1530.14	194.875	1538.38	193.825	1546.72	192.775	1555.14
195.900	1530.33	194.850	1538.58	193.800	1546.92	192.750	1555.34
195.875	1530.53	194.825	1538.78	193.775	1547.12	192.725	1555.55
195.850	1530.72	194.800	1538.98	193.750	1547.32	192.700	1555.75
195.825	1530.92	194.775	1539.17	193.725	1547.52	192.675	1555.95
195.800	1531.12	194.750	1539.37	193.700	1547.72	192.650	1556.15
195.775	1531.31	194.725	1539.57	193.675	1547.92	192.625	1556.35
195.750	1531.51	194.700	1539.77	193.650	1548.11	192.600	1556.55
195.725	1531.70	194.675	1539.96	193.625	1548.31	192.575	1556.76
195.700	1531.90	194.650	1540.16	193.600	1548.51	192.550	1556.96
195.675	1532.09	194.625	1540.36	193.575	1548.71	192.525	1557.16
195.650	1532.29	194.600	1540.56	193.550	1548.91	192.500	1557.36
195.625	1532.49	194.575	1540.76	193.525	1549.11	192.475	1557.57
195.600	1532.68	194.550	1540.95	193.500	1549.32	192.450	1557.77
195.575	1532.88	194.525	1541.15	193.475	1549.52	192.425	1557.97
195.550	1533.07	194.500	1541.35	193.450	1549.72	192.400	1558.17
195.525	1533.27	194.475	1541.55	193.425	1549.92	192.375	1558.38
195.500	1533.47	194.450	1541.75	193.400	1550.12	192.350	1558.58
195.475	1533.66	194.425	1541.94	193.375	1550.32	192.325	1558.78
195.450	1533.86	194.400	1542.14	193.350	1550.52	192.300	1558.98
195.425	1534.05	194.375	1542.34	193.325	1550.72	192.275	1559.19
195.400	1534.25	194.350	1542.54	193.300	1550.92	192.250	1559.39
195.375	1534.45	194.325	1542.74	193.275	1551.12	192.225	1559.59
195.350	1534.64	194.300	1542.94	193.250	1551.32	192.200	1559.79
195.325	1534.84	194.275	1543.13	193.225	1551.52	192.175	1560.00
195.300	1535.04	194.250	1543.33	193.200	1551.72	192.150	1560.20
195.275	1535.23	194.225	1543.53	193.175	1551.92	192.125	1560.40
195.250	1535.43	194.200	1543.73	193.150	1552.12	192.100	1560.61
192.225	1535.63	194.175	1543.93	193.125	1552.32	192.075	1560.81
192.200	1535.82	194.150	1544.13	193.100	1552.52	192.050	1561.01
192.175	1536.02	194.125	1544.33	193.075	1552.73	192.025	1561.22
192.150	1536.22	194.100	1544.53	193.050	1552.93	191.000	1561.42
192.125	1536.41	194.075	1544.72	193.025	1553.13	191.975	1561.62
192.100	1536.61	194.050	1544.92	193.000	1553.33	191.950	1561.83
192.075	1536.81	194.025	1545.12	192.975	1553.53	191.925	1562.03
						191.900	1562.23

While this grid defines a standard, users are free to use the wavelengths in arbitrary ways and to choose from any part of the spectrum. In addition, manufacturers can deviate from the grid by extending the upper and lower bounds or by spacing the wavelengths more closely, typically at 50 GHz, to double the number of channels. The closer the spacing, the more channel cross-talk results. In addition, the impact of some fiber nonlinearities, such as FWM, increases. Spacing at

50 GHz also limits the maximum data rate per wavelength to 10 Gb/s. The implications of the flexibility in implementation are twofold:

There is no guarantee of compatibility between two end systems from different vendors.

There exists a design trade-off in the spacing of wavelengths between number of channels and maximum bit rate.

Appendix D – Ordering

Purpose

This appendix contains information on ordering ONS 15454 equipment and software. The information in this appendix shows you what is available for the ONS 15454 and serves as a guideline when ordering.

Contents

This appendix includes the following topics:

How to Order

Cisco Systems offers multiple ways to order products and services. You can order direct from Cisco, order through a Cisco partner, or order from an online retailer. Select the best ordering method for your business needs. For more information, contact your account manager.

Registered Cisco Direct Customers

Please login into Cisco Connection Online (CCO) using the login link www.cisco.com and navigate to the Ordering home page to use Cisco Internet commerce tools. Complete these easy steps to order online using the Internet Commerce tools:

1. Complete the online registration form to become a Cisco.com registered user.

2. Complete an Internet Commerce Agreement (ICA) if you want to submit orders online.

3. Ordering online requires a valid Cisco purchase order or sales order number for your company and your company billing information.

If you do not have a purchase order or sales order number available or would like to be added to your company's existing Internet Commerce Agreement, please contact Cisco customer service.

Order Direct From Cisco

For customers with an existing Cisco Direct Purchasing Agreement who order using Cisco's Internet commerce tools, order direct from Cisco. Follow the steps above to order direct from Cisco using CCO.

Order Through a Cisco Partner

For customers looking for a Cisco Partner who will aid in expert and specialized network design, consultation, installation and support services, order through a Cisco Partner. Search the Cisco global database at www.cisco.com to find a local Cisco partner that can provide expert or specialized network design, consultation, installation, and support services.

Order Through an Online Retailer

For customers at small and medium sized business who want to order online from one of Cisco's authorized Online Retailer stores, order through an Online Retailer. Search the Cisco Online Retailers database at www.cisco.com to find a retailer that can provide the products and services you need.

List of Parts

Component	Part Number	Part Name	Part Description
Common Cards			
	15454-AIC=	AIC	Alarm Interface Control
	15454-AIC-I=	AIC-I	Alarm Interface Card Enhanced
	15454-XC=	XC	XConn, 288 STS
	15454-XC-VT=	XC-VT	XConn, 576 STS, 672 VT
	15454-XC-10G=	XC-10G	Xconn, 1152 STS-1 ports, 672 VT1.5 ports
	15454-TCC+=	TCC+	Timing Communications Control **+**
	15454-TCC2=	TCC2	Timing Communications Control **+**
	15454-COMMON-KIT	COMMON-KIT	CISCO 15454 COMMON CARD KIT
	15454-COMMON2-KIT	COMMON2-KIT	CISCO 15454 COMMON CARD KIT
Software loaded on TCC+			
	SF15454-R2.2.0	R2.2.0 AE FP/CD	Rel.2.2.0 SW, Pre-loaded on TCC+
	SF15454-R2.2.1	R2.2.1 AE FP/CD	Rel.2.2.1 SW, Pre-loaded on TCC+
	SF15454-R3.0.1	R3.0.1 AE FP/CD	Rel.3.0.1 SW, Pre-loaded on TCC+
	SF15454-R3.1.0	R3.1.0 AE FP/CD	Rel.3.1.0 SW, Pre-loaded on TCC+
	SF15454-R3.2.0	R3.2.0 AE FP/CD	Rel.3.2.0 SW, Pre-loaded on TCC+
	SF15454-R3.3.0	R3.3.0 AE FP/CD	Rel.3.3.0 SW, Pre-loaded on TCC+
	SF15454-R3.4.0	R3.4.0 AE FP/CD	Rel.3.4.0 SW, Pre-loaded on TCC+
	SF15454-R3.4.1	R3.4.1 AE FP/CD	Rel.3.4.1 SW, Pre-loaded on TCC+
Software loaded on TCC2			
	SF15454-R4.0.0	R4.0.0 AE FP/CD	Rel.4.0.0 SW, Pre-loaded on TCC+

Assemblies			
	15454-SA-ANSI=	SA-ANSI	15454 Shelf Assembly NEBS 3 ANSI, 10Gbps, power rating (-48VDC, 25 AMPS)
	15454-SA-NEBS3E	15454 Bay Assembly Duct Kit	15454 Shelf Assembly NEBS3 Extended Fiber Mgmt.
	Cisco 15454	15454 ATO	15454 ATO (Assemble To Order)
	15454-SA-HDAHDB2=	SA-HDAHDB2	15454-ANSI Shelf Assembly, mounted with BNC-A48 and BNC-B48
	15454-3SA-OPTBIC	3-Shelf Bay Assembly, Config. BIC Selection	15454 3-Shelf Bay Assy., Config. BIC Selection.
	15454-4SA-OPTBIC	4-Shelf Bay Assembly, Config. BIC Selection	15454 4-Shelf Bay Assy., Config. BIC Selection.
	15454-4SA-1BNC	4-Shelf Bay Assembly, 1 BNC48	15454 4-Shelf Bay Assy, 1 BNC48
	15454-SHELF-KIT	SHELF-KIT	CISCO 15454 SHELF, FAN TRAY AND FILTER
	15454-OSA=	0-shelf bay assembly	15454 0-shelf bay assembly
	15454-BAY-DUCT-1=	15454 Bay Assy. Duct. Kit	15454 Bay Assy. Duct. Kit
	Cisco 15454 10G=	SA-10G	10G Bundled Program-reqs 2ea. XC-10G +2 ea OC192 or G1000-4.
iTEMP	15454-FTA3-T	FTA3	Fan Tray Assembly, ANSI, 15454, HPCFM, Itemp
iTEMP	15454-FTA2=	FTA2	Shelf Fan Tray Assembly, NEBS3E, itemp, 15454 includes filter
	15454-FTF2=	FTF2	Fan tray filter, compatible with FTA, FTA3, & FTA3-T
	15454-RCA=	Rear Cover assembly, AB side, 15454	Rear Cover assembly, AB side, 15454
	15454-EMEA-KIT=	EMEA-KIT	EMEA Compliance Kit for ANSI Shelf Assembly
Electrical Interface Adapter (Installed on Shelf)			
	15454-EIA-BNC-A24	EIA-BNC-A/24	Elect I/F, 24 BNC, A Side Installed on Shelf
	15454-EIA-BNC-B24	EIA-BNC-B/24	Elect I/F, 24 BNC, B Side Installed on Shelf
	15454-EIA-BNC-A48	EIA-BNC-A/48	Elect I/F, 48 BNC, A Side Installed on Shelf
	15454-EIA-BNC-B48	EIA-BNC-B/48	Elect I/F, 48 BNC, B Side Installed on Shelf
	15454-EIA-SMB-A84	EIA-SMB-A/84	Elect I/F, 84 SMB, A Side Installed on Shelf
	15454-EIA-SMB-B84	EIA-SMB-B/84	Elect I/F, 84 SMB, B Side Installed on Shelf
	15454-EIA-AMP-A84	EIA-AMP-A/84	Elect I/F, 84 AMP, A Side Installed on Shelf
	15454-EIA-AMP-B84	EIA-AMP-B/84	Elect I/F, 84 AMP, B Side Installed on Shelf
	15454-WW-14=	DS1 Elect I/F adapters, 14 SMB-WW	DS1 Elect I/F, 14 SMB-WW Qty 30

TRANSCEIVERS (MULTI-SERVICE CARDS)			
Electric Cards			
iTEMP	15454-DS1-14=	DS1-14	DS1, DSX, 14 CKT ITEMP
iTEMP	15454-DS1N-14=	DS1-N 14	DS1, 1:N, DSX, 14 CKT ITEMP
iTEMP	15454-DS3-12=	DS3-12	DS3, DSX, 12 CKT, Enh Test ITEMP
iTEMP	15454-DS3-12E=	DS3-12	DS3, DSX, Enhanced PM, 12 CKT, ITEMP
iTEMP	15454-DS3N-12=	DS3-N 12	DS3, 1:N, DSX, 12 CKT ITEMP
iTEMP	15454-DS3N-12E=		DS3, 1:N, DSX, Enhanced PM, 12 CKT ITEMP
iTEMP	15454-EC1-12=	EC1-12	EC1, 12 CKT ITEMP
iTEMP	15454-DS3XM-6=	DS3XM-6	DS3, DSX Transmux, 6 CKT ITEMP
Optical SONET Cards			
iTEMP	15454-OC34IR1310=	OC3-4 IR	OC3, IR, 1310, 4 CKT, SC, ITEMP
iTEMP	15454-OC3I81310=	OC3-4 IR	OC3, IR, 1310, 8 CKT, SC, ITEMP
iTEMP	15454-OC121IR1310=	OC12-1 IR	OC12, IR, 1310, 1 CKT, SC, ITEMP
iTEMP	15454-OC121LR1310=	OC12-1 LR-1310	OC12, LR, 1310, 1 CKT, SC, ITEMP
iTEMP	15454-OC121LR1550=	OC12-1 LR-1550	OC12, LR, 1550, 1 CKT, SC ITEMP
iTEMP	15454-OC12I41310=	OC12-4 IR	OC12, IR, 1310, 4 CKT, SC, ITEMP
	15454-OC481IR1310=	OC48-1 IR	OC48, IR, 1310, 1 CKT, SC
	15454-OC48IR1310A=	OC48A-1 IR	OC48, IR, 1310A, 1 CKT, Any Slot, SC
	15454-OC481LR1550=	OC48-1 LR	OC48, LR, 1550, 1 CKT, SC
	15454-OC481LR1550A=	OC48-1 LR-A	OC48, LR, 1550A, 1 CKT, Any Slot, SC
	15454-OC1921LR1550=	OC192-1 LR	OC192, LR, 1550, 1 CKT, SC
	15454-OC1921SR1310=	OC192-1 SR	OC192, SR, 1310, 1 CKT, SC
	15454-OC1921IR1550=	OC192-1 IR	OC192, IR, 1550, 1 CKT, SC

ITU GRID OC-48 ELR @ 200GHz			
	15454-OC48E-47.72=		OC-48, ELR, 1547.72, 200GHz, 1CKT, SC (RED)
	15454-OC48E-49.32=		OC-48, ELR, 1549.32, 200GHz, 1CKT, SC (RED)
	15454-OC48E-50.92=		OC-48, ELR, 1550.92, 200GHz, 1CKT, SC (RED)
	15454-OC48E-52.52=		OC-48, ELR, 1552.52, 200GHz, 1CKT, SC (RED)
	15454-OC48E-54.13=		OC-48, ELR, 1554.13, 200GHz, 1CKT, SC (RED)
	15454-OC48E-55.75=		OC-48, ELR, 1555.75, 200GHz, 1CKT, SC (RED)
	15454-OC48E-57.36=		OC-48, ELR, 1557.36, 200GHz, 1CKT, SC (RED)
	15454-OC48E-58.98=		OC-48, ELR, 1558.98, 200GHz, 1CKT, SC (RED)
	15454-OC48E-60.61=		OC-48, ELR, 1560.61, 200GHz, 1CKT, SC (RED)
	15454-OC48E-30.33=		OC-48, ELR, 1530.33, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-31.90=		OC-48, ELR, 1531.90, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-33.47=		OC-48, ELR, 1533.47, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-35.04=		OC-48, ELR, 1535.04, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-36.61=		OC-48, ELR, 1536.61, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-38.19=		OC-48, ELR, 1538.19, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-39.77=		OC-48, ELR, 1539.77, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-41.35=		OC-48, ELR, 1541.35, 200GHz, 1CKT, SC (BLUE)
	15454-OC48E-42.94=		OC-48, ELR, 1542.94, 200GHz, 1CKT, SC (BLUE)

ITU GRID OC-48 ELR @ 100GHz			
	15454-OC48E-1-28.7=		OC-48/STM16, ELR, 1528.77, 100GHz, 1CKT, SC
	15454-OC48E-1-30.3=		OC-48/STM16, ELR, 1530.33, 100GHz, 1CKT, SC
	15454-OC48E-1-31.1=		OC-48/STM16, ELR, 1531.12, 100GHz, 1CKT, SC
	15454-OC48E-1-31.9=		OC-48/STM16, ELR, 1531.90, 100GHz, 1CKT, SC
	15454-OC48E-1-32.6=		OC-48/STM16, ELR, 1532.68, 100GHz, 1CKT, SC
	15454-OC48E-1-33.4=		OC-48/STM16, ELR, 1533.77, 100GHz, 1CKT, SC
	15454-OC48E-1-34.2=		OC-48/STM16, ELR, 1534.25, 100GHz, 1CKT, SC
	15454-OC48E-1-35.0=		OC-48/STM16, ELR, 1535.04, 100GHz, 1CKT, SC
	15454-OC48E-1-35.8=		OC-48/STM16, ELR, 1535.82, 100GHz, 1CKT, SC
	15454-OC48E-1-36.6=		OC-48/STM16, ELR, 1536.61, 100GHz, 1CKT, SC
	15454-OC48E-1-38.1=		OC-48/STM16, ELR, 1538.19, 100GHz, 1CKT, SC
	15454-OC48E-1-38.9=		OC-48/STM16, ELR, 1538.98, 100GHz, 1CKT, SC
	15454-OC48E-1-39.7=		OC-48/STM16, ELR, 1539.77, 100GHz, 1CKT, SC
	15454-OC48E-1-40.5=		OC-48/STM16, ELR, 1540.56, 100GHz, 1CKT, SC
	15454-OC48E-1-42.1=		OC-48/STM16, ELR, 1542.14, 100GHz, 1CKT, SC
	15454-OC48E-1-41.3=		OC-48/STM16, ELR, 1541.35, 100GHz, 1CKT, SC
	15454-OC48E-1-42.9=		OC-48/STM16, ELR, 1542.94, 100GHz, 1CKT, SC
	15454-OC48E-1-43.7=		OC-48/STM16, ELR, 1543.73, 100GHz, 1CKT, SC
	15454-OC48E-1-44.5=		OC-48/STM16, ELR, 1544.53, 100GHz, 1CKT, SC
	15454-OC48E-1-46.9=		OC-48/STM16, ELR, 1546.92, 100GHz, 1CKT, SC
	15454-OC48E-1-46.1=		OC-48/STM16, ELR, 1546.12, 100GHz, 1CKT, SC
	15454-OC48E-1-47.7=		OC-48/STM16, ELR, 1547.72, 100GHz, 1CKT, SC
	15454-OC48E-1-48.5=		OC-48/STM16, ELR, 1548.51, 100GHz, 1CKT, SC
	15454-OC48E-1-49.3=		OC-48/STM16, ELR, 1549.32, 100GHz, 1CKT, SC
	15454-OC48E-1-50.1=		OC-48/STM16, ELR, 1550.12, 100GHz, 1CKT, SC
	15454-OC48E-1-50.9=		OC-48/STM16, ELR, 1550.92, 100GHz, 1CKT, SC
	15454-OC48E-1-51.7=		OC-48/STM16, ELR, 1551.72, 100GHz, 1CKT, SC
	15454-OC48E-1-52.5=		OC-48/STM16, ELR, 1552.52, 100GHz, 1CKT, SC
	15454-OC48E-1-54.1=		OC-48/STM16, ELR, 1554.13, 100GHz, 1CKT, SC
	15454-OC48E-1-54.9=		OC-48/STM16, ELR, 1554.94, 100GHz, 1CKT, SC
	15454-OC48E-1-55.7=		OC-48/STM16, ELR, 1555.75, 100GHz, 1CKT, SC
	15454-OC48E-1-56.5=		OC-48/STM16, ELR, 1556.55, 100GHz, 1CKT, SC

	15454-OC48E-1-57.3=		OC-48/STM16, ELR, 1557.36, 100GHz, 1CKT, SC
	15454-OC48E-1-58.1=		OC-48/STM16, ELR, 1558.17, 100GHz, 1CKT, SC
	15454-OC48E-1-58.9=		OC-48/STM16, ELR, 1558.98, 100GHz, 1CKT, SC
	15454-OC48E-1-59.7=		OC-48/STM16, ELR, 1559.79, 100GHz, 1CKT, SC
	15454-OC48E-1-60.6=		OC-48/STM16, ELR, 1560.61, 100GHz, 1CKT, SC
ITU GRID OC-192-LR @ 100GHz			
	15454-OC192L-1-1534.25=		OC-192/STM-64, LR, 1534.25, 100GHz, 1CKT, SC
	15454-OC192L-1-1535.04=		OC-192/STM-64, LR, 1535.04, 100GHz, 1CKT, SC
	15454-OC192L-1-1535.82=		OC-192/STM-64, LR, 1535.82, 100GHz, 1CKT, SC
	15454-OC192L-1-1536.61=		OC-192/STM-64, LR, 1536.61, 100GHz, 1CKT, SC
	15454-OC192L-1-1538.19=		OC-192/STM-64, LR, 1538.19, 100GHz, 1CKT, SC
	15454-OC192L-1-1538.98=		OC-192/STM-64, LR, 1538.98, 100GHz, 1CKT, SC
	15454-OC192L-1-1539.77=		OC-192/STM-64, LR, 1539.77, 100GHz, 1CKT, SC
	15454-OC192L-1-1540.56=		OC-192/STM-64, LR, 1540.56, 100GHz, 1CKT, SC
	15454-OC192L-1-1550.12=		OC-192/STM-64, LR, 1550.12, 100GHz, 1CKT, SC
	15454-OC192L-1-1550.92=		OC-192/STM-64, LR, 1550.92, 100GHz, 1CKT, SC
	15454-OC192L-1-1551.72=		OC-192/STM-64, LR, 1551.72, 100GHz, 1CKT, SC
	15454-OC192L-1-1552.52=		OC-192/STM-64, LR, 1552.52, 100GHz, 1CKT, SC
	15454-OC192L-1-1554.13=		OC-192/STM-64, LR, 1554.13, 100GHz, 1CKT, SC
	15454-OC192L-1-1554.94=		OC-192/STM-64, LR, 1554.94, 100GHz, 1CKT, SC
	15454-OC192L-1-1555.75=		OC-192/STM-64, LR, 1555.75, 100GHz, 1CKT, SC
	15454-OC192L-1-1556.55 =		OC-192/STM-64, LR, 1556.55, 100GHz, 1CKT, SC

Ethernet			
	15454-E100T=	E100T	10/100 BaseT, 12 CKT, RJ45
	15454-E1000-2=	E1000-2	Gigabit Ethernet, 2 CKT, GBIC
	15454-E100T-G=	E100T-G	10/100BT, 12 CKT, RJ45, compatible with XC, XCVT, XC-10G
	15454-E1000-2-G=	E1000-2-G	Gigabit Ethernet, 2 CKT, GBIC, compatible with XC, XCVT, XC-10G
	15454-G1K-4	4 Port Gigabit Ethernet	4 port Gigabit Ethernet
	15454-G1000-4	4 Port Gigabit Ethernet	4 port Gigabit Ethernet
	15454-ML100T-12	ML100T-12	10/100 BaseT, 12 CKT, RJ45
	15454-ML1000-2	2 Port Gigabit Ethernet	2 port Gigabit Ethernet with Layer 2 and Layer 3 switching and IOS
	15454-SFP-LC-SX=	SFP-LC-SX	1000Base-SX, small form pluggable LC connector
	15454-SFP-LC-LX=	SFP-LC-LX	1000Base-LX, small form pluggable LC connector
	15454-GBIC-SX=	GBIC-SX	1000Base-SX, MM, standardized for 15454/15327
	15454-GBIC-LX=	GBIC-LX	1000Base-LX, MM, standardized for 15454/15327
ONS 15454 Documentation			
System Documentation			
	15454-DOC2.2.0CD=	Sys. DOC 2.2.0 CD-ROM	Sys. Doc. Rel 2.2.0 English, CD
	15454-DOC2.2.0PP=	Sys. DOC 2.2.0 Paper	Sys. Doc. Rel 2.2.0 English, Paper
	15454-DOC2.2.1CD=	Sys. DOC 2.2.1 CD-ROM	Sys. Doc. Rel 2.2.1 English, CD
	15454-DOC2.2.1PP=	Sys. DOC 2.2.1 Paper	Sys. Doc. Rel 2.2.1 English, Paper
	15454-DOC-7811321=	Sys. DOC 2.2.1 Paper	Install the Timing Comm and CONT+ Card in Cisco ONS15454
	15454-DOC7811458=	Sys. DOC 2.2.1 Paper	ONS15454 Product Overview
	15454-DOC3.0.1CD=	Sys. DOC 3.0.1 CD-ROM	Sys. Doc. Rel 3.0.1 English, CD
	15454-DOC3.1.0PP=	Sys. DOC 3.1.0Paper	Sys. Doc. Rel 3.1.0 English, Paper
	15454-DOC3.1.0CD=	Sys. DOC 3.1.0 CD-ROM	Sys. Doc. Rel 3.1.0 English, CD
	15454-DOC3.2.0CD=	Sys. DOC 3.2.0 CD-ROM	Sys. Doc. Rel 3.2.0 English, CD
	15454-DOC3.2.0PP	Sys. DOC 3.2.0Paper	Sys. Doc. Rel 3.2.0 English, Paper
	15454-DOC3.3.0CD=	Sys. DOC 3.3.0 CD-ROM	Sys. Doc. Rel 3.3.0 English, CD
	15454-DOC3.3.0PP	Sys. DOC 3.3.0Paper	Sys. Doc. Rel 3.3.0 English, Paper
	15454-DOC3.4.0CD=	Sys. DOC 3.4.0 CD-ROM	Sys. Doc. Rel 3.4.0 English, CD
	15454-DOC3.4.0PP	Sys. DOC 3.4.0 Paper	Sys. Doc. Rel 3.4.0 English, Paper
	15454-DOC3.4.1CD=	Sys. DOC 3.4.1 CD-ROM	Sys. Doc. Rel 3.4.1 English, CD
	15454-DOC3.4.1PP	Sys. DOC 3.4.1 Paper	Sys. Doc. Rel 3.4.1 English, Paper
	15454-DOC4.0.0CD=	Sys. DOC 4.0.0 CD-ROM	Sys. Doc. Rel 4.0.0 English, CD
	15454-DOC4.0.0PP	Sys. DOC 4.0.0 Paper	Sys. Doc. Rel 4.0.0 English, Paper

Cisco Systems

ONS 15454 Software			
System Software			
	15454-R2.2.0SW/CD=	R2.2.0 AE FP/CD	Rel.2.2.0 AE Feature Pkg, CD
	15454-R2.2.1SWCD=	R2.2.1 AE FP/CD	Rel.2.2.1 AE Feature Pkg, CD
	15454-R2.2.2SWCD=	R2.2.2 AE FP/CD	Rel.2.2.2 AE Feature Pkg, CD
	15454-R3.0.1SWCD=	R3.0.1 AE FP/CD	Rel.3.0.1 Feature Pkg, CD
	15454-R3.0.3SWCD=	R3.0.3 AE FP/CD	Rel 3.0.3 Feature Pkg. CD
	15454-R3.1.0 SWCD=	R3.1.0 AE FP/CD	Rel.3.1.0 Feature Pkg, CD
	15454-R3.2.0 SWCD=	R3.2.0 AE FP/CD	Rel.3.2.0 Feature Pkg, CD
	15454-R3.3.0 SWCD=	R3.3.0 AE FP/CD	Rel.3.3.0 Feature Pkg, CD
	15454-R3.4.0 SWCD=	R3.4.0 AE FP/CD	Rel.3.4.0 Feature Pkg, CD
	15454-R3.4.1 SWCD=	R3.4.1 AE FP/CD	Rel.3.4.1 Feature Pkg, CD
	15454-R4.0.0 SWCD=	R4.0.0 AE FP/CD	Rel.4.0.0 Feature Pkg, CD
Cisco ONS 15454			
Relicensing			
	LL-ONS-15454		ONS 15454 Feature Package License
Relicensing			
	15454-LIC-UPG		Upgrade license, one required for each deployed system being upgraded, includes system software on CD/ROM

Equipment shipped Individually (spares)			
	Installation Accessories		
	15454-BLANK=	BLANK	Empty slot Filler Panel
	15454-SHIPKIT=	SHIP KIT	Shelf install accessories (Spare)
	15454-RCA=	RCA	Rear Cover Assy, AB side
	15454-BP-COVER-A=	BP Cover	Rear Backplane Cover Assy, A Side
	15454-BP-COVER-B=	BP Cover	Rear Backplane Cover Assy, B Side
	15454-FIBER-BOOT=	FIBER BOOTS	QTY of 15, 90 Degree fiber retention boots
	15454-WW-14=	EIA-WW-14	DS1 Elect I/F, 14 SMB-WW Qty 30
	15454-FTF2=	FTF	Shelf Fan Tray Filter (Fits NEBS3 and NEBS3E shelves)
	15454-FTA=	FTA	Compatable with Cisco 15454-SA-NEBS3 ONLY
	15454-FTA2=	FTA	Compatable with Cisco 15454-SA-NEBSE3 ONLY
	15454-BAY-KIT=	15454 Bay Assy. Kit	15454 Bay Assy. Kit
	15454-BAY-FMT-1=	15454 Bay Assy. Fiber Mgmt. Tray	15454 Bay Assy. Fiber Mgmt. Tray
	15454-BAY-FAP-1=	15454 Bay Assy. Fuse and Alarm Panel	15454 Bay Assy. Fuse and Alarm Panel
	15454-BAY-EXT=	15454 Bay Extender Kit	15454 Bay Extender Kit
	15454-BAY-Cover=	15454 Bay Side Cover Kit	15454 Bay Side Cover Kit
	15454-Bay GUARD	15454 Bay End Guard Kit	15454 Bay End Guard Kit
	15454-Bay-ACC	15454 Bay Accessory Kit	15454 Bay Accessory Kit
	15454-SA-GNDKIT=	15454 Spare Door and Ground Cable	15454 Spare Door and Ground Cable
Electrical Interfaces			
	15454-EIA-BNC-B24=	EIA-BNC-B/24	Elect I/F, 24 BNC, B Side
	15454-EIA-BNC-A24=	EIA-BNC-A/24	Elect I/F, 24 BNC, A Side
	15454-EIA-BNC-B48=	EIA-BNC-B/48	Elect I/F, 48 BNC, B Side
	15454-EIA-BNC-A48=	EIA-BNC-A/48	Elect I/F, 48 BNC, A Side
	15454-EIA-SMB-B84=	EIA-SMB-B/84	Elect I/F, 84 SMB, B Side
	15454-EIA-SMB-A84=	EIA-SMB-A/84	Elect I/F, 84 SMB, A Side
	15454-EIA-AMP-B84=	EIA-AMP-B/84	Elect I/F, 84 AMP, B Side
	15454-EIA-AMP-A84=	EIA-AMP-A/84	Elect I/F, 84 AMP, A Side

OEM			
OEM Modem			
	15454-SGAZ-MODEM=	StarGazer 1700	StarGazer 1700 LanModem 10BT/POTS
Cable Assemblies			
	15454-SMB-BNC-10=	SMB-BNC-10	Cable Assembly, SMB-BNC, 10 FT
	15454-SMB-BNC-30=	SMB-BNC-30	Cable Assembly, SMB-BNC, 30 FT
	15454-SMB-BNC-50=	SMB-BNC-50	Cable Assembly, SMB-BNC, 50 FT
	15454-SMB-BNC-75=	SMB-BNC-75	Cable Assembly, SMB-BNC, 75 FT
	15454-AMP-WW-30=	AMP-WW-30	Cable Assembly, AMP-WW, 30 FT
	15454-AMP-WW-50=	AMP-WW-50	Cable Assembly, AMP-WW, 50 FT
	15454-AMP-WW-100=	AMP-WW-100	Cable Assembly, AMP-WW, 100 FT
	15454-AMP-WW-250=	AMP-WW-250	Cable Assembly, AMP-WW, 250 FT
Training			
	15454-TRAINING	Training Services	Please call Global Knowledge at 800-854-9055

Acronyms

Numerics

10BaseT
standard 10 megabit per second local area network over unshielded twisted pair copper wire

100BaseT
standard 100 megabit per second Ethernet network

100BaseTX
specification of 100BaseT that supports full duplex operation

A

ACO
Alarm Cutoff

ACT/STBY
Active/Standby

ADM
Add-Drop Multiplexer

AIC
Alarm Interface Controller

AID
Access Identifier

AIP
Alarm Interface Panel

AIS
Alarm Indication Signal

AIS-L
Line Alarm Indication Signal

AMI
Alternate Mark Inversion

ANSI
American National Standards Institute

APS
Automatic Protection Switching

ARP
Address Resolution Protocol

ATAG
Autonomous Message Tag

ATM
Asynchronous Transfer Mode

AWG
American Wire Gauge

B

B8ZS
Bipolar 8 Zero Substitution

BER
Bit Error Rate

BIC
Backplane Interface Connector

BIP
Bit Interleaved Parity

BITS
Building Integrated Timing Supply

BLSR
Bi-directional line switched ring

BNC
Bayonet Neill-Concelman (coaxial cable bayonet locking connector)

BPDU
Bridge Protocol Data Unit

C

CAT 5
Category 5 (cabling)

CCITT
Consultative Committee International Telegraph and Telephone (France)

CEO
Central Office Environment

CEV
Controlled Environment Vaults

CLEI
Common Language Equipment Identifier code

CLNP
Correctionless Network Protocol

CMIP
Common Management Information Protocol

cm
centimeter

COE
Central Office Environment

CORBA
Common Object Request Broker Architecture

CPE
Customer Premises Environments

CSU
Channel Service Unit

CTAG
Correlation Tag

CTC
Cisco Transport Controller

D

DCC
Data Communications Channel

DCN
Data Communications Network

DCS
Distributed Communications System

DRAM
Dynamic Random Access Memory

DS-1
Digital Signal Level One

DS-3
Digital Signal Level Three

DS1-14
Digital Signal Level One (14 ports)

DS1N-14
Digital Signal Level One (N-14 ports)

DS3-12
Digital Signal Level Three (12 ports)

DS3N-12
Digital Signal Level Three (N-12 ports)

DS3XM-6
Digital Service, level 3 Trans Multiplexer 6 ports

DSU
Data Service Unit

DSX
Digital Signal Cross Connect frame

E

EDFA
Erbium Doped Fiber Amplifier

EFT
Electrical Fast Transient/Burst

EIA
Electrical Interface Assemblies

ELR
Extended Long Reach

EMI
Electromagnetic interface

EML
Element Management Layer

EMS
Element Management System

EOW
Express Orderwire

ERDI
Enhanced Remote Defect Indicator

ES
Errored Seconds

ESD
Electrostatic Discharge

ESF
Extended Super Frame

ETSI
European Telecommunications Standards Institute

F

FC
Failure Count

FDDI
Fiber Distributed Data Interface

FE
Frame Bit Errors

FG1
Frame Ground #1(pins are labeled “FG1,” “FG2,” etc.)

FSB
Field Service Bulletin

G

Gb/s
Gigabits per second

GBIC
Gigabit Interface Converter

GR-253-CORE
General Requirements #253 Council Of Registrars

GR-1089
General Requirements #1089

GUI
Graphical User Interface

H

HDLC
High-Level Data Link Control

I

IEEE
Institute of Electrical and Electronics Engineers

IETF
Internet Engineering Task Force

IP
Internet Protocol

IPPM
Intermediate-Path Performance Monitoring

I/O
Input/Output

ITU-T
The International Telecommunication Union- Telecommunication Standards Sector

IXC
Interexchange Carrier

J

JRE
Java Runtime Environment

L

LAN
Local Area Network

LCD
Liquid Crystal Display

LDCC
Line Data Communications Channel

LOP
Loss of Pointer

LOS
Loss of Signal

LOF
Loss of Frame

LOW
Local Orderwire

LTE
Line Terminating Equipment

LVDS
Low Voltage Differential Signal

M

MAC
Media Access Control

Mb/s
Million bits per second, or Million bytes per second

MHz
Megahertz

MIB
Management Information Bases

MIME
Multipurpose Internet Mail Extensions

Mux/Demux
Multiplexer/Demultiplexer

N

NE
Network Element

NEL
Network Element Layer

NEBS
Network Equipment-Building Systems

NML
Network Management Layer

NMS
Network Management System

O

OAM&P
Operations, Administration, Maintenance, and Provisioning

OC
Optical carrier

OOS AS
Out of Service Assigned

OSI
Open Systems Interconnection

OSPF
Open Shortest Path First

OSS
Operations Support System

OSS/NMS
Operations Support System/Network Management System

P

PCM
Pulse Code Modulation

PCMCIA
Personal Computer Memory Card International Association

PCN
Product Change Notices

PDI-P
STS Payload Defect Indication-Path

POP
Point of Presence

PM
Performance Monitoring

PPMN
Path-Protected Mesh Network

PSC
Protection Switching Count

PSD
Protection Switching Duration

PTE
Path Terminating Equipment

R

RAM
Random Access Memory

RDI-L
Remote Defect Indication Line

RES
Reserved

RJ45
Registered Jack #45 (8 pin)

RMA
Return Material Authorization

RMON
Remote Network Monitoring

RS232
Recommended Standard #232 (ANSI Electrical Interface for Serial Communication

Rx
Receive

S

SCI
Serial Communication Interface

SCL
System Communications Link

SDCC
Section Data Communications Channel

SDH/SONET
Synchronous Digital Hierarchy/Synchronous Optical Network

SEF
Severely Errored Frame

SELV
Safety Extra Low Voltage

SES
Severely Errored Seconds

SF
Super Frame

SML
Service Management Layer

SMF
Single Mode Fiber

SNMP
Simple Network Management Protocol

SNTP
Simple Network Time Protocol

SONET
Synchronous Optical Network

SPE
Synchronous Payload Envelope

SSM
Synchronous Status Messaging

STA
Spanning Tree Algorithm

STP
Shielded Twisted Pair

STS-1
Synchronous Transport Signal Level 1

SWS
SONET WAN Switch

SXC
SONET Cross Connect ASIC

T

TAC
Technical Assistance Center

TBOS
Telemetry Byte Oriented Serial protocol

TCA
Threshold Crossing Alert

TCC+
Timing Communications and Control+ Card

TCP/IP
Transmission Control Protocol/Internet Protocol

TDM
Time Division Multiplexing

TDS
Time Division Switching

TID
Target Identifier

TL1
Transaction Language 1

TLS
Transparent LAN service

TMN
Telecommunications Management Network

TSA
Time Slot Assignment

TSI
Time-Slot Interchange

Tx
Transmit

U

UAS
Unavailable Seconds

UDP/IP
User Datagram Protocol/Internet Protocol

UID
User Identifier

Path Protection Configuration
Path Protection Configuration

UTC
Universal Time Coordinated

UTP
Unshielded Twisted Pair

V

VDC
Volts Direct Current

VLAN
Virtual Local Area Network

VPN
Virtual Private Network

VT1.5
Virtual Tributary equals 1.544 megabits per second

W

WAN
Wide Area Network

W
Watts

X

XC
Cross Connect

XCVT
Cross-connect Virtual Tributary

X.25
Protocol providing devices with direct connection to a packet switched network

Glossary

Numerics

1:1 protection
A card protection scheme that pairs a working card with a protect card of the same type in an adjacent slot. If the working card fails, the traffic from the working card switches to the protect card. When the failure on the working card is resolved, traffic reverts back to the working card if this option is set. This
protection scheme is specific to electrical cards.

1+1 protection
A card protection scheme that pairs a single working card with a single dedicated protect card. A term specific to optical cards.

1:N protection
A card protection scheme that allows a single card to protect several working cards. When the failure on the working card is resolved, traffic reverts back to the working card. A term specific to electrical cards.

A

Access drop
Points where network devices can access the network.

Address mask
Bit combination used to describe the portion of an IP address that refers to the network or subnet and the part that refers to the host. Sometimes referred to as mask. See also subnet mask.

ADM
Add/drop multiplexer. ADM allows a signal to be added into or dropped from a SONET span.

Agent
1. Generally, software that processes queries and returns replies on behalf of an application.
2. In a network management system, a process that resides in all managed devices and reports the values of specified variables to management stations.

AID
Access Identifier. An access code used in TL1 messaging that identifies and addresses specific objects within the ONS 15454. These objects include individual pieces of equipment, transport spans, access tributaries, and others.

AIS
Alarm indication signal is an alarm state that means that either: 1) The input to the multi-service card has gone down. 2) A regenerator on the network has failed. See also Blue Alarm.

AMI
Alternate Mark Inversion. Line-code format used on T1 circuits that transmit ones by alternate positive and negative pulses. 01 represents zeroes during each bit cell and 11 or 00 represents ones, alternately, during each bit cell. AMI requires that the sending device maintain ones density. Ones
density is not maintained independently of the data stream. Sometimes called binary-coded alternate mark inversion.

APS
Automatic Protection Switching. SONET switching mechanism that routes traffic from working lines to protect lines in case a line card failure or fiber cut occurs.

Asynchronous Transmission
Allows data to be sent in irregular intervals. The transmitter and receiver are able to identify data through the use of start and stop bits.

ATAG
Autonomous Message Tag. ATAG is used for TL1 message sequencing.

ATM
Asynchronous Transfer Mode is cell-based technology that is connection oriented. ATM is a good solution for multiple-site-inter-connectivity.

B

B3ZS
Bipolar 3 Zero Substitution is a line coding method for T3 lines. Basic condition is that no more than 3 consecutive zeros can be sent across the T3 line.

B8ZS
Binary 8-zero Substitution. A line-code type, used on T1 circuits, that substitutes a special code whenever 8 consecutive zeros are sent over the link. This code is then interpreted at the remote end of the connection. This technique guarantees ones density independent of the data stream. Sometimes called bipolar 8-zero substitution.

BER
Bit Error Rate. Ratio of received bits that contain errors.

Bit
Binary digit either 0 or 1.

Bit interleaving
Method of placing multiple lower speed lines to a higher speed medium. This method is utilized in inverse multiplexing as well as T3 for conventional M13 framing. Bit interleaving places bits from each input into the higher medium frame structure.

Bit rate
Speed at which bits are transmitted, usually expressed in bits per second.

BITS
Building Integrated Timing Supply. A single building master timing supply that minimizes the number of synchronization links entering an office. Sometimes referred to as a Synchronization Supply Unit.

BLSR
Bi-directional Line Switched Ring. SONET ring architecture that provides working and protection fibers between nodes. If the working fiber between nodes is cut, traffic is automatically routed onto the protection fiber.

Blue alarm
Blue alarm is an alarm state that means that either: 1) The input to the multi-service card has gone down. 2) A regenerator on the network has failed. See also AIS.

Blue band
Dense Wavelength Division Multiplexing (DWDM) wavelengths are broken into two distinct bands: red and blue. DWDM cards for the ONS 15454 operate on wavelengths between 1530.33nm and 1542.94nm in the blue band. The blue band is the lower frequency band.

BPV
Bipolar violation occurs when the next successive pulse in transmission is of the same polarity at the previous pulse.

Bridge
Device that connects and passes packets between two network segments that use the same communications protocol. In general, a bridge will filter, forward, or flood an incoming frame based on the MAC address of that frame.

Broadcast
Data packet that will be sent to all nodes on a network. Broadcasts are identified by a broadcast address. Compare with multicast and unicast. See also Broadcast address.

Broadcast address
Special address reserved for sending a message to all stations. Generally, a broadcast address is a MAC destination address of all ones.

Broadcast storm
Undesirable network event in which many broadcasts are sent simultaneously across all network segments. A broadcast storm uses substantial network bandwidth and, typically, causes network time-outs.

Bus
Common physical signal path composed of wires or other media across which signals can be sent from one part of a computer to another.

C

C2 byte
The C2 byte is the signal label byte in the STS path overhead. This byte tells the equipment what the SONET payload envelope contains and how it is constructed.

Card
In this document, card refers to one of the common or multi-service plug-in cards for the ONS 15454. ONS 15454 cards serve as channel service units and provide network termination, keep alive, electrical protection, regeneration of signal, and supports loopbacks.

C bit
C bits are control bits. Their functionality varies depending on T3 framing format. Traditionally, C bits are used for stuffing bit indicators.

C bit parity framing
T3 framing structure that uses the traditional management overhead bits (X, P, M, F), but differs in that the control bits (C bits) are used for additional functions (FID, FEAC, FEBE, TDL, CP).

Channel
Channel is used in this document to refer to a DWDM wavelength or data communications path.

Collision
In Ethernet, the result of two nodes transmitting simultaneously. The frames from each device impact and are damaged when they meet on the physical media.

Concatenation
A mechanism for allocating contiguous bandwidth for payload transport. Through the use of Concatenation Pointers, multiple OC-1s can be linked together to provide contiguous bandwidth through the network, from end to end.

CRC
Cyclic Redundancy Check is a process used to check the integrity of a block of data. CRC is a common method of establishing that data was correctly received in data communications.

Crosspoint
A set of physical or logical contacts that operate together to extend the speech and signal channels in a switching network.

CTAG
Correlation Tag. A unique identifier given to each input command by the TL1 operator. When the ONS 15454 system responds to a specific command, it includes the command's CTAG in the reply. This eliminates discrepancies about which response corresponds to which command.

CTC
Cisco Transport Controller. A Java-based graphical user interface (GUI) that allows operations, administration, maintenance, and provisioning (OAM&P) of the ONS 15454 using an Internet browser.

CTM
Cisco Transport Manager. A Java-based network management tool used to support large networks of Cisco 15000-class equipment.

CV
Code violation

D

D4/SF
The D4/Superframe (SF) format groups 12 T1 frames together and utilizes the 12 T1 framing bits to provide a repetitive pattern that allows other equipment on the T1 line to lock onto the framing pattern.

DACS
Digital Access Cross-Connect System is a device that will take a full T1 service in, and be able to route data from particular channels to differing output ports.

DCC
Data Communications Channel. Used to transport information about operation, administration, maintenance, and provisioning (OAM&P) over a SONET interface. DCC can be located in section DCC (SDCC) or line overhead (LDCC.)

Demultiplex
To separate multiple multiplexed input streams from a common physical signal back into multiple output streams. See also Multiplexing.

Destination
The endpoint where traffic exits an ONS 15454 network. Endpoints can be a path (STS or STS/VT for optical card endpoints), port (for electrical circuits, such as DS1, VT, DS3, STS), or card (for circuits on DS1 and Ethernet cards).

DS1
Digital Signal Level 1 represents an electrical signal having a line rate of 1.544 Mb/s in North America.

DS2
Digital Signal Level 2 is the second layer in digital hierarchy. It represents an electrical signal having a line rate of 6.312 Mb/s in North America.

DS3
Digital Signal Level 3 is the third layer in digital hierarchy. It represents an electrical signal having a line rate of 6.312 Mb/s in North America.

DSX
Digital Signal Cross-connect frame. A manual bay or panel where different electrical signals are wired. A DSX permits cross-connections by patch cords and plugs.

DWDM
Dense Wave Division Multiplexing. A technology that increases the information carrying capacity of existing fiber optic infrastructure by transmitting and receiving data on different light wavelengths. Many of these wavelengths can be combined on a single strand of fiber.

E

EDFA
Erbium Doped Fiber Amplifier. A type of fiber optical amplifier that transmits a light signal through a section of erbium-doped fiber and amplifies the signal with a laser pump diode. EDFA is used in transmitter booster amplifiers, in-line repeating amplifiers, and in receiver preamplifiers.

EIA
Electrical Interface Assemblies. Provides connection points for the ONS 15454 and DS-1, DS-3, or EC-1 units.

EMI
Electromagnetic Interference. Interference by electromagnetic signals that can cause reduced data integrity and increased error rates on transmission channels.

Envelope
The part of messaging that varies in composition from one transmittal step to another. It identifies the message originator and potential recipients, documents its past, directs its subsequent movement by the Message Transfer System (MTS), and characterizes its content.

EOW
Express Orderwire. A permanently connected voice circuit between selected stations for technical control purposes.

ES
Errored Second is a 1-second period with one or more errored blocks.

Ethernet switch
An Ethernet data switch. Ethernet switches provide the capability to increase the aggregate LAN bandwidth by allowing simultaneous switching of packets between switch ports. Ethernet switches subdivide previously-shared LAN segments into multiple networks with fewer stations per network.

External timing reference
A timing reference obtained from a source external to the communications system, such as one of the navigation systems. Many external timing references are referenced to Coordinated Universal Time (UTC).

F

Falling threshold
A falling threshold is the counterpart to a rising threshold. When the number of occurrences drops below a falling threshold, this triggers an event to reset the rising threshold. See also rising threshold.

FDDI
Fiber Distributed Data Interface. LAN standard, defined by ANSI X3T9.5, specifying a 100-Mbps token-passing network using fiber optic cable, with transmission distances of up to 2 km. FDDI uses a dual-ring architecture to provide redundancy.

Frame
Logical grouping of information sent as a data link layer unit over a transmission medium. Often refers to the header and trailer, used for synchronization and error control that surrounds the user data contained in the unit.

Free run synchronization mode
Occurs when the external timing sources have been disabled and the ONS 15454 is receiving timing from its Stratum 3 level internal timing source.

G

GBIC
Gigabit Interface Converter. A hot-swappable input/output device that plugs into a Gigabit Ethernet port to link the port with the fiber optic network.

H

Hard reset
The physical removal and insertion of a card. A card pull.

HDLC
High-Level Data Link Control. Bit-oriented, synchronous, data-link layer protocol developed by ISO. HDLC specifies a data encapsulation method on synchronous serial links using frame characters and checksums.

Host number
Part of IP address used to address an individual host within the network or sub network.

Hot swap
The process of replacing a failed component while the rest of the system continues to function normally.

I

Input alarms
Used for external sensors such as open doors, temperature sensors, flood sensors, and other environmental conditions.

IP
Internet Protocol. Network layer protocol in the TCP/IP stack offering a connectionless internetwork service. IP provides features for addressing, type-of-service specification, fragmentation and reassembly, and security.

IP address
32-bit address assigned to host using TCP/IP. An IP address belongs to one of five classes (A, B, C, D, or E) and is written as 4 octets separated by periods (dotted decimal format). Each address consists of a network number, an optional sub network number, and a host number.

J

Jitter
Jitter is caused when devices that process information in a network insert delay when relaying the information through the network. If the delay or variance in signal is greater than 10 UI (Unit Intervals/Bit Positions) it is called Wander.

K

K bytes
Automatic protection switching bytes. K1 and K2 bytes are located in the SONET line overhead and monitored by equipment for an indication to switch to protection.

L

LAN
Local Area Network. High-speed, low error data network covering a relatively small geographic area. LANs connect workstations, peripherals, terminals, and other devices in a single building or other geographically limited area. Ethernet, FDDI, and Token Ring are widely used LAN technologies.

LCD
Liquid Crystal Display. An alphanumeric display using liquid crystal sealed between two pieces of glass. LCDs conserve electricity.

Line Coding
Methods for ensuring that 1's density requirements are met on a T1 line. The two choices of line coding are AMI and B8ZS.

Line layer
Refers to the segment between two SONET devices in the circuit. The line layer deals with SONET payload transport, and its functions include multiplexing and synchronization. Sometimes called a maintenance span.

Line timing mode
A node that derives its clock from the SONET lines.

Link budget
The difference between the output power and receiver power of an optical signal expressed in dB. Link refers to an optical span and all of its component parts (optical transmitters, repeaters, receivers, and cables). See also Span Budget.

Link integrity
The network communications channel is intact.

LOF
Loss of Frame is a condition detected in the SONET signal overhead at the receiver, indicating that a valid framing pattern could not be obtained.

Loopback test
Test that sends signals then directs them back toward their source from some point along the communications path. Loopback tests are often used to test network interface usability.

LOS
Loss of Signal is a condition directly detected at the physical level (photonic or electric) at the receiver indicating the signal has been lost.

LOW
Local Orderwire. A communications circuit between a technical control center and selected terminal or repeater locations.

M

M12
M12 is a designation for a multiplex, which interfaces between four DS1s and one DS2 circuit.

M13
The multiplexer equivalent of T1 in North America. A M13 multiplexer takes 28 DS1 inputs and combines them into a single 44.736 Mb/s (DS3) stream. The data is bit interleaved.

MAC address
Standardized data link layer address that is required for every port or device that connects to a LAN. Other devices in the network use these addresses to locate specific ports in the network and to create and update routing tables and data structures. MAC addresses are six bytes long and are controlled by the IEEE. Also known as the hardware address, MAC-layer address, and physical address.

Maintenance user
A security level that limits user access to maintenance options only. See also Superuser, Provisioning User, and Retrieve User.

Managed device
A network node that contains an SNMP agent and resides on a managed network. Managed devices include routers, access servers, switches, bridges, hubs, computer hosts, and printers.

Managed object
In network management, a network device that can be managed by a network management protocol. Sometimes called an MIB object.

Mapping
A logical association between one set of values, such as addresses on one network, with quantities or values of another set, such as devices on another network.

MIB
Management Information Base. Database of network management information that is used and maintained by a network management protocol such as SNMP or CMIP. The value of a MIB object can be changed or retrieved using SNMP or CMIP commands, usually through a GUI network management system. MIB objects are organized in a tree structure that includes public (standard) and private (proprietary) branches.

Multicast
Single packets copied by the network and sent to a specific subset of network addresses.

Multiplex payload
Generates section and line overhead, and converts electrical/optical signals when the electrical/optical card is transmitting.

Multiplexer/MUX
A multiplexer is a device that allows multiple inputs to be placed across a single output.

Multiplexing
Scheme that allows multiple logical signals to be transmitted simultaneously across a single physical channel. Compare with Demultiplex.

N

NE
Network Element. In an Operations Support System, a single piece of telecommunications equipment used to perform a function or service integral to the underlying network.

Network number
Part of an IP address that specifies the network where the host belongs.

NMS
Network Management System. System that executes applications that monitor and control managed devices. NMSs provide the bulk of the processing and memory resources required for network management.

Node
Endpoint of a network connection or a junction common to two or more lines in a network. Nodes can be processors, controllers, or workstations. Nodes, which vary in routing and other functional capabilities, can be interconnected by links, and serve as control points in the network. Node is sometimes used generically to refer to any entity that can access a network. In this manual the term “node” usually refers to an ONS 15454.

NPJC
negative pointer justification count

O

OAM&P
Operations, Administration, Maintenance, and Provisioning. Provides the facilities and personnel required to manage a network.

Optical amplifier
A device that amplifies an optical signal without converting the signal from optical to electrical and back again to optical energy.

Optical receiver
An opto-electric circuit that detects incoming lightwave signals and converts them to the appropriate signal for processing by the receiving device.

Orderwire
Equipment that establishes voice contact between a central office and carrier repeater locations.

Output contacts (alarms)
Triggers that drive visual or audible devices such as bells and lights. Output contacts can control other devices such as generators, heaters, and fans.

P

P bits
These bits are used a parity check for the previous M-Frame. Possible values are 11 and 00.

Passive devices
Components that do not require external power to manipulate or react to electronic output. Passive devices include capacitors, resisters, and coils.

Path Layer
The segment between the originating equipment and the terminating equipment. This path segment may encompass several consecutive line segments or segments between two SONET devices.

Payload
Portion of a cell, frame, or packet that contains upper-layer information (data).

Ping
Packet internet grouper. ICMP echo message and its reply. Often used in IP networks to test the reachability of a network device.

PPJC
Positive pointer justification count

PPMN
Path Protected Mesh Network. PPMN extends the protection scheme of a Path Protection Configuration beyond the basic ring configuration to the meshed architecture of several interconnecting rings.

Priority queuing
Routing feature that divides data packets into two queues: one low-priority and one high-priority.

Provisioning user
A security level that allows the user to access only provisioning and maintenance options in CTC. See also Superuser, Maintenance user, and Retrieve user.

Q

Queue
In routing, a backlog of packets waiting to be forwarded over a router interface.

R

Red band
DWDM wavelengths are broken into two distinct bands: red and blue. The red band is the higher frequency band. The red band DWDM cards for the ONS 15454 operate on wavelengths between 1547.72nm and 1560.61nm.

Retrieve user
A security level that allows the user to retrieve and view CTC information but not set or modify parameters. See also Superuser, Maintenance user, and Provisioning user.

Revertive switching
A process that sends electrical interfaces back to the original working card after the card comes back online.

Rising threshold
The number of occurrences (collisions) that must be exceeded to trigger an event.

RMON
Remote Network Monitoring. Allows a network operator to monitor the health of the network with a Network Management System (NMS). RMON watches several variables, such as Ethernet collisions, and triggers an event when a variable crosses a threshold in the specified time interval.

S

SNMP
Simple Network Management Protocol. Network management protocol used almost exclusively in TCP/IP networks. SNMP monitors and controls network devices and manages configurations, statistics collection, performance, and security.

SNTP
Simple Network Time Protocol. Using an SNTP server ensures that all ONS 15454 network nodes use the same date and time reference. The server synchronizes alarm timing during power outages or software upgrades.

Soft reset
A soft reset reloads the operating system, application software, etc., and reboots the card. It does not initialize the ONS 15454 ASIC hardware.

SONET
Synchronous Optical Network. High-speed synchronous network specification developed by Telcordia Technologies, Inc. and designed to run on optical fiber. STS-1 is the basic building block of SONET. Approved as an international standard in 1988.

Source
The endpoint where traffic enters an ONS 15454 network. Endpoints can be a path (STS or STS/VT for optical card endpoints), port (for electrical circuits, such as DS1, VT, DS3, STS), or card (for circuits on DS1 and Ethernet cards).

Spanning tree
Loop-free subset of a network topology. See also STA and STP.

SPE
Synchronous Payload Envelope. A SONET term describing the envelope that carries the user data or payload.

SSM
Sync Status Messaging. A SONET protocol that communicates information about the quality of the timing source using the S1 byte of the line overhead.

STA
Spanning-Tree Algorithm. An algorithm used by the spanning tree protocol to create a spanning tree. See also Spanning tree and STP.

Static route
A route that is manually entered into a routing table. Static routes take precedence over routes chosen by all dynamic routing protocols.

STP
Spanning Tree Protocol. Bridge protocol that uses the spanning-tree algorithm to enable a learning bridge to dynamically work around loops in a network topology by creating a spanning tree. See also Spanning tree, STA, and Learning bridge.

STS-1
Synchronous Transport Signal 1. Basic building block signal of SONET, operating at 51.84 Mbps for transmission over OC-1 fiber. Faster SONET rates are defined as STS-n, where n is a multiple of 51.84 Mb/s. See also SONET.

Subnet mask
32-bit address mask used in IP to indicate the bits of an IP address that are used for the subnet address. Sometimes referred to simply as mask. See also IP address mask and IP address.

Sub network
In IP networks, a network confined to a particular subnet address. Sub networks are networks segmented by a network administrator in order to provide a multilevel, hierarchical routing structure while shielding the sub network from the addressing complexity of attached networks. Sometimes called a subnet.

Subtending rings
SONET rings that incorporate nodes that are also part of an adjacent SONET ring.

Superuser
A security level that can perform all of the functions of the other security levels as well as set names, passwords, and security levels for other users. A Superuser is usually the network element administrator. See also Retrieve user, Maintenance user, and Provisioning user.

T

T1
T1 transmits DS-1-formatted data at 1.544 Mbps through the telephone-switching network using AMI or B8ZS coding. See also AMI, B8ZS, and DS-1.

T3
T3 is an unbalanced coaxial pair connection, 1 connection for transmit and 1 for receive. T3 is Full Duplex in nature. The line rate on a T3 is 44.736 Mb/s, which is the same as a DS3. The unbalanced connectors are BNC type RG59 75 Ohm. The T3 is equivalent to 28 T1s.

Tag
Identification information, including a number plus other information.

TDM
Time Division Multiplexing. Allocates bandwidth on a single wire for information from multiple channels based on preassigned time slots. Bandwidth is allocated to each channel regardless of whether the station has data to transmit.

Telcordia
Telcordia Technologies, Inc., formerly named Bellcore. Eighty percent of the U.S. telecommunications network depends on software invented, developed, implemented, or maintained by Telcordia.

TID
Target Identifier. Identifies the particular network element (in this case, the ONS 15454) where each TL1 command is directed. The TID is a unique name given to each system at installation.

TLS
Transparent LAN Service. Provides private network service across a SONET backbone.

Transponder
Optional devices of a DWDM system providing the conversion of one optical wavelength to a precision narrow band wavelength.

Trap
Message sent by an SNMP agent to an NMS (CTM), console, or terminal to indicate the occurrence of a significant event, such as an exceeded threshold.

Tributary
The lower-rate signal directed into a multiplexer for combination (multiplexing) with other low rate signals to form an aggregate higher rate level.

Trunk
Network traffic travels across this physical and logical connection between two switches. A backbone is composed of a number of trunks. See also Backbone.

Tunneling
Architecture that is designed to provide the services necessary to implement any standard point-to-point encapsulation scheme. See also encapsulation.

U

Unicast
The communication of a single source to a single destination.

Path Protection Configuration
Path Protection Configuration. Path-switched SONET rings that employ redundant, fiber- optic transmission facilities in a pair configuration. One fiber transmits in one direction and the backup fiber transmits in the other. If the primary ring fails, the backup takes over.

Upstream
Set of frequencies used to send data from a subscriber to the headend.

V

Virtual fiber
A fiber that carries signals at different rates and uses the same fiber optic cable.

Virtual ring
Entity in a source-route bridging (SRB) network that logically connects two or more physical rings together either locally or remotely. The concept of virtual rings can be expanded across router boundaries.

Virtual wires
Virtual wires route external alarms to one or more alarm collection centers across the SONET transport network.

VLAN
Virtual LAN. Group of devices located on a number of different LAN segments that are configured (using management software) to communicate as if they were attached to the same wire. Because VLANs are based on logical instead of physical connections, they are extremely flexible.

VPN
Virtual Private Network. Enables IP traffic to travel securely over a public TCP/IP network by encrypting all traffic from one network to another. A VPN uses “tunneling” to encrypt all information at the IP level. See also Tunneling.

VT
Virtual Tributary. A structure designed for the transport and switching of sub-DS3 payloads.

VT layer
The VT layer or electrical layer occurs when the SONET signal is broken down into an electrical signal.

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