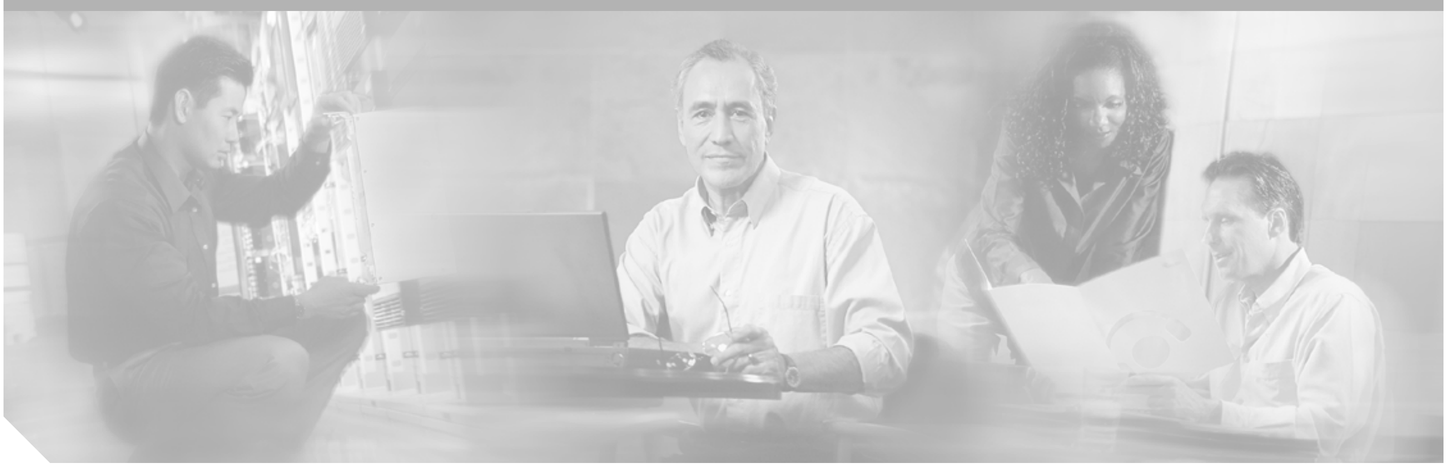
Cisco Systems



Cisco ONS 15454 Engineering Planning Guide

R5.0
November 2009

Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 526-4100

Text Part Number: OL-7510-01

CONTENTS

FIGURES

TABLES

About this Guide

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.

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

- Document Objectives
- Audience
- Document Organization
- Document Conventions
- Obtaining Optical Networking Information
- Obtaining Documentation and Submitting a Service Request

In this guide, the term "node" refers to a single ONS 15454 system containing hardware and software.

Revision History

Date	Notes
March 2007	Revision History Table added for the first time
September 2007	Updated About this Guide chapter
February 2009	Made corrections in Section and Line Overhead sections in Appendix B, SONET Primer.
November 2009	Updated the section Automatic Node Setup in the chapter DWDM.

For additional information about the ONS 15454 system, go to the following Cisco documents:

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

For detailed reference information about the Cisco ONS 15454 system, refer to the Cisco ONS 15454 Reference Manual.

For alarm clearing, general troubleshooting, and hardware replacement procedures, refer 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 of Reissue

This document is being reissued to address new hardware and software features supported in Release 5.0 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.
8/29/2003	4.1	Updated document with Release 4.1 hardware and software features.
1/30/2004	4.6	Updated document with Release 4.6 hardware and software features.
1/30/2005	5.0	Updated document with Release 5.0 hardware and software features.

Document Objectives

The <Doc Type> provides information about the features, engineering guidelines, applications, configurations, and technical specifications for the Cisco ONS 15454 MSPP system. Use this <Doc Type> in conjunction with the appropriate publications listed in the Obtaining Documentation and Submitting a Service Request section.

Audience

To use this publication, you should be familiar with Cisco or equivalent optical transmission hardware and cabling, telecommunications hardware and cabling, electronic circuitry and wiring practices, and preferably have experience as a telecommunications technician.

Document Organization

This *Cisco ONS 15454 Engineering Planning Guide* is organized into the chapters listed in Table 2. Information about regulatory and standards compliances, basic SONET principles, an introduction to dense wavelength 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 an overview of the Cisco ONS 15454 and list of new features for System Release 5.0.x.
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	This chapter provides general Dense Wave Division Multiplexing (DWDM) design guidelines and explains the various DWDM node configuration, topologies, optical performances, and features that are available for the ONS 15454.
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.
Appendix E – Acronyms	This appendix lists acronyms and abbreviations used in this document.

Table 3 Appendices

Title	Summary
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.

Document Conventions

This publication uses the following conventions:

Convention	Application
boldface	Commands and keywords in body text.
italic	Command input that is supplied by the user.
[ ]	Keywords or arguments that appear within square brackets are optional.
{ x | x | x }	A choice of keywords (represented by x) appears in braces separated by vertical bars. The user must select one.
Ctrl	The control key. For example, where Ctrl + D is written, hold down the Control key while pressing the D key.
`screen font`	Examples of information displayed on the screen.
`boldface screen font`	Examples of information that the user must enter.
< >	Command parameters that must be replaced by module-specific codes.

Note Means *reader take note*. Notes contain helpful suggestions or references to material not covered in the document.

Caution Means *reader be careful*. In this situation, the user might do something that could result in equipment damage or loss of data.

Warning **IMPORTANT SAFETY INSTRUCTIONS**

This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device. Statement 1071

SAVE THESE INSTRUCTIONS

Waarschuwing **BELANGRIJKE VEILIGHEIDSINSTRUCTIES**

Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van de standaard praktijken om ongelukken te voorkomen. Gebruik het nummer van de verklaring onderaan de waarschuwing als u een vertaling van de waarschuwing die bij het apparaat wordt geleverd, wilt raadplegen.

BEWAAR DEZE INSTRUCTIES

Varoitus **TÄRKEITÄ TURVALLISUUSOHJEITA**

Tämä varoitusmerkki merkitsee vaaraa. Tilanne voi aiheuttaa ruumiillisia vammoja. Ennen kuin käsittelet laitteistoa, huomioi sähköpiirien käsittelemiseen liittyvät riskit ja tutustu onnettomuuksien yleisiin ehkäisytapoihin. Turvallisuusvaroitusten käännökset löytyvät laitteen mukana toimitettujen käännettyjen turvallisuusvaroitusten joukosta varoitusten lopussa näkyvien lausuntonumeroiden avulla.

SÄILYTÄ NÄMÄ OHJEET

Attention **IMPORTANTES INFORMATIONS DE SÉCURITÉ**

Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures ou des dommages corporels. Avant de travailler sur un équipement, soyez conscient des dangers liés aux circuits électriques et familiarisez-vous avec les procédures couramment utilisées pour éviter les accidents. Pour prendre connaissance des traductions des avertissements figurant dans les consignes de sécurité traduites qui accompagnent cet appareil, référez-vous au numéro de l'instruction situé à la fin de chaque avertissement.

CONSERVEZ CES INFORMATIONS

Warnung **WICHTIGE SICHERHEITSHINWEISE**

Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu Verletzungen führen kann. Machen Sie sich vor der Arbeit mit Geräten mit den Gefahren elektrischer Schaltungen und den üblichen Verfahren zur Vorbeugung vor Unfällen vertraut. Suchen Sie mit der am Ende jeder Warnung angegebenen Anweisungsnummer nach der jeweiligen Übersetzung in den übersetzten Sicherheitshinweisen, die zusammen mit diesem Gerät ausgeliefert wurden.

BEWAHREN SIE DIESE HINWEISE GUT AUF.

Avvertenza **IMPORTANTI ISTRUZIONI SULLA SICUREZZA**

Questo simbolo di avvertenza indica un pericolo. La situazione potrebbe causare infortuni alle persone. Prima di intervenire su qualsiasi apparecchiatura, occorre essere al corrente dei pericoli relativi ai circuiti elettrici e conoscere le procedure standard per la prevenzione di incidenti. Utilizzare il numero di istruzione presente alla fine di ciascuna avvertenza per individuare le traduzioni delle avvertenze riportate in questo documento.

CONSERVARE QUESTE ISTRUZIONI

Advarsel **VIKTIGE SIKKERHETSINSTRUKSJONER**

Dette advarselssymbolet betyr fare. Du er i en situasjon som kan føre til skade på person. Før du begynner å arbeide med noe av utstyret, må du være oppmerksom på farene forbundet med elektriske kretser, og kjenne til standardprosedyrer for å forhindre ulykker. Bruk nummeret i slutten av hver advarsel for å finne oversettelsen i de oversatte sikkerhetsadvarslene som fulgte med denne enheten.

TA VARE PÅ DISSE INSTRUKSJONENE

Aviso **INSTRUÇÕES IMPORTANTES DE SEGURANÇA**

Este símbolo de aviso significa perigo. Você está em uma situação que poderá ser causadora de lesões corporais. Antes de iniciar a utilização de qualquer equipamento, tenha conhecimento dos perigos envolvidos no manuseio de circuitos elétricos e familiarize-se com as práticas habituais de prevenção de acidentes. Utilize o número da instrução fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham este dispositivo.

GUARDE ESTAS INSTRUÇÕES

¡Advertencia! **INSTRUCCIONES IMPORTANTES DE SEGURIDAD**

Este símbolo de aviso indica peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considere los riesgos de la corriente eléctrica y familiarícese con los procedimientos estándar de prevención de accidentes. Al final de cada advertencia encontrará el número que le ayudará a encontrar el texto traducido en el apartado de traducciones que acompaña a este dispositivo.

GUARDE ESTAS INSTRUCCIONES

Varning! **VIKTIGA SÄKERHETSANVISNINGAR**

Denna varningssignal signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanliga förfaranden för att förebygga olyckor. Använd det nummer som finns i slutet av varje varning för att hitta dess översättning i de översatta säkerhetsvarningar som medföljer denna anordning.

SPARA DESSA ANVISNINGAR

FONTOS BIZTONSÁGI ELOÍRÁSOK

Ez a figyelmezeto jel veszélyre utal. Sérülésveszélyt rejto helyzetben van. Mielott bármely berendezésen munkát végezte, legyen figyelemmel az elektromos áramkörök okozta kockázatokra, és ismerkedjen meg a szokásos balesetvédelmi eljárásokkal. A kiadványban szereplo figyelmeztetések fordítása a készülékhez mellékelt biztonsági figyelmeztetések között található; a fordítás az egyes figyelmeztetések végén látható szám alapján keresheto meg.

ORIZZE MEG EZEKET AZ UTASÍTÁSOKAT!

Предупреждение **ВАЖНЫЕ ИНСТРУКЦИИ ПО СОБЛЮДЕНИЮ ТЕХНИКИ БЕЗОПАСНОСТИ**

Этот символ предупреждения обозначает опасность. То есть имеет место ситуация, в которой следует опасаться телесных повреждений. Перед эксплуатацией оборудования выясните, каким опасностям может подвергаться пользователь при использовании электрических цепей, и ознакомьтесь с правилами техники безопасности для предотвращения возможных несчастных случаев. Воспользуйтесь номером заявления, приведенным в конце каждого предупреждения, чтобы найти его переведенный вариант в переводе предупреждений по безопасности, прилагаемом к данному устройству.

СОХРАНИТЕ ЭТИ ИНСТРУКЦИИ

警告 重要的安全性说明

此警告符号代表危险。您正处于可能受到严重伤害的工作环境中。在您使用设备开始工作之前，必须充分意识到触电的危险，并熟练掌握防止事故发生的标准工作程序。请根据每项警告结尾提供的声明号码来找到此设备的安全性警告说明的翻译文本。

请保存这些安全性说明

警告 安全上の重要な注意事項

「危険」の意味です。人身事故を予防するための注意事項が記述されています。装置の取り扱い作業を行うときは、電気回路の危険性に注意し、一般的な事故防止策に留意してください。警告の各国語版は、各注意事項の番号を基に、装置に付属の「Translated Safety Warnings」を参照してください。

これらの注意事項を保管しておいてください。

주의 중요 안전 지침

이 경고 기호는 위험을 나타냅니다. 작업자가 신체 부상을 일으킬 수 있는 위험한 환경에 있습니다. 장비에 작업을 수행하기 전에 전기 회로와 관련된 위험을 숙지하고 표준 작업 관례를 숙지하여 사고를 방지하십시오. 각 경고의 마지막 부분에 있는 경고문 번호를 참조하여 이 장치와 함께 제공되는 번역된 안전 경고문에서 해당 번역문을 찾으십시오.

이 지시 사항을 보관하십시오.

Aviso **INSTRUÇÕES IMPORTANTES DE SEGURANÇA**

Este símbolo de aviso significa perigo. Você se encontra em uma situação em que há risco de lesões corporais. Antes de trabalhar com qualquer equipamento, esteja ciente dos riscos que envolvem os circuitos elétricos e familiarize-se com as práticas padrão de prevenção de acidentes. Use o número da declaração fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham o dispositivo.

GUARDE ESTAS INSTRUÇÕES

Advarsel **VIGTIGE SIKKERHEDSANVISNINGER**

Dette advarselssymbol betyder fare. Du befinder dig i en situation med risiko for legemesbeskadigelse. Før du begynder arbejde på udstyr, skal du være opmærksom på de involverede risici, der er ved elektriske kredsløb, og du skal sætte dig ind i standardprocedurer til undgåelse af ulykker. Brug erklæringsnummeret efter hver advarsel for at finde oversættelsen i de oversatte advarsler, der fulgte med denne enhed.

GEM DISSE ANVISNINGER

تحذير **إرشادات الأمان الهامة**

يوضح رمز التحذير هذا وجود خطر. وهذا يعني أنك متواجد في مكان قد ينتج عنه التعرض لإصابات. قبل بدء العمل، احذر مخاطر التعرض للصدمات الكهربائية وكن على علم بالإجراءات القياسية للحيلولة دون وقوع أي حوادث. استخدم رقم البيان الموجود في أخر كل تحذير لتحديد مكان ترجمته داخل تحذيرات الأمان المترجمة التي تأتي مع الجهاز.

قم بحفظ هذه الإرشادات

Upozorenje **VAŽNE SIGURNOSNE NAPOMENE**

Ovaj simbol upozorenja predstavlja opasnost. Nalazite se u situaciji koja može prouzročiti tjelesne ozljede. Prije rada s bilo kojim uređajem, morate razumjeti opasnosti vezane uz električne sklopove, te biti upoznati sa standardnim načinima izbjegavanja nesreća. U prevedenim sigurnosnim upozorenjima, priloženima uz uređaj, možete prema broju koji se nalazi uz pojedino upozorenje pronaći i njegov prijevod.

SAČUVAJTE OVE UPUTE

Upozornění **DŮLEŽITÉ BEZPEČNOSTNÍ POKYNY**

Tento upozorňující symbol označuje nebezpečí. Jste v situaci, která by mohla způsobit nebezpečí úrazu. Před prací na jakémkoliv vybavení si uvědomte nebezpečí související s elektrickými obvody a seznamte se se standardními opatřeními pro předcházení úrazům. Podle čísla na konci každého upozornění vyhledejte jeho překlad v přeložených bezpečnostních upozorněních, která jsou přiložena k zařízení.

USCHOVEJTE TYTO POKYNY

Προειδοποίηση ΣΗΜΑΝΤΙΚΕΣ ΟΔΗΓΙΕΣ ΑΣΦΑΛΕΙΑΣ

Αυτό το προειδοποιητικό σύμβολο σημαίνει κίνδυνο. Βρίσκεστε σε κατάσταση που μπορεί να προκαλέσει τραυματισμό. Πριν εργαστείτε σε οποιοδήποτε εξοπλισμό, να έχετε υπόψη σας τους κινδύνους που σχετίζονται με τα ηλεκτρικά κυκλώματα και να έχετε εξοικειωθεί με τις συνήθεις πρακτικές για την αποφυγή ατυχημάτων. Χρησιμοποιήστε τον αριθμό δήλωσης που παρέχεται στο τέλος κάθε προειδοποίησης, για να εντοπίσετε τη μετάφρασή της στις μεταφρασμένες προειδοποιήσεις ασφαλείας που συνοδεύουν τη συσκευή.

ΦΥΛΑΞΤΕ ΑΥΤΕΣ ΤΙΣ ΟΔΗΓΙΕΣ

אזהרה **הוראות בטיחות חשובות**

סימן אזהרה זה מסמל סכנה. אתה נמצא במצב העלול לגרום לפציעה. לפני שתעבוד עם ציוד כלשהו, עליך להיות מודע לסכנות הכרוכות במעגלים חשמליים ולהכיר את הנהלים המקובלים למניעת תאונות. השתמש במספר ההוראה המסופק בסופה של כל אזהרה כד לאתר את התרגום באזהרות הבטיחות המתורגמות שמצורפות להתקן.

שמור הוראות אלה

Opomena ВАЖНИ БЕЗБЕДНОСНИ НАПАТСТВИЈА

Симболот за предупредување значи опасност. Се наоѓате во ситуација што може да предизвика телесни повреди. Пред да работите со опремата, бидете свесни за ризикот што постои кај електричните кола и треба да ги познавате стандардните постапки за спречување на несреќни случаи. Искористете го бројот на изјавата што се наоѓа на крајот на секое предупредување за да го најдете неговиот период во преведените безбедносни предупредувања што се испорачани со уредот.

ЧУВАЈТЕ ГИ ОВИЕ НАПАТСТВИЈА

Ostrzeżenie **WAŻNE INSTRUKCJE DOTYCZĄCE BEZPIECZEŃSTWA**

Ten symbol ostrzeżenia oznacza niebezpieczeństwo. Zachodzi sytuacja, która może powodować obrażenia ciała. Przed przystąpieniem do prac przy urządzeniach należy zapoznać się z zagrożeniami związanymi z układami elektrycznymi oraz ze standardowymi środkami zapobiegania wypadkom. Na końcu każdego ostrzeżenia podano numer, na podstawie którego można odszukać tłumaczenie tego ostrzeżenia w dołączonym do urządzenia dokumencie z tłumaczeniami ostrzeżeń.

NINIEJSZE INSTRUKCJE NALEŻY ZACHOWAĆ

Upozornenie **DÔLEŽITÉ BEZPEČNOSTNÉ POKYNY**

Tento varovný symbol označuje nebezpečenstvo. Nachádzate sa v situácii s nebezpečenstvom úrazu. Pred prácou na akomkoľvek vybavení si uvedomte nebezpečenstvo súvisiace s elektrickými obvodmi a oboznámte sa so štandardnými opatreniami na predchádzanie úrazom. Podľa čísla na konci každého upozornenia vyhľadajte jeho preklad v preložených bezpečnostných upozorneniach, ktoré sú priložené k zariadeniu.

USCHOVAJTE SI TENTO NÁVOD

Obtaining Optical Networking Information

This section contains information that is specific to optical networking products. For information that pertains to all of Cisco, refer to the Obtaining Documentation and Submitting a Service Request section.

Where to Find Safety and Warning Information

For safety and warning information, refer to the *Cisco Optical Transport Products Safety and Compliance Information* document that accompanied the product. This publication describes the international agency compliance and safety information for the Cisco ONS 15454 system. It also includes translations of the safety warnings that appear in the ONS 15454 system documentation.

Cisco Optical Networking Product Documentation CD-ROM

Optical networking-related documentation, including Cisco ONS 15xxx product documentation, is available in a CD-ROM package that ships with your product. The Optical Networking Product Documentation CD-ROM is updated periodically and may be more current than printed documentation.

Obtaining Documentation and Submitting a Service Request

For information on obtaining documentation, submitting a service request, and gathering additional information, see the monthly *What's New in Cisco Product Documentation,* which also lists all new and revised Cisco technical documentation, at:

http://www.cisco.com/en/US/docs/general/whatsnew/whatsnew.html

Subscribe to the *What's New in Cisco Product Documentation* as a Really Simple Syndication (RSS) feed and set content to be delivered directly to your desktop using a reader application. The RSS feeds are a free service and Cisco currently supports RSS version 2.0.

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.

This chapter provides an overview of the Cisco ONS 15454 and a list of new features for System Release 5.0.

The following topics are covered in this chapter:

Introduction to the ONS 15454

The Cisco ONS 15454 provides efficient bandwidth delivery and management in optical networks. It can be configured as a multi-service provisioning platform (MSPP), multi-service transport platform (MSTP), or hybrid MSPP/MSTP.

As an MSPP, the ONS 15454 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. It 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.

System Release 4.5 introduced ONS 15454 DWDM cards and ONS 15454 MSTP configuration that used the ONS 15454 shelf assembly to provide wavelength services and DWDM channel aggregation.

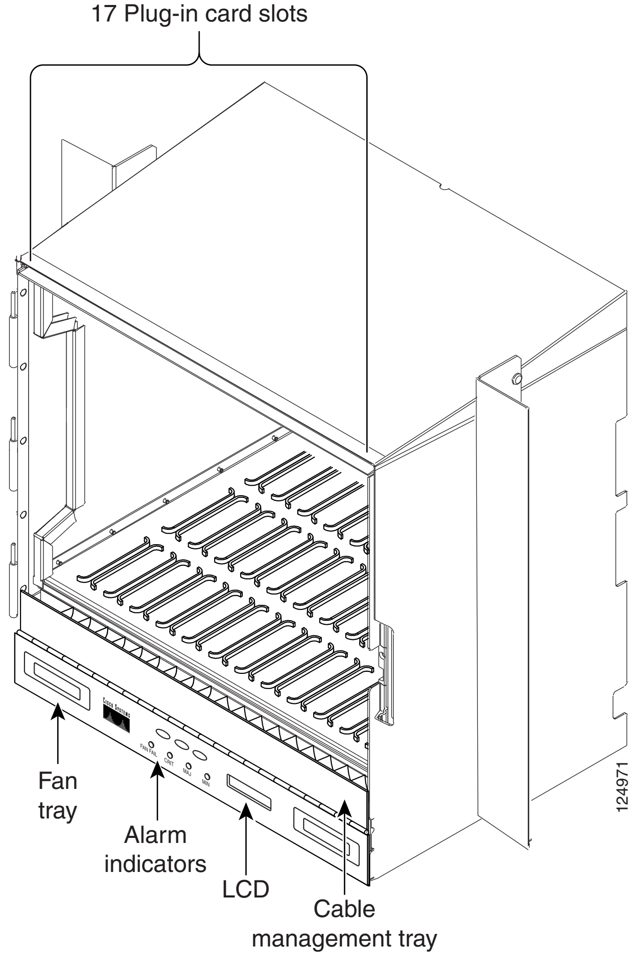
Consolidated software loads in Releases 4.6 and 5.0 allow you to deploy the ONS 15454 in a hybrid mode that supports both MSPP and MSTP configurations in a single chassis. The choice of multi-service aggregation, wavelength aggregation, and wavelength transport, combined with DWDM transmission in a single platform enables networks to be cost-optimized for any mix of services.

ONS 15454 Shelf Assemblies and Backplane Hardware

In this document, the terms “ONS 15454” and “shelf assembly” are used interchangeably. In the installation context, these terms have the same meaning. Otherwise, shelf assembly refers to the physical steel enclosure that holds cards and connects power, and ONS 15454 refers to the entire system, both hardware and software.

The ONS 15454 temperature-hardened 15454-SA-ANSI shelf assembly shown in Figure 1-1 contains 17 plug-in card slots, a backplane interface, a fan tray with LCD and alarm indicators, and a cable management tray. Starting with Release 4.6, the 15454-SA-HD (high-density) shelf assembly replaces the 15454-SA-ANSI as the default chassis for new installations. You can install both 15454-SA-ANSI and 15454-SA-HD the shelf assemblies in a 19- or 23-inch rack. Both shelf assemblies weigh approximately 42 pounds without mounting ears and plug-in cards.

Figure 1-1 Cisco ONS 15454 15454-SA-ANSI Shelf Assembly



When installed in an equipment rack, the shelf 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 or Telcordia-standard racks.

The ANSI and HD shelf assemblies are 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. Both shelves measure 18.5 inches high and 19 or 23 inches wide (depending on which way the mounting ears are attached). The 15454-SA-ANSI shelf with the standard door measures 12 inches deep and 14 inches deep with the optional deep door. You can install up to four of the ANSI or HD shelves in a seven-foot equipment rack. Each shelf must have 1 inch of airspace between them to allow air flow to the fan intake. When a second shelf is installed, the air ramp on top of the lower shelf assembly provides the air spacing needed and should not be modified in any way.

The backplane provides access to alarm contacts, external interface contacts, power terminals, and BNC, SMB, AMP Champ, and SCSI connectors. The lower section of the ONS 15454 backplane is covered either by a clear plastic or metal protector.

Electrical Interface Assemblies

Optional electrical interface assemblies (EIAs) are attached to the shelf assembly backplane to provide electrical interface cable connections. EIA backplane covers are typically preinstalled when ordered with the ONS 15454. EIAs must be ordered when using DS-1, DS-3, DS3XM, or EC-1 cards.

Seven different EIA backplane covers are available for the ONS 15454: BNC, High-Density BNC, Mini-BNC, SMB, AMP Champ, Universal Backplane Interface Connector – Vertical (UBIC-V) and UBIC - Horizontal (UBIC-H). UBIC-V and UBIC-H backplane covers are typically preinstalled when ordered with the ONS 15454 high density shelf (15454-SA-HD). Either UBIC-V or UBIC-H EIAs are required when using the high-density (48-port DS-3/EC-1 and 56-port DS-1) electrical cards. If the shelf was not shipped with the correct EIA interface, you must order and install the correct EIA.

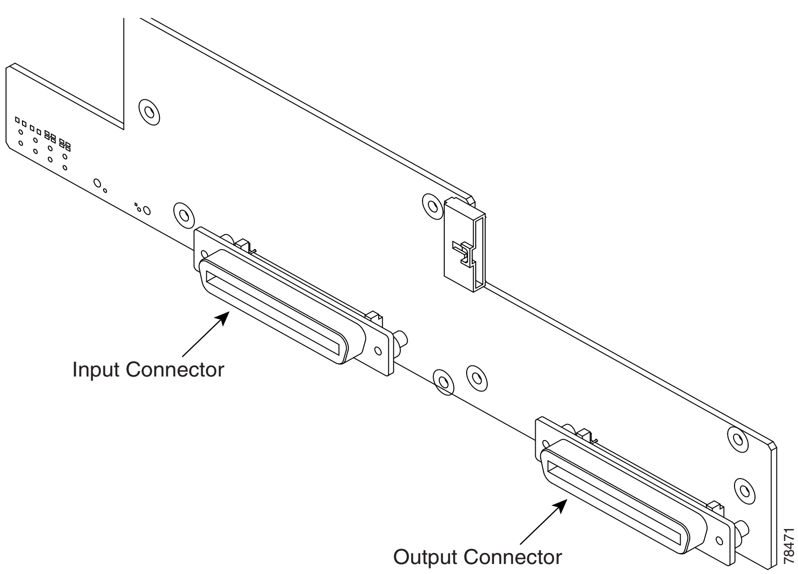
EIAs are available with SMB, BNC, Mini-BNC, UBIC-H, and UBIC-V connectors for DS-3, DS3XM (TMUX) or EC-1 cards. EIAs are available with AMP Champ, UBIC-H, and UBIC-V connectors for DS-1 cards. You must use SMB (with wire wrap Balun), UBIC-H or UBIC-V EIAs for DS-1 twisted-pair cable installation. You 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 UBIC-V on side B, and so forth).

As you face the rear of the ONS 15454 shelf assembly, the right side is the A side and the left side is the B side. The EIA connector columns are labeled transmit (Tx) and receive (Rx) to correspond to transmit and receive cables.

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. Ethernet cards have RJ45 connectors on the faceplate. Fiber optic and CAT 5 cables are routed into the front of the optical and Ethernet cards. Electrical cards (DS-1, DS-3, DS3XM, 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.
- Optional universal cable-router inserts (recommended to route jumper cables in any direction desired), as in Figure 1-4.
- Jumper slack storage reels (2) on each side panel that reduce the amount of slack in cables that are connected to other devices.
- Optional fiber management tray (recommended for DWDM nodes)
- Optional tie-down bar (recommended for use with the UBIC-V and UBIC-H)

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 reversible jumper routing fins.

Figure 1-3 Managing Cables on the Front Panel

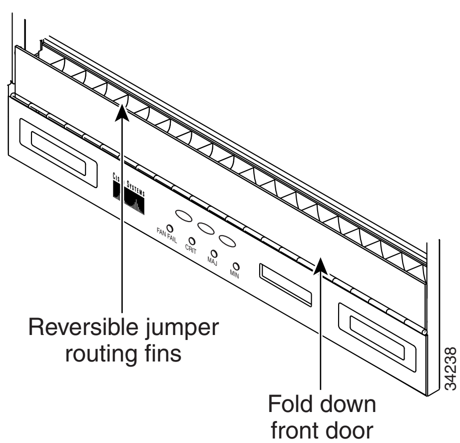
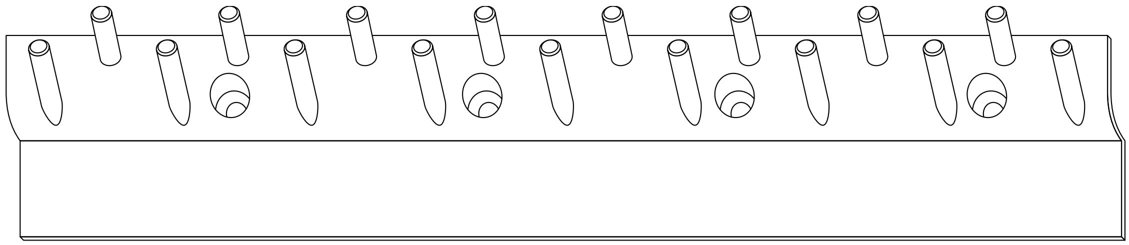


Figure 1-4 shows the optional universal cable-router inserts, which has round posts that allow you to route cables out either side of the cable-routing channel.

Figure 1-4 Universal Cable-Router Inserts



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 15454-SA-ANSI 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/STM16 SH 1310, OC48LR/STM 16 LH 1550, OC48ELR 1550, and OC192LR/STM64LH 1550 cards. Slots 5, 6, 12 and 13 are high-speed slots, which can host all ONS 15454 cards except the OC3/STM-6 and 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. The 15454-SA-HD shelf assembly is the same as the 15454-SA-ANSI, except slots 1 to 3 and 15 to 17 can supports greater electrical termination capacities required for the high-density (HD) DS-1, DS-3, and EC-1 interface cards. The HD cards are planned for a future release. Slots 7 and 11 are dedicated to Timing, Comunication and Control (TCC) cards. Slots 8 and 10 are dedicated to cross-connect (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. You can only install cards in slots where the symbol on the card's faceplate matches the symbol on the slot. Table 1-1 shows the slot and card symbol definitions.

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

Card & Slot Symbol Color/Shape	Slot Definition
Orange/Circle	Multispeed slots 1 to 6 and 12 to 17. Only install traffic cards with an orange circle on the faceplate.
Blue/Triangle	High-speed slots 5, 6, 12, and 13. Only install traffic cards with a blue triangle on the faceplate.
Purple/Square	TCC slots 7 and 11 (TCC+, TCC2, TCC2Pcards only)
Green/Cross	Cross-connect slots 8 and 10 (XC, XCVT, XC10G cards only)
Red/P	Protection slots 3 and 15 used in 1:N protection schemes.
Red/Diamond	AIC/AIC-I slot 9.
Gold/Star	Multispeed slots 1 to 4 and 14 to 17. Only install traffic cards with a gold star on the faceplate.
Blue/Hexagon	High-density slots 1 to 3 and 15 to 17 only on the 15454-SA-HD shelf. Only install HD traffic cards with a blue hexagon 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
TCC2	The enhanced TCC2 card performs all the same functions as the TCC+, but also has additional features including supply voltage monitoring, support for up to 84 data communication channel/generic communication channel (DCC/GCC) terminations, and an on-card lamp test. The TCC2 is the standard processor card shipped with System Releases 4.0 to 4.6.
TCC2P	The TCC2P card is an advanced version of the TCC2 card. The advanced functions included with the TCC2P are new Ethernet data communications security features and 64Kbps composite clock BITS timing.
XCVT	The XCVT establishes STS-1 and VT 1.5 connections and performs SONET TDM switching at the STS-1 level.
XC10G	The XC10G 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, OC3-8, and OC12-4.
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.
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.

ONS 15454 Interface Cards

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 Interface Cards

Card	Description
SONET/SDH	
OC3 IR 4 SH 1310 and OC3 IR 4/STM1 SH 1310	The OC3 IR 4 SH 1310 and OC3 IR 4/STM1 SH 1310 cards are functionally the same. Both cards provides four intermediate- or short-range SONET/SDH OC-3 ports compliant with ITU-T G.707, G.957, and Telcordia GR-253.
OC-3 IR 8/STM1 1310	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.
OC12 IR 1310 and OC12 IR/STM4 SH 1310	The OC12 IR 1310 and OC12 IR/STM4 SH 1310 cards are functionally the same. Both cards provide one intermediate or short range SONET/SDH OC-12 port compliant with the ITU-T G.707, G.957, and Telcordia GR-253.

Table 1-3 List of Cisco ONS 15454 Interface Cards (continued)

Card	Description
OC12 IR/STM4 SH 1310-4	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, G.957, and Telcordia GR-253.
OC12 LR 1310 and OC12 LR/STM4 LH 1310	The OC12 LR 1310 and OC12 LR/STM4 LH 1310 cards are functionally the same. Both cards provide one long-range, ITU-T G.707, ITU-T G.957, and Telcordia-compliant, GR-253 SONET OC-12 port per card.
OC12 LR 1550 and OC12 LR/STM4 LH 1550	The OC12 LR 1550 and OC12 LR/STM4 LH 1550 cards are functionally the same. Both cards provide one long-range SONET/SDH OC-12 port compliant with ITU-T G.707, G.957, and Telcordia GR-253.
OC48 IR 1310	The OC48 IR 1310 card provides one intermediate-range, Telcordia-compliant, GR-253 SONET OC-48 port per card.
OC48 IR/STM16 SH AS 1310	The OC48 IR/STM16 SH AS 1310 card provides one intermediate or short-range SONET/SDH OC-48 port compliant with the ITU-T G.707, G.957, and Telcordia GR-253.
OC48 LR 1550	The OC48 LR 1550 card provides one long-range, Telcordia-compliant, GR-253 SONET OC-48 port per card.
OC48 LR/STM16 LH AS 1550	The OC48 LR/STM16 LH AS 1550 card provides one long-range SONET/SDH OC-48 port compliant with ITU-T G.707, G.957, and Telcordia GR-253.
OC192 LR/STM64 LH 1550	The OC192 LR/STM64 LH 1550 card provides one long-range SONET/SDH OC-192 port compliant with ITU-T G.707, G.957, and Telcordia GR-1377 and GR-253.
OC-192/STM64 IR 1550	The 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.
OC-192/STM64 SR 1310	The 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.
DWDM	
OC48 ELR/STM16 EH 100 GHz	Thirty-seven distinct OC-48 ELR/STM16 EH ITU 100GHz dense wavelength division multiplexing (DWDM) cards operating within the 1530nm to 1562nm frequency band.
OC192 LR/STM64 LH ITU 15xx.xx	The new OC192 LR/STM64 LH ITU 15xx.xx cards provide eight distinct dense wavelength division multiplexing (DWDM) channels operating within the 1530nm to 1562nm frequency band.
2.5 Gb/s Multirate Transponder-100 GHz	The TXP_MR_2.5G card (2.5-Gb/s Multirate Transponder-100-GHz-Tunable xx.xx-xx.xx) processes one 8-Mbps to 2.488-Gbps signal (client side) into one 8-Mbps to 2.5-Gbps, 100-GHz DWDM signal (trunk side).
10 Gb/s Multirate Transponder-100 GHz	The TXP_MR_10G card (10-Gbps Transponder-100-GHz-Tunable xx.xx-xx.xx) processes one 10-Gbps signal (client side) into one 10-Gbps, 100-GHz DWDM signal (trunk side).
2.5 Gb/s - 10 Gb/s Muxponder-100 GHz	The MXP_2.5G_10G card (2.5-Gbps-10-Gbps Muxponder-100 GHz-Tunable xx.xx-xx.xx) multiplexes/demultiplexes four 2.5-Gbps signals (client side) into one 10-Gbps, 100-GHz DWDM signal (trunk side).

Table 1-3 List of Cisco ONS 15454 Interface Cards (continued)

Card	Description
Optical Service Channel (OSC) Modules	There are two versions of the OSC modules: the OSCM and the OSC-CSM, which contain a combiner and separator module in addition to the OSC module. The 1510-nm wavelength and does not affect client traffic. The primary purpose of the OSC is to carry clock synchronization and orderwire channel communications for the DWDM network. It also provides transparent links between each node in the network. The OSC is an OC-3 formatted signal.
Optical Amplifiers	Optical amplifiers are used in amplified nodes, such as hub nodes, amplified OADM nodes, and line amplifier nodes. There are two forms of amplifiers, the Optical Preamplifier (OPT-PRE) and the Optical Booster (OPT-BST) amplifier.
Multiplexer and Demultiplexer Cards	There are three cards that multiplex and demultiplex DWDM optical channels. They include the 32-Channel Multiplexer (32MUX-O), the 32-Channel Demultiplexer (32DMX-O), and the 4-Channel Multiplexer/Demultiplexer (4MD-xx.x).
Optical Add/Drop Multiplexer (OADM) Cards	There are two groups of OADM cards: Band OADM cards add and drop one or four bands of adjacent channels; Channel OADM cards add and drop one, two, or four adjacent channels.
Electrical	
DS1-14	The ONS 15454 DS1-14 card provides 14 Telcordia-compliant, GR-499 DS-1 ports.
DS1N-14	The DS1N-14 card can function as a working or protect card in 1:1 or 1:N protection schemes and as a working or protect card in 1:N protection scheme.
DS3-12	The ONS 15454 DS3-12 card provides 12 Telcordia-compliant, GR-499 DS-3 ports per card.
DS3N-12	The DS3N-12 card operates as a working or protect card in 1:1 or 1:N protection scheme.
DS3-12E	The DS3-12E card provides 12 Telcordia-compliant ports per card and enhanced performance monitoring functions.
DS3N-12E	The DS3N-12E card also provides enhanced performance monitoring functions and can operate as a working or protect card in 1:1 or 1:N protection scheme.
DS3/EC1-48	The DS3/EC1-48 provides 48 Telcordia-compliant ports per card. Each port operates at 44.736 Mbps over a single 75-ohm, 728A or equivalent coaxial span. The EC-1 function is not supported in Software Release 5.0.
EC1-12	The EC1-12 card provides 12 Telcordia-compliant, GR-253 STS-1 electrical ports per card.
DS3XM-6 (Transmux)	The DS3XM-6 card, commonly referred to as a transmux card, provides six Telcordia-compliant, GR-499-CORE M13 multiplexing functions.
DS3XM-12	The DS3XM-12 card provides 12 Telcordia-compliant GR-499-CORE M13 multiplexing functions.
Ethernet	

Table 1-3 List of Cisco ONS 15454 Interface Cards (continued)

Card	Description
E100T-12[1]	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.
E100T-G	E100T-G card is used for Ethernet (10 Mb/s) and Fast Ethernet (100 Mb/s) when the XC, XC-VT, or XC-10G cross-connect card is used. 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.
ML100T-12	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.
E1000-2[1]	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.
E1000-2-G	The E1000-2-G cards are used for Gigabit Ethernet (1000 Mb/s), when the XC, XC-VT, and XC-10G cross-connect card are used. It provides two IEEE-compliant, 1000 Mb/s ports for high-capacity customer LAN interconnections.
G1000-4[1]	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.
G1K-4	The 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.
ML1000-2	The 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.
Storage Access Networking (SAN)	
FC_MR-4	The Fibre Channel (FC)/FICON (FC_MR-4) card uses pluggable Gigabit Interface Converters (GBICs) to transport non-SONET/SDH-framed, block-coded protocols over SONET/SDH in virtually or contiguously concatenated payloads.

1. See http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html for an update on End-Of-Life and End-Of-Sale notices.

ONS 15454 GBIC and SFP Connectors

Table 1-4 lists the GBICs and SFPs supported by the ONS 15454.

Table 1-4 List of Cisco ONS 15454 GBICs and SFPs

GBIC/SFP	Description
SX	Is an IEEE 1000Base-SX compliant, 850 nm multi-mode GBIC optical module.
LX	Is an IEEE 1000Base-LX-compliant, 1300 nm single-mode GBIC optical module.
ZX	Is an IEEE 1000Base-ZX-complaint, 1550 nm single-mode GBIC optical module.
CWDM	Is a 1000Base CWDM GBIC optical module.
DWDM	Is a 1000Base DWDM GBIC optical module.
GX FC	GX-2FC-SML is a 2Gb FC 1310nm Single-mode with SC connectors; GX-2FC-MMI is a 2Gb FC 850nm Multi-mode with SC connectors
SX SFP	Is an IEEE 1000Base-SX-compliant 850 nm multi-mode SFP optical module.
LX SFP	Is an IEEE 1000Base-LX-compliant 1300 nm single-mode SFP optical module

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. Your 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.

SNMP Traps

The ONS 15454 can receive SNMP requests from a number of SNMP managers and send traps to 10 trap receivers. The ONS 15454 generates all alarms and events as SNMP traps. The ONS 15454 generates traps containing an object ID that uniquely identifies the alarm. An entity identifier uniquely identifies the entity that generated the alarm (slot, port, synchronous transport signal [STS], Virtual Tributary [VT], bidirectional line switched ring [BLSR], Spanning Tree Protocol [STP], and so on). The traps give the severity of the alarm (critical, major, minor, event, and so on) and indicate whether the alarm is service affecting or non-service affecting. The traps also contain a date/time stamp that shows the date and time the alarm occurred. The ONS 15454 also generates a trap for each alarm when the alarm condition clears. For additional information about SNMP and list of traps supported by the ONS 15454, see the Cisco ONS 15454 Reference Manual, Release 5.0.

ONS 15454 Connection Methods

The Cisco ONS 15454 provides you multiple ways to connect to the node. You can connect your PC directly the ONS 15454 (local craft connection) using the RJ-45 port on the TCC card or the LAN pins on the backplane, connect your PC to a hub or switch that is connected to the ONS 15454, connect to the ONS 15454 through a LAN, a LAN modem, or establish TL1 connections from a PC or TL1 terminal. Table 1-5 lists the ONS 15454 connection methods and requirements.

Table 1-5 ONS 15454 Connection Methods

Method	Description	Requirements
Local Craft	Refers to onsite network connections between the Cisco Transport Controller (CTC) computer and the ONS 15454 using one of the following: • The RJ-45 (LAN) port on the TCC2/TCC2P card • The LAN pins on the ONS 15454 backplane • A hub or switch to which the ONS 15454 is connected	If you do not use Dynamic Host Configuration Protocol (DHCP), you must change the computer IP address, subnet mask, and default router, or use automatic host detection.
Corporate LAN	Refers to a connection to the ONS 15454 through a corporate or network operations center (NOC) LAN.	• The ONS 15454 must be provisioned for LAN connectivity, including IP address, subnet mask, default gateway. • The ONS 15454 must be physically connected to the corporate LAN. • The CTC computer must be connected to the corporate LAN that has connectivity to the ONS 15454.
TL1	Refers to a connection to the ONS 15454 using TL1 rather than CTC. TL1 sessions can be started from CTC, or you can use a TL1 terminal. The physical connection can be a craft connection, corporate LAN, or a TL1 terminal.	Refer to the Cisco ONS 15454 and Cisco ONS 15327 TL1 Command Guide.
Remote	Refers to a connection made to the ONS 15454 using a LAN modem.	The LAN modem must be connected to the RJ-45 port on a TCC card or to the LAN pins on the ONS 15454 backplane. The LAN modem must be properly configured for use with the ONS 15454. When the modem is installed, dial-up access to the ONS 15454 is available using a personal computer modem. To run CTC, the modem must be provisioned for Ethernet access.

Cisco Transport Controller

ONS 15454 provisioning and administration is performed using the Cisco Transport Controller (CTC), the software interface.

CTC Software Delivery Method

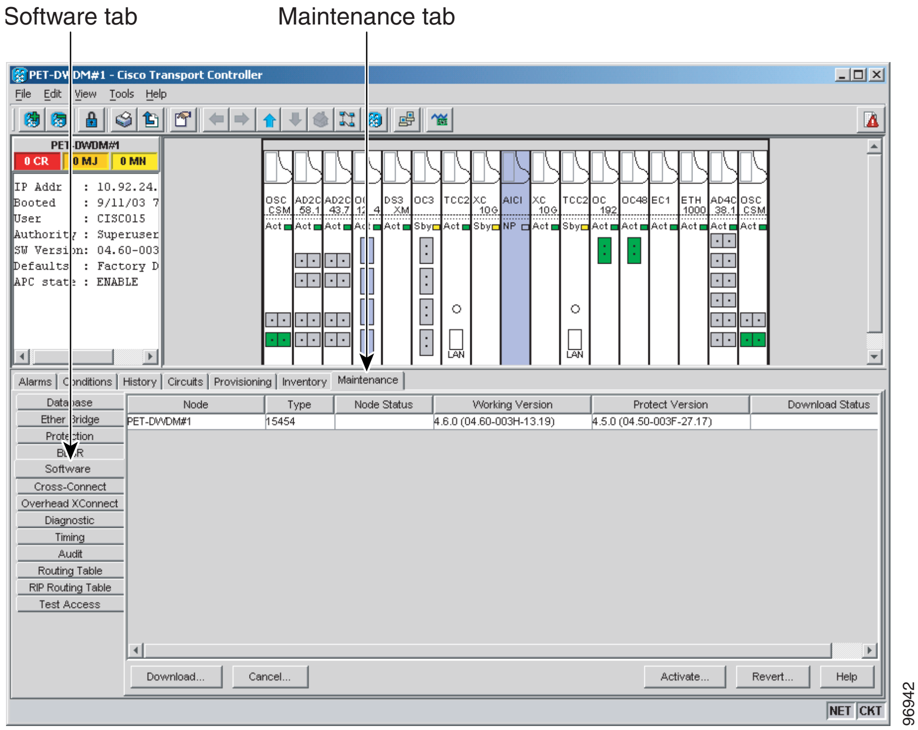
CTC is a Java application that is preloaded on the ONS 15454 TCC cards from the factory and is automatically downloaded to your computer or workstation the first time you log into the ONS 15454 with a new software release. Downloading the CTC software files automatically ensures that your computer is running the same CTC software version as the TCC cards you are accessing. The CTC files are stored in the temporary directory designated by your computer operating system. You can use the Delete CTC Cache button to remove files stored in the temporary directory. If the files are deleted, they download the next time you connect to an ONS 15454. Downloading the Java archive files, called "JAR" files, for CTC takes several minutes depending on the bandwidth of the connection between your computer and the ONS 15454. For example, JAR files downloaded from a modem or a data communication channel (DCC) network link require more time than JAR files downloaded over a LAN connection.

CTC Software Upgrade

When you upgrade CTC software, the TCC cards store the new CTC version as the protect software version. When you activate the new CTC software, the TCC cards store the older CTC version as the protect software version, and the newer CTC release becomes the working version. Before allowing a software activation or reversion to proceed, ONS 15454 nodes running Software Release 5.0 verify that their current state meets required activation criteria. Activation criteria must be met in order to avoid traffic hits. All BLSR spans on the nodes must be locked-out, and no 1:1, 1:N, 1+1 or Y-Cable protection switches can be in progress.

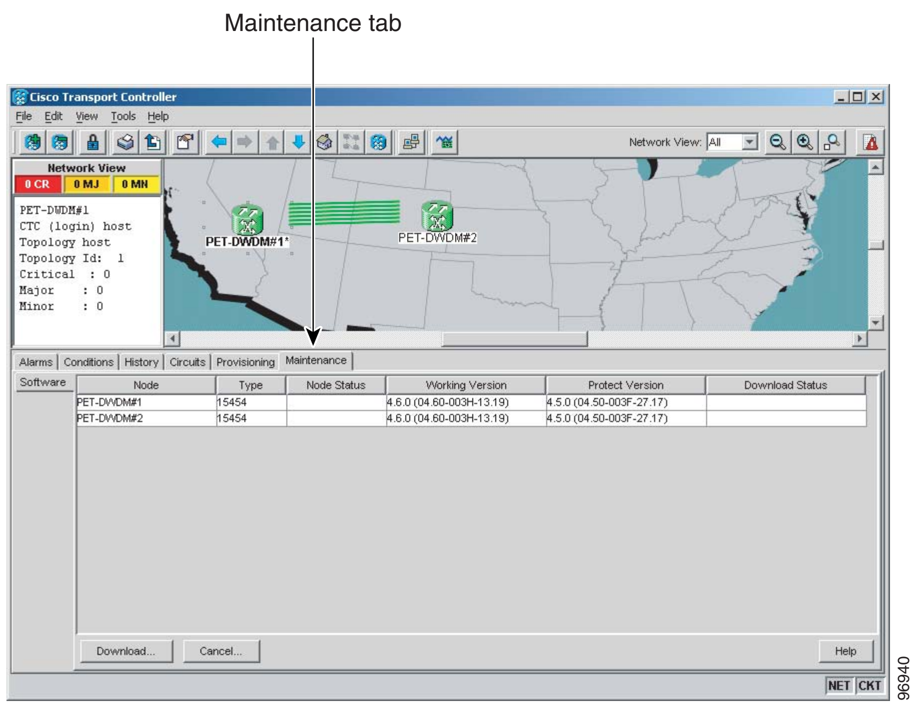
You can view the working and protect software versions that are installed on an ONS 15454 by selecting the Maintenance > Software tabs in node view (Figure 1-5).

Figure 1-5 CTC Software Versions Found In Node View



When a new CTC software version is released, use the Cisco ONS 15454 Software Upgrade Guide to upgrade the ONS 15454 software on the TCC cards. Select the Maintenance > Software tabs in network view to display the software versions installed on all the network nodes (Figure 1-6).

Figure 1-6 CTC Software Versions Found In Network View



CTC Software Revert

When you click the Activate button after a software upgrade, the TCC copies the current working database and saves it in a reserved location in the TCC flash memory. If you later need to revert to the original working software load from the protect software load, the saved database installs automatically. You do not need to restore the database manually or recreate circuits.

Note The TCC card does not carry any software earlier than Software R4.0. You will not be able to revert to a software release earlier than Software R4.0 with TCC cards installed.

The revert feature is useful if a maintenance window closes while you are upgrading CTC software. You can revert to the protect software load without losing traffic. When the next maintenance window opens, complete the upgrade and activate the new software load.

Circuits created or provisioning done after a software load is activated (upgraded to a higher release) do not reinstate with a revert (for example, 4.0 to 3.4). The database configuration at the time of activation is reinstated after a revert. This does not apply to maintenance reverts (for example, 2.2.2 to 2.2.1), because maintenance releases use the same database.

CTC Operations

To use CTC in the ONS 15454, your computer must have a web browser with the correct Java Runtime Environment (JRE) installed. The correct JRE for each CTC software release is included on the Cisco ONS 15454 software CD and the ONS 15454 documentation CD. If you are running multiple CTC software releases on a network, the JRE installed on the computer must be compatible with the different software releases.

You can change the JRE version on the Preferences dialog box JRE tab. When you change the JRE version on the JRE tab, you must exit and restart CTC for the new JRE version to take effect. Table 1-6 shows JRE compatibility with ONS software releases.

Table 1-6 JRE Compatibility with ONS Software Releases

ONS Software Release	JRE 1.2.2 Compatible	JRE 1.3 Compatible	JRE 1.4 Compatible
Release 2.2.1 and lower	Yes	No	No
Release 2.2.2	Yes	Yes	No
Release 3.0	Yes	Yes	No
Release 3.1	Yes	Yes	No
Release 3.2	Yes	Yes	No
Release 3.3	Yes	Yes	No
Release 3.4	No	Yes	No
Release 4.01[1]	No	Yes	No
Release 4.1	No	Yes	No
Release 4.5	No	Yes	No
Release 4.6	No	Yes	Yes
Release 5.0	No	Yes	Yes

1. Software Releases 4.0 and higher notify you if an older version of the JRE is running on your PC or UNIX workstation.

In addition to the JRE, the Java plug-in and modified java.policy file are also included on the ONS 15454 software CD and the ONS 15454 documentation CD.

Computer Requirements

Table 1-7 lists the computer requirements for PCs and UNIX workstations to run CTC.

Table 1-7 Computer Requirements

Area	Requirements	Notes
Processor	Pentium III (or higher) 700 MHz, UltraSPARC, or equivalent	700 MHz is the recommended processor speed. You can use computers with a lower processor speed; however, you may experience longer response times and slower performance.
RAM	384 MB RAM recommended, 512 MB RAM optimum	Cisco recommends using 512 MB RAM for networks with 25 nodes or more to avoid longer response times and slower performance.
Hard Drive	20 GB recommended with 50 MB vacant space available	—
Ethernet Network Interface Converter (NIC)	10/100 BaseT	—
Operating System	• PC: Windows 98, Windows NT 4.0 with Service Pack 6, Windows 2000, or Windows XP • Workstation: Solaris versions 8 or 9	—
JRE	JRE 1.4.2 or 1.3.1_02	JRE 1.4.2 is installed by the CTC Installation Wizard included on the Cisco ONS 15454 software and documentation CDs. JRE 1.4.2 provides enhancements to CTC performance, especially for large networks with numerous circuits. Cisco recommends that you use JRE 1.4.2 for networks with Software R4.6 nodes. If CTC must be launched directly from nodes running software earlier than R4.6, Cisco recommends JRE 1.3.1_02.

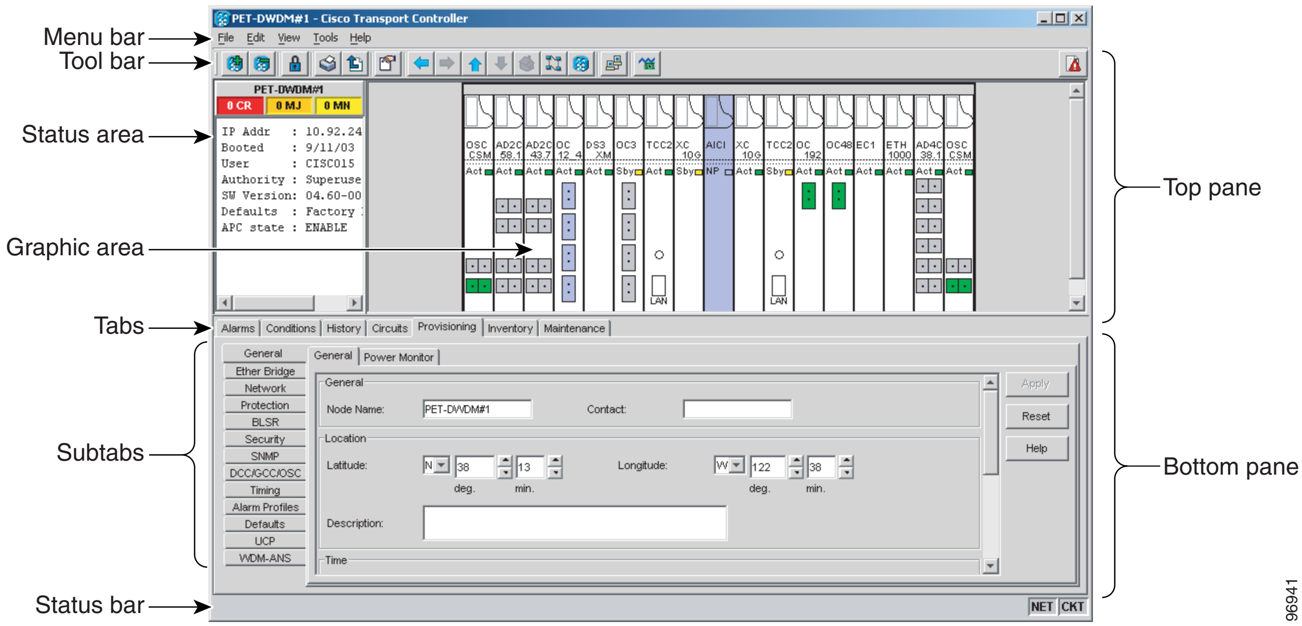
Table 1-7 Computer Requirements

Area	Requirements	Notes
Web Browser	PC: Netscape 4.76, Netscape 7.x, Internet Explorer 6.x UNIX Workstation: Netscape 4.76, Netscape 7.x	For the PC, use JRE 1.4.2 or 1.3.1_02 with any supported web browser. For UNIX, use JRE 1.4.2 with Netscape 7.x or JRE 1.3.1_02 with Netscape 4.76. Netscape 4.76 or 7.x is available at the following site: http://browser.netscape.com Internet Explorer 6.x is available at the following site: http://www.microsoft.com
java.policy File	A java.policy file modified for CTC	The java.policy file is modified by the CTC Installation Wizard included on the Cisco ONS 15454 software and documentation CDs.
Cable	User-supplied CAT-5 straight-through cable with RJ-45 connectors on each end to connect the computer to the ONS 15454 directly or through a LAN port on the TCC faceplate.	—
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	—

CTC Windows

The CTC window appears after you log into an ONS 15454 (Figure 1-7). The window includes a menu bar, toolbar, and a top and bottom pane. The top pane provides status information about the selected objects and a graphic of the current view. The bottom pane provides tabs and subtab to view ONS 15454 information and perform ONS 15454 provisioning and maintenance. From this window you can display three ONS 15454 views: network, node, and card.

Figure 1-7 Node View (Default Login View)



Node View

Node view, shown in Figure 1-7, is the first view that appears after you log into an ONS 15454. The login node is the first node shown, and it is the "home view" for the session. Node view allows you to manage one ONS 15454 node. The status area shows the node name; IP address; session boot date and time; number of Critical (CR), Major (MJ), and Minor (MN) alarms; the name of the current logged-in user; and the security level of the user; software version; and the network element default setup.

CTC Card Colors

The graphic area of the CTC window depicts the ONS 15454 shelf assembly. The colors of the cards in the graphic reflect the real-time status of the physical card and slot (Table 1-8).

Table 1-8 Node View Card Colors

Card Color	Card Status
Gray	Slot is not provisioned; no card is installed.
Violet	Slot is provisioned; no card is installed.
White	Slot is provisioned; a functioning card is installed.
Yellow	Slot is provisioned; a functioning card is installed; a Minor alarm condition exists.
Orange	Slot is provisioned; a functioning card is installed; a Major alarm condition exists.
Red	Slot is provisioned; a functioning card is installed; a Critical alarm exists.

The wording on a card in node view shows the state of a card (Active, Standby, Loading, or Not Provisioned). Table 1-9 lists the card states.

Table 1-9 Node View Card States

Card State	Description
Sty	Card is in standby
Act	Card is active
NP	Card is not present
Ldg	Card is resetting

Ports can be assigned one of four states, OOS, IS, OOS-AINS, or OOS-MT. The color of the port in both card and node view indicates the port state. Table 1-10 lists the port colors and their states.

Table 1-10 Node View Card Port Colors

Port Color	State	Description
Cyan (blue)	OOS-MA, LPBK	(Out-of-Service and Management, Loopback) Port is in a loopback state. On the card in node view, a line between ports indicates that the port is in terminal or facility loopback. Traffic is carried and alarm reporting is suppressed. Raised fault conditions, whether or not their alarms are reported, can be retrieved on the CTC Conditions tab or by using the TL1 RTRV-COND command.
	OOS-MA, MT	(Out-of-Service and Management, Maintenance) Port is out-of-service for maintenance. Traffic is carried and loopbacks are allowed. Alarm reporting is suppressed. Raised fault conditions, whether or not their alarms are reported, can be retrieved on the CTC Conditions tab or by using the TL1 RTRV-COND command. Use OOS-MA,MT for testing or to suppress alarms temporarily. Change the state to IS-NR, OOS-MA,DSBLD, or OOS-AU,AINS when testing is complete.
Gray	OOS-MA, DSBLD	(Out-of-Service and Management, Disabled) The port is out-of-service and unable to carry traffic. Loopbacks are not allowed in this service state.
Green	IS-NR	(In-Service and Normal) The port is fully operational and performing as provisioned. The port transmits a signal and displays alarms; loopbacks are not allowed.
Violet	OOS-AU, AINS	(Out-of-Service and Autonomous, Automatic In-Service) The port is out-of-service, but traffic is carried. Alarm reporting is suppressed. The node monitors the ports for an error-free signal. After an error-free signal is detected, the port stays in OOS-AU,AINS state for the duration of the soak period. After the soak period ends, the port service state changes to IS-NR. Raised fault conditions, whether or not their alarms are reported, can be retrieved on the CTC Conditions tab or by using the TL1 RTRV-COND command. The AINS port will automatically transition to IS-NR when a signal is received for the length of time provisioned in the soak field.

Node View Card Shortcuts

If you move your mouse over cards in the graphic area, pop-ups display additional information about the card including the card type; the card status (active or standby); the type of alarm, such as Critical, Major, and Minor (if any); the alarm profile used by the card; and for TXP or MXP cards, the wavelength of the DWDM port. Right-click a card to reveal a shortcut menu, which you can use to open, reset, delete, or change a card. Right-click a slot to pre-provision a card (that is, provision a slot before installing the card).

Node View Tabs

Table 1-11 lists the tabs and subtabs available in the node view.

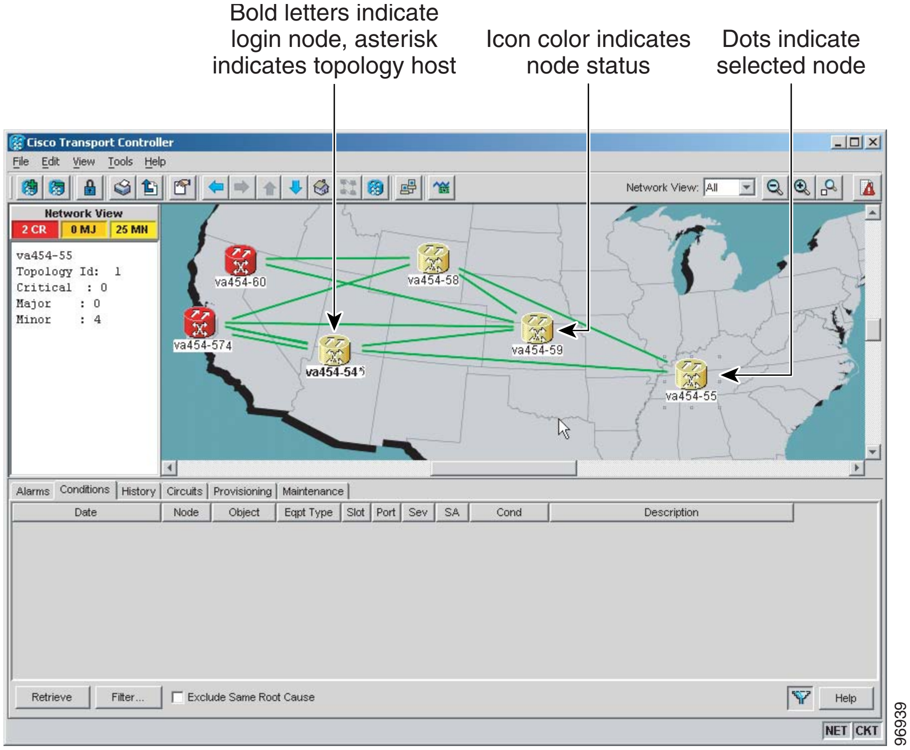
Table 1-11 Node View Tabs and Subtabs

Tab	Description	Subtab
Alarms	Lists current alarms (CR, MJ, MN) for the node and updates them in real time.	None
Conditions	Displays a list of standing conditions on the node.	None
History	Provides a history of node alarms including date, type, and severity of each alarm. The Session subtab displays alarms and events for the current session. The Node subtab displays alarms and events retrieved from a fixed-size log on the node.	Session, Node
Circuits	Creates, deletes, edits, and maps circuits.	None
Provisioning	Provisions the ONS 15454 node.	General, Ether Bridge, Network, Protection, BLSR, Security, SNMP, DCC/GCC/OSC, Timing, Alarm Profiles, Defaults, UCP, WDM-ANS
Inventory	Provides inventory information (part number, serial number, Common Language Equipment Identification [CLEI] codes) for cards installed in the node. Allows you to delete and reset cards, and change card service state.	None
Maintenance	Performs maintenance tasks for the node.	Database, Ether Bridge, Protection, BLSR, Software, Cross-connect, Overhead XConnect, Diagnostic, Timing, Audit, Routing Table, RIP Routing Table, Test Access

Network View

Network view allows you to view and manage ONS 15454s that have DCC connections to the node that you logged into and any login node groups you may have selected (Figure 1-8).

Figure 1-8 Network In CTC Network View



Note Nodes with DCC connections to the login node do not appear if you checked the Disable Network Discovery check box in the Login dialog box.

The graphic area displays a background image with colored ONS 15454 icons. A Superuser can set up the logical network view feature, which enables each user to see the same network view. The lines show DCC connections between the nodes. DCC connections can be green (active) or gray (fail). The lines can also be solid (circuits can be routed through this link) or dashed (circuits cannot be routed through this link).

There are four possible combinations for the appearance of DCCs: green/solid, green/dashed, gray/solid, and gray/dashed. DCC appearance corresponds to the following states: active/routable, active/nonroutable, failed/routable, or failed/nonroutable. Circuit provisioning uses active/routable links. Selecting a node or span in the graphic area displays information about the node and span in the status area.

The color of a node in network view, shown in Table 1-12, indicates the node alarm status.

Table 1-12 Node Status Shown in Network View

Color	Alarm Status
Green	No alarms
Yellow	Minor alarms
Orange	Major alarms
Red	Critical Alarms
Gray with Unknown#	Node initializing for the first time (CTC displays Unknown# because CTC has not discovered the name of the node yet)

Table 1-13 lists the tabs and subtabs available in network view.

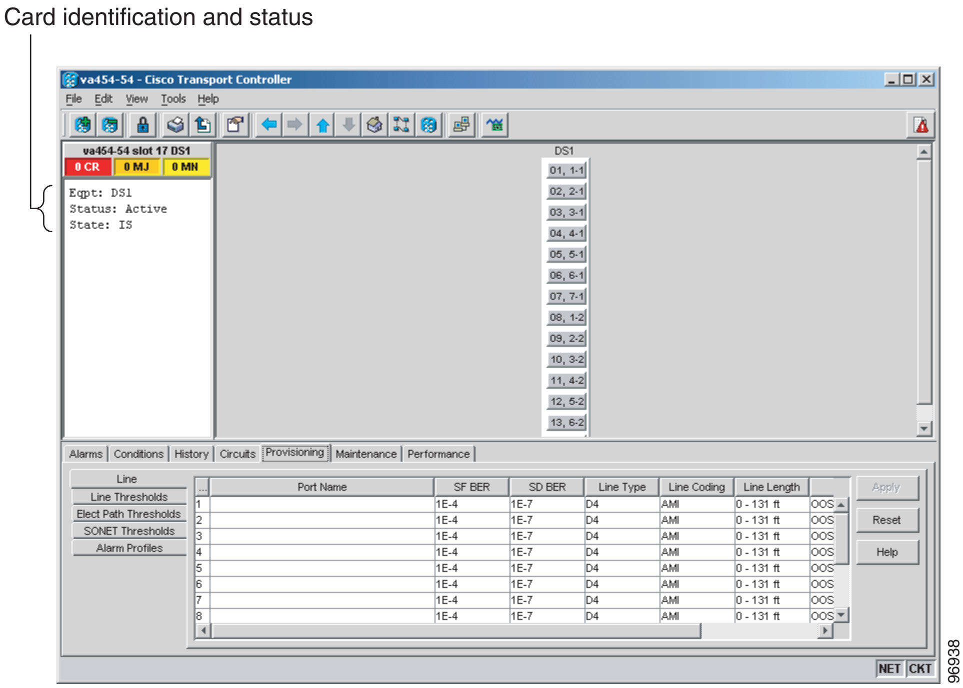
Table 1-13 Network View Tabs and Subtabs

Tab	Description	Subtab
Alarms	Lists current alarms (CR, MJ, MN) for the network and updates them in real time.	None
Conditions	Displays a list of standing conditions on the network.	None
History	Provides a history of network alarms including date, type, and severity of each alarm.	None
Circuits	Creates, deletes, edits, filters, and searches for network circuits.	None
Provisioning	Provisions security, alarm profiles, BLSRs, and overhead circuits.	Security, Alarm Profiles, BLSR, Overhead Circuits
Maintenance	Displays the type of equipment and the status of each node in the network; displays working and protect software versions; and allows software to be downloaded.	None

Card View

Card view provides information about individual ONS 15454 cards. Use this window to perform card-specific maintenance and provisioning (Figure 1-9). A graphic showing the ports on the card is shown in the graphic area. The status area displays the node name, slot, number of alarms, card type, equipment type, and the card status (active or standby), card and port service states, when a card is present. The information that appears and the actions you can perform depend on the card.

Figure 1-9 CTC Card View Showing a DS1 Card



Note CTC provides a card view for all ONS 15454 cards except the TCC2, TCC2P, XC, XCVT, and XC10G cards. Provisioning for these common control cards occurs at the node view; therefore, no card view is necessary.

Use the card view tabs and subtabs, shown in Table 1-14, to provision and manage the ONS 15454. The subtabs, fields, and information shown under each tab depend on the card type selected. The Performance tab is not available for the AIC or AIC-I cards.

Table 1-14 Card View Tabs and Subtabs

Tab	Description	Subtab
Alarms	Lists current alarms (CR, MJ, MN) for the network and updates them in real time.	None
Conditions	Displays a list of standing conditions on the network.	None
History	Provides a history of network alarms including date, type, and severity of each alarm.	Session (displays alarms and events for the current session), Card (displays alarms and events retrieved from a fixed-size log on the card)
Circuits	Creates, deletes, edits, filters, and searches for network circuits.	Circuits

Table 1-14 Card View Tabs and Subtabs

Tab	Description	Subtab
Provisioning	Provisions an ONS 15454 card.	DS-N and OC-N cards: Line, Line Thresholds (different threshold options are available for DS-N and OC-N cards), Elect Path Thresholds, SONET Thresholds, or SONET STS, and Alarm Profiles TXP and MXP cards: Card, Line, Line Thresholds (different threshold options are available for electrical and optical cards), Optics Thresholds, OTN, and Alarm Profiles DWDM cards (subtabs depend on card type): Optical Line, Optical Chn, Optical Amplifier, Parameters, Optics Thresholds
Maintenance	Performs maintenance tasks for the card.	Loopback, Info, Protection, J1 Path Trace, AINS Soak (options depend on the card type), Automatic Laser Shutdown (TXP and MXP cards only)
Performance	Performs performance monitoring for the card.	DS-N and OC-N cards: no subtabs TXP and MXP cards: Optics PM, Payload PM, OTN PM DWDM cards (subtabs depend on card type): Optical Line, Optical Chn, Optical Amplifier, Parameters, Optics Thresholds
Inventory	Displays an Inventory screen of the ports (TXP and MXP cards only).	None

Card Reset

You can reset the ONS 15454 plug-in cards by using CTC (a soft reset) or by physically reseating a card (a hard reset).

You can apply a soft reset from CTC to either an active or standby TCC2/TCC2P card without affecting traffic. A soft reset reboots the TCC2/TCC2P card and reloads the operating system and the application software. If you need to perform a hard reset on an active TCC2/TCC2P card, put the TCC2/TCC2P card into standby mode first by performing a soft reset. Additionally, a hard reset temporarily removes power from the TCC2/TCC2P card and clears all buffer memory.

Note When a CTC reset is performed on an active TCC2/TCC2P card, the AIC and AIC-I cards go through an initialization process and also resets because the AIC and AIC-I cards are controlled by the active TCC2/TCC2P.

Network Configurations

The ONS 15454 supports a variety of network configurations, including terminal mode (TM), linear ADM, path protection, two- and four-fiber bidirectional 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 wavelength division multiplexing (DWDM) networks.

New Features in Release 5.0.x

Table 1-15 lists the new hardware and software features provided in Release 5.0.x that are covered in this document.

Table 1-15 New Hardware and Software Feature

New Features in Release 5.0.x	
Hardware	2.5G Data Muxponder (MXP_MR_2.5G and MXPP_MR_2.5G) Cards
	12-Port DS3XM-12 Transmux Card with Portless Interface Mode
	48-Port DS3/EC1-48 Card
	8-Port CE-100T-8 Ethernet Mapper Card with GFP, VCAT, LCAS[1]
	96-Port Mini-BNC EIA Panels
	DSX Wiring Verification Kit
	Detectable Filler Card (Software support i R6.0)
	Enhanced 2.5-Gb/s-10-Gb/s Muxponder-100 GHz-Tunable (MXP_2.5G_10E) Card
	Enhanced 10-Gb/s Transponder-100-GHz-Tunable (TXP_MR_10E) Card
	Reconfigurable OADM (ROADM) with 32-Channel Demultiplexer (32DMX) and 32-Channel Wavelength Selective Switch (32WSS) Cards
	Small Form-Factor Pluggables
	TCC2P Card
	Universal Backplane Interface Connector – Horizontal (UBIC-H)[2]
	UBIC-H Cable Assemblies[2.]

Table 1-15 New Hardware and Software Feature (continued)

New Features in Release 5.0.x	
Software	1+1 VT Protection Support
	Admin SSM
	Consolidated R4.7 DWDM Software
	TL1-CTC Circuit Unification
	Dual-Ring Interconnect for BLSR
	GFP-F Support on ML-Series Ethernet Cards
	Hi-Capacity RMON
	In-Service Topology Upgrades
	Linear Port-Mapped Ethernet Mode
	Link Capacity Adjustment
	Manual Provisioning of STS Around a Ring[3]
	Open GNE
	Optimized 1+1 Protection
	Portless Transmux Circuits
	Provisionable Patchcords
	Runtime Diagnostics
	SL-Series Fibre Channel Card Enhancements
	State Verification Scan Before Activation
	TCC2P Secure Mode Operation
	VCAT Member Routing Enhancements

1. CE-100T-8 Ethernet mapper card will be available in R5.0.2.
2. Product is release independent and was introduced between R4.6 and R5.0.
3. For provisioning a STS around a ring, refer to the Cisco ONS 15454 Procedures Guide.

End of Life

Table 1-16 outlines the products which have entered the End-of-Life (EoL) process but have not reached End-of-Sale (EoS). You should analyze your spares needs in order to place an order for last time purchases. All EoL product bulletins for the ONS 15454 can be accessed at the following URL:

http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html

Table 1-16 Products in End-of-Life Process

EOL Product Name	EoL Product Bulletin #	Replacement Product Name
15454-EIA-AMP-A84	2481	15454-EIA-1AMPA84
15454-EIA-AMP-B84	2481	15454-EIA-1AMPB84
15454-EIA-BNC-A24	2481	15454-EIA-1BNCA48
15454-EIA-BNC-B24	2481	15454-EIA-1BNCB48

Table 1-16 Products in End-of-Life Process (continued)

EOL Product Name	EoL Product Bulletin #	Replacement Product Name
15454-EIA-BNC-A48	2481	15454-EIA-1BNCA48
15454-EIA-BNC-B48	2481	15454-EIA-1BNCB48
15454-EIA-SMB-A84	2481	15454-EIA-1SMBA84
15454-EIA-SMB-B84	2481	15454-EIA-1SMBB84
15454-SA-ANSI	2480	15454-SA-HD
15454-EIA-1BNC-A24	2632	15454-EIA-1BNCA48
15454-EIA-1BNC-B24	2632	15454-EIA-1BNCB48
15454-DS3-12	2633	15454-DS3-12E
15454-DS3N-12	2633	15454-DS3N-12E
15454-OC192LR1550	2559	15454-OC192LR2
15454-OC48IR1310	2353	15454-OC48IR1310A
15454-OC48LR1550	2353	15454-OC48LR1550A

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.

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 primer in Appendix B. For information about Telcordia’s generic requirements for SONET, see GR-253-CORE.

The following topics are covered in this chapter:

Rates and Formats

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-6C and STS-24C line rates, because the STS-6C and STS-24C 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.

Concatenated STS Time Slot Assignments

Table 2-3 shows the available time slot assignments for concatenated STSs when using CTC to provision circuits.

Table 2-3 STS Mapping Using CTC

Starting STS	STS-3c	STS-6c	STS-9c	STS-12c	STS-24c	STS-48c
1	Yes	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	No	Yes	No
7	Yes	Yes	No	No	Yes	No
10	Yes	No	Yes	No	Yes	No
13	Yes	Yes	Yes	Yes	Yes	No
16	Yes	Yes	Yes	No	Yes	No
19	Yes	Yes	Yes	No	Yes	No
22	Yes	No	No	No	Yes	No
25	Yes	Yes	Yes	Yes	Yes	No
28	Yes	Yes	Yes	No	No	No
31	Yes	Yes	Yes	No	No	No
34	Yes	No	Yes	No	No	No
37	Yes	Yes	Yes	Yes	No	No
40	Yes	Yes	Yes	No	No	No
43	Yes	Yes	Yes	No	No	No
46	Yes	No	Yes	No	No	No
49	Yes	Yes	Yes	Yes	Yes	Yes
52	Yes	Yes	Yes	No	Yes	No
55	Yes	Yes	Yes	No	Yes	No
58	Yes	No	Yes	No	Yes	No
61	Yes	Yes	Yes	Yes	Yes	No
64	Yes	Yes	Yes	No	Yes	No
67	Yes	Yes	Yes	No	Yes	No
70	Yes	No	Yes	No	Yes	No
73	Yes	Yes	Yes	Yes	Yes	No
76	Yes	Yes	Yes	No	No	No
79	Yes	Yes	Yes	No	No	No
82	Yes	No	Yes	No	No	No
85	Yes	Yes	Yes	Yes	No	No
88	Yes	Yes	Yes	No	No	No
91	Yes	Yes	Yes	No	No	No
94	Yes	No	Yes	No	No	No
97	Yes	Yes	Yes	Yes	Yes	Yes
100	Yes	Yes	Yes	No	Yes	No
103	Yes	Yes	Yes	No	Yes	No
106	Yes	No	Yes	No	Yes	No

Table 2-3 STS Mapping Using CTC (continued)

Starting STS	STS-3c	STS-6c	STS-9c	STS-12c	STS-24c	STS-48c
109	Yes	Yes	Yes	Yes	Yes	No
112	Yes	Yes	Yes	No	Yes	No
115	Yes	Yes	Yes	No	Yes	No
118	Yes	No	Yes	No	Yes	No
121	Yes	Yes	Yes	Yes	Yes	No
124	Yes	Yes	Yes	No	No	No
127	Yes	Yes	Yes	No	No	No
130	Yes	No	Yes	No	No	No
133	Yes	Yes	Yes	Yes	No	No
136	Yes	Yes	Yes	No	No	No
139	Yes	Yes	Yes	No	No	No
142	Yes	No	Yes	No	No	No
145	Yes	Yes	Yes	Yes	Yes	Yes
148	Yes	Yes	Yes	No	Yes	No
151	Yes	Yes	No	No	Yes	No
154	Yes	No	Yes	No	Yes	No
157	Yes	Yes	Yes	Yes	Yes	No
160	Yes	Yes	Yes	No	Yes	No
163	Yes	Yes	Yes	No	Yes	No
166	Yes	No	No	No	Yes	No
169	Yes	Yes	Yes	Yes	Yes	No
172	Yes	Yes	Yes	No	No	No
175	Yes	Yes	No	No	No	No
178	Yes	No	No	No	No	No
181	Yes	Yes	Yes	Yes	No	No
184	Yes	Yes	Yes	No	No	No
187	Yes	Yes	No	No	No	No
190	Yes	No	No	No	No	No

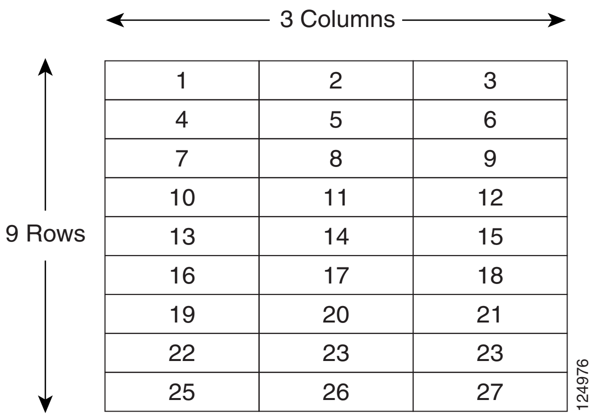
VT Structure

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 seven 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



Each STS-1 can support 28 VT1.5 mapped DS1 signals. Table 2-4 illustrates how the ONS 15454 numbers these VT1.5 mapped signals compared to the VT Group numbering scheme defined in Telcordia GR-253-CORE.

Table 2-4 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

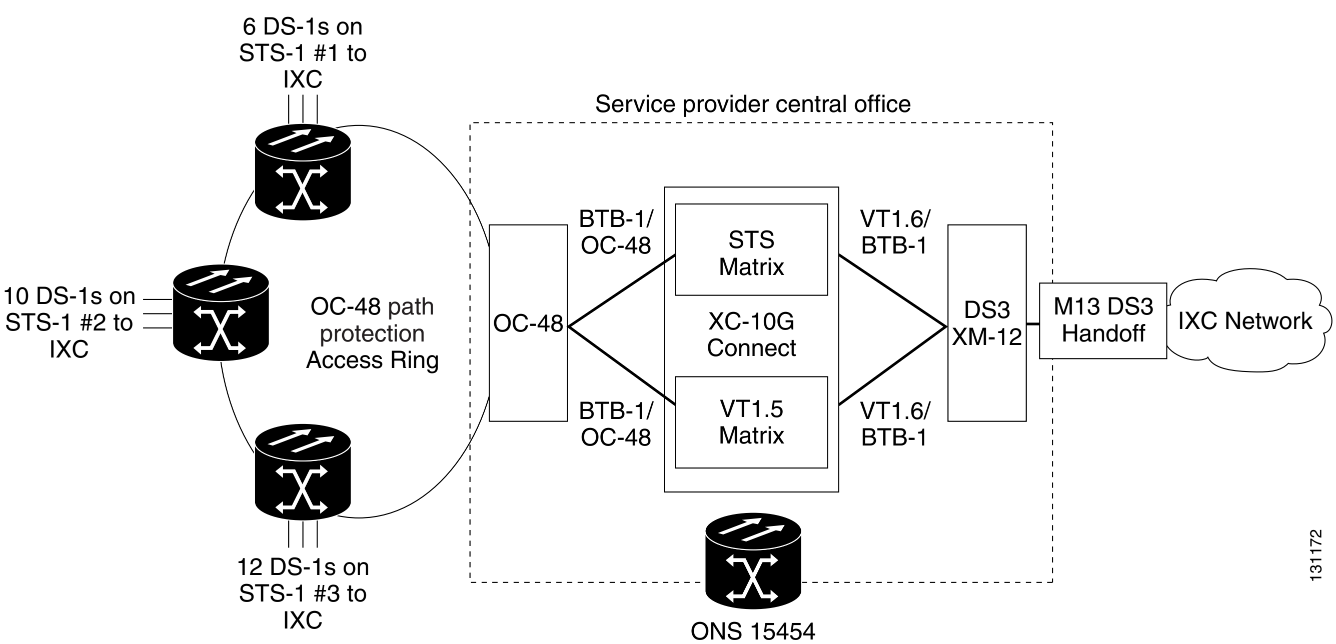
Table 2-4 ONS 15454 VT1.5 Numbering Scheme (continued)

DS1 Number	ONS 15454 VT1.5 Number	GR-253-CORE VT Group Number	GR-253-CORE VT Number
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

M13 Multiplexing

The ONS 15454 provides GR499-CORE compliant M13 multiplexing to groom D1s into channelized DS3 signals. This transmux function is provided by the DS3XM-6 and DS3XM-12 transmux cards. In Figure 2-2, the ONS 15454 is pictured collecting multiple DS1s from IXC customers around the OC-48 path protection access ring and, in the ONS 15454 node at the Service Provider's Central Office, transmitting them within a channalized DS3 signal to the IXC's network.

Figure 2-2 Ported Transmux Function



The DS3XM-6 and DS3XM-12 cards can terminate either C-bit or M13 formatted DS-3 signals and demultiplex them into DS1 signals for transport as VC11/VT1.5 payloads. 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.

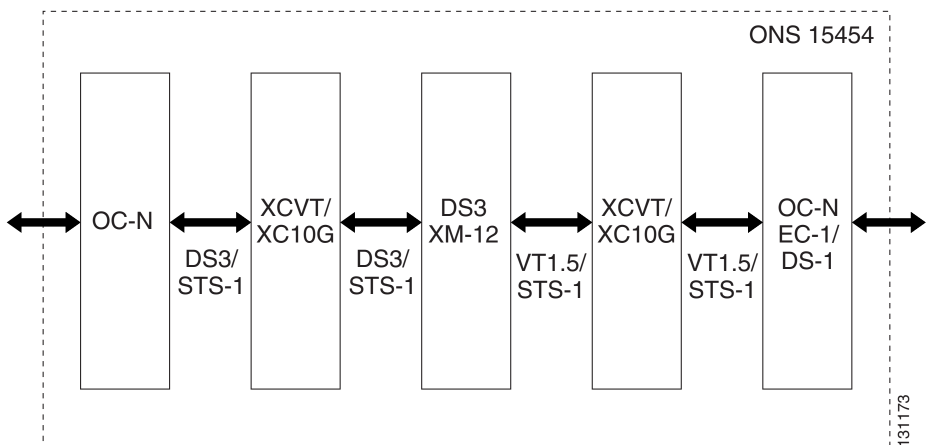
Conversely, these transmux cards can take 28 T-1s and multiplex them into a channeled C-bit or M13 framed DS3. This is accomplished in two steps. In the first step, 4 DS1 signals are multiplexed to reach a 6.312 Mb/s transmission rate inside the M13 multiplex unit. The M13 unit then multiplexes 7 of the 6.312 Mb/s signals to generate the DS3 output.

With the introduction of the DS3XM-12 card in Release 5.0, the ONS 15454 can support up to 96 DS3 transmux ports in a single shelf.

Portless Transmux Function

The portless transmux function enables the ONS 15454 to multiplex and demultiplex DS3 signals directly from optical interfaces without requiring an external DS3 card to groom DS1s from DS3 signals inside an STS-1 from an optical port. Only the DS3XM-12 card can provide this function, which is illustrated in Figure 2-3.

Figure 2-3 Portless Transmux Function



Only the DS3XM-12 card provides portless transmux interfaces that can change transported DS3s within optical interfaces into VT1.5s. Each DS3XM-12 card can provide either 6 or 12 portless transmux interfaces depending on the card's slot position and the type of cross-connect card as follows:

If the DS3XM12 card is in slots 1-4 or 14-17 and the cross-connect is an XC-VT then the backplane bandwidth size is an STS-12, which supports a maximum of 6 portless transmux ports.

If the DS3XM12 card is slots 5-6 or 12-13 and the cross-connect is an XC-VT, or slots 1-6 and 12-17 and cross-connect is an XC-10G the backplane size is an STS-48, which supports a maximum of 12 portless transmux ports.

Overhead Mapping

The individual SONET overhead byte designations are laid out in Table 2-5.

Table 2-5 SONET Transport and Path Overhead Byte Designations

Transport Overhead					Path Overhead
Section	**Framing**		**Trace**		**Trace**
	A1	A2	J0/Z1		J1
	BIP-8 B1/undefined	**Orderwire** E1/undefined	**User** F1/undefined		**BIP-8** B3
	Section DCC				**Signal Label**
	D1/undefined	D2/undefined	D3/undefined		C2
Line	**Pointer** H1	**Pointer** H2	**Pointer Action** H3		**Path Status** G1
	BIP-8 B2/undefined	**APS** K1/undefined	**APS** K2/undefined		**User Channel** F2
	Line DCC				**Indicator**
	D4/undefined	D5/undefined	D6/undefined		H4
	Line DCC				**Growth**
	D7/undefined	D8/undefined	D9/undefined		Z3
	Line DCC				**Growth**
	D10/undefined	D11/undefined	D12/undefined		Z4
	SSM S1/Z1	**REI-L** M0 or M1/Z2	**Orderwire** E2/undefined		**Tandem Connection** Z5

Table 2-6 provides a list of supported and unsupported SONET overhead bytes for the Cisco ONS 15454.

Table 2-6 Supported and Unsupported SONET Overhead Bytes

SONET Overhead			Status
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

Table 2-6 Supported and Unsupported SONET Overhead Bytes (continued)

Line	H –H3	STS Pointer	Supported
	B2	Line BIP-8	Supported
	K –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
	H –H2	AIS-P Detect	Supported
	J1–J2	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
	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

Table 2-6 Supported and Unsupported SONET Overhead Bytes (continued)

VT Path	V1–V3	VT Pointer	Supported
	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 Communications Channel (DCC) Operations

SONET provides four data communications channels (DCCs) for network element operation, administration, maintenance, and provisioning: one on the SONET Section layer (D1 to D3 bytes) and three on the SONET Line layer (D4 to D12 bytes). The ONS 15454 uses the Section DCC (SDCC) for ONS 15454 management and provisioning. An SDCC and Line DCC (LDCC) each provide 192 Kb/s of bandwidth per channel. The aggregate bandwidth of the three LDCCs is 576 Kb/s. When multiple DCC channels exist between two neighboring nodes, the ONS 15454 balances traffic over the existing DCC channels using a load balancing algorithm. This algorithm chooses a DCC for packet transport by considering packet size and DCC utilization.

Note Software Release 4.6 enables existing TCC2/TCC2P-equipped network elements to support 1 Section Data Communications Channel (SDCC) termination per OC-N span and up to 68 data communications channel (DCC) terminations, providing hosting of up to 34 path protection configurations, 5 bi-directional line switched rings (BLSRs), or a combination of the two. This enhancement supports provisionable threshold-crossing-alert (TCA) settings for -48 VDC system input monitoring. With Release 4.0, there can be 1 SDCC termination per OC-N span, with a maximum of 32 DCC terminations per ONS 15454. Previous software releases can support 1 SDCC termination per OC-N span, with a maximum of 10 DCC terminations per ONS 15454.

The SDCC is defined in the first STS-1 of an STS-N frame. 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 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.

You can tunnel the SONET DCC from third party equipment across ONS 15454 networks using one of two tunneling methods, a traditional DCC tunnel or an IP-encapsulated tunnel.

Traditional DCC Tunnels

In traditional DCC tunnels, you can use the 3 LDCCs and the SDCC (when not used for ONS 15454 DCC terminations) for a maximum of 4 DCC tunnels. A traditional DCC tunnel endpoint is defined by slot, port, and DCC, where a DCC can be either the section DCC or one of the line DCCs (see Figure 2-4). You can link LDCCs to LDCCs and link SDCCs to SDCCs. You can also link a SDCC to a LDCC, and a LDCC to a SDCC. To create a DCC tunnel, you connect the tunnel endpoints from one ONS 15454 optical port to another. Software Release 4.0 and higher can support a maximum of 84 DCC tunnel connections for each ONS 15454. Table 2-7 shows the DCC tunnels that you can create using different OC-N cards.

Figure 2-4 Selecting DCC Tunnel End-Points

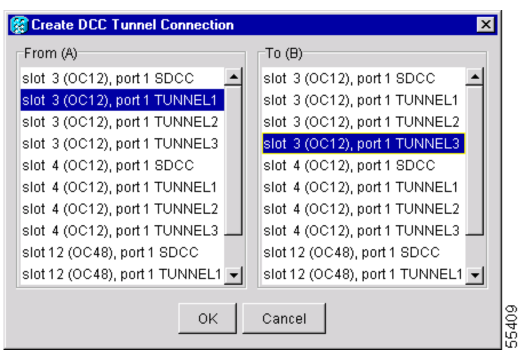


Table 2-7 Allowable DCC Tunnels

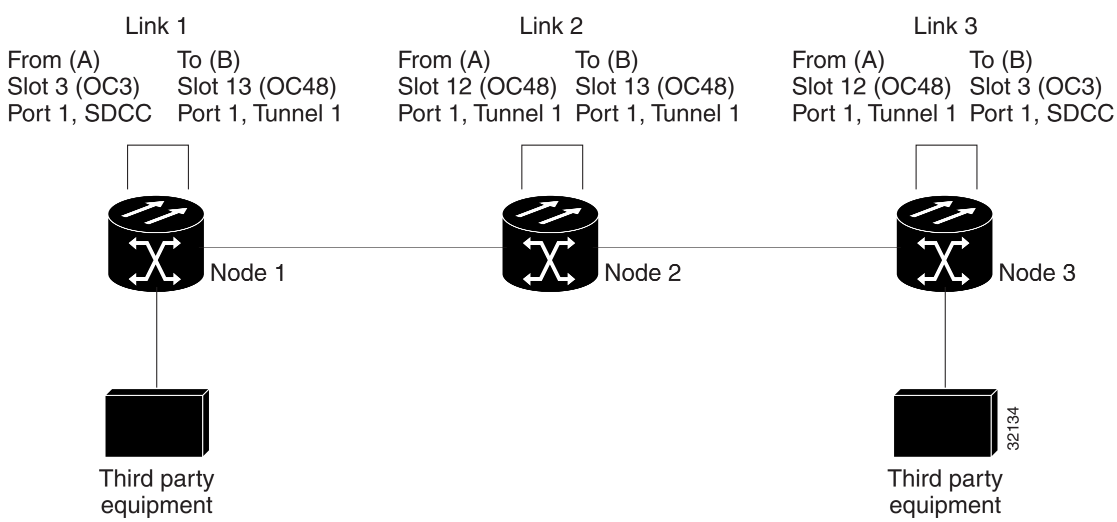
Card	DCC	SONET Layer	Overhead Bytes
OC3 IR 4/STM1 SH 1310	DCC1	Section	D1 – D3

Table 2-7 Allowable DCC Tunnels (continued)

Card	DCC	SONET Layer	Overhead Bytes
OC3 IR/STM1 SH 1310-8; All OC-12, OC-48, and OC-192 cards	DCC1	Section	D1 – D3
	DCC2	Line	D4 – D6
	DCC3	Line	D7 – D9
	DCC4	Line	D10 – D12

Figure 2-5 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 2-5 DCC Tunnel Example



When you create DCC tunnels, keep the following guidelines in mind:

- Each ONS 15454 can have up to 84 DCC tunnel connections.
- Each ONS 15454 can have up to 84 Section DCC terminations.
- A section DCC that is terminated cannot be used as a DCC tunnel endpoint.
- A section DCC that is used as a DCC tunnel endpoint cannot be terminated.
- All DCC tunnel connections are bi-directional.

IP-Encapsulated Tunnels

An IP-encapsulated tunnel puts a SDCC in an IP packet at a source node and dynamically routes the packet to a destination node. To compare traditional DCC tunnels with IP-encapsulated tunnels, a traditional DCC tunnel is configured as one dedicated path across a network and does not provide a failure recovery mechanism if the path is down. An IP-encapsulated tunnel is a virtual path, which adds protection when traffic travels between different networks.

IP-encapsulated tunneling has the potential of flooding the DCC network with traffic resulting in a degradation of performance for CTC. The data originating from an IP tunnel can be throttled to a user-specified rate, which is a percentage of the total SDCC bandwidth.

Each ONS 15454 supports up to 10 IP-encapsulated tunnels. You can convert a traditional DCC tunnel to an IP-encapsulated tunnel or an IP-encapsulated tunnel to a traditional DCC tunnel. Only tunnels in the DISCOVERED state can be converted.

Caution Converting from one tunnel type to the other is service-affecting.

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 2-8 when a 1+1 fiber protection scheme is used.

Table 2-8 Meaning of K1 Bits 1 to 4

K1 Bits	Description
1111	Lockout of Protection
1101	SF - High Priority
1011	SD - High Priority
1001	(not used)
0111	(not used)
0101	(not used)
0011	(not used)
0001	Do Not Revert
1110	Forced Switch
1100	SF - Low Priority
1010	SD - Low Priority
1000	Manual Switch
0110	Wait-to-Restore (Note 3)
0100	Exercise (Note 4)
0010	Reverse Request (Note 5)
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

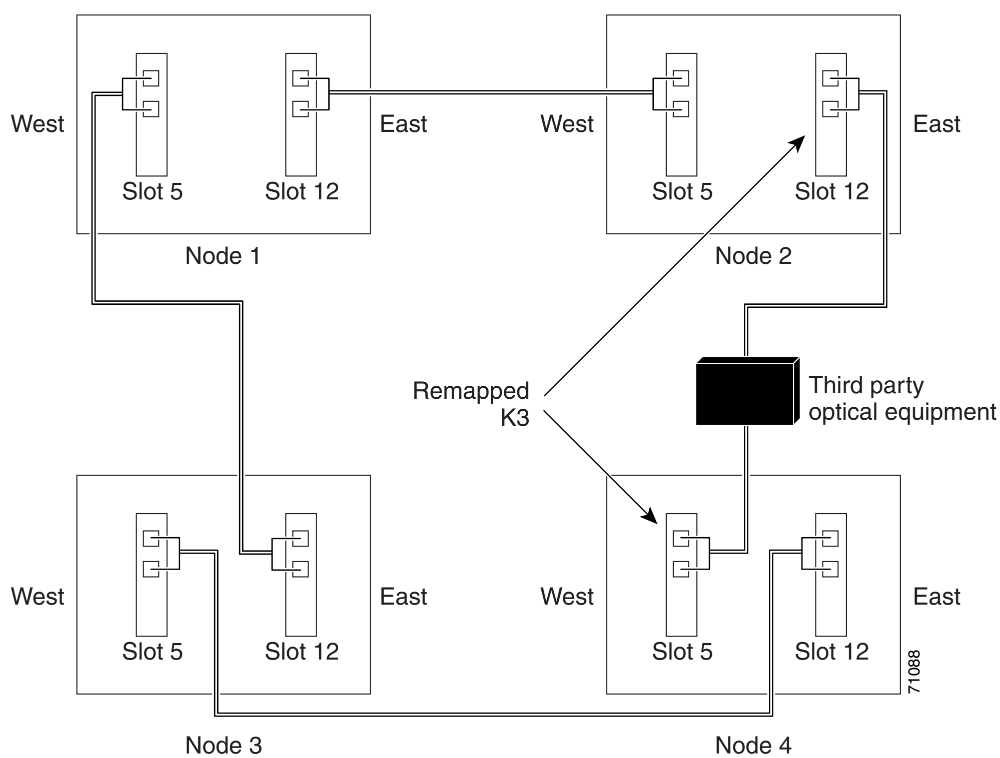
Warning **Do not perform K3 byte remapping on the Cisco ONS 15454 unless it is required to complete a BLSR that connects to third-party equipment.**

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 2-6, 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 2-6 BLSR Provisioned with Remapped K3 Byte



J1 and J2 Path Trace

The SONET J1 and J2 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. J1 Path Trace 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 as the baseline J1 string.
- Manual—The receiving port uses a string that you manually enter as the baseline J1 string.

Table 2-9 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. The DS3XM-12 card supports J2 path trace for VT circuits.

Table 2-9 ONS 15454 Cards Supporting J1 Path Trace

J1 Function	Cards
Tramsmit and Receive	CE-100T-8
	DS1-14, DS1N-14
	DS3-12E, DS3N-12E, DS3XM-6, DS3XM-12, DS3/EC1-48
	G1000-4, G1K-4
	ML100T-12, ML1000-2
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

Path Signal Label, C2 Byte

One of the overhead bytes in the SONET frame is the C2 byte. The SONET standard defines the C2 byte as the path signal label. The purpose of this byte is to communicate the payload type being encapsulated by the STS path overhead (POH). The C2 byte functions similarly to EtherType and Logical Link Control (LLC)/Subnetwork Access Protocol (SNAP) header fields on an Ethernet network; it allows a single interface to transport multiple payload types simultaneously. C2 byte hex values supported by the ONS 15454 are provided in Table 2-10.

Table 2-10 C2 STS Path Signal Label Assignments for Signals

Hex Code	Content of the STS Synchronous Payload Envelope (SPE)
0x00	Unequipped
0x01	Equipped - nonspecific payload
0x02	VT structured STS-1 (DS-1)
0x03	Locked VT mode
0x04	Asynchronous mapping for DS-3
0x12	Asynchronous mapping for DS4NA
0x13	Mapping for Asynchronous Transfer Mode (ATM)
0x14	Mapping for distributed queue dual bus (DQDB)
0x15	Asynchronous mapping for fiber distributed data interface (FDDI)
0x16	High level data link control (HDLC) over SONET mapping
0xFD	Reserved
0xFE	0.181 Test signal (TSS1 to TSS3) mapping SDH network
0xFF	Alarm indication signal, path (AIS-P)

If a circuit is provisioned using a terminating card, the terminating card provides the C2 byte. A VT circuit is terminated at the XCVT or XC10G card, which generates the C2 byte (0x02) downstream to the STS terminating cards. The XCVT or XC10G card generates the C2 value (0x02) to the DS1 or DS3XM terminating card. If an optical circuit is created with no terminating cards, the test equipment must supply the path overhead in terminating mode. If the test equipment is in pass-through mode, the C2 values usually change rapidly between 0x00 and 0xFF. Adding a terminating card to an optical circuit usually fixes a circuit having C2 byte problems. Table 2-11 lists label assignments for signals with payload defects.

Table 2-11 C2 STS Path Signal Label Assignments for Signals with Payload Defects

Hex Code	Content of the STS SPE
0xE1	VT-structured STS-1 SPE with 1 VTx payload defect (STS-1 with 1 VTx PD)
0xE2	STS-1 with 2 VTx PDs
0xE3	STS-1 with 3 VTx PDs
0xE4	STS-1 with 4 VTx PDs
0xE5	STS-1 with 5 VTx PDs
0xE6	STS-1 with 6 VTx PDs

Table 2-11 C2 STS Path Signal Label Assignments for Signals with Payload Defects (continued)

Hex Code	Content of the STS SPE
0xE7	STS-1 with 7 VTx PDs
0xE8	STS-1 with 8 VTx PDs
0xE9	STS-1 with 9 VTx PDs
0xEA	STS-1 with 10 VTx PDs
0xEB	STS-1 with 11 VTx PDs
0xEC	STS-1 with 12 VTx PDs
0xED	STS-1 with 13 VTx PDs
0xEE	STS-1 with 14 VTx PDs
0xEF	STS-1 with 15 VTx PDs
0xF0	STS-1 with 16 VTx PDs
0xF1	STS-1 with 17 VTx PDs
0xF2	STS-1 with 18 VTx PDs
0xF3	STS-1 with 19 VTx PDs
0xF4	STS-1 with 20 VTx PDs
0xF5	STS-1 with 21 VTx PDs
0xF6	STS-1 with 22 VTx PDs
0xF7	STS-1 with 23 VTx PDs
0xF8	STS-1 with 24 VTx PDs
0xF9	STS-1 with 25 VTx PDs
0xFA	STS-1 with 26 VTx PDs
0xFB	STS-1 with 27 VTx PDs
0xFC	VT-structured STS-1 SPE with 28 VT1.5 (Payload defects or a non-VT-structured STS-1 or STS-Nc SPE with a payload defect.)
0xFF	Reserved

Payload Mapping

The SONET and SDH payloads supported by the ONS 15454 are shown in Table 2-12.

Table 2-12 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 2-13.

Table 2-13 ONS 15454 SONET Payload Mappings

ONS 15454 Card Type	I/O Format	No. of I/O Ports	Internal SONET Mapping	No. of STSs
DS1-14 DS1N-14	DS1	14	VT1.5 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
DS3/EC1-48	Any type of DS3 mapping, plus J1 path trace[1].	48	DS3 mapped in an STS.	48
DS3XM-6	M13 mapped DS3	6	VT1.5 mapped in an STS	6
DS3XM-12	M13 mapped DS3	12	DS3 or VT1.5 mapped in an STS-1	48
EC1-12	DS3 mapped STS, VT1.5 mapped STS or clear channel STS (Electrical)	12	DS3, VT1.5 mapped in an STS or STS-1	12
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

Table 2-13 ONS 15454 SONET Payload Mappings (continued)

ONS 15454 Card Type	I/O Format	No. of I/O Ports	Internal SONET Mapping	No. of STSs
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 STSNc. 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 STSNc. 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
CE-100T-8	Ethernet (Electrical)	8	10/100 Mb/s Ethernet traffic in HDLC, mapped into STS-12 payloads, making use of low order (VT1.5) virtual concatenation, high order (STS-1) virtual concatenation, and generic framing procedure (GFP), point-to-point protocol/high-level data link control (PPP/HDLC) framing protocols. It also supports the link capacity adjustment scheme (LCAS).	12
E100T E100T-G	Ethernet (Electrical)	12	10/100 Mb/s Ethernet traffic in HDLC, mapped in an STS-Nc.	12
E1000-2 E1000-G	Ethernet (Electrical)	2	1000 Mb/s Ethernet traffic in HDLC, mapped in an STS-Nc.	12

Table 2-13 ONS 15454 SONET Payload Mappings (continued)

ONS 15454 Card Type	I/O Format	No. of I/O Ports	Internal SONET Mapping	No. of STSs
G1000-4 G1K-4	Ethernet (Optical)	4	1000 Mb/s Ethernet traffic 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
ML100T-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
ML1000-2	Ethernet (Optical) Layer 2/Layer 3 Routing	2	1000 Mb/s Ethernet traffic 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

Table 2-13 ONS 15454 SONET Payload Mappings (continued)

ONS 15454 Card Type	I/O Format	No. of I/O Ports	Internal SONET Mapping	No. of STSs
FC_MR-4	Fibre Channel/ Fiber Connectivity (FICON)	4	This card transports non-SONET-framed, block-coded protocols over SONET in virtually or contiguously concatenated payloads. The FC_MR-4 can transport Fibre Channel over SONET using Fibre-Channel client interfaces and allows transport of up to two STS-24c/VC4-8c or one STS-48c/VC4-16c, or two VCAT circuits (STC3c-8V/VC4-8v).	48
OSCM	The OSCM has one set of optical ports and one Ethernet port.	2	OC-3/STM-1 formatted OSC.	3
OSC-CSM	The OSC-CSM has three sets of optical ports and one Ethernet port.	4	OC-3/STM-1 formatted OSC.	3
OPT-PRE	The OPT-PRE amplifier card is designed to support 64 channels at 50-GHz channel spacing, but currently limited to 32 channels at 100 GHz.	5	C-band DWDM OC-N.	192
OPT-BST	The OPT-BST amplifier card is designed to support 64 channels at 50-GHz channel spacing, but currently limited to 32 channels at 100 GHz.	4	C-band DWDM OC-N.	192
32MUX-O	The 32-Channel Multiplexer (32MUX-O) card multiplexes 32 100-GHz-spaced channels identified in the channel plan.	5	C-band DWDM OC-N.	192
32DMX-O	The 32-Channel Demultiplexer (32DMX-O) card demultiplexes 32 100-GHz-spaced channels identified in the channel plan.	5	C-band DWDM OC-N.	192
32DMX	The card receives an aggregate optical signal on its COM RX port and demultiplexes it into to 32 100-GHz-spaced channels.	5	C-band DWDM OC-N.	192
32WSS	The 32-Channel Wavelength Selective Switch (32WSS) card performs channel add/drop processing within the ONS 15454 DWDM node.	7	C-band DWDM OC-N.	192
4MD-xx.x	The 4-Channel Multiplexer/Demultiplexer (4MD-xx.x) card multiplexes and demultiplexes four 100-GHz-spaced channels identified in the channel plan.	5	C-band DWDM OC-N.	192

Table 2-13 ONS 15454 SONET Payload Mappings (continued)

ONS 15454 Card Type	I/O Format	No. of I/O Ports	Internal SONET Mapping	No. of STSs
AD-1C-xx.x	The 1-Channel OADM (AD-1C-xx.x) card passively adds or drops one of the 32 channels utilized within the 100-GHz-spacing of the DWDM card system.	3	C-band DWDM OC-N.	192
AD-2C-xx.x	The 2-Channel OADM (AD-2C-xx.x) card passively adds or drops two adjacent 100-GHz channels within the same band.	4	C-band DWDM OC-N.	192
AD-4C-xx.x	The 4-Channel OADM (AD-4C-xx.x) card passively adds or drops all four 100-GHz-spaced channels within the same band.	6	C-band DWDM OC-N.	192
AD-1B-xx.x	The 1-Band OADM (AD-1B-xx.x) card passively adds or drops a single band of four adjacent 100-GHz-spaced channels.	3	C-band DWDM OC-N.	192
AD-4B-xx.x	The 4-Band OADM (AD-4B-xx.x) card passively adds or drops four bands of four adjacent 100-GHz-spaced channels.	6	C-band DWDM OC-N.	192
MXP_2.5G_10G	2.5 Gb/s signals	4/1	This card multiplexes/ demultiplexes four 2.5 Gb/s signals (client side) into one 10-Gbps, 100-GHz DWDM signal (trunk side). It provides one extended long-range STM-64/OC-192 port per card on the trunk side	192
MXP_2.5G_10E	Four 2.5 Gb/s client interfaces (OC-48/STM-16) and one 10 Gb/s trunk.	9	The four OC-48 signals are mapped into a ITU-T G.709 OTU2 signal using standard ITU-T G.709 multiplexing.	192

Table 2-13 ONS 15454 SONET Payload Mappings (continued)

ONS 15454 Card Type	I/O Format	No. of I/O Ports	Internal SONET Mapping	No. of STSs
MXP_MR_2.5G and MXPP_MR_2.5G	The 2.5-Gb/s Multirate Muxponder-100 GHz-Tunable 15xx.xx-15yy.yy (MXP_MR_2.5G) card aggregates a mix and match of client Storage Area Network (SAN) service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s STM-16/OC-48 DWDM signal on the trunk side. It provides one long-reach STM-16/OC-48 port per card and is compliant with Telcordia GR-253-CORE. The 2.5-Gb/s Multirate Muxponder-Protected-100GHz - Tunable 15xx.xx-15yy.yy (MXPP_MR_2.5G) card aggregates various client SAN service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s STM-16/OC-48 DWDM signal on the trunk side. It provides two long-reach STM-16/OC-48 ports per card and is compliant with ITU-T G.957 and Telcordia GR-253-CORE.	9/10	The client interface supports the following payload types. • GE • 1G FC • 2G FC • 1G FICON • 2G FICON All of the client interfaces supported use the Transparent Generic Framing Procedure (GFP-T) encapsulation method. The current version of the GFP-T, G.7041, supports transparent mapping of 8B/10B block-coded protocols, including Gigabit Ethernet, Fibre Channel, and FICON. In addition to the GFP mapping, 1 Gb/s traffic on port 1 or port 2 of the high-speed SERDES is mapped to an STS-24c channel. If two 1 Gb/s client signals are present at port 1 and port 2 of the high-speed SERDES, the port 1 signal is mapped into the first STS-24c channel and the port 2 signal into the second STS-24c channel. The two channels are then mapped into an OC-48 trunk channel. Only Contiguous concatenation is supported for the MXP_MR_2.5G and MXPP_MR_2.5G (no VCAT). Port one supports: • 1GE and 1G-FC mapped over first STS-24c payload • 2G-FC mapped over STS-48c Port two supports: • 1GE and 1G-FC mapped over second STS-24c payload.	48

Table 2-13 ONS 15454 SONET Payload Mappings (continued)

ONS 15454 Card Type	I/O Format	No. of I/O Ports	Internal SONET Mapping	No. of STSs
TXP_MR_2.5G and TXPP_MR_2.5G	The TXP_MR_2.5G card processes one 8-Mb/s to 2.488-Gb/s signal (client side) into one 8-Mb/s to 2.5-Gb/s, 100-GHz DWDM signal (trunk side). The TXPP_MR_2.5G card processes one 8-Mb/s to 2.488-Gb/s signal (client side) into two 8-Mb/s to 2.5-Gb/s, 100-GHz DWDM signals (trunk side).	2/3	For 2R operation mode, the TXP_MR_2.5G and TXPP_MR_2.5G cards have the ability to pass data through transparently from client side interfaces to a trunk side interface, which resides on an ITU grid. For 3R+ operation mode, the TXP_MR_2.5G and TXPP_MR_2.5G cards apply a digital wrapper to the incoming client interface signals (OCN, 1G-FC, 2G-FC, GE).	48
TXP_MR_10E	This card is a multi-rate transponder that processes one 10-Gb/s signal (client side) into one 10-Gb/s, 100-GHz DWDM signal (trunk side) that is tunable on four wavelength channels (ITU-T 100-GHz grid). The client interface is implemented by an on-board XFP module, a tri-rate transponder that provides a single port that can be configured in the field to support STM-64/OC-192 (with an SR-1 optics module that plugs into the XFP module), 10GE (10GBASE-LR), or 10G FC protocols. The XFP module supports 10 GE LAN PHY, 10 GE WAN PHY, STM-64, and OC-192 client signals. Two types of pluggable client-side optics modules are available for the XFP module on the TXP_MR_10E card: an OC-192 SR-1/I-64.2 interface (ITU-T G.691) or an S-64.2 optical interface (ITU-T G.691). The SR-1 is a 1310-nm optical interface that uses LC connectors. SR-1 is typically used in short-reach intra-office applications with ranges typically up to 7 km. On the trunk side, the TXP_MR_10E card provides a 10 Gb/s STM-64/OC-192 interface. Four tunable channels are available in the 1550-nm band on the 100-GHz ITU grid for the DWDM interface.	2	The TXP_MR_10E card can perform ODU2-to-OCh mapping, which allows you to provision data payloads in a standard way across 10-Gb/s optical links.	192

1. STS-1 mapping for EC1 signals will be supported in a future release.

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-6 cards cannot be cross-connected on the ONS 15454, because the DS3 cards are DS3 mapped and the DS3XM cards are VT1.5 mapped. The DS3 and the DS3XM-12 cards can be cross-connected if the DS3XM-12 port is in portless mode and the circuit interconnecting the two cards is DS-3 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 XC10G. The crossconect capacity of these cards is summarized in Table 2-14.

Table 2-14 Capacity of ONS 15454 Cross-Connect Cards

Cross-Connect	Card STS and VT1.5 Capacities
XCVT	• 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
XC10G	• 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

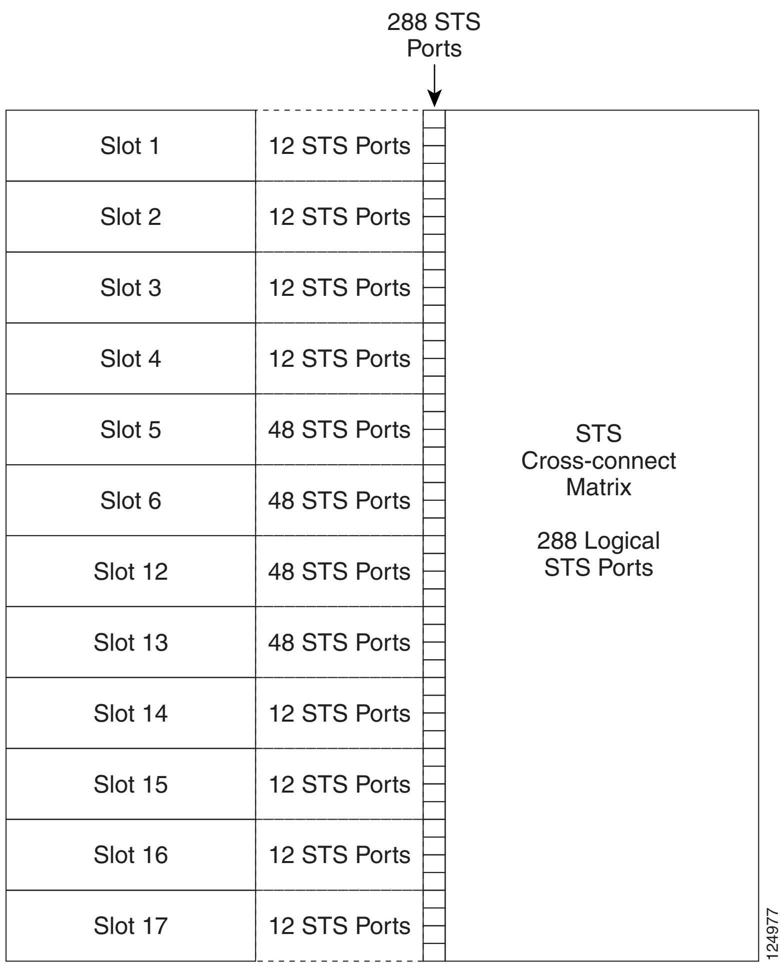
XC Cross-Connect Card

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 2-7 is a block diagram of the XC cross-connect matrix.

Figure 2-7 XC Cross-Connect Matrix



Point-to-multipoint connections are used for drop and continue sites in path protection 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.

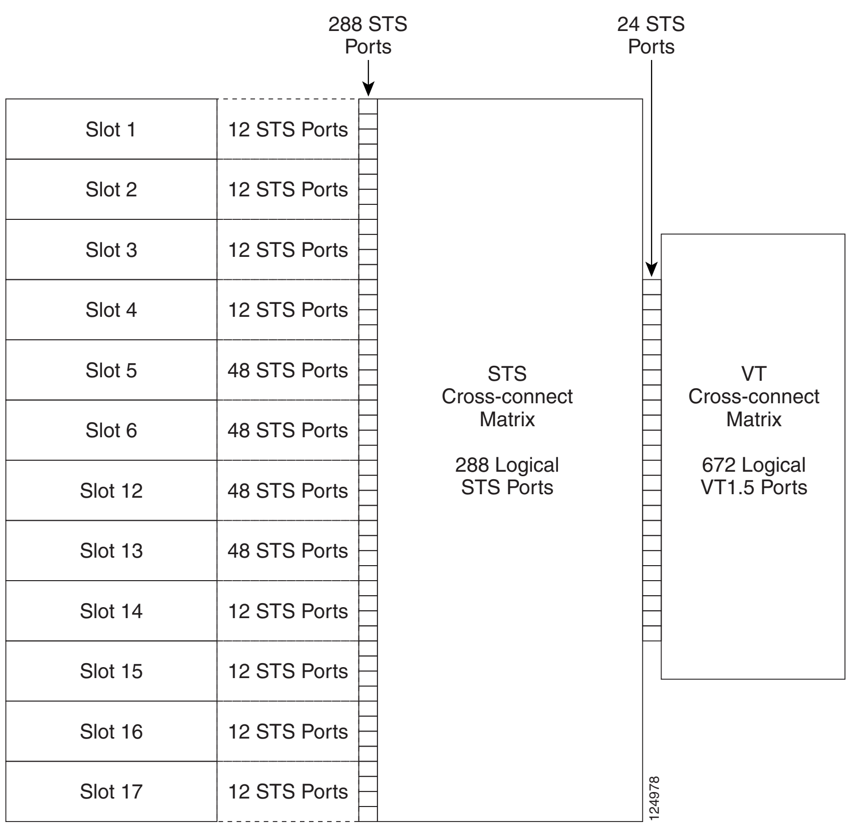
Unidirectional connections can be measured in .5 increments, because the cross-connect views a bi-directional flow as 2 unidirectional connections. An STS-1 on any input port can be mapped to any output port. Therefore the STS cross-connect is non-blocking, because it has the capacity to switch all 288 ports and STSs to all 288 ports and STSs.

XCVT Cross-Connect Card

The XCVT 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-bidirectional 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 XCVT card consists of 288 bidirectional ports and adds a VT matrix that can manage up to 336 bidirectional VT1.5 ports or the equivalent of a bidirectional 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 2-8 is a block diagram of XCVT cross-connect matrix.

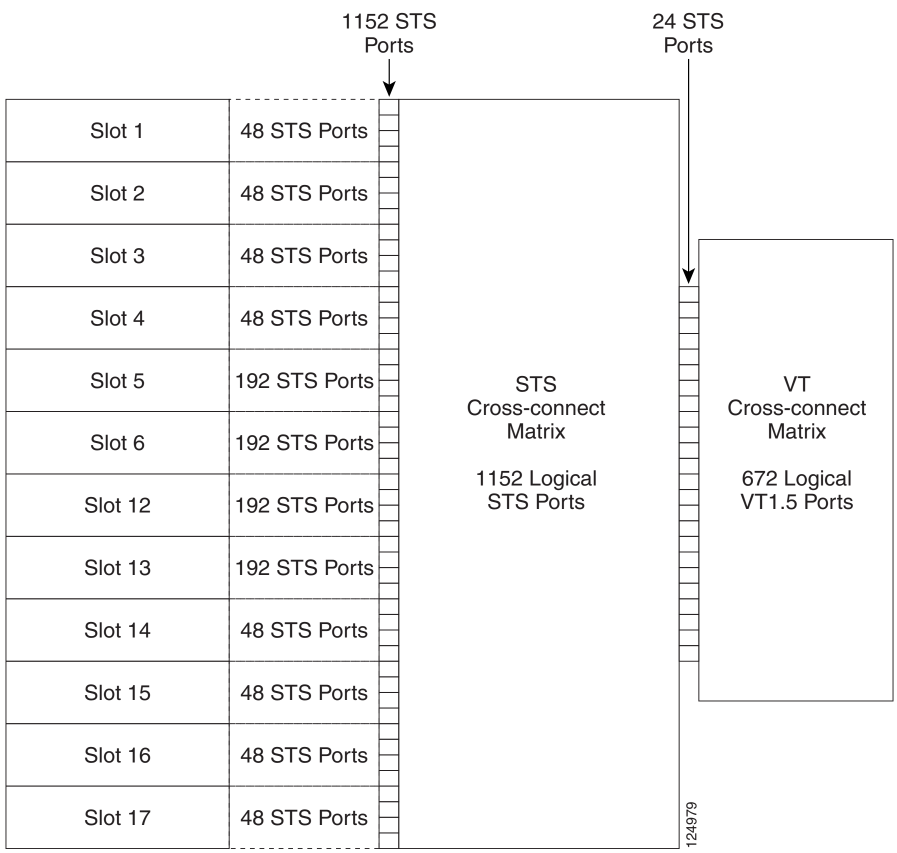
Figure 2-8 XCVT Cross-Connect Matrix



XC-10G Cross-Connect Card

The XC10G is required for OC-192 transport. It has all the STS cross-connect and VT cross-connect functions as the XCVT, but supports four times the STS bandwidth of the XC and XCVT cards. The switch matrix on the XC10G card has 1152 bidirectional STS ports capable of supporting 576 STS cross-connect. The XC10G also includes a VT switch matrix consisting of 672 bidirectional VT1.5 ports capable of supporting up to 336 bidirectional VT1.5 cross-connects. As with the XC and XCVT cards, the XC10G card also supports VT tunneling. There are with 24 of those ports available for VT1.5 switching. Figure 2-9 is a block diagram of the XC10G cross-connect matrix.

Figure 2-9 XC10G 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 2-15 shows the cross-connect capability of each I/O slot on the Cisco ONS 15454.

Table 2-15 Cross-connect Capability of I/O Slots

I/O Slot	High- or Multi-Speed Slot	Cross-connect Capability
1	Multi-Speed	STS12 / STS48

Table 2-15 Cross-connect Capability of I/O Slots

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 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 2-16 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.

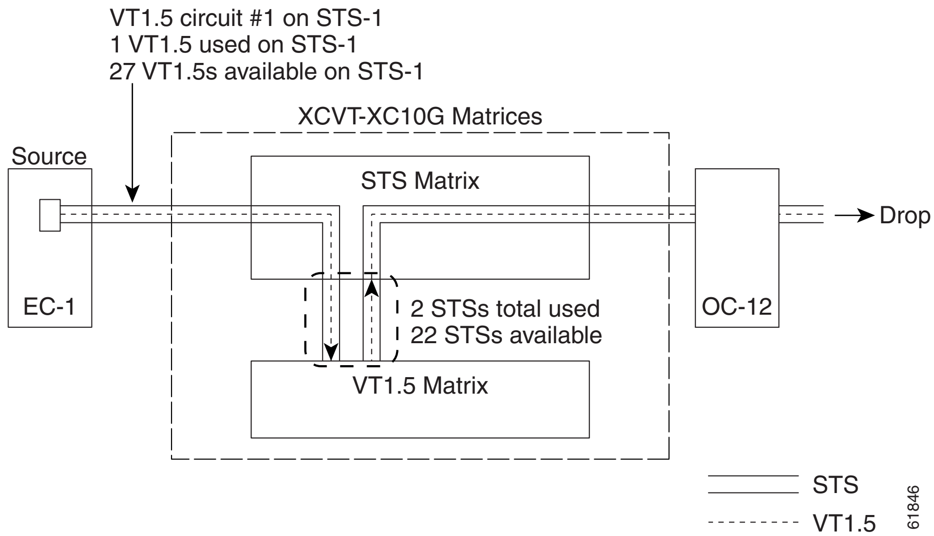
Table 2-16 VT1.5 Cross-connect and VT Tunnel Capacities

Cross-connect Card	Total VT1.5 Ports	VT1.5 Cross-connect Capacity (BLSR)	VT1.5 Cross-connect Capacity (path protection or 1+1)	VT Tunnel Capacity in STS-1S (BLSR, path protection, or 1+1)
XC	0	0	0	144
XC-VT	672	336	224	144
XC-10G	672	336	224	576

Figure 2-10 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 2-10 Example of a VT1.5 Circuit in a BLSR



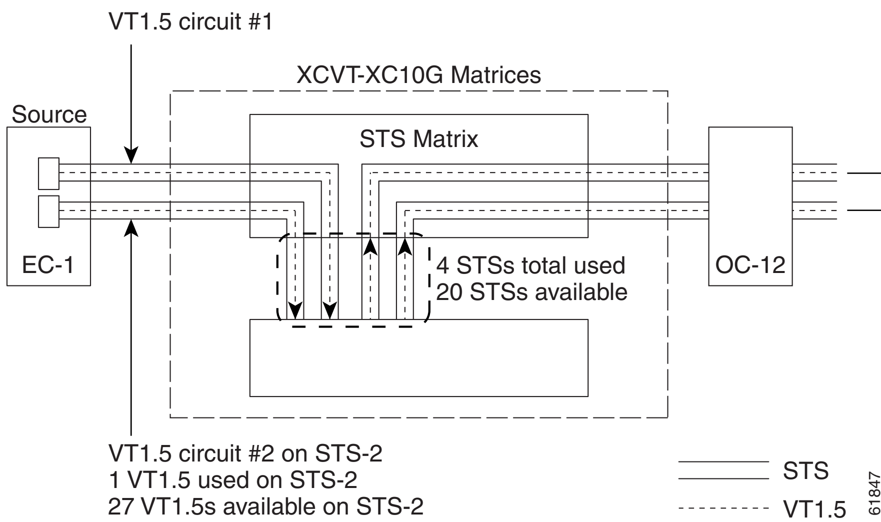
When calculating the VT cross-connect capacity, it is not important to count VT1.5 connections or VT1.5 ports. Instead, count the number of STS ports terminating on the VT1.5 matrix because the terminations on the VT1.5 matrix are STS-based, not VT-based. In an STS that needs VT1.5 cross-connecting, 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 2-11, a second VT1.5 circuit is created from the EC-1 card example illustrated in Figure 2-10. 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 2-11 Example of Two VT1.5 Circuits in a BLSR



If you create VT1.5 circuits on nodes in path protection 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 2-12 shows a VT1.5 circuit at a path protection 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 2-12 Example of a VT1.5 Circuit in a Path Protection or 1+1 Protected Network

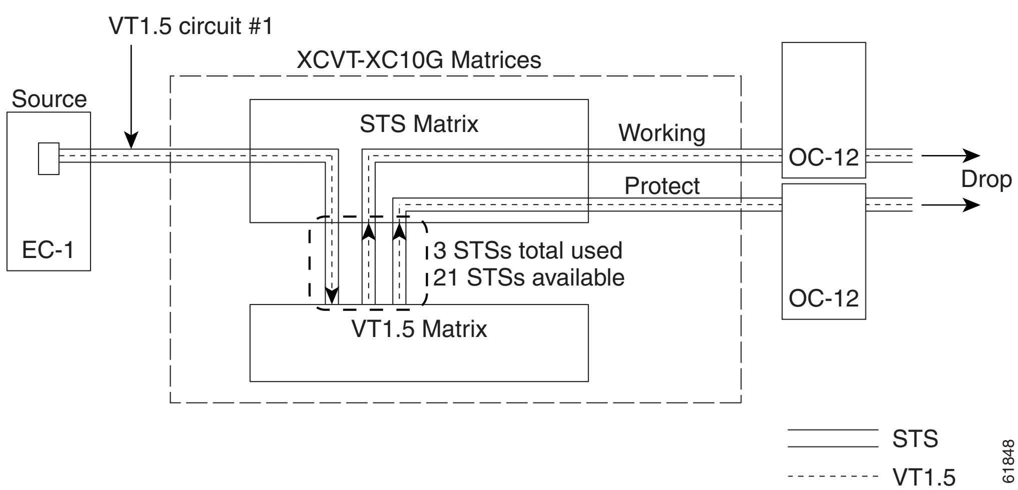
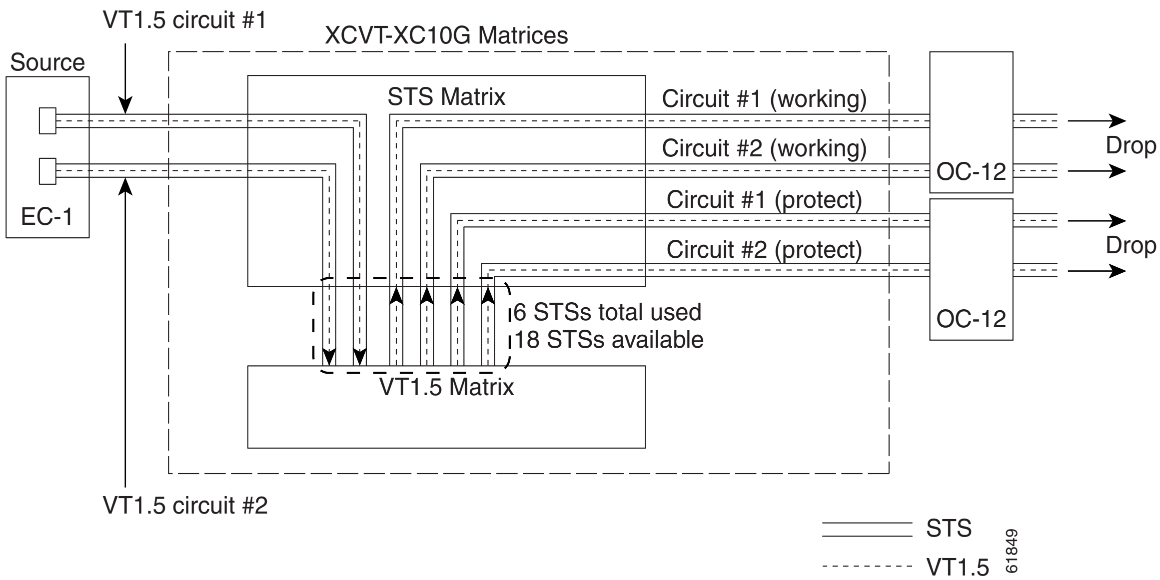


Figure 2-13 shows a second VT1.5 circuit that was created using STS-2. When the second VT1.5 circuit is created:

- 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 2-13 Example of Two VT1.5 Circuits in a Path Protection 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 2-10 example, and no STS ports are used at the pass-through nodes using VT tunnels. In the Figure 2-12 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 2-10 example, and 3 STS ports are used at each node in the Figure 2-12 example.
- In the Figure 2-11 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 2-13, 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.

With Release 5.0 support for VT 1+1 protection increases from 224 to 336 VTs. The CTC Resource Allocation Usage screen is updated to display the working and protect allocation.

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 2-16). 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 2-14 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 2-14 Example of a VT Tunnel

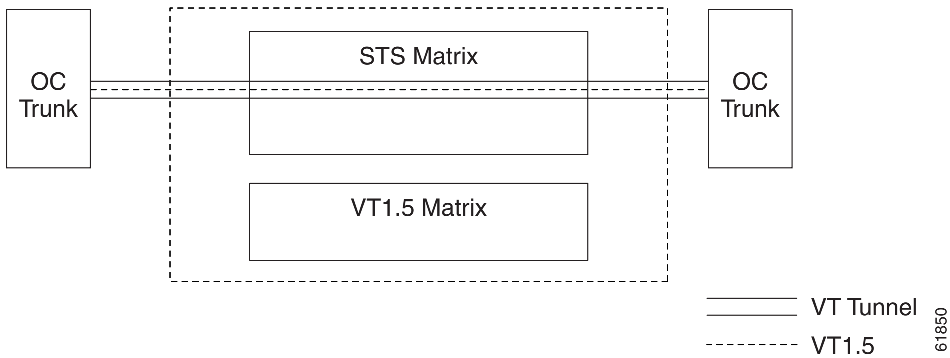


Figure 2-15 shows a six-node ONS 15454 ring with two VT tunnels. One tunnel carries VT1.5 circuits from Node 1 to Node 3. The second tunnel carries VT1.5 circuits from Node 1 to Node 4. Table 2-17 shows the STS usage on the VT 1.5 matrix at each node in a ring based on a given protection scheme and use of VT tunnels. In the Figure 2-15 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 2-15 Example of a Six Node Ring with Two VT Tunnels

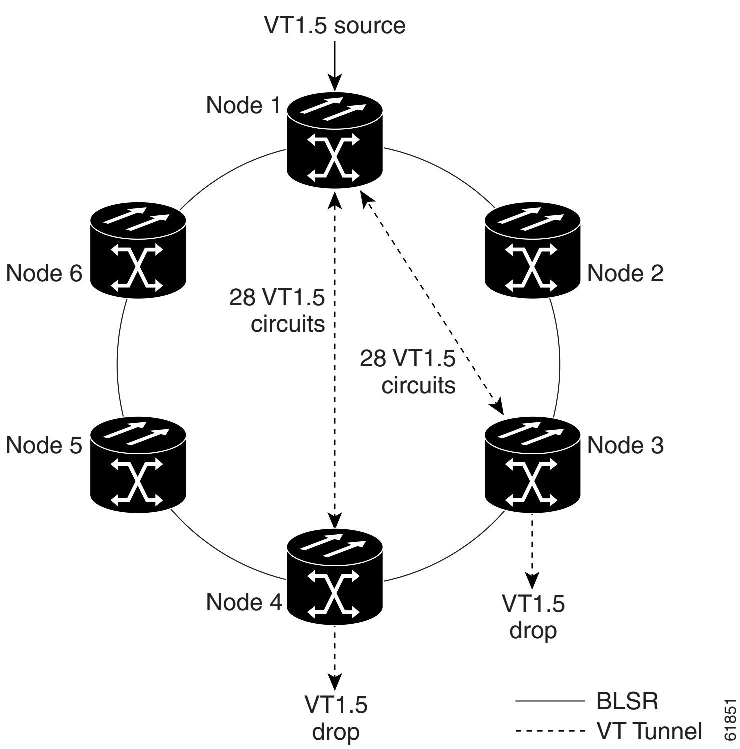


Table 2-17 STS Usage on the VT1.5 Matrix

Node	VT Tunnel (BLSR)	VT Tunnel (path protection or 1+1)	No VT Tunnel (BLSR)	No VT Tunnel (path protection)	No VT Tunnel (1+1)
1	4	6	4	6	6
2	0	0	4	4	4
3	2	3	4	5	5
4	2	3	4	5	5
5	0	0	4	4	4
6	0	0	4	4	4

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.

VT Mapping

The VT structure is designed to transport and switch payloads below the DS3 rate. The ONS 15454 performs VT mapping according to Telcordia GR-253-CORE. Table 2-18 shows the VT numbering scheme for the ONS 15454 as it relates to the Telcordia standard.

Table 2-18 VT Mapping

ONS 15454 VT Number	Telcordia Group/VT Number
VT1	Group1/VT1
VT2	Group2/VT1
VT3	Group3/VT1
VT4	Group4/VT1
VT5	Group5/VT1
VT6	Group6/VT1
VT7	Group7/VT1

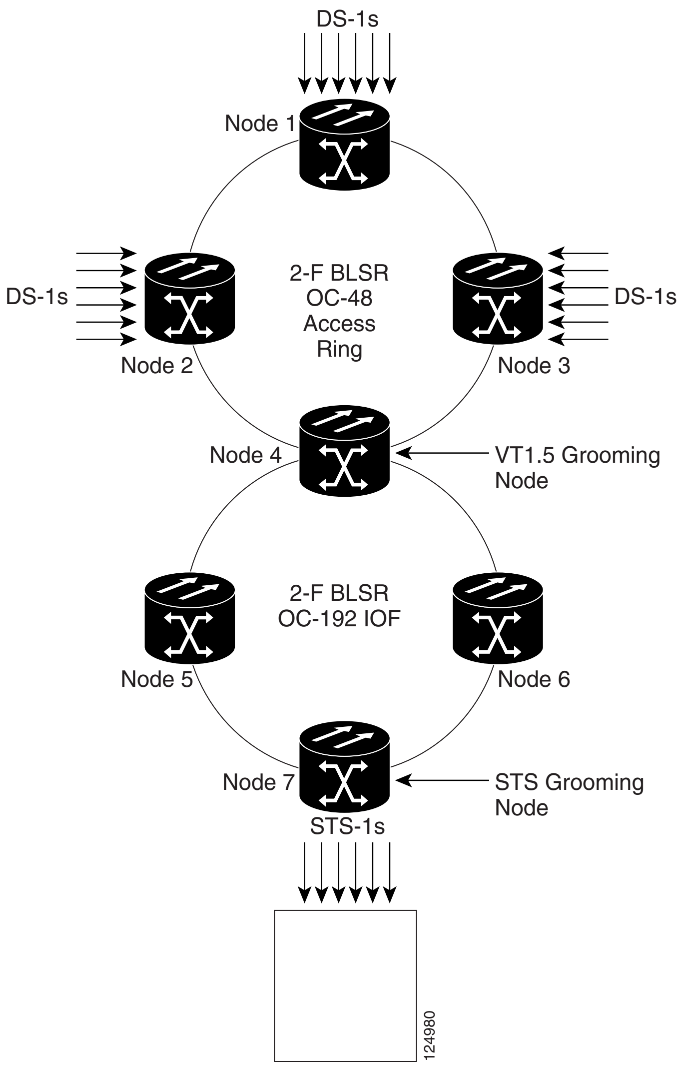
Table 2-18 VT Mapping (continued)

ONS 15454 VT Number	Telcordia Group/VT Number
VT8	Group1/VT2
VT9	Group2/VT2
VT10	Group3/VT2
VT11	Group4/VT2
VT12	Group5/VT2
VT13	Group6/VT2
VT14	Group7/VT2
VT15	Group1/VT3
VT16	Group2/VT3
VT17	Group3/VT3
VT18	Group4/VT3
VT19	Group5/VT3
VT20	Group6/VT3
VT21	Group7/VT3
VT22	Group1/VT4
VT23	Group2/VT4
VT24	Group3/VT4
VT25	Group4/VT4
VT26	Group5/VT4
VT27	Group6/VT4
VT28	Group7/VT4

VT Aggregation Point (VAP)

Starting with System Release 4.0, VT aggregation point (VAP) is a provisioning option only if you are creating DS-1 (VT1.5) circuits where the circuit source or destination is on an EC-1, DS3XM-6, DS3XM-12, or OC-N port on a BLSR, 1+1, or unprotected node. The VAP aggregates VT1.5s from multiple sources onto a single STS at a VT grooming node. The STS grooming node is the destination node where the STS containing the aggregated VT1.5s will be dropped off to either non-ONS 15454 networks or equipment, such as a switch or DACS (see Figure 2-16). VAPs allow VT1.5 circuits packed into a single STS to be routed through intermediate nodes located between the VAP grooming node and VAP destination node, without using any of the intermediate nodes' VT1.5 cross-connect ports. This saves VT1.5 matrix resources at the intermediate nodes.

Figure 2-16 VT Aggregation Point (VAP)



Note VAPs can be created for circuits on BLSR, 1+1, or unprotected ONS 15454 nodes. They cannot be created for circuits on path protection nodes.

The maximum number of VAPs that you can create depends on the node protection topology and number of VT1.5 circuits that terminate on the node. Assuming no other VT1.5 circuits terminate at the node, the maximum number of VAPs that you can terminate at one node is 8 for 1+1 and path protection and 12 for BLSR protection.

Circuits

You can create circuits across and within ONS 15454 nodes and assign different attributes to circuits. For example, you can:

- Create one-way, two-way (bidirectional), or broadcast circuits.
- Assign user-defined names to circuits.

- Assign different circuit sizes.
- Automatically or manually route circuits.
- Automatically create multiple circuits with autoranging. Virtual tributary (VT) tunnels do not use autoranging.
- Provide full protection to the circuit path.
- Provide only protected sources and destinations for circuits.
- Define a secondary circuit source or destination that allows you to interoperate an ONS 15454 path protection with third-party equipment path protection configurations.
- Set path protection circuits as revertive or nonrevertive.

You can provision circuits at any of the following points:

- Before cards are installed. The ONS 15454 allows you to provision slots and circuits before installing the traffic cards. (To provision an empty slot, right-click it and choose a card from the shortcut menu.) However, circuits cannot carry traffic until you install the cards and place their ports in service. For card installation procedures and ring-related procedures, refer to the *Cisco ONS 15454 Procedure Guide*.
- After cards are installed, but before their ports are in service (enabled). You must place the ports in service before circuits can carry traffic.
- After cards are installed and their ports are in service. Circuits carry traffic as soon as the signal is received.

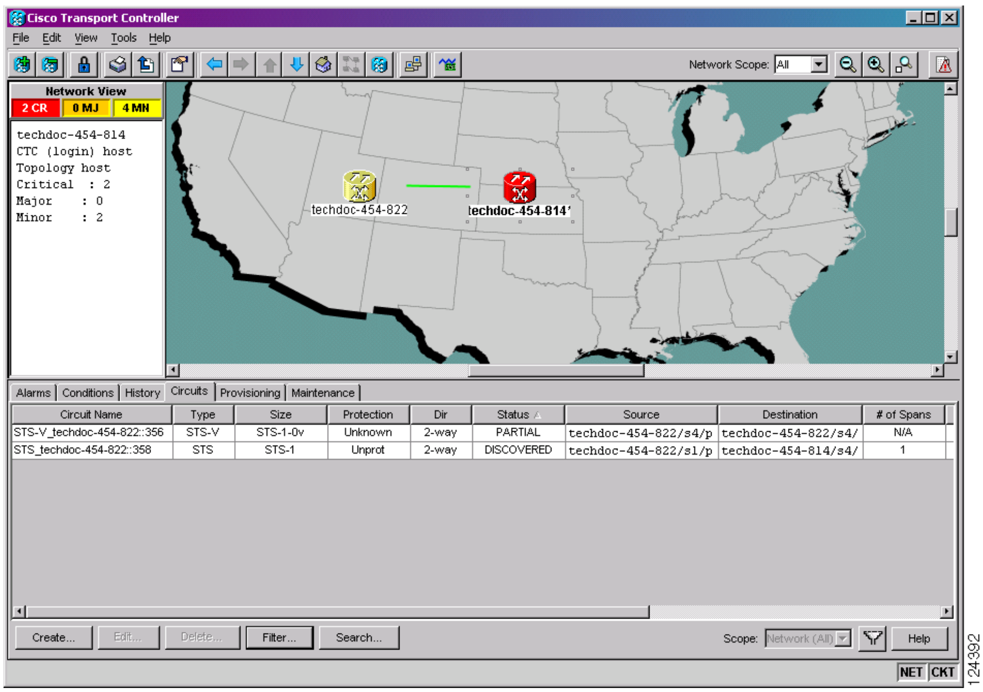
Circuit Properties

The ONS 15454 Circuits window, which appears in network, node, and card view, is where you can view information about circuits. The Circuits window, shown in Figure 2-17, provides the following information:

- Name—The name of the circuit. The circuit name can be manually assigned or automatically generated.
- Type—The circuit types are STS (STS circuit), VT (VT circuit), VTT (VT tunnel), VAP (VT aggregation point), OCHNC (dense wavelength division multiplexing [DWDM] optical channel network connection, STS-V (STS virtual concatenated [VCAT] circuit), or VT-V (VT VCAT circuit).
- Size—The circuit size. VT circuits are 1.5. STS circuit sizes are 1, 3c, 6c, 9c, 12c, 24c, 36c, 48c, and 192c. OCHNC sizes are equipped non specific, Multi-rate, 2.5 Gb/s No FEC (forward error correction), 2.5 Gb/s FEC, 10 Gbps No FEC, and 10 Gb/s FEC (OCHNC is DWDM only). VCAT circuits are VT1.5-n, STS-1-n, STS-3c-n, and STS-12c-n, where n is the number of members.
- OCHNC When—For OCHNCs, the wavelength provisioned for the optical channel network connection.
- Direction—The circuit direction is either two-way or one-way.
- OCHNC Dir—For OCHNCs, the direction of the optical channel network connection is either east to west or west to east.
- Protection—Specifies the type of circuit protection.
- Status—The circuit status. See the "10.2.2 Circuit Status" section on page 10-5.

- Source—The circuit source in the format: node/slot/port "port name"/STS/VT. (The port name appears in quotes.) Node and slot always appear; port "port name"/STS/VT might appear, depending on the source card, circuit type, and whether a name is assigned to the port. If the circuit size is a concatenated size (3c, 6c, 12c, etc.), STSs used in the circuit are indicated by an ellipsis, for example, S7..9, (STSs 7, 8, and 9) or S10..12 (STS 10, 11, and 12).
- Destination— The circuit destination in same format (node/slot/port "port name"/STS/VT) as the circuit source.
- # of VLANS—The number of VLANs used by an Ethernet circuit.
- # of Spans—The number of inter-node links that constitute the circuit. Right-clicking the column displays a shortcut menu from which you can choose to show or hide circuit span detail.
- State—The circuit state.

Figure 2-17 ONS 15454 Circuit Window in Network View



Circuit Status

The circuit statuses that appear in the Circuit window Status column are generated by CTC based on conditions along the circuit path. Table 2-19 shows the statuses that can appear in the Status column.

Table 2-19 ONS 15454 Circuit Status

Status	Definition/Activity
CREATING	CTC is creating a circuit.
DISCOVERED	CTC created a circuit. All components are in place and a complete path exists from circuit source to destination.
DELETING	CTC is deleting a circuit.

Table 2-19 ONS 15454 Circuit Status (continued)

Status	Definition/Activity
PARTIAL	A CTC-created circuit is missing a cross-connect or network span, a complete path from source to destinations does not exist, or an alarm interface panel (AIP) change occurred on one of the circuit nodes and the circuit is in need of repair. (AIPs store the node MAC address.) In CTC, circuits are represented using cross-connects and network spans. If a network span is missing from a circuit, the circuit status is PARTIAL. However, an PARTIAL status does not necessarily mean a circuit traffic failure has occurred, because traffic might flow on a protect path. Network spans are in one of two states: up or down. On CTC circuit and network maps, up spans appear as green lines, and down spans appear as gray lines. If a failure occurs on a network span during a CTC session, the span remains on the network map but its color changes to gray to indicate that the span is down. If you restart your CTC session while the failure is active, the new CTC session cannot discover the span and its span line does not appear on the network map. Subsequently, circuits routed on a network span that goes down appear as DISCOVERED during the current CTC session, but appear as PARTIAL to users who log in after the span failure.
DISCOVERED_TL1	A TL1-created circuit or a TL1-like, CTC-created circuit is complete. A complete path from source to destinations exists.
PARTIAL_TL1	Missing a cross-connect or circuit span (network link), and a complete path from source to destination does not exist.
CONVERSION_PENDING	An existing circuit in a topology upgrade is set to this state. The circuit returns to the DISCOVERED state once the topology upgrade is complete.
PENDING_MERGE	Any new circuits created to represent an alternate path in a topology upgrade are set to this status to indicate that it is a temporary circuit. These circuits can be deleted if a topology upgrade fails.

Circuit States

The circuit state is the status of all the cross-connect states within the circuit. The Release 5.0 circuit creation wizard uses the new node default value, CTC.circuits.state, as the default circuit state when creating a circuit. This default can be set in the NE Defaults window, and will not be overridden by the "sticky" command feature, which caused the default value to be abandoned when using the circuit provisioning wizard in previous software releases.

A circuit can be in one of the following states:

- If all cross-connects in a circuit are in the In-Service and Normal (IS-NR) service state, the circuit service state is In-Service (IS).
- If all cross-connects in a circuit are in the Out-of-Service and Management, Maintenance (OOS-MA,MT); Out-of-Service and Management, Disabled (OOS-MA,DSBLD); or Out-of-Service and Autonomous, Automatic In-Service (OOS-AU,AINS) service state, the circuit service state is Out-of-Service (OOS).

- PARTIAL is appended to the OOS circuit service state when circuit cross-connects state are mixed and not all in IS-NR. The OOS-PARTIAL state can occur during automatic or manual transitions between states. For example, OOS-PARTIAL appears if you assign the IS,AINS administrative state to a circuit with DS-1 or DS3XM cards as the source or destination. Some cross-connects transition to the In-Service and Normal (IS-NR) service state, while others transition to Out-Of-Service and Autonomous, Automatic In-Service (OOS-AU,AINS). OOS-PARTIAL can appear during a manual transition caused by an abnormal event such as a CTC crash or communication error, or if one of the cross-connects could not be changed. Refer to the *Cisco ONS 15454 Troubleshooting Guide* for troubleshooting procedures. The OOS-PARTIAL circuit state does not apply to OCHNC circuit types.

The state of a VCAT circuit is an aggregate of its member circuits. An In Group member has cross-connects in the IS-NR; OOS-MA,AINS; or OOS-MA,MT service states. An Out of Group member has cross-connects in the OOS-MA,DSBLD or OOS-MA,OOG service states. You can view whether a VCAT member is In Group or Out of Group in the VCAT State column on the Edit Circuits window. VCAT circuits can be in one of the following states:

- If all member circuits are IS, the VCAT circuit is IS.
- If all In Group member circuits are OOS, the VCAT circuit state is OOS.
- If no member circuits exist or are all Out of Group, the state of a VCAT circuit is OOS.
- A VCAT circuit is OOS-PARTIAL when In Group member states are mixed and not all in IS.

You can assign a state to circuit cross-connects at two points:

- During circuit creation, you can set the state on the Create Circuit wizard.
- After circuit creation, you can change a circuit state on the Edit Circuit window or from the Tools > Circuits > Set Circuit State menu.

During circuit creation, you can apply a service state to the drop ports in a circuit; however, CTC does not apply a requested state other than IS-NR to drop ports if:

- The port is a timing source.
- The port is provisioned for orderwire or tunnel orderwire.
- The port is provisioned as a DCC or DCC tunnel.
- The port supports 1+1 or bidirectional line switched rings (BLSRs).

Circuits do not use the soak timer, but ports do. The soak period is the amount of time that the port remains in the OOS-AU,AINS service state after a signal is continuously received. When the cross-connects in a circuit are in the OOS-AU,AINS service state, the ONS 15454 monitors the cross-connects for an error-free signal. It changes the state of the circuit from OOS to IS or to OOS-PARTIAL as each cross-connect assigned to the circuit path is completed. This allows you to provision a circuit using TL1, verify its path continuity, and prepare the port to go into service when it receives an error-free signal for the time specified in the port soak timer. Two common examples of state changes you see when provisioning circuits using CTC are:

- When assigning the IS,AINS administrative state to cross-connects in VT1.5 circuits and VT tunnels, the source and destination ports on the VT1.5 circuits remain in the OOS-AU,AINS service state until an alarm-free signal is received for the duration of the soak timer. When the soak timer expires and an alarm-free signal is found, the VT1.5 source port and destination port service states change to IS-NR and the circuit service state becomes IS.

- When assigning the IS,AINS administrative state to cross-connects in STS circuits, the circuit source and destination ports transition to the OOS-AU,AINS service state. When an alarm-free signal is received, the source and destination ports remain OOS-AU,AINS for the duration of the soak timer. After the port soak timer expires, STS source and destination ports change to IS-NR and the circuit service state to IS.

To find the remaining port soak time, choose the Maintenance > AINS Soak tabs in card view and click the Retrieve button. If the port is in the OOS-AU,AINS state and has a good signal, the Time Until IS column shows the soak count down status. If the port is OOS-AU,AINS and has a bad signal, the Time Until IS column indicates that the signal is bad. You must click the Retrieve button to obtain the latest time value.

Circuit Protection Types

The Protection column on the Circuit window shows the card (line) and SONET topology (path) protection used for the entire circuit path. Table 2-20 shows the protection type indicators that appear in this column.

Table 2-20 Circuit Protection Types

Protection Type	Description
1+1	The circuit is protected by a 1+1 protection group.
2F BLSR	The circuit is protected by a two-fiber BLSR.
4F BLSR	The circuit is protected by a four-fiber BLSR.
2F-PCA	The circuit is routed on a protection channel access (PCA) path on a two-fiber BLSR. PCA circuits are unprotected.
4F-PCA	The circuit is routed on a PCA path on a four-fiber BLSR. PCA circuits are unprotected.
BLSR	The circuit is protected by both a two-fiber and a four-fiber BLSR.
DRI	The circuit is protected by a dual-ring interconnection.
N/A	A circuit with connections on the same node is not protected.
PCA	The circuit is routed on a PCA path on both two-fiber and four-fiber BLSRs. PCA circuits are unprotected.
Protected	The circuit is protected by diverse SONET topologies, for example, a BLSR and a path protection, or a path protection and 1+1.
Unknown	A circuit has a source and destination on different nodes and communication is down between the nodes. This protection type appears if not all circuit components are known.
Unprot (black)	A circuit with a source and destination on different nodes is not protected.
Unprot (red)	A circuit created as a fully protected circuit is no longer protected due to a system change, such as removal of a BLSR or 1+1 protection group.
Path protection	The circuit is protected by a path protection.
SPLITTER	The circuit is protected by the protect transponder (TXPP_MR_2.5G) splitter protection.
Y-Cable	The circuit is protected by a transponder or muxponder card Y-cable protection group.

Circuit Information in the CTC Edit Circuit Window

The detailed circuit map on the CTC Edit Circuit window allows you to view information about ONS 15454 circuits. Routing information that appears includes the following:

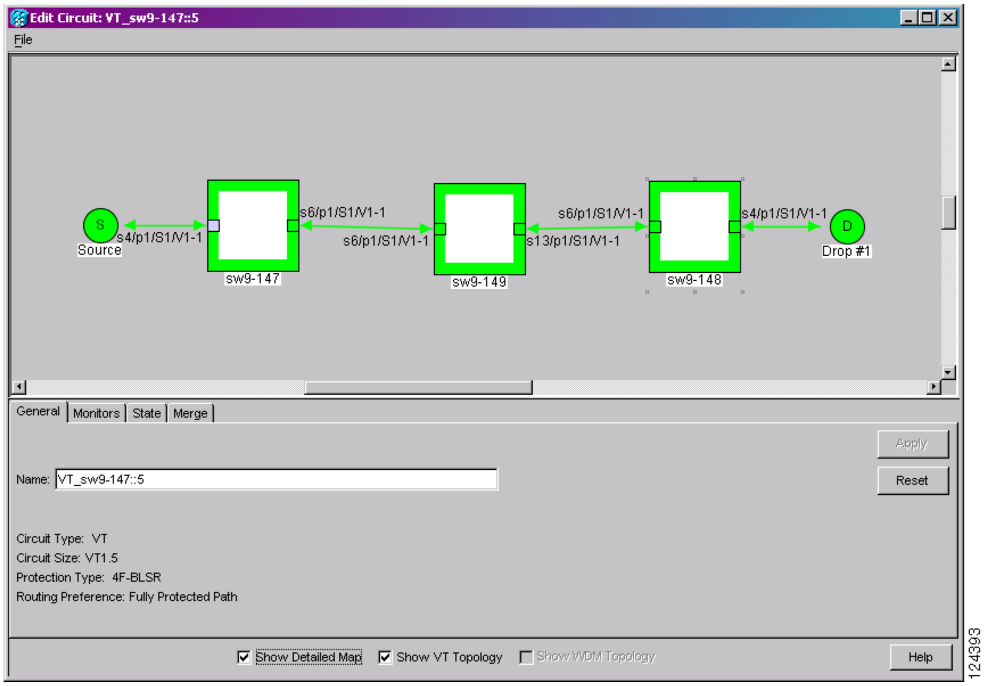
- Circuit direction (unidirectional/bidirectional)
- The nodes, STSs, and VTs through which a circuit passes, including slots and port numbers
- The circuit source and destination points
- Open Shortest Path First (OSPF) area IDs
- Link protection (path protection, unprotected, BLSR, 1+1) and bandwidth (OC-N)
- Provisionable patchcords between two cards on the same node or different nodes. For BLSRs, the detailed map shows the number of BLSR fibers and the BLSR ring ID. For path protection configurations, the map shows the active and standby paths from circuit source to destination, and it also shows the working and protect paths. The map indicates nodes set up as dual-ring interconnect nodes. For VCAT circuits, the detailed map is not available for an entire VCAT circuit. However, you can view the detailed map to view the circuit route for each individual member.

You can also view alarms and states on the circuit map, including the following:

- Alarm states of nodes on the circuit route
- Number of alarms on each node organized by severity
- Port service states on the circuit route
- Alarm state/color of most severe alarm on port
- Loopbacks
- Path trace states
- Path selector states

Figure 2-18 shows a VT circuit routed on a four-fiber BLSR.

Figure 2-18 BLSR Circuit Displayed on the Detailed Circuit Map



By default, the working path is indicated by a green, bidirectional arrow, and the protect path is indicated by a purple, bidirectional arrow. Source and destination ports are shown as circles with an S and D. Port states are indicated by colors, shown in Table 2-21.

Table 2-21 Port State Color Indicators

Port Color	Service State
Green	IS-NR
Gray	OOS-MA,DSBLD
Violet	OOS-AU,AINS
Blue (Cyan)	OOS-MA,MT

A notation within or by the squares in detailed view indicates switches and loopbacks, including:

- F = Force switch
- M = Manual switch
- L = Lockout switch
- Arrow = Facility (outward) or terminal (inward) loopback

Move the mouse cursor over nodes, ports, and spans to see tooltips with information including the number of alarms on a node (organized by severity), port service state, and the protection topology. Right-click a node, port, or span on the detailed circuit map to initiate the following circuit actions:

- Right-click a unidirectional circuit destination node to add a drop to the circuit.
- Right-click a port containing a path-trace-capable card to initiate the path trace.
- Right-click a path protection span to change the state of the path selectors in the path protection circuit.

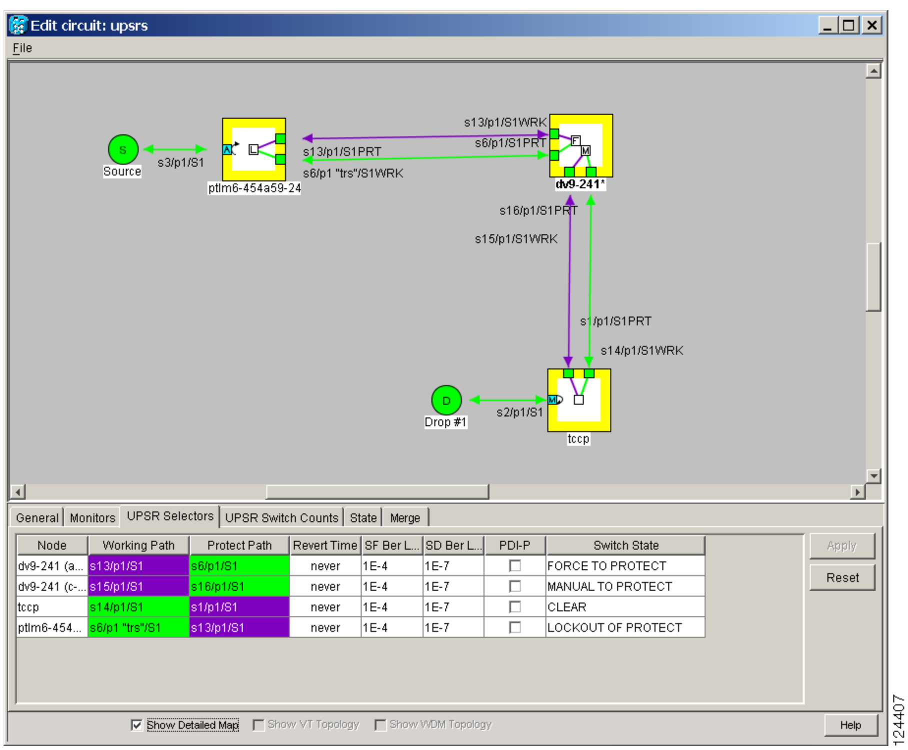
Figure 2-19 shows an example of the information that can appear. From this example, you can determine:

- The circuit has one source and one destination.
- The circuit has three nodes in its route; the state of the most severe alarm can be determined by the color of the node icons. For example, yellow indicates that the most severe alarm is minor in severity.
- The STSs and ports that the circuit passes through from source to destination.
- The port states and severity of the most severe alarm on each port.
- A facility loopback exists on the port at one end of the circuit; a terminal loopback exists at the other end port.
- An automatic path trace exists on one STS end of the circuit; a manual path trace exists at the other STS end.
- The circuit is path protection-protected (by path selectors). One path selector has a Lockout, one has a Force switch, one has a Manual switch, and the others are free of external switching commands.
- The working path (green) flows from ptlm6-454a59-24/s6/p1/S1 to dv9-241/s6/p1/S1, and from dv9-241/s16/p1/S1 to tccp/s14/p1/vc3-3. The protect path (purple) is also visible.
- On ptlm6-454a59-24 and tccp, the working path is active; on dv9-241, the protect path is active.

From the example, you could perform the following actions:

- Display any port or node view.
- Edit the path trace states of any port that supports path trace.
- Change the path selector state of any path protection path selector.

Figure 2-19 Detailed Circuit Map Showing a Terminal Loopback



VCAT Circuits

Virtual concatenated (VCAT) circuits, also called VCAT groups (VCGs), transport traffic using noncontiguous time division multiplexing (TDM) timeslots, avoiding the bandwidth fragmentation problem that exists with contiguous concatenated circuits. The cards that support VCAT circuits are the CE-100T-8, FC_MR-4 (both line rate and enhanced mode), and ML-Series cards.

In a VCAT circuit, circuit bandwidth is divided into smaller circuits called VCAT members. The individual members act as independent TDM circuits. All VCAT members should be the same size and must originate/terminate at the same end points. At the terminating nodes, these member circuits are multiplexed into a contiguous stream of data. Intermediate ONS 15454 nodes treat the VCAT members as normal circuits that are independently routed and protected by the SONET network. For two-fiber BLSR configurations, some members can be routed on protected time slots and others on PCA time slots. If a member is unprotected, all members must be unprotected. Path protection is not supported.

VCAT Circuit Size

Table 2-22 lists supported circuit rates and number of members for each card.

Table 2-22 ONS 15454 Card VCAT Circuit Rates and Members

Card	Circuit Rate	Number of Members
CE-100T-8	VT1.5	1–64
	STS-1	1–3[1]
FC_MR-4 (line rate mode)	STS-1	24 (1Gbps port) 48 (2Gbps port)
	STS-3c	8 (1Gbps port) 16 (2Gbps port)
FC_MR-4 (enhanced mode)	STS-1	1–24 (1Gbps port) 1–48 (2Gbps port)
	STS-3c	1–8 (1Gbps port) 1–16 (2Gbps port)
ML-Series	STS-1, STS-3c, STS-12c	2

1. A VCAT circuit with a CE-100T-8 card as a source or destination and an ML-Series card as a source or destination can have only two members.

Use the Members tab on the CTC Edit Circuit window to add or delete members from a VCAT circuit. The capability to add or delete members depends on the card and whether the VCAT circuit is LCAS, Sw-LCAS, or non-LCAS.

- CE-100T-8 card - You can add or delete members to an LCAS VCAT circuit without affecting service. Before deleting a member of an LCAS VCAT circuit, Cisco recommends that you put the member in the OOS-MA,OOG service state. If you create non-LCAS VCAT circuits on the CE-100T-8 card, adding members to the circuit is possible, but service-affecting. You cannot delete members from non-LCAS VCAT circuits without affecting the entire VCAT circuit.

- FC_MR-4 (enhanced mode) card - You can add or delete Sw-LCAS VCAT members, although it might affect service. Before deleting a member, Cisco recommends that you put the member in the OOS-MA,OOG service state. You cannot add or delete members from non-LCAS VCAT circuits on FC_MR-4 cards.
- FC_MR-4 (line mode) card - All VCAT circuits using FC_MR-4 (line mode) cards have a fixed number of members; you cannot add or delete members.
- ML-Series card - All VCAT circuits using ML-Series cards have a fixed number of members; you cannot add or delete members.

Table 2-23 summarizes the VCAT capabilities for each card.

Table 2-23 VCAT Card Capabilities

Card	Mode	Add A Member	Delete A Member	Support OOS-MA,OOG
CE-100T-8	LCAS	Yes	Yes	Yes
	SW-LCAS	No	No	No
	Non-LCAS	Yes	No	No
FC_MR-4 (enhanced mode)	SW-LCAS	Yes	Yes	Yes
	Non-LCAS	No	No	No
FC_MR-4 (line mode)	Non-LCAS	No	No	No
ML-Series	SW-LCAS	No	No	No
	Non-LCAS	No	No	No

VCAT Member Routing

The automatic and manual routing selection applies to the entire VCAT circuit, that is, all members are manually or automatically routed. Bidirectional VCAT circuits are symmetric, which means that the same number of members travel in each direction. With automatic routing, you can specify the constraints for individual members; with manual routing, you can select different spans for different members.

Two types of automatic and manual routing are available for VCAT members: common fiber routing and split routing. CE-100T-8, FC_MR-4 (both line rate and enhanced mode), and ML-Series cards support common fiber routing. In common fiber routing, all VCAT members travel on the same fibers, which eliminates delay between members. Three protection options are available for common fiber routing: Fully Protected, PCA, and Unprotected.

CE-100T-8 cards also support split fiber routing, which allows the individual members to be routed on different fibers or each member to have different routing constraints. This mode offers the greatest bandwidth efficiency and also the possibility of differential delay, which is handled by the buffers on the terminating cards. Four protection options are available for split fiber routing: Fully Protected, PCA, Unprotected, and DRI.

In both common fiber and split fiber routing, each member can use a different protection scheme; however, for common fiber routing, CTC checks the combination to make sure a valid route exists. If it does not, the user must modify the protection type. In both common fiber and split fiber routing, intermediate nodes treat the VCAT members as normal circuits that are independently routed and protected by the SONET network. At the terminating nodes, these member circuits are multiplexed into a contiguous stream of data. Figure 2-20 shows an example of common fiber routing and Figure 2-21 shows an example of split fiber routing.

Figure 2-20 VCAT on Common Fiber

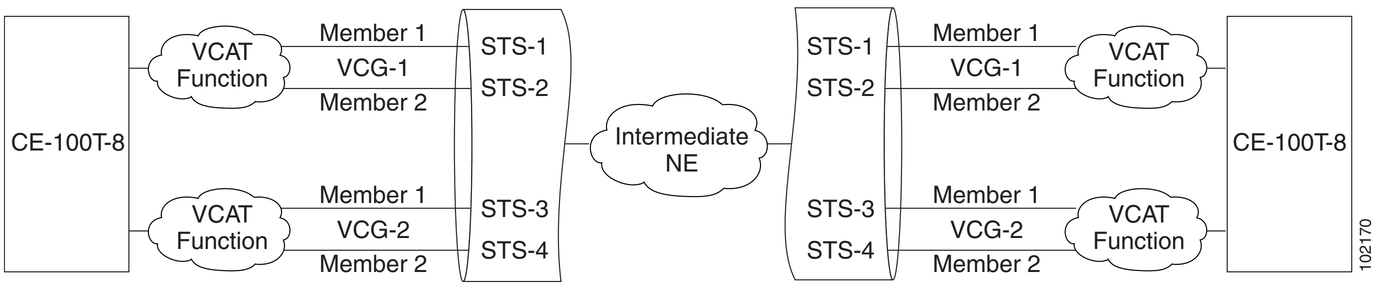
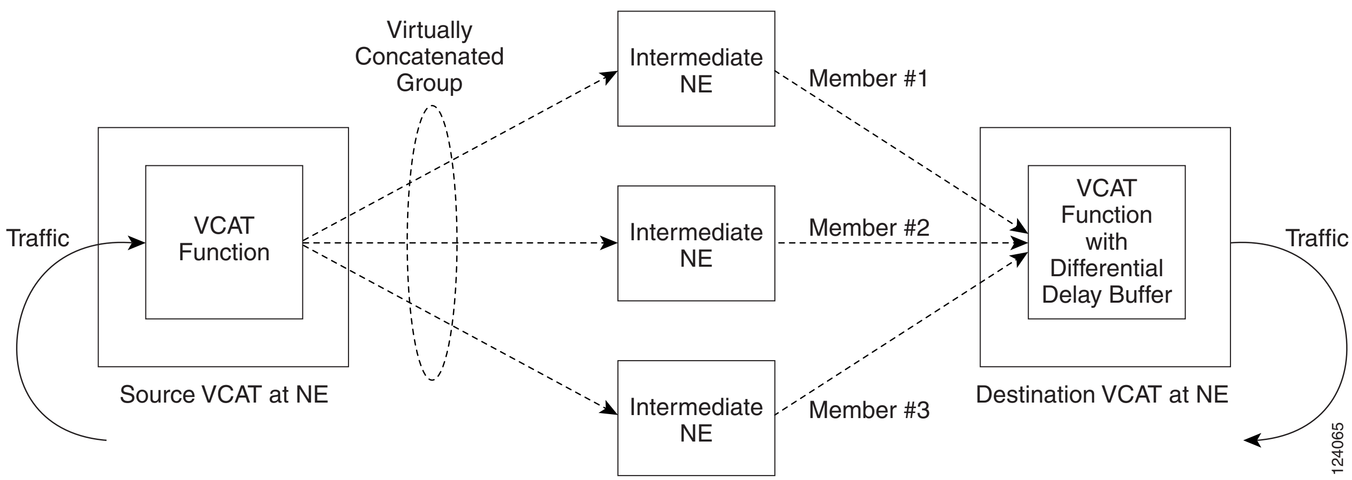


Figure 2-21 VCAT Split Fiber Routing



LCAS

The CE-100T-8 card supports Link Capacity Adjustment Scheme (LCAS), which is a signaling protocol that allows dynamic bandwidth adjustment of VCAT circuits. When a member fails, a brief traffic hit occurs. LCAS temporarily removes the failed member from the VCAT circuit for the duration of the failure, leaving the remaining members to carry the traffic. When the failure clears, the member circuit is automatically added back into the VCAT circuit without affecting traffic. You can select LCAS during VCAT circuit creation.

Note Although LCAS operations are errorless, a SONET error can affect one or more VCAT members. If this occurs, the VCAT Group Degraded (VCG-DEG) alarm is raised. For information on clearing this alarm, refer to the *Cisco ONS 15454 Troubleshooting Guide*.

Instead of LCAS, the FC_MR-4 (enhanced mode) and ML-Series cards support Software-Link Capacity Adjustment Scheme (Sw-LCAS). Sw-LCAS is a limited form of LCAS that allows the VCAT circuit to adapt to member failures and keep traffic flowing at a reduced bandwidth. Sw-LCAS uses legacy SONET failure indicators like AIS-P and RDI-P to detect member failure. Sw-LCAS removes the failed member from the VCAT circuit, leaving the remaining members to carry the traffic. When the failure clears, the member circuit is automatically added back into the VCAT circuit. For ML-Series cards, Sw-LCAS allows circuit pairing over two-fiber BLSRs. With circuit pairing, a VCAT circuit is set up between two ML-Series cards; one is a protected circuit (line protection) and the other is PCA. For four-fiber BLSR, member protection cannot be mixed. You select Sw-LCAS during VCAT circuit creation. The FC_MR-4 (line rate mode) does not support Sw-LCAS.

In addition, you can create non-LCAS VCAT circuits, which do not use LCAS or Sw-LCAS. While LCAS and Sw-LCAS member cross-connects can be in different service states, all In Group non-LCAS members must have cross-connects in the same service state. A non-LCAS circuit can mix Out of Group and In Group members, as long as the In Group members are in the same service state. Non-LCAS members do not support the OOS-MA,OOG service state; to put a non-LCAS member in the Out of Group VCAT state, use OOS-MA,DSBLD.

Note Protection switching for LCAT and non-LCAS VCAT circuits may exceed 60 ms. Traffic loss for VT VCAT circuits is approximately two times more than an STS VCAT circuit. You can minimize traffic loss by reducing path differential delay.

Portless Transmux Circuits

The DS3XM-12 card provides a portless transmux interface to change DS-3s into VT1.5s. For XC-VT drop slots (1–4 or 14–17), the DS3XM-12 card provides a maximum of 6 portless transmux interfaces. For XC-VT trunk slots and XC-10G any slots, the DS3XM-12 card provides a maximum of 12 portless transmux interfaces. If a pair of ports are configured as portless transmux, CTC allows you to create a DS3/STS1 circuit using one of these ports as the circuit end point. You can create separate DS1/VT1.5 circuits (up to 28) using the other port in this portless transmux pair.

Table 2-24 lists the portless transmux mapping for Slots 1–4 and 14–17 with the XC-VT cross-connect (STS-12).

Table 2-24 Portless Transmux Mapping with the XCVT

DS3XM-12 Card Slot	Physical Port	Portless Port Pair
1–4 or 14–17	1, 2	13, 14
	3, 4	15, 16
	4, 6	17, 18
	7, 8	19, 20
	9, 10	21, 22
	11, 12	23, 24

Table 2-25 lists the portless transmux mapping for Slots 5–6 and 12–13 with the XCVT cross-connect (STS-48).

Table 2-25 Portless Transmux Mapping for Slots 5–6 and 12–13 with the XCVT

Physical Port	Portless Port Pairs
1	13, 14
2	25, 26
3	15, 16
4	27, 28
5	17, 18
6	29, 30
7	19, 20
8	31, 32
9	21, 22
10	33, 34
11	23, 24
12	35, 36

Table 2-26 lists the portless tranmux mapping for Slots 1–6 and 12–17 with the XC10G cross-connect (STS-48).

Table 2-26 Portless Transmux Mapping with the XC10G

Physical Port	Portless Port Pairs
1	13, 14
2	25, 26
3	15, 16
4	27, 28
5	17, 18
6	29, 30
7	19, 20
8	31, 32
9	21, 22
10	33, 34
11	23, 24
12	35, 36

Multiple Destinations for Unidirectional Circuits

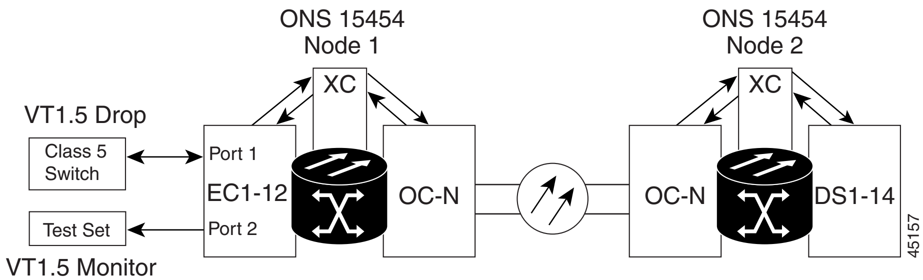
Unidirectional circuits can have multiple destinations for use in broadcast circuit schemes. In broadcast scenarios, one source transmits traffic to multiple destinations, but traffic is not returned to the source.

When you create a unidirectional circuit, the card that does not have its backplane receive (Rx) input terminated with a valid input signal generates a loss of signal (LOS) alarm. To mask the alarm, create an alarm profile suppressing the LOS alarm and apply the profile to the port that does not have its Rx input terminated.

Monitor Circuits

Monitor circuits are secondary circuits that monitor traffic on primary bidirectional circuits. At Node 1, a VT1.5 is dropped from Port 1 of an EC1-12 card. To monitor the VT1.5 traffic, plug test equipment into Port 2 of the EC1-12 card and provision a monitor circuit to Port 2. Circuit monitors are one-way. The monitor circuit in Figure 2-22 monitors VT1.5 traffic received by Port 1 of the EC1-12 card.

Figure 2-22 VT1.5 Monitor Circuit Received at an EC1-12 Port



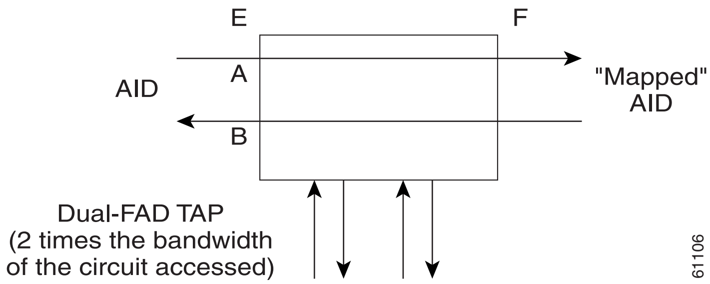
Note Monitor circuits cannot be used with Ethernet circuits.

Test Access

The test access feature allows a third-party broadband remote test unit (BRTU) to create non-intrusive test access points (TAPs) to monitor the circuits on the ONS 15454 for errors. The test access feature also allows the circuit to be split (intrusive), so that the transmission paths can be tested for bit errors via the use of various bit test patterns. The two BRTUs supported by the ONS 15454 are the Hekimian/Spirent BRTU-93 (6750) and the TTC/Acterna Centest 650.

A test access point (TAP) provides the capability of connecting the circuit under test to a BRTU. This connection initially provides in-service monitoring capability to permit the tester to determine that the circuit under test is idle. The monitor connection should not disturb the circuit under test. The access point and BRTU also provide the capability of splitting a circuit under test. A split consists of breaking the transmission path of the circuit under test. This is done out of service. The two sides of the access point are called the Equipment (E) and Facility (F) directions. For a 4-wire or 6-wire circuit, the transmission pairs within the access point are defined as the A and B pairs. In Figure 2-23, the circuit under test should be wired into the access point so the direction of transmission on the A pair is from E to F, and the transmission direction for the B pair is from F to E.

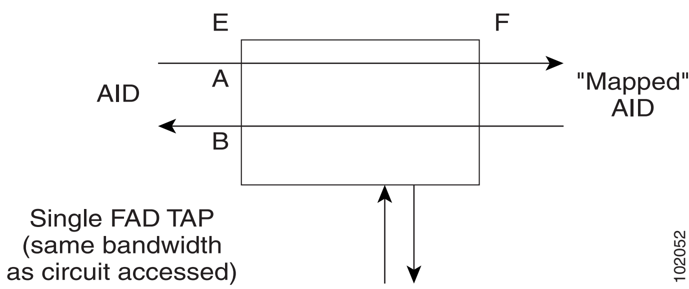
Figure 2-23 Circuit With No Access Dual FAD TAP



A dual FAD (facility access digroup) TAP uses twice the bandwidth of the circuit under test. This can be specified by the TAPTYPE parameter in the ED-<MOD2> command. The values are SINGLE/DUAL. It defaults to DUAL.

A single FAD TAP uses half the bandwidth as that of the dual FAD i.e., it will use the same bandwidth as the circuit accessed for the TAP creation. This can be specified by the TAPTYPE parameter. The values are SINGLE/DUAL. The MONEF, SPLTEF, LOOPEF modes are not supported by Single FAD TAPs (see Figure 2-24).

Figure 2-24 Circuit With No Access Single FAD TAP



Use TL1 commands for creating and deleting TAPs, connecting or disconnecting TAPs to circuit cross-connects and changing the mode of test access on the ONS 15454. You can view test access information in CTC, from in node view click the Maintenance > Test Access tabs.

When you provision a port to be a test access port, the next immediate port should be available and is automatically selected to be part of the Test Access Pair (TAP). In the example below, only the VT1-3-1-1-1 is explicitly entered in the command, but since TAP's are provisioned in pairs, the 15454, automatically selects VT1-3-1-2-1 also, to be part of this TAP #1. Refer to the *Cisco ONS SONET TL1 Command Guide* for the TL1 commands to create, delete, connect, change, retrieve, and disconnect TAPs.

- Open a TL1 session:
  - C:\>telnet 10.89.238.234 2361
- Login to the ONS 15454:
  - ACT-USER::CISCO15:100;
- Create a TAP on a DS1 card:
  - ED-VT1::VT1-3-1-1-:100:::TACC=1;
- Create a DS1 TAP on the last 2 ports of DS1 card
  - ED-VT1::VT1-3-1-6-2:100:::TACC=2;

Note When provisioning a port to be first port of a TAP, you should never select the very last port of the DS1 card, otherwise, the command will be denied.

Path Protection Circuits

Use the CTC Edit Circuits window to change path protection selectors and switch protection paths (see Figure 2-25). In the UPSR Selectors subtab on the Edit Circuits window, you can:

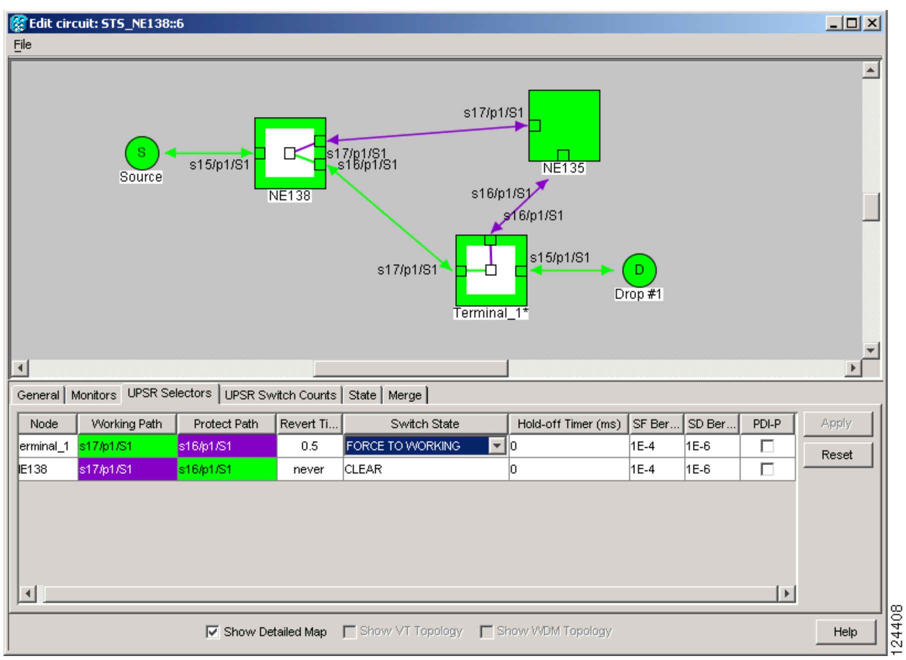
- View the path protection circuit's working and protection paths.
- Edit the reversion time.
- Set the hold-off timer.
- Edit the Signal Fail/Signal Degrade thresholds.
- Change PDI-P settings.

Note In the UPSR Selectors tab, the SF Ber Level and SD Ber Level columns display "N/A" for those nodes that do not support VT signal bit error rate (BER) monitoring. In Software Release 5.0, only the Cisco ONS 15310-CL supports VT signal BER monitoring.

In the UPSR Switch Counts subtab, you can:

- Perform maintenance switches on the circuit selector.
- View switch counts for the selectors.

Figure 2-25 Editing Path Protection Selectors



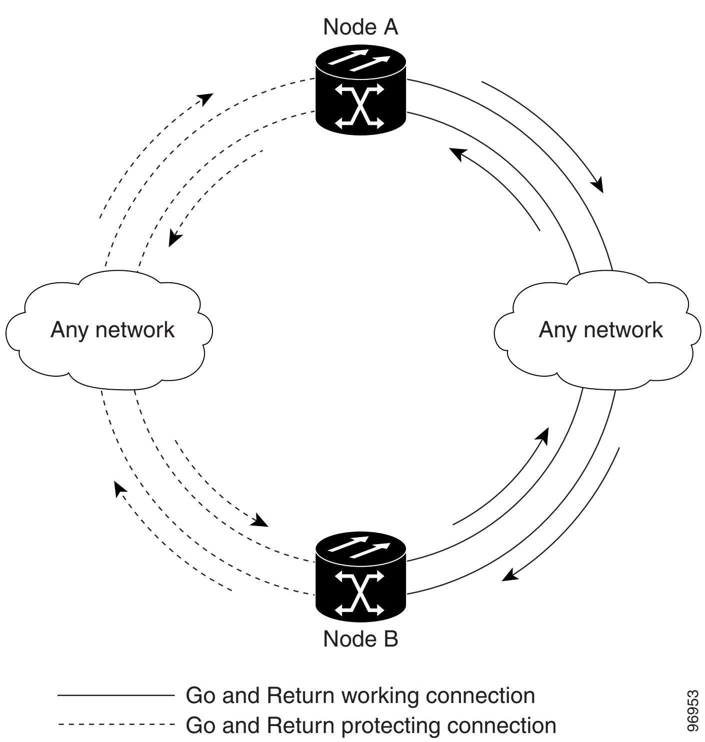
Open-Ended Path Protection Circuits

If ONS 15454 nodes are connected to a third-party network, you can create an open-ended path protection circuit to route a circuit through it. To do this, you create three circuits. One circuit is created on the source ONS 15454 network. This circuit has one source and two destinations, one at each ONS 15454 that is connected to the third-party network. The second circuit is created on the third-party network so that the circuit travels across the network on two paths to the ONS 15454s. That circuit routes the two circuit signals across the network to ONS 15454 nodes that are connected to the network on other side. At the destination node network, the third circuit is created with two sources, one at each node connected to the third-party network. A selector at the destination node chooses between the two signals that arrive at the node, similar to a regular path protection circuit.

Go-and-Return Path Protection Routing

The go-and-return path protection routing option allows you to route the path protection working path on one fiber pair and the protect path on a separate fiber pair (see Figure 2-26). The working path will always be the shortest path. If a fault occurs, both the working and protection fibers are not affected. This feature only applies to bidirectional path protection circuits. The go-and-return option appears on the Circuit Attributes panel of the Circuit Creation wizard.

Figure 2-26 Path Protection Go-and-Return Routing



BLSR Protection Channel Access Circuits

You can provision circuits to carry traffic on BLSR protection channels when conditions are fault-free. Traffic routed on BLSR protection channel access (PCA) circuits, called extra traffic, has lower priority than the traffic on the working channels and has no means for protection. During ring or span switches, PCA circuits are preempted and squelched. For example, in a two-fiber OC-48 BLSR, STSs 25-48 can carry extra traffic when no ring switches are active, but PCA circuits on these STSs are preempted when a ring switch occurs. When the conditions that caused the ring switch are remedied and the ring switch is removed, PCA circuits are restored. If the BLSR is provisioned as revertive, this occurs automatically after the fault conditions are cleared and the reversion timer has expired.

Traffic provisioning on BLSR protection channels is performed during circuit provisioning. The Protection Channel Access check box appears whenever Fully Protected Path is unchecked on the circuit creation wizard. Refer to the *Cisco ONS 15454 Procedure Guide* for more information. When provisioning PCA circuits, two considerations are important to keep in mind:

- If BLSRs are provisioned as nonrevertive, PCA circuits are not restored automatically after a ring or span switch. You must switch the BLSR manually.
- PCA circuits are routed on working channels when you upgrade a BLSR from a two-fiber to a four-fiber or from one optical speed to a higher optical speed. For example, if you upgrade a two-fiber OC-48 BLSR to an OC-192, STSs 25-48 on the OC-48 BLSR become working channels on the OC-192 BLSR.

Automatic Circuit Routing

If you select automatic routing during circuit creation, CTC routes the circuit by dividing the entire circuit route into segments based on protection domains. For unprotected segments of circuits provisioned as fully protected, CTC finds an alternate route to protect the segment, creating a virtual path protection. Each segment of a circuit path is a separate protection domain. Each protection domain is protected in a specific protection scheme including card protection (1+1, 1:1, etc.) or SONET topology (path protection, BLSR, etc.).

The following list provides principles and characteristics of automatic circuit routing:

- Circuit routing tries to use the shortest path within the user-specified or network-specified constraints. VT tunnels are preferable for VT circuits because VT tunnels are considered shortcuts when CTC calculates a circuit path in path-protected mesh networks.
- If you do not choose Fully Path Protected during circuit creation, circuits can still contain protected segments. Because circuit routing always selects the shortest path, one or more links and/or segments can have some protection. CTC does not look at link protection while computing a path for unprotected circuits.
- Circuit routing does not use links that are down. If you want all links to be considered for routing, do not create circuits when a link is down.
- Circuit routing computes the shortest path when you add a new drop to an existing circuit. It tries to find the shortest path from the new drop to any nodes on the existing circuit.
- If the network has a mixture of VT-capable nodes and VT-incapable nodes, CTC can automatically create a VT tunnel. Otherwise, CTC asks you whether a VT tunnel is needed.
- To create protected circuits between topologies, install an XCVT or XC10G cross-connect card on the shared node.

- For STS circuits, you can use portless transmux interfaces if a DS3XM-12 card is installed in the network. CTC automatically routes the circuit over the portless transmux interfaces on the specified node creating an end-to-end STS circuit.

Bandwidth Allocation and Routing

Within a given network, CTC routes circuits on the shortest possible path between source and destination based on the circuit attributes, such as protection and type. CTC considers using a link for the circuit only if the link meets the following requirements:

- The link has sufficient bandwidth to support the circuit.
- The link does not change the protection characteristics of the path.
- The link has the required time slots to enforce the same time slot restrictions for BLSR.

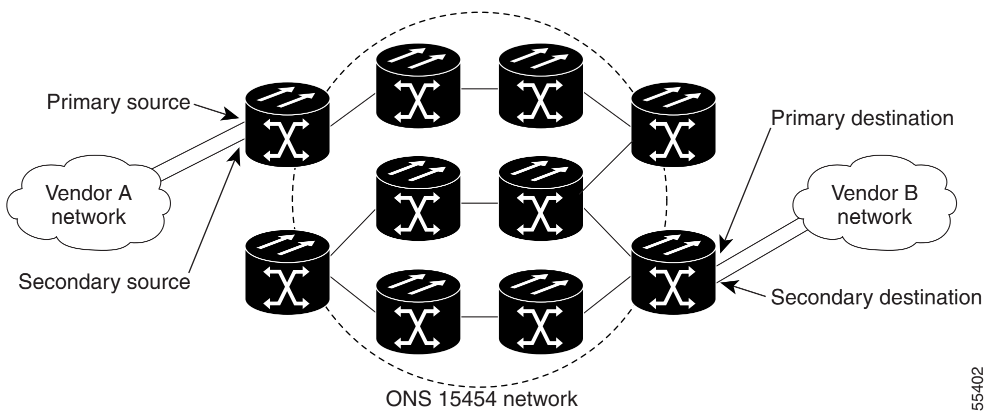
If CTC cannot find a link that meets these requirements, an error appears.

The same logic applies to VT circuits on VT tunnels. Circuit routing typically favors VT tunnels because VT tunnels are shortcuts between a given source and destination. If the VT tunnel in the route is full (no more bandwidth), CTC asks whether you want to create an additional VT tunnel.

Secondary Sources and Destination

CTC supports secondary circuit sources and destinations (drops). Secondary sources and destinations typically interconnect two third-party networks, as shown in Figure 2-27. Traffic is protected while it goes through a network of ONS 15454 nodes.

Figure 2-27 Secondary Sources and Destinations



Several rules apply to secondary sources and destinations:

- CTC does not allow a secondary destination for unidirectional circuits because you can always specify additional destinations after you create the circuit.
- The sources and destinations cannot be DS-3, DS3XM, or DS-1-based STS-1s or VT1.5s.
- Secondary sources and destinations are permitted only for regular STS/VT1.5 connections (not for VT tunnels and multicard EtherSwitch circuits).
- For point-to-point (straight) Ethernet circuits, only SONET STS endpoints can be specified as multiple sources or destinations.

For bidirectional circuits, CTC creates a path protection connection at the source node that allows traffic to be selected from one of the two sources on the ONS 15454 network. If you check the Fully Path Protected option during circuit creation, traffic is protected within the ONS 15454 network. At the destination, another path protection connection is created to bridge traffic from the ONS 15454 network to the two destinations. A similar but opposite path exists for the reverse traffic flowing from the destinations to the sources.

For unidirectional circuits, a path protection drop-and-continue connection is created at the source node.

Manual Circuit Routing

Routing circuits manually allows you to:

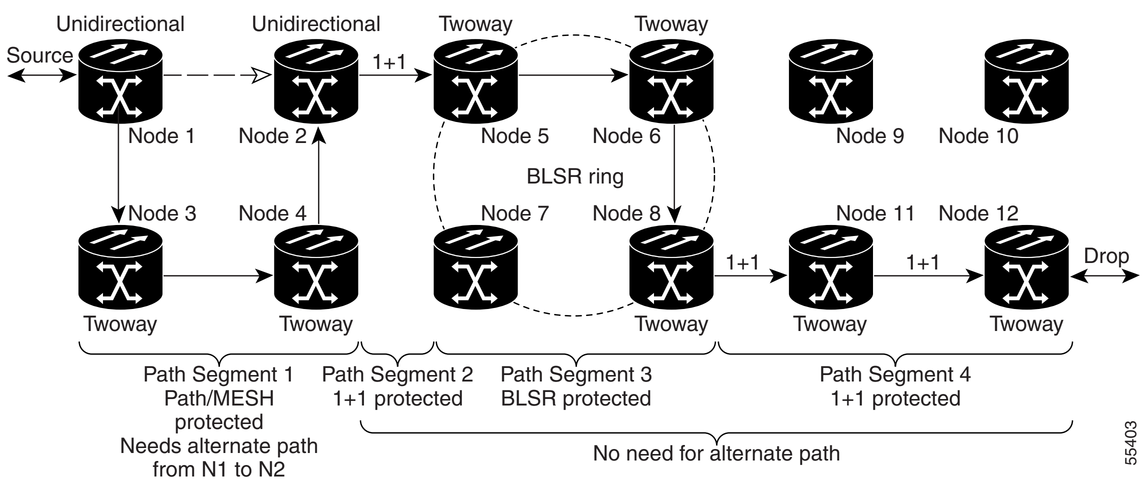
- Choose a specific path, not necessarily the shortest path.
- Choose a specific STS/VT1.5 on each link along the route.
- Create a shared packet ring for multicard EtherSwitch circuits.
- Choose a protected path for multicard EtherSwitch circuits, allowing virtual path protection segments.

CTC imposes the following rules on manual routes:

All circuits, except multicard EtherSwitch circuits in a shared packet ring, should have links with a direction that flows from source to destination. This is true for multicard EtherSwitch circuits that are not in a shared packet ring.

If you enabled Fully Path Protected, choose a diverse protect (alternate) path for every unprotected segment (Figure 2-28).

Figure 2-28 Alternate Paths for Virtual Path Protection Segments



When you create circuits, you can choose Fully Protected Path to protect the circuit from source to destination. The protection mechanism used depends on the path CTC calculates for the circuit. If the network is composed entirely of BLSR or 1+1 links, or the path between source and destination can be entirely protected using 1+1 or BLSR links, no path-protected mesh network (PPMN), or virtual path protection, protection is used.

If PPMN protection is needed to protect the path, set the level of node diversity for the PPMN portions of the complete path on the Circuit Routing Preferences area of the Circuit Creation dialog box from the following options:

- Nodal Diversity Required—Ensures that the primary and alternate paths of each PPMN domain in the complete path have a diverse set of nodes.
- Nodal Diversity Desired—CTC looks for a node diverse path; if a node-diverse path is not available, CTC finds a link-diverse path for each PPMN domain in the complete path.
- Link Diversity Only—Creates only a link-diverse path for each PPMN domain.

When you choose automatic circuit routing during circuit creation, you have the option to require or exclude nodes and links in the calculated route. You can use this option to achieve the following results:

- Simplify manual routing, especially if the network is large and selecting every span is tedious. You can select a general route from source to destination and allow CTC to fill in the route details.
- Balance network traffic. By default, CTC chooses the shortest path, which can load traffic on certain links while other links have most of their bandwidth available. By selecting a required node and/or a link, you force the CTC to use (or not use) an element, resulting in more efficient use of network resources.

CTC considers required nodes and links to be an ordered set of elements. CTC treats the source nodes of every required link as required nodes. When CTC calculates the path, it makes sure the computed path traverses the required set of nodes and links and does not traverse excluded nodes and links.

The required nodes and links constraint is only used during the primary path computation and only for PPMN domains/segments. The alternate path is computed normally; CTC uses excluded nodes/links when finding all primary and alternate paths on PPMNs.

TL1-Like Circuits

You can create cross-connects with CTC, like you would with TL1 commands by selecting the Create TL1-Like option before creating a circuit. The TL1-Like option instructs the ONS 15454 node to create only cross-connects and places the resulting circuits in an UPGRADABLE state. This state allows you upgrade circuits created with the TL1-Like option to be converted to CTC circuits, if desired.

Merge Circuits

A circuit merge combines a single selected circuit with one or more circuits. You can merge tunnels, VAP circuits, VLAN-assigned circuits, CTC-created circuits, and TL1-created circuits. To merge circuits, you choose a circuit on the CTC Circuits tab window and the circuits that you want to merge with the chosen (master) circuit on the Merge tab in the Edit Circuits window. The Merge tab shows only the circuits that are available for merging with the master circuit:

- Circuit cross-connects must create a single, contiguous path.
- Circuit types must be a compatible. For example, you can combine an STS circuit with a VAP circuit to create a longer VAP circuit, but you cannot combine a VT circuit with an STS circuit.
- Circuit directions must be compatible. You can merge a one-way and a two-way circuit, but not two one-way circuits in opposing directions.
- Circuit sizes must be identical.
- VLAN assignments must be identical.
- Circuit end points must send or receive the same framing format.

- The merged circuits must become a DISCOVERED circuit.

If all connections from the master circuit and all connections from the merged circuits align to form one complete circuit, the merge is successful. If all connections from the master circuit and some, but not all, connections from the other circuits align to form a single complete circuit, CTC notifies you and gives you the chance to cancel the merge process. If you choose to continue, the aligned connections merge successfully into the master circuit, and unaligned connections remain in the original circuits.

All connections from the master circuit and at least one connection from the other selected circuits must be used in the resulting circuit for the merge to succeed. If a merge fails, the master circuit and all other circuits remain unchanged. When the circuit merge completes successfully, the resulting circuit retains the name of the master circuit.

Reconfigure Circuits

You can reconfigure multiple circuits, which is typically necessary when a large number of circuits are in the PARTIAL status. When reconfiguring multiple circuits, the selected circuits can be any combination of DISCOVERED, PARTIAL, DISCOVERED_TL1, or PARTIAL_TL1 circuits. You can reconfigure tunnels, VAP circuits, VLAN-assigned circuits, CTC-created circuits, and TL1-created circuits.

Use the CTC Tools > Circuits > Reconfigure Circuits command to reconfigure selected circuits. During reconfiguration, CTC reassembles all connections of the selected circuits into circuits based on path size, direction, and alignment. Some circuits might merge and others might split into multiple circuits. If the resulting circuit is a valid circuit, it appears as a DISCOVERED circuit. Otherwise, the circuit appears as a PARTIAL or PARTIAL_TL1 circuit.

TL1-CTC Circuit Unification

In Release 5.0 CTC fully supports TL1-created circuits and TL1 fully supports CTC-created circuits. Release 5.0 circuit behavior and appearance is unified across both management interfaces, and you can easily alternate between the two. It is also no longer necessary to upgrade a TL1 circuit for CTC, or to downgrade a CTC circuit for TL1. The following circuit unification enhancements are supported with Release 5.0:

- Release 5.0 cross-connects can be given names via TL1 using ENT-CRS and ED-CRS (use the "CKTID" parameter).
- CTC-created circuits can now be fully deleted if all cross-connects are deleted via TL1. (Deleting a source node cross-connect automatically deletes the CTC "circuitInfo" database object.)
- VCAT group objects (VCGs) can be given names via TL1 using ENT-VCG and ED-VCG commands (with the "CKTID" parameter).
- CTC-created VCAT circuits can now be fully deleted if both VCGs are deleted via TL1. (Deleting a source node VCG automatically deletes the CTC "circuitInfo" database object.)
- TL1 circuits now have names (like CTC circuits).
- You can use TL1 to change the name of any circuit, TL1-created or CTC-created.
- Low order (LO) tunnels and LO aggregation point circuits created via TL1 are now recognized and displayed in CTC.
- You can use TL1 to add cross-connects to a CTC-created circuit.
- You can edit TL1 circuits using CTC. (No need for upgrading the circuit first.)

- Circuit "upgrade" and "downgrade" functions have been removed.
- You can merge two or more CTC circuits into a single CTC circuit. (Circuit Merge and Circuit Reconfigure.)
- "ACTIVE" circuits are now called "DISCOVERED."
- "INCOMPLETE" circuits are now called "PARTIAL."
- "UPGRADABLE" circuits are now called "DISCOVERED_TL1."
- "INCOMPLETE_UPGRADABLE circuits are now called "PARTIAL_TL1."

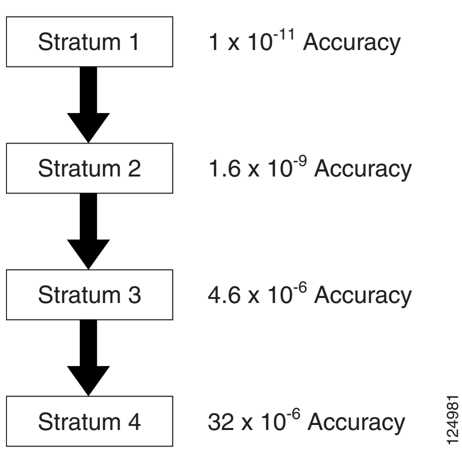
Synchronization and Timing

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 2-29 shows the timing accuracy hierarchy supported by the ONS 15454.

Figure 2-29 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.

Synchronous Status Messaging (SSM)

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, refer to Chapter 7 to determine which message set to use.

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 BITS signal is a DS-1 level, 1.544 MHz signal, formatted either as Superframe (SF) with 12 frames per superframe, or the Extended Superframe (ESF) with 24 frames per extended superframe. SF is also referred to as D4 framing. 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 (D4) signals. In the SF (D4) mode, the AIS signal (unframed 'all-ones') indicates an unsuitable reference.

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 SONET protection modes supported by the Cisco ONS 15454 are described in Table 2-27.

Table 2-27 SONET 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 is the default mode for 1+1 protection groups in the ONS 15454.
Bidirectional	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 Line 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 Table 2-33.
Nonrevertive	In nonrevertive 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. Nonrevertive protection is illustrated in Figure 2-31.

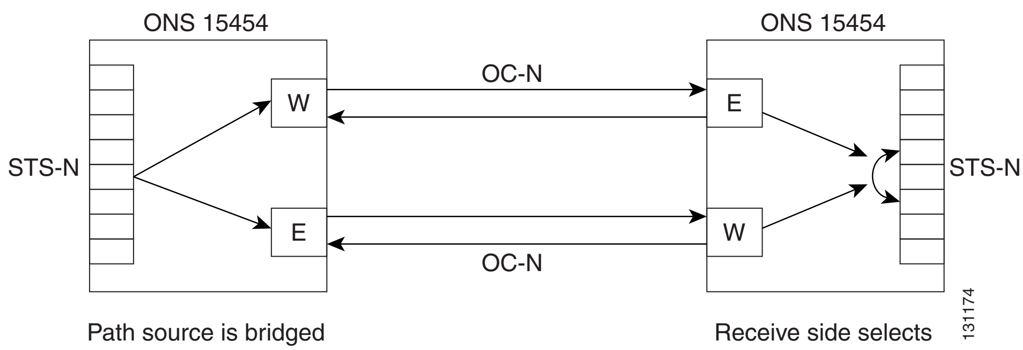
Path Protection Switching

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 2-30, 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 2-30 STS Path Switching

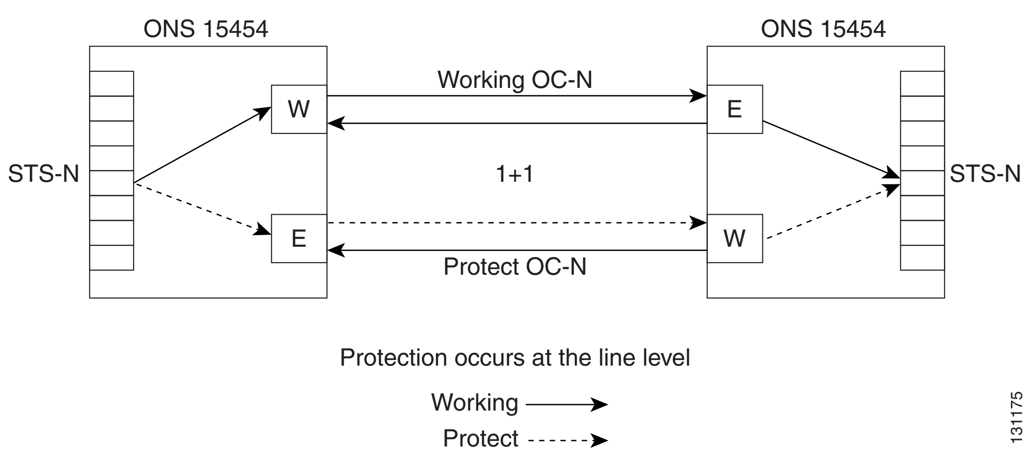


Line Protection Switching

The Line protection switching example shown in Figure 2-31, 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 2-31 Line Protection Switching



Automatic Protection Switching

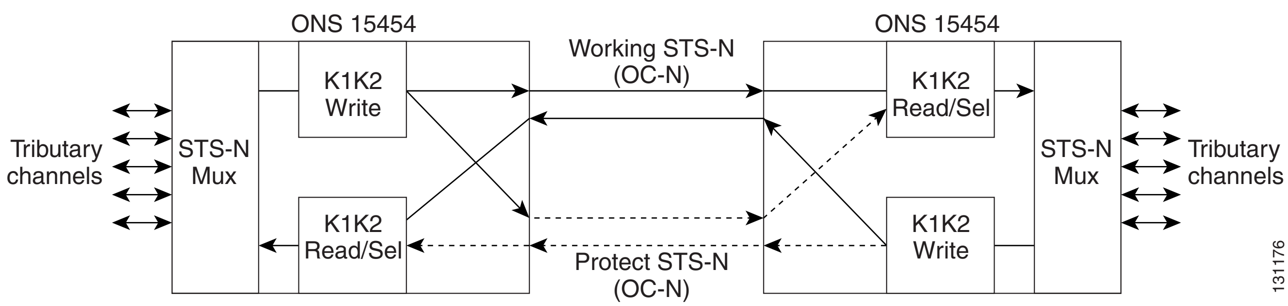
Automatic Protection Switching (APS) is switching that is initiated by the ONS 15454 based on built-in algorithms, assisted by Performance Management (PM) threshold settings and protection options stored in the TCC2/TCC2P database. The first setting stored in the TCC2/TCC2P is the type of SONET OC-N 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 TCC2/TCC2P 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 2-32.

Figure 2-32 APS Example



1+1 Protection Switching

Any OC-N card can use 1+1 protection. With 1+1 port-to-port protection, 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 OC-12 must be paired with another single-port OC-12, and a four-port OC-12 must be paired with another four-port OC-12. You cannot create a 1+1 protection group if one card is single-port and the other is multiport, even if the OC-N rates are the same. The protection takes place on the port level, and 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. In other words, all the ports on the protect card are used in the protection scheme.

1+1 span protection can be either revertive or nonrevertive. Revertive 1+1 protection automatically switches the signal back to the working card when the working card comes back online (see Figure 2-33). 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 (see Figure 2-34). 1+1 protection is unidirectional and nonrevertive by default; revertive switching is easily provisioned using CTC.

Figure 2-33 Revertive Switching

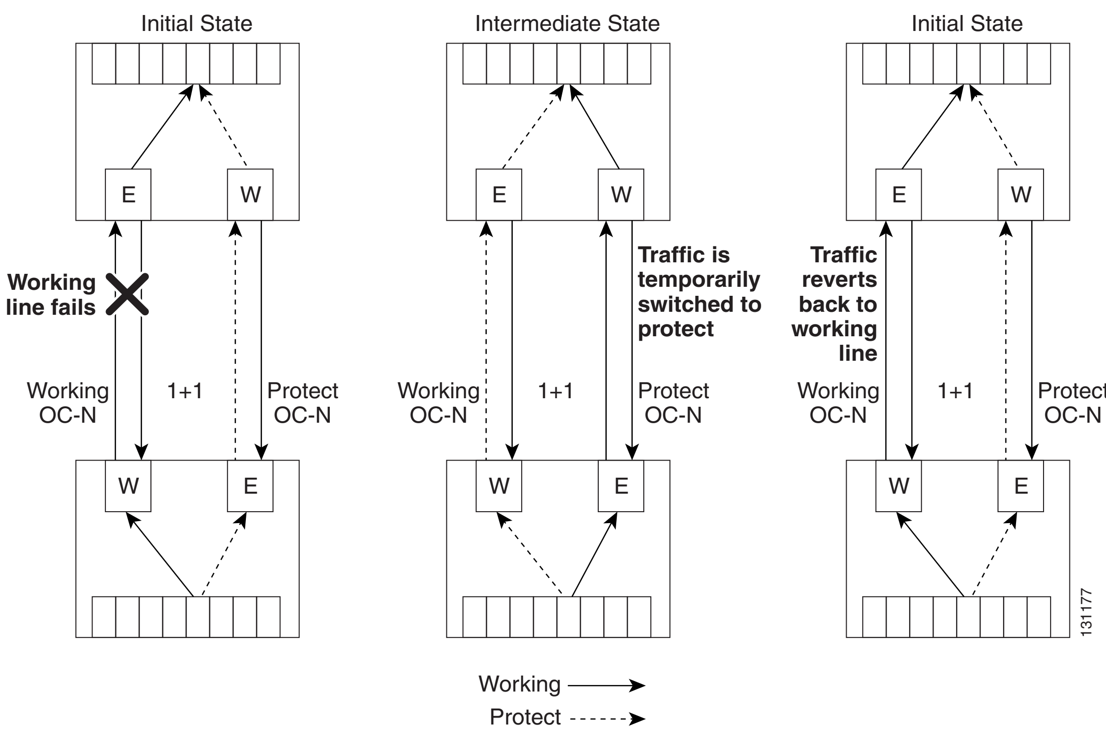
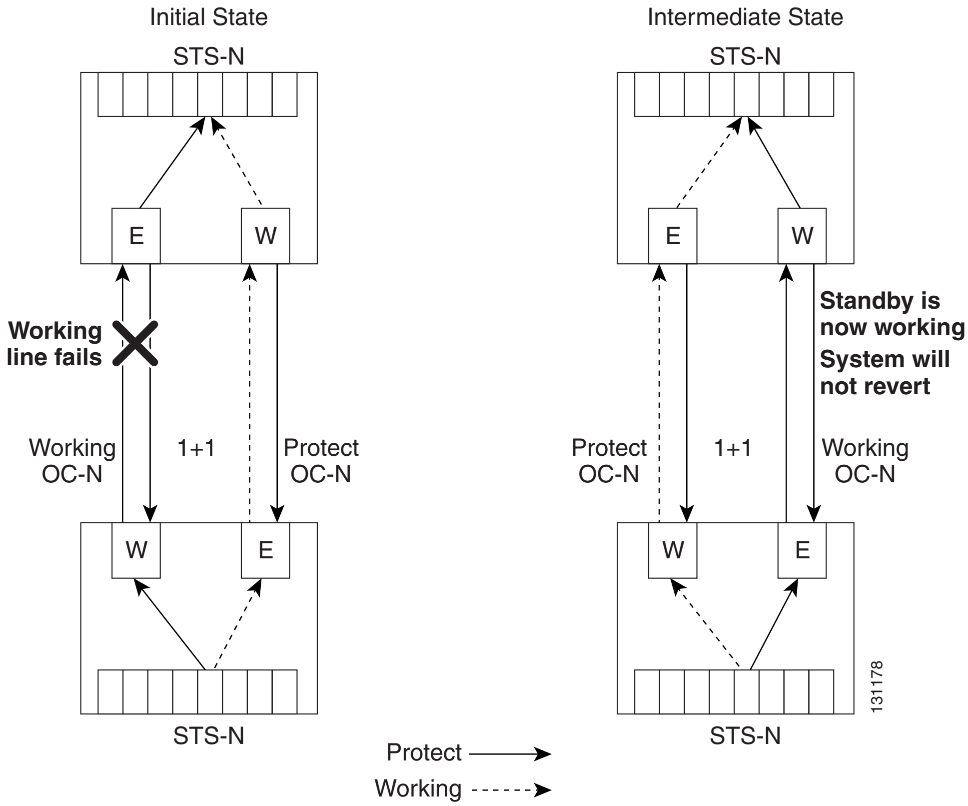


Figure 2-34 Nonrevertive Switching



Optimized 1+1 Protection

Optimized 1+1 protection is used in networks that mainly use the linear 1+1 bidirectional protection scheme. Optimized 1+1 is a line-level protection scheme using two lines, working and protect. One of the two lines assumes the role of the primary channel, where traffic is selected, and the other line assumes the role of secondary channel, which protects the primary channel. Traffic switches from the primary channel to the secondary channel based on either line conditions or an external switching command performed by the user. After the line condition clears, the traffic remains on the secondary channel. The secondary channel is automatically renamed as the primary channel and the former primary channel is automatically renamed as the secondary channel.

Unlike 1+1 span protection, 1+1 optimized span protection does not use the revertive or nonrevertive feature. Also, 1+1 optimized span protection does not use the Manual switch command. The 1+1 optimized span protection scheme is supported only on the Cisco ONS 15454 using either OC3-4 cards or OC3-8 cards with ports that are provisioned for SDH payloads.

With optimized 1+1 port-to-port protection, 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 installed 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 four-port OC-3 must be paired with another four-port OC-3, and an eight-port OC-3 must be paired with another eight-port OC-3. You cannot create an optimized 1+1 protection group if the number of ports do not match, even if the OC-N rates are the same.

The protection takes place on the port level, and 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.

External Switching Commands

The external switching commands on the ONS 15454 are Manual, Force, and Lockout. If you choose a Manual switch, the command will switch traffic only if the path has an error rate less than the signal degrade (SD) bit error rate threshold. A Force switch will switch traffic even if the path has SD or signal fail (SF) conditions; however, a Force switch will not override an SF on a 1+1 protection channel.

A Force switch has a higher priority than a Manual switch. Lockouts, which prevent traffic from switching to the protect port under any circumstance, can only be applied to protect cards (in 1+1 configurations) . Lockouts have the highest priority. In a 1+1 configuration you can also apply a lock on to the working port. A working port with a lock on applied cannot switch traffic to the protect port in the protection group (pair). In 1:1 protection groups, working or protect ports can have a lock on.

Note Force and Manual switches do not apply to 1:1 protection groups; these ports have a single switch command.

Dual-Ring Interconnect—Path Protection

In System Release 4.0, the ONS 15454 will support path protection dual-ring interconnection (DRI), which provides added path-level protection for both VT1.5 and STS circuits. The ONS 15454 conforms to the dual interconnected ring architecture defined in Telcordia GR-1400-CORE. 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 to interconnect the two rings, while the integrated DRI only uses two ONS 15454 nodes.

Figure 2-35 shows ONS 15454 nodes in a traditional dual ring interconnect topology. In Ring number 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 6 and 10. Duplicate signals are sent from Node 3 (Ring 1) to Node 6 (Ring 2), and between Node 4 (Ring 1) and Node 10 (Ring 2). In Ring number1, traffic at Node 3 is dropped (to Node 6) and continued (to Node 4). Similarly, at Node 4, traffic is dropped (to Node 10) and continued (to Node 5).

Figure 2-35 Traditional Dual Ring Interconnect

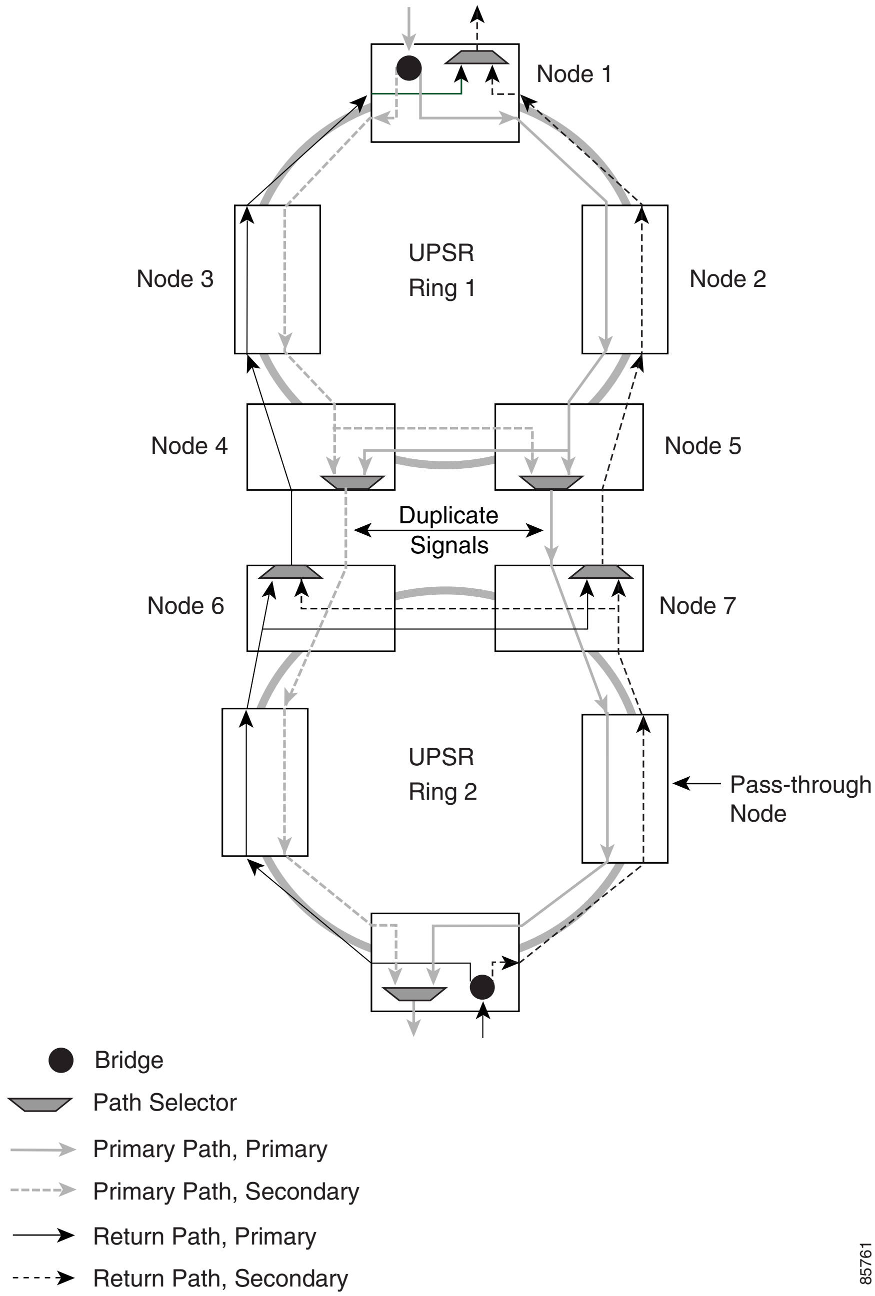


Figure 2-36 shows ONS 15454 nodes in an integrated dual ring interconnect topology. The same drop and continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an addition OC-N trunk at the two interconnect nodes as illustrated in Figure 2-37.

Figure 2-36 Integrated Dual Ring Interconnect

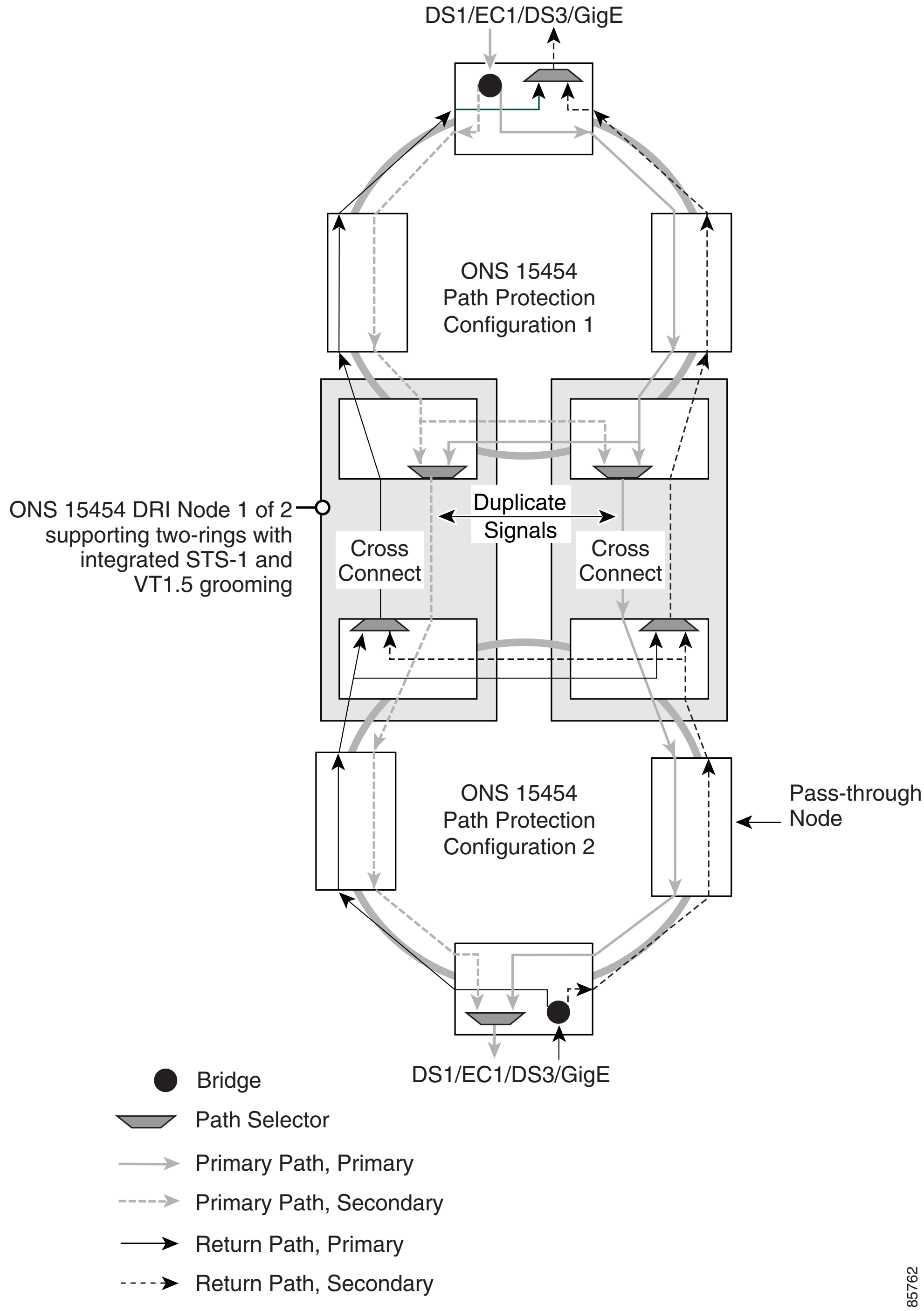
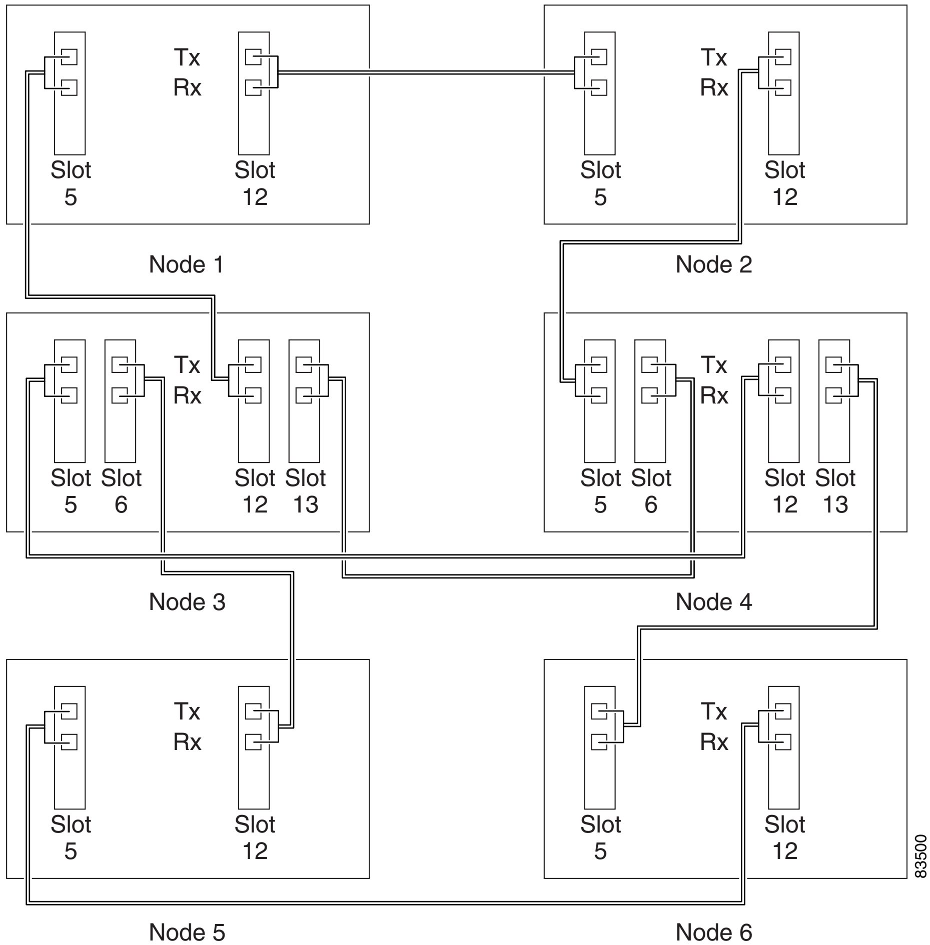


Figure 2-37 Integrated Path Protection Fiber Connections



Dual Ring Interconnect—BLSR

Unlike BLSR automatic protection switching (APS) protocol, BLSR-DRI is a path-level protection protocol at the circuit level. Drop-and-continue BLSR-DRI requires a service selector in the primary node for each circuit routing to the other ring. Service selectors monitor signal conditions from dual feed sources and select the one that has the best signal quality. Same-side routing drops the traffic at primary nodes set up on the same side of the connected rings, and opposite-side routing drops the traffic at primary nodes set up on the opposite sides of the connected rings. For BLSR-DRI, primary and secondary nodes cannot be the circuit source or destination.

Note A DRI circuit cannot be created if an intermediate node exists on the interconnecting link. However, an intermediate node can be added on the interconnecting link after the DRI circuit is created.

DRI protection circuits act as protection channel access (PCA) circuits. In CTC, you set up DRI protection circuits by selecting the PCA option when setting up primary and secondary nodes during DRI circuit creation.

Figure 2-38 shows ONS 15454 nodes in a traditional BLSR-DRI topology with same-side routing. In Ring 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 8 and 9 are the interconnect nodes. Duplicate signals are sent between Node 4 (Ring 1) and Node 9 (Ring 2), and between Node 3 (Ring 1) and Node 8 (Ring 2). The primary nodes (Nodes 4 and 9) are on the same side, and the secondary nodes (Nodes 3 and 8) provide an alternative route. In Ring 1, traffic at Node 4 is dropped (to Node 9) and continued (to Node 10). Similarly, at Node 9, traffic is dropped (to Node 4) and continued (to Node 5).

Figure 2-38 ONS 15454 Traditional BLSR Dual-Ring Interconnect (Same-Side Routing)

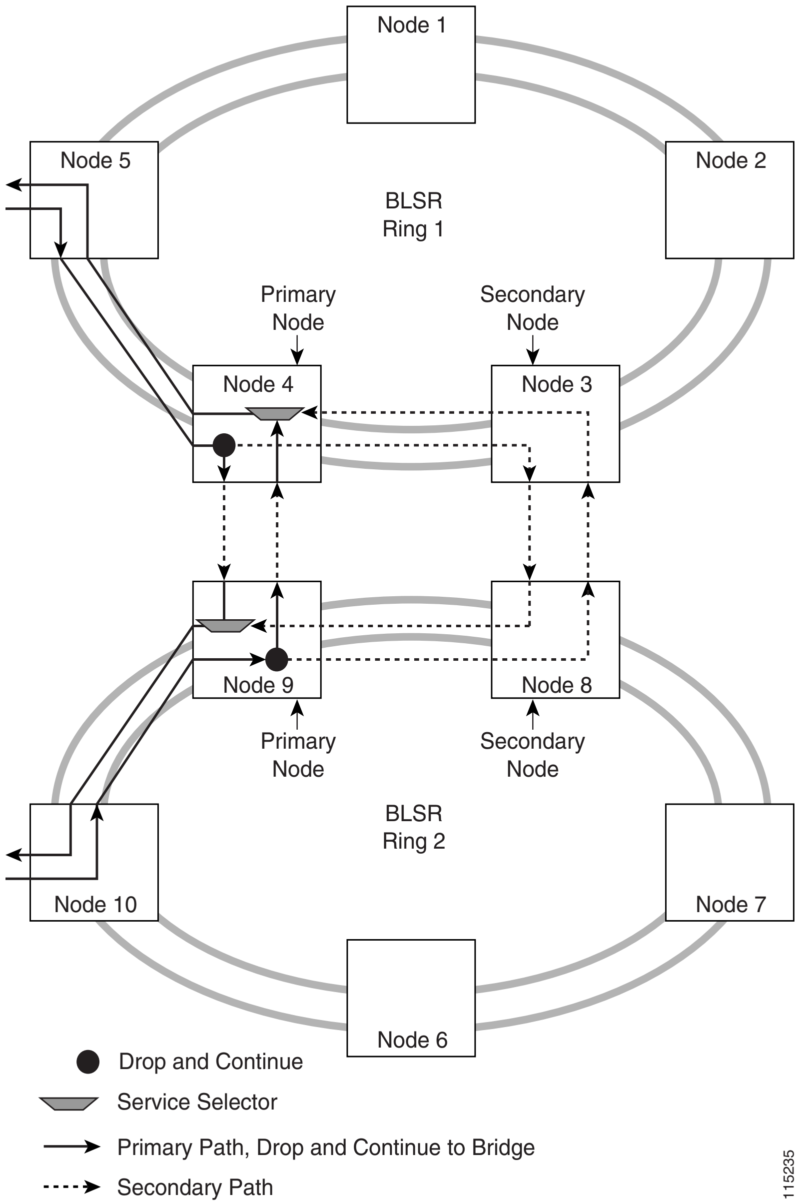


Figure 2-39 shows ONS 15454 nodes in a traditional BLSR-DRI topology with opposite-side routing. In Ring 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 8 and 9 are the interconnect nodes. Duplicate signals are sent from Node 4 (Ring 1) to Node 8 (Ring 2), and between Node 3 (Ring 1) and Node 9 (Ring 2). In Ring 1, traffic at Node 4 is dropped (to Node 9) and continued (to Node 8). Similarly, at Node 8, traffic is dropped (to Node 3) and continued (to Node 4).

Figure 2-39 ONS 15454 Traditional BLSR Dual-Ring Interconnect (Opposite-Side Routing)

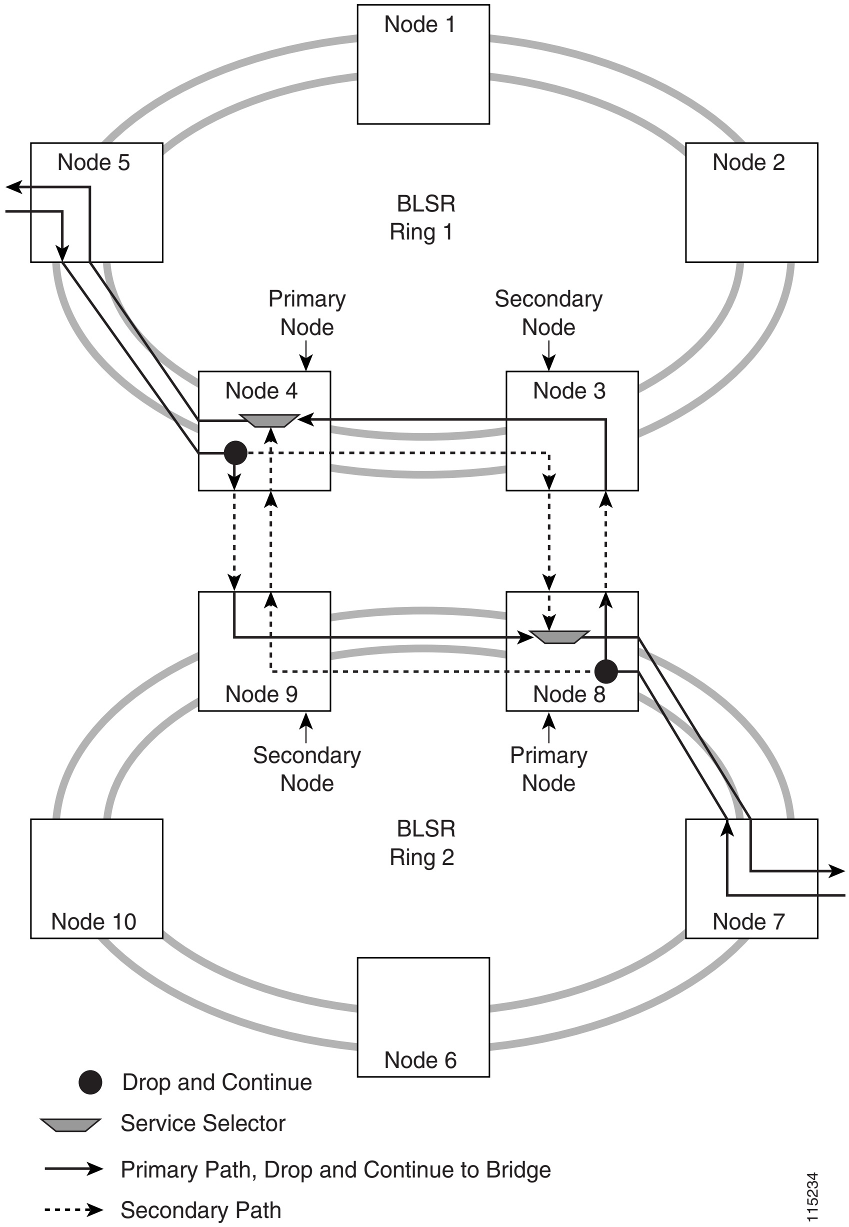
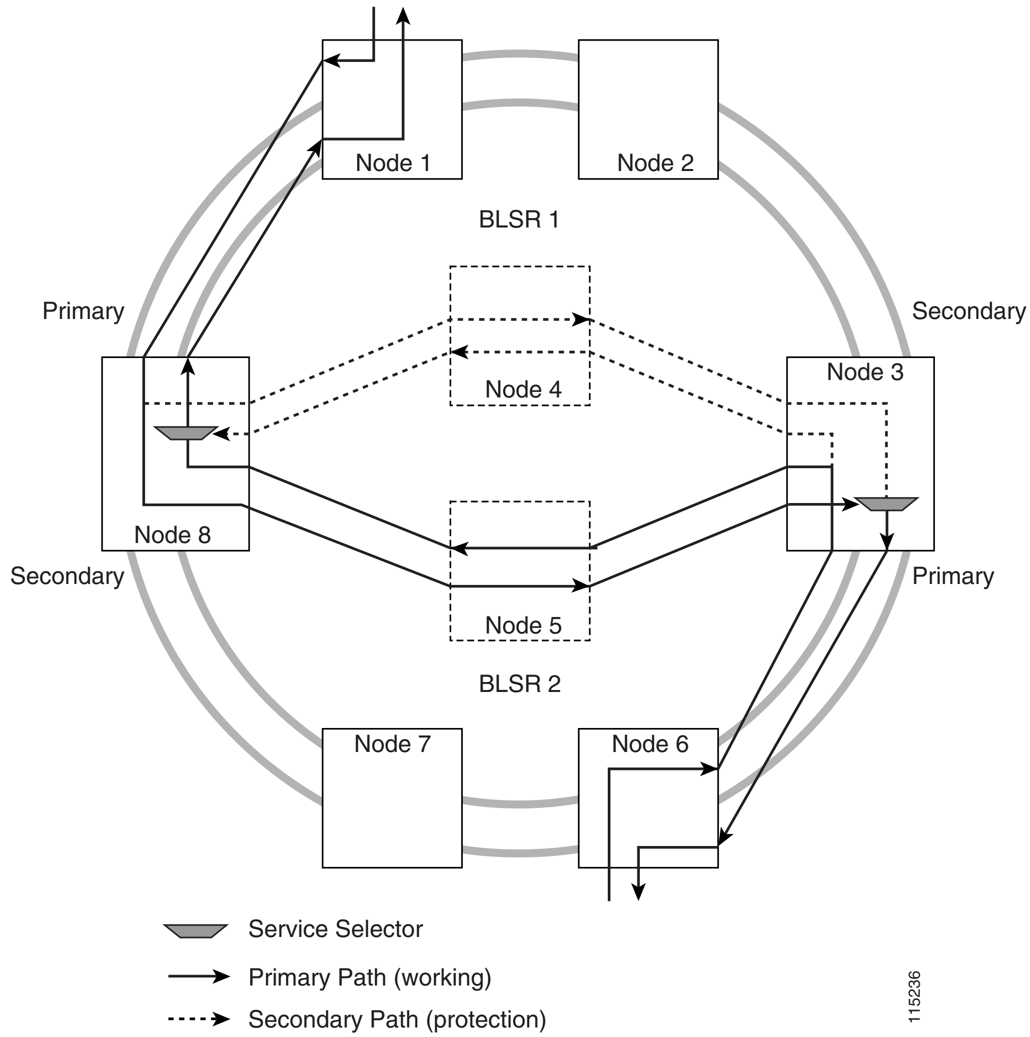


Figure 2-40 shows ONS 15454 nodes in an integrated BLSR-DRI topology. The same drop-and-continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an addition OC-N trunk at the two interconnect nodes. Nodes 3 and 8 are the interconnect nodes.

Figure 2-40 ONS 15454 Integrated BLSR Dual-Ring Interconnect



Protection Switch Initiation Time

The switch initiation time is the time that it takes the ONS 15454 to detect a SF or SD condition and initiate a switch (if appropriate). The switch initiation time criteria listed below are not applicable for manually initiated switches. Manual switches initiated by the user can take longer to initiate.

For SF conditions caused by LOS, LOF, or AIS defects, the ONS 15454 will initiate a switch in 10 ms or less.

For SD condition caused by LOS, LOF, or AIS defects, the ONS 15454 will initiate a switch in 8 ms or less.

For SF and SD conditions based on BER, the switch initiation time will vary, because the occurrence of errors on an OC-N signal is generally random. The ONS 15454 will initiate a switch when the actual BER is greater than or equal to the SF and SD thresholds set for the particular rate of the span's OC-N signal.

Protection Switch Completion Time

An ONS 15454 operating in a network comprised of ONS 15454 nodes configured for APS or 1+1 protection will complete a switch in 50 ms or less, once it is initiated automatically by the ONS 15454 or manually by the user.

In network configurations made up of nodes from different suppliers, the overall switch time may be greater than 50 ms. This situation exists, because each supplier's node must perform various actions before a switch can be completed. Since the algorithms and methods used by suppliers vary for switching, it may take longer for the protection switch to complete.

Node Latency

Use the formulas below to calculate the latency through an ONS 15454 node. Input and output times for the multi-service interfaces are given below the formulas. Insert those times into the formulas to get the overall latency through a node for various configurations. For example, an STS-1 circuit coming in on a DS-3 card and leaving on an OC-48 card will have a latency calculation of: 7 micro seconds + 1 micro second + 3.5 micro seconds = 11.5 micro seconds. The general latency formulas are as follows:

- For a STS circuit, the XC, XCVT, or XC-10G Latency = Input Card (micro second) +1 micro second + Output Card (micro second)
- For a VT1.5 circuit, the XCVT or XC-10G Latency = Input Card (micro second) + 45 micro second + Output Card (micro second)

The latency for each of the multi-service cards is as follows:

- OC-3 Card = 8.5 micro seconds
- OC-12 Cards = 4.5 micro seconds
- OC-48 Cards = 3.5 micro seconds
- DS-1 Cards = 35 micro seconds
- DS-3 Cards = 7 micro seconds
- EC1 Card = 10 micro seconds

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, two-fiber and four-fiber bidirectional 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 four fibers in protected configurations. 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 2-41 shows the traffic flow for a typical TM configuration.

Figure 2-41 Terminal Network Traffic Flow

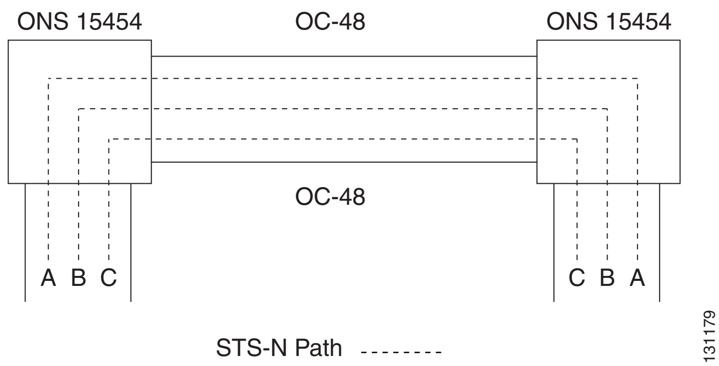
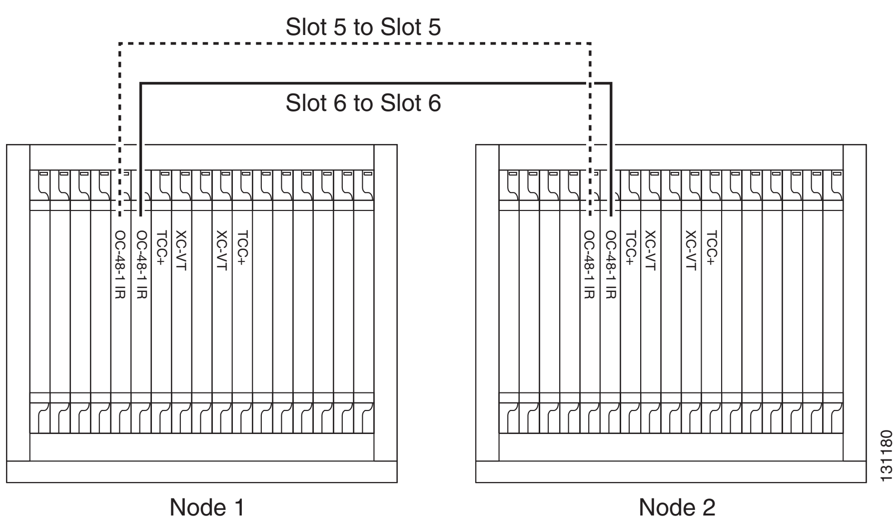


Figure 2-42 shows the node configuration for a protected point-to-point TM ONS 15454 network. Working traffic flows from Node 1/Slot 6 to Node 2/Slot 6. The protect path runs from Node 1/Slot 5 to Node 2/Slot 5.

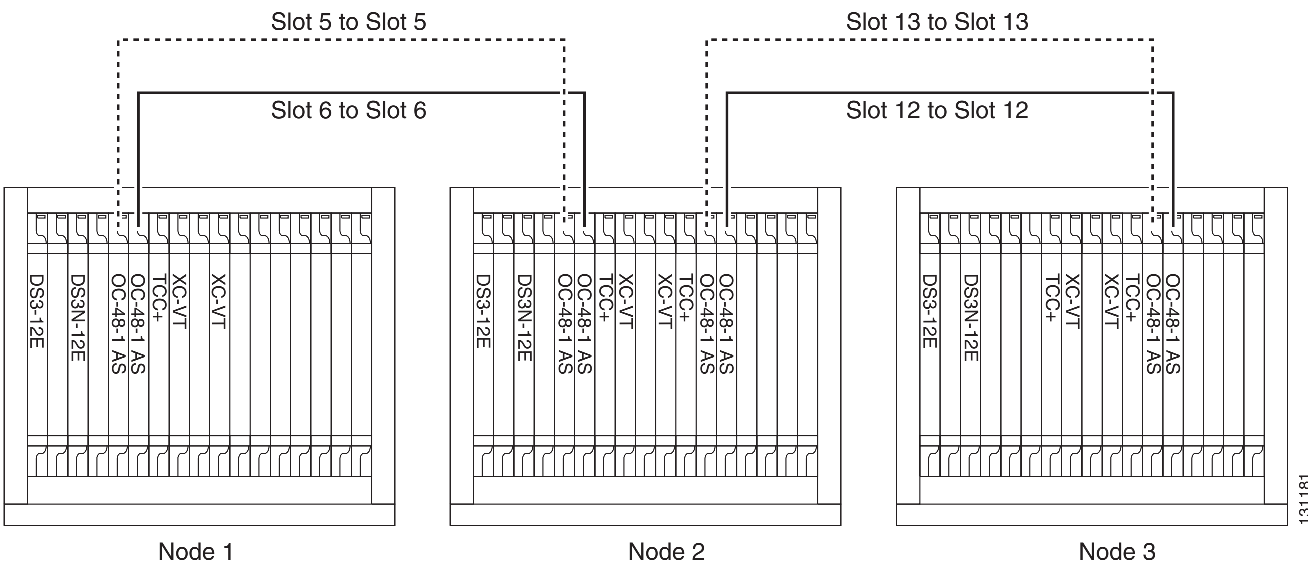
Figure 2-42 Terminal Node Network Configuration



Linear Add/Drop Multiplexer Network

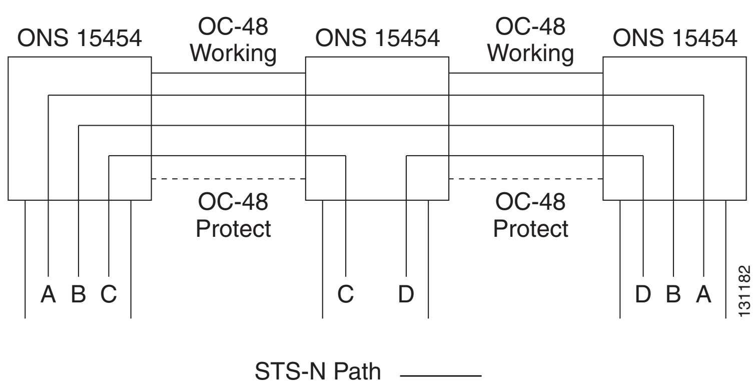
Any ONS 15454 node can be designed as an add/drop multiplexer (ADM) and provide add/drop for DS1, DS3, EC-1, OC-3, OC-12, and OC-48 signals as shown in Figure 2-43. A linear ADM ONS 15454 system can be provisioned for unidirectional or bi-directional OC-N line switching. In unidirectional switching, 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 2-43 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 2-44 shows the traffic flow for a typical linear ADM network. Each ONS 15454 node requires four 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 2-44 Linear ADM Traffic Flow



Path Protection

Path protection is the default topology used for connecting ONS 15454 nodes together. Path protection configuratoions 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 in the working traffic path, the receiving node switches to the path coming from the opposite direction. Because each traffic path is transported around the entire ring, path protection configurations are best suited for networks where traffic concentrates at one or two locations and is not widely distributed. path protection capacity is equal to its bit rate. Services can originate and terminate on the same path protection, or they can be passed to an adjacent access or interoffice ring for transport to the service-terminating location.

Path protection design requirements for the ONS 15454 are based on the path protection criteria listed in Telcordia GR-1400-CORE. It is a survivable, closed-loop design that survives cable cuts and equipment failure by providing duplicate fiber paths for each service. The ONS 15454 supports path protection functionality on the OC-3, OC-12, OC-48, and OC-192 cards. Starting in System Release 4.6 you can have up to a maximum of 34 path protection configurations on a single ONS 15454. With Releases 4.0 and 4.1, you can have up to a maximum of 16 path protection configurations on a single ONS 15454 node. Systems prior to Release 4.0 can have a maximum of 5 path protection configurations on a single node. Table 2-28 shows the maximum number of path protection configurations that can be created on a single ONS 15454 node.

Table 2-28 Protection Modes

System Release	Path Protection
>= Release 4.6	34
>= Release 4.0	16
<= Release 3.4	5

Path protection traffic is defined within the ONS 15454 on a circuit-by-circuit basis. If a path-protected circuit is not defined within a 1+1 or Bi-directional Line Switched Ring (BLSR) line protection scheme and path protection is available and specified, CTC uses path protection as the default. Each circuit path may be provisioned for revertive or non-revertive switching. The ONS 15454 default is non-revertive. If you choose revertive switching, the default wait-to-restore (WTR) time is 5 minutes. This default setting may be changed from 0.5 – 12 minutes if needed. Network element (NE) default settings can be modified as needed.

Figure 2-45 shows a basic path protection network. Working and protect traffic are routed over separate fiber paths in opposite directions. For example, if Node ID 0 sends a signal to Node ID 2, the working signal travels on the working traffic path through Node ID 1. The same signal is also sent on the protect traffic path through Node ID 3. Each span uses STS-1 bandwidth capacity along the entire circumference of the ring. If a fiber break occurs as shown in Figure 2-46, Node ID 2 switches its active receiver to the protect signal coming through Node ID 3.

Figure 2-45 Path Protection Network

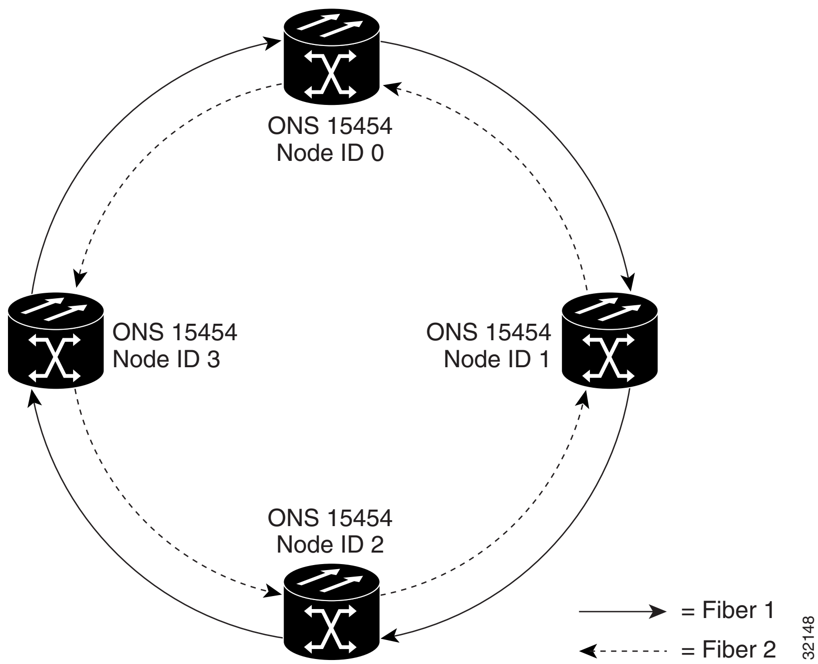
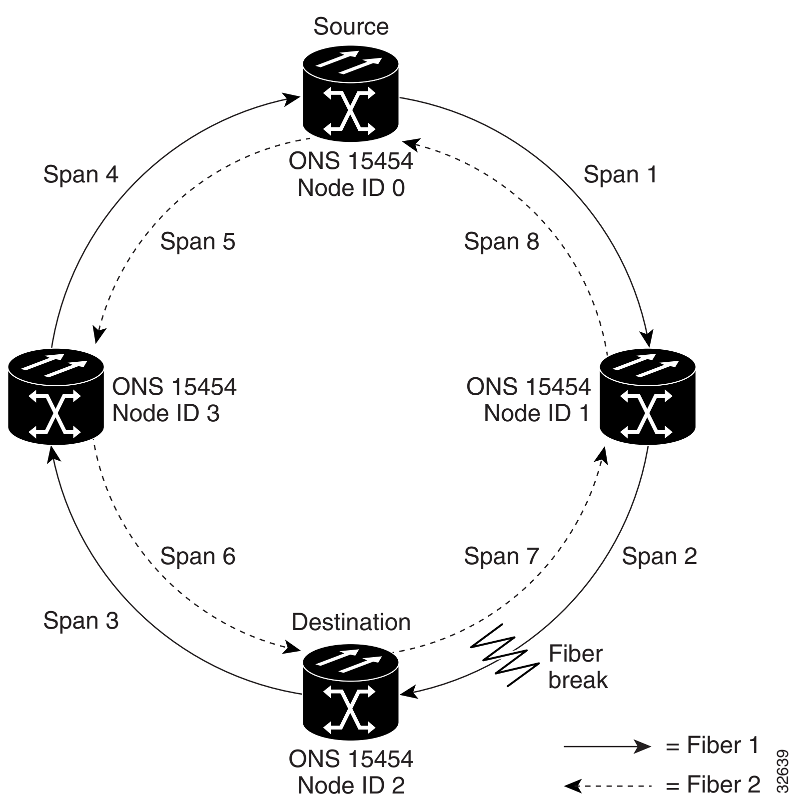


Figure 2-46 Path Protection with a Fiber Break

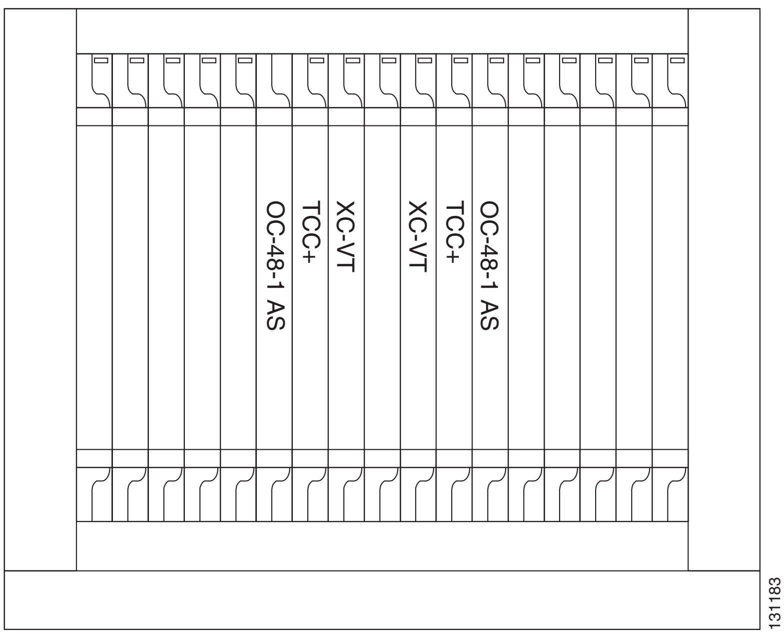


Only two OC-N trunk cards are required per node for the SONET span. This design saves network equipment costs as opposed to a linear design where each intermediate node needs four OC-N trunk cards for 1+1 protection. A Cisco ONS 15454 path protection node consists of the following cards for each node within the network:

- 1 Working OC-N card (West trunk)
- 1 Protect OC-N card (East trunk)
- 2 TCC cards
- 2 Cross-connect cards

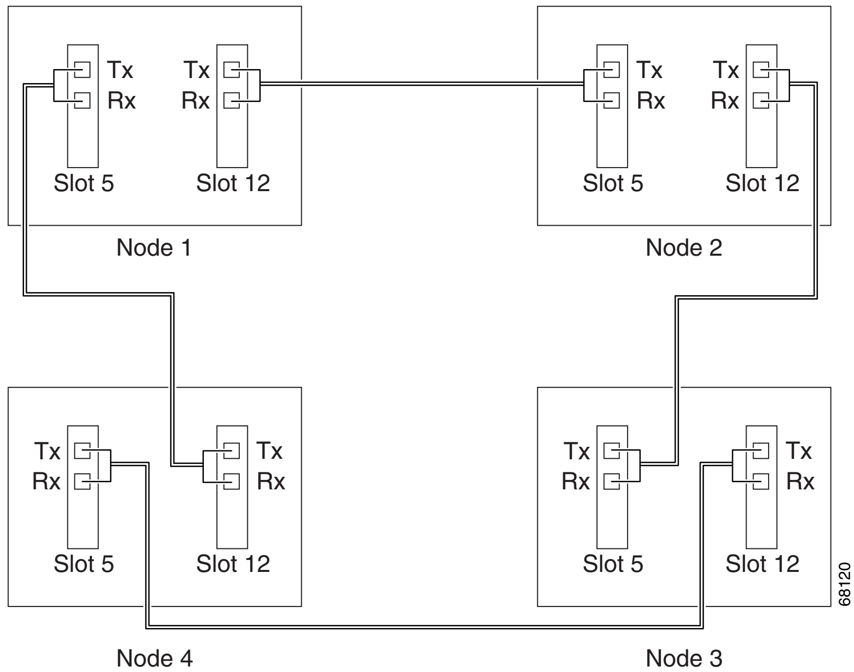
Figure 2-47 shows the typical SONET configuration for each ONS 15454 node in a path protection network.

Figure 2-47 Path Protection Node Configuration



The West Working OC-N facility is physically cabled to the East Working OC-N facility of the adjacent ONS 15454 node. Figure 2-48 shows the fiber routes for a 4 node path protection.

Figure 2-48 Routing Fiber for a Path Protection

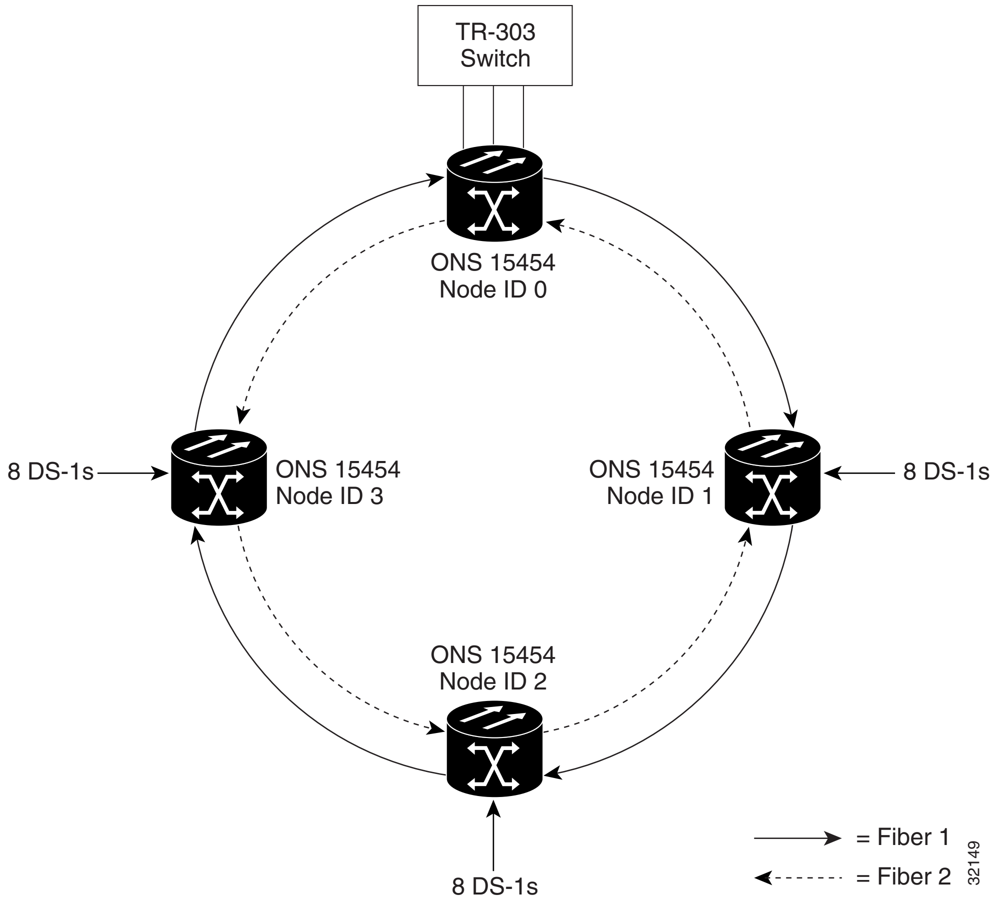


Path protection designs are very common in the metropolitan area. In Figure 2-46, note that the working traffic between nodes travels clockwise (East to West) over spans 1, 2, 3, and 4. Traffic from a user on Node 1 to a user on Node 2 uses the path: Node 1-to-Span 1-to-Node 2 for two-way communication. Traffic from a user on Node 2 to a user on Node 1 uses path: Node 2-to-Span-2-to-Span-3-to-Span-4-to-Node 1. Spans 5, 6, 7, and 8 are not used for working traffic. They are used when one of the working spans fails. Traffic on these spans travels counter-clockwise (West to East). For each STS-N circuit, each end node will transmit the bit stream both ways around the ring. The receiving node will monitor both bit streams, and choose to receive from the bit stream with the lower bit error rate. If both streams are error-free, one or the other may be chosen, depending on settings. Should a fiber cut affecting traffic in one direction, the other direction acts as protection.

Common Path Protection Application

The access network application shown in Figure 2-49 requires most of its traffic to run between customer locations and an end office or point-of-presence (POP). In this common path protection application, OC-3 optics provide remote switch connectivity to a host TR-303 switch. In the example, each ONS 15454 node requires 8 DS-1s to return to the host switch. Figure 2-50 and Figure 2-51 show the shelf layout for each node.

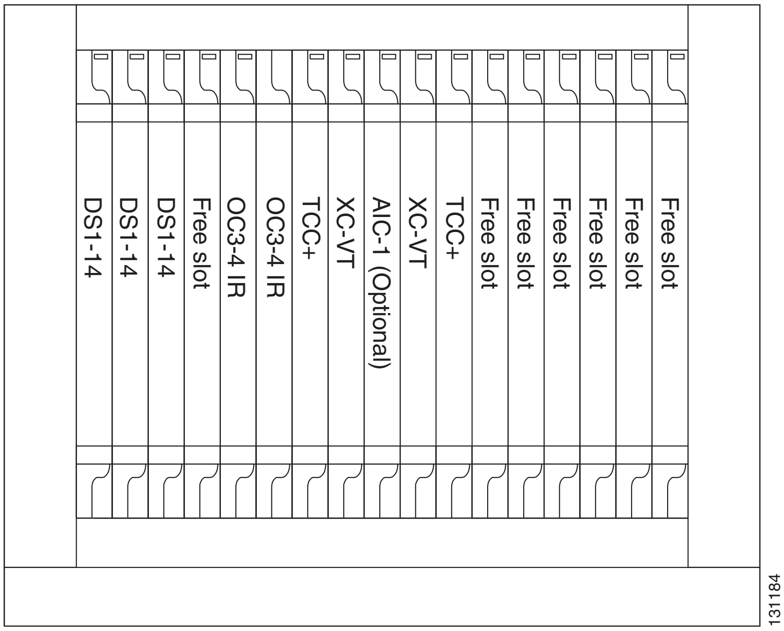
Figure 2-49 OC-3 Path Protection Access Network



Node ID 0 has three DS1-14 cards (two working, and one protect) to provide 24 active DS-1 ports. The other nodes only require two DS1-14 cards (one working and one protect) to handle the eight DS-1s to and from the remote switch. You can use the other half of each ONS 15454 node's shelf assembly to provide support for a second or third ring to other existing or planned remote sites.

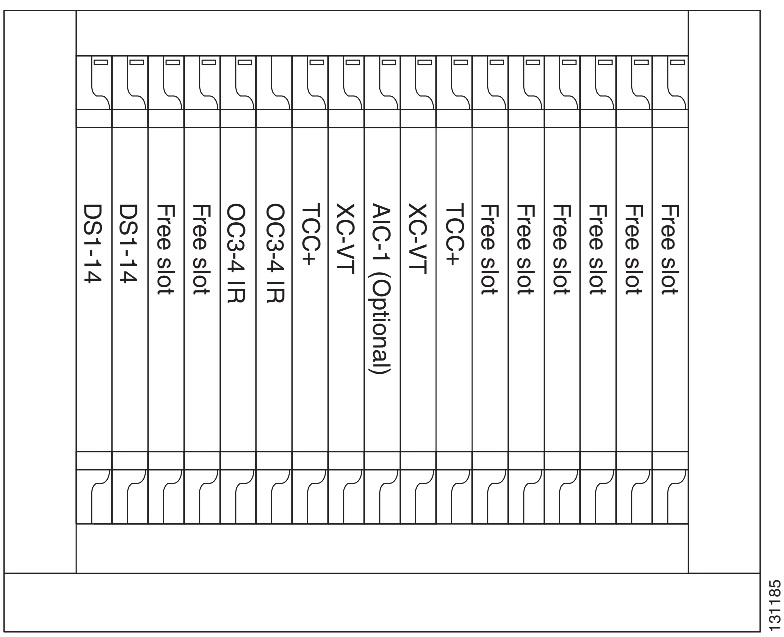
In this sample OC-3 path protection, Node ID 0 contains 4 DS1-14 cards and 2 OC3 IR 4 1310 cards. Six free slots also exist in this setup and can be provisioned with cards or left empty. Figure 2-50 shows an efficient way to configure the ONS 15454 for these cards using only half of a shelf.

Figure 2-50 Layout of Node ID 0 in the OC-3 Path Protection



In the Figure 2-49, Nodes IDs 1 through 3 each contain 2 DS1-14 cards and 2 OC3 4 IR 1310 cards. Eight free slots exist. They can be provisioned with other cards or left empty. Figure 2-51 shows the shelf assembly setup for this configuration sample.

Figure 2-51 Layout of Nodes IDs 1–3 in the OC-3 Path Protection



Two-Fiber Bidirectional Path Switched Ring

A bidirectional 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. BLSR nodes can terminate traffic coming from either side of the ring. Therefore, BLSRs are suited for distributed node-to-node traffic applications such as interoffice networks and access networks.

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. Table 2-29 shows the bi-directional capacity for two-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 2-29 Two-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[1] – PT
OC-192	STS 1-96	STS 97-192	96 x N[1] – 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 two-fiber BLSR to provide unprotected transport for extra traffic when no failures are present. Table 2-30 shows the maximum number of two-fiber BLSRs each ONS 15454 node can support.

Table 2-30 Maximum Number of Two-Fiber BLSRs Supported

System Release	Maximum Number of Two-Fiber BLSRs
>= Release 4.0	5
<= Release 4.0	2

Each of the two-fiber BLSR can have up to 32 ONS 15454 nodes. The supported BLSRs include OC-12, OC-48, and OC-192 only, because the working and protect bandwidths must be equal.

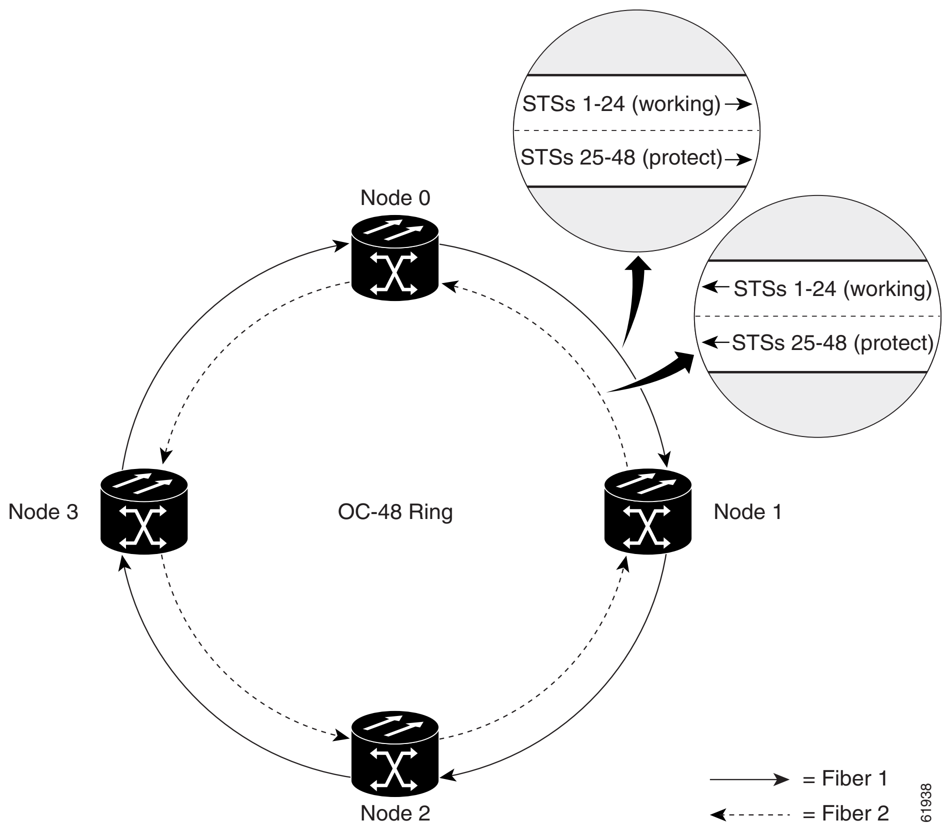
Note For best performance, BLSRs should have one LAN connection for every 10 nodes in the BLSR.

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.

Two-fiber BLSR is the most common topology used by Local Exchange Carriers (LECs) in major metropolitan areas. A two-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 two-fibers are used to close the ring, two-fiber BLSRs are economical to deploy.

In two-fiber BLSRs, each fiber is divided into working and protect bandwidths. In the OC-48 BLSR example shown in Figure 2-52, 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 2-53, 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 2-52 Four-Node, Two-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 2-53 shows a sample traffic pattern on a four-node, two-fiber BLSR.

Figure 2-53 4-Node, 2-Fiber BLSR Sample Traffic Pattern

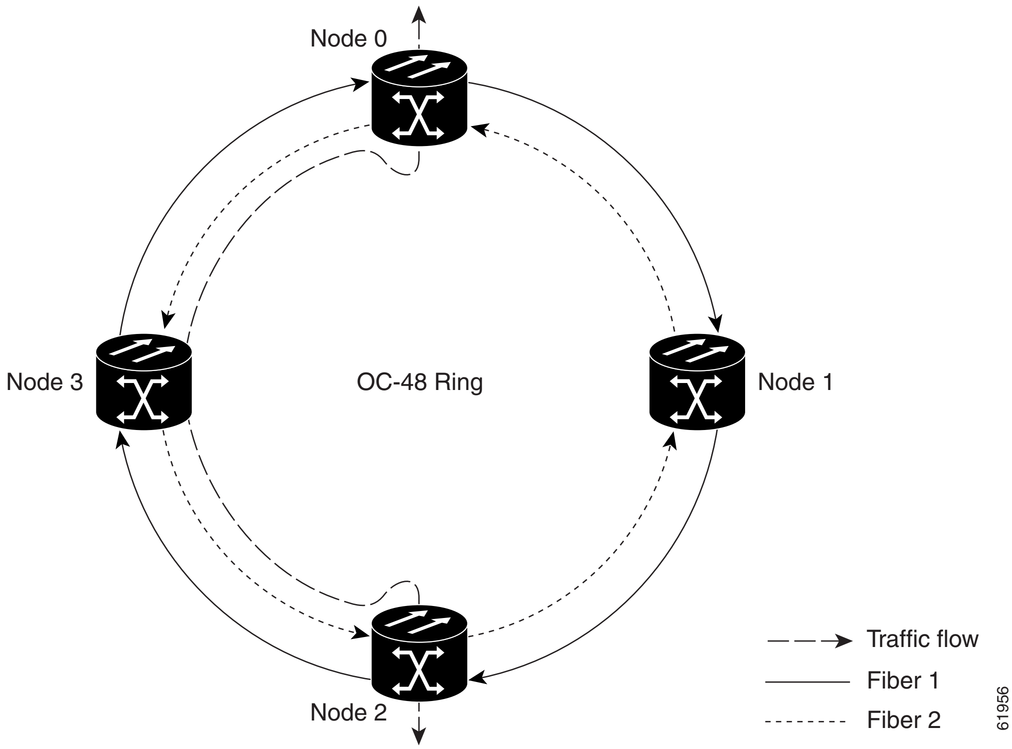
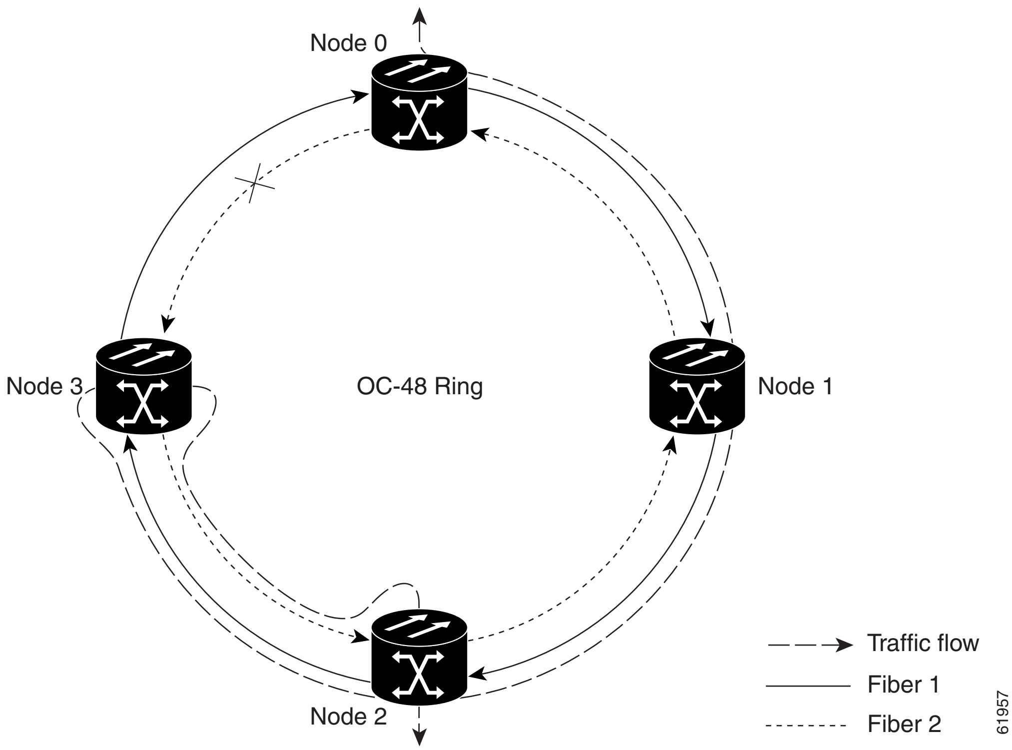


Figure 2-54 shows how traffic is rerouted following a line break between Node 0 and Node 3.

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 2-54 4-Node, 2-Fiber BLSR Traffic Pattern Following Line Break



Four-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 2-55. To implement a four-fiber BLSR, you must install 4 OC-48 or OC-48AS cards, or 4 OC-192 cards at each BLSR node.

Table 2-31 shows the maximum number of four-fiber BLSRs each ONS 15454 node can support.

Table 2-31 Maximum Number of Four-Fiber BLSRs Supported

System Release	Maximum Number of Four-Fiber BLSRs
<= Release 4.0	1

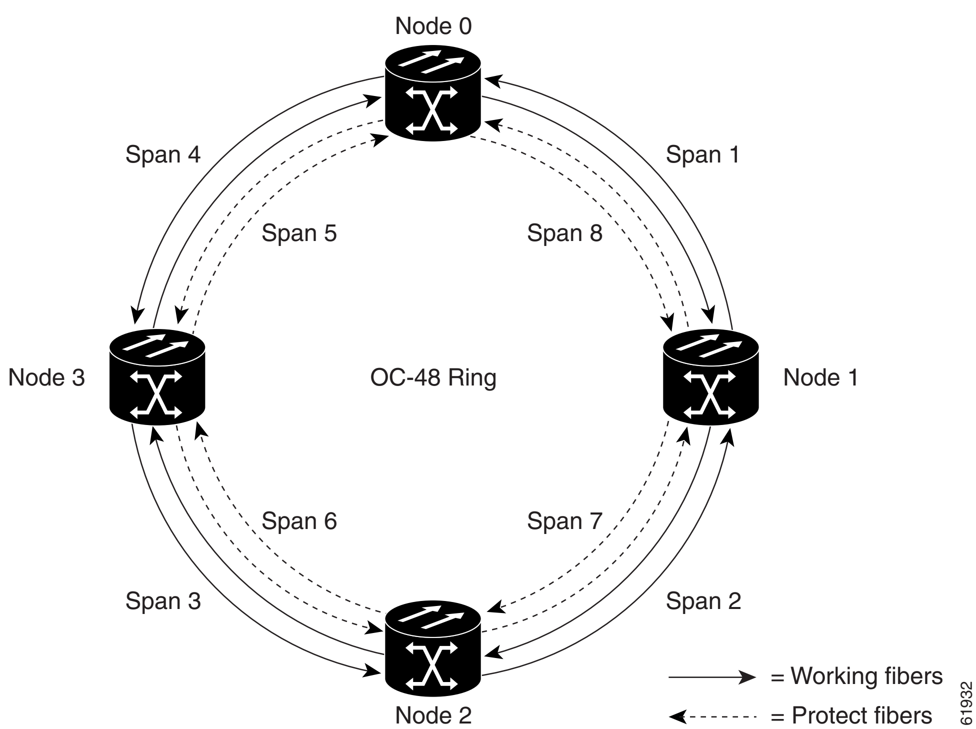
Each four-fiber BLSR can have up to 32 ONS 15454 nodes. Because the working and protect bandwidths must be equal, you can create only OC-48, or OC-192 BLSRs. Table 2-32 shows the bi-directional bandwidth capacities of four-fiber BLSRs.

Table 2-32 Four-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[1] – 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 2-55 Four-Node, Four-Fiber BLSR



Four-Fiber Span and Ring Switching

Cisco ONS 15454 four-fiber BLSRs provide span and ring switching as follows:

- Span switching, shown in Figure 2-56, 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 four-fiber BLSR and not cause traffic to drop.
- Ring switching, shown in Figure 2-57, 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 four-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 2-56 Four-Fiber BLSR Span Switch

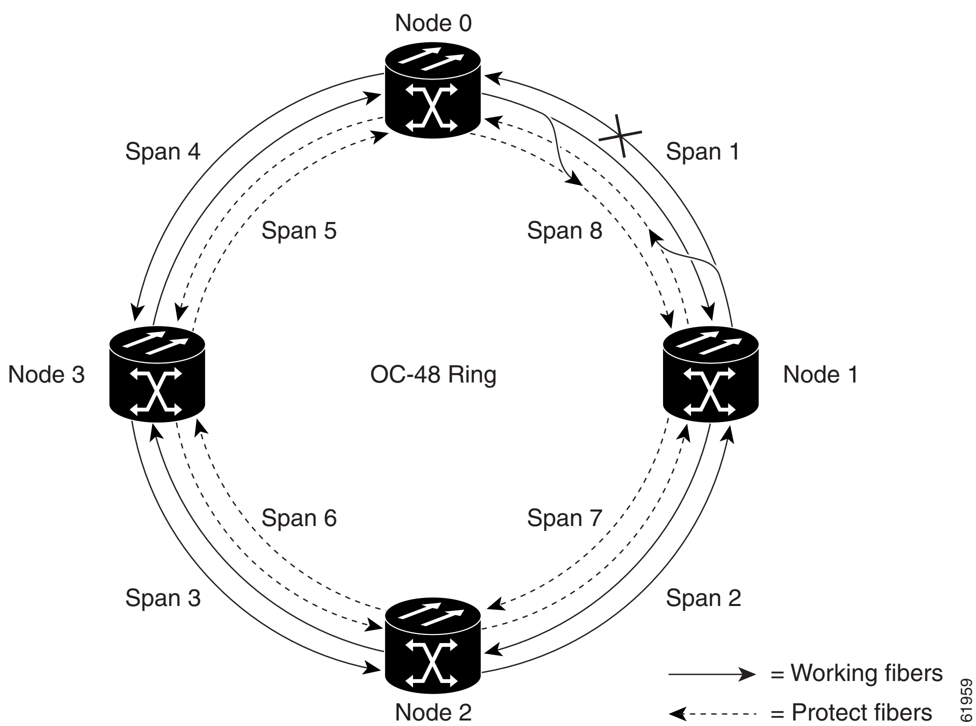
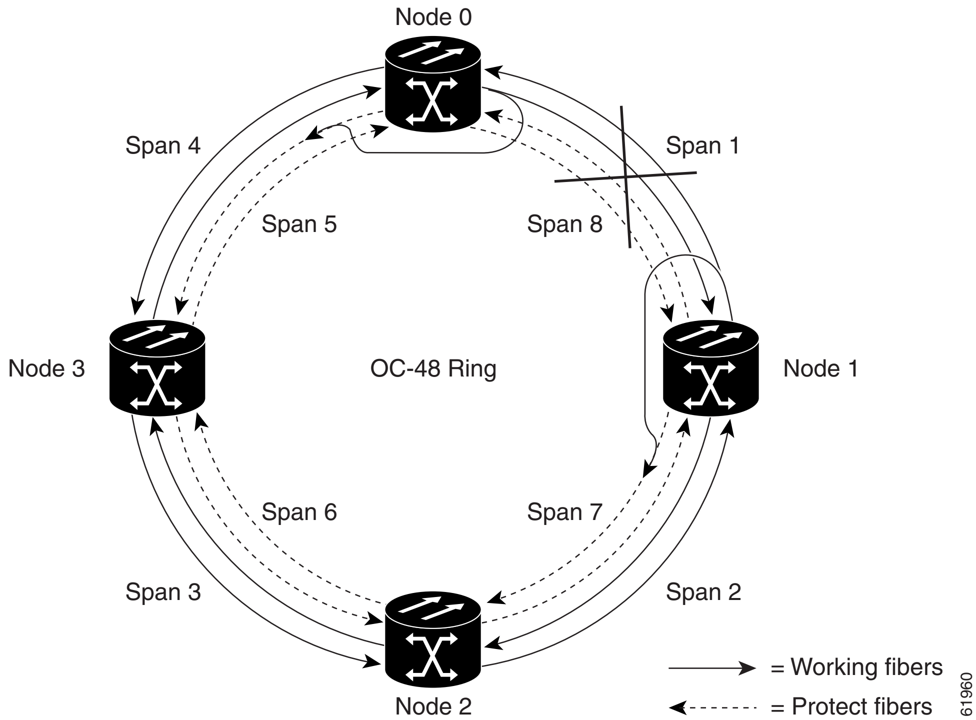


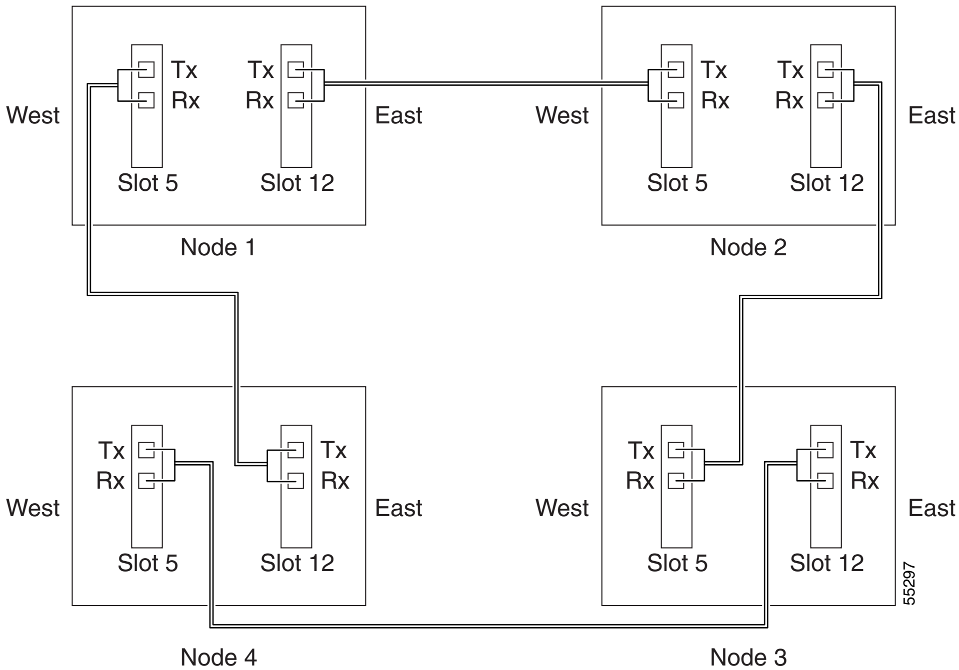
Figure 2-57 Four-Fiber BLSR Ring Switch



BLSR Fiber Connections

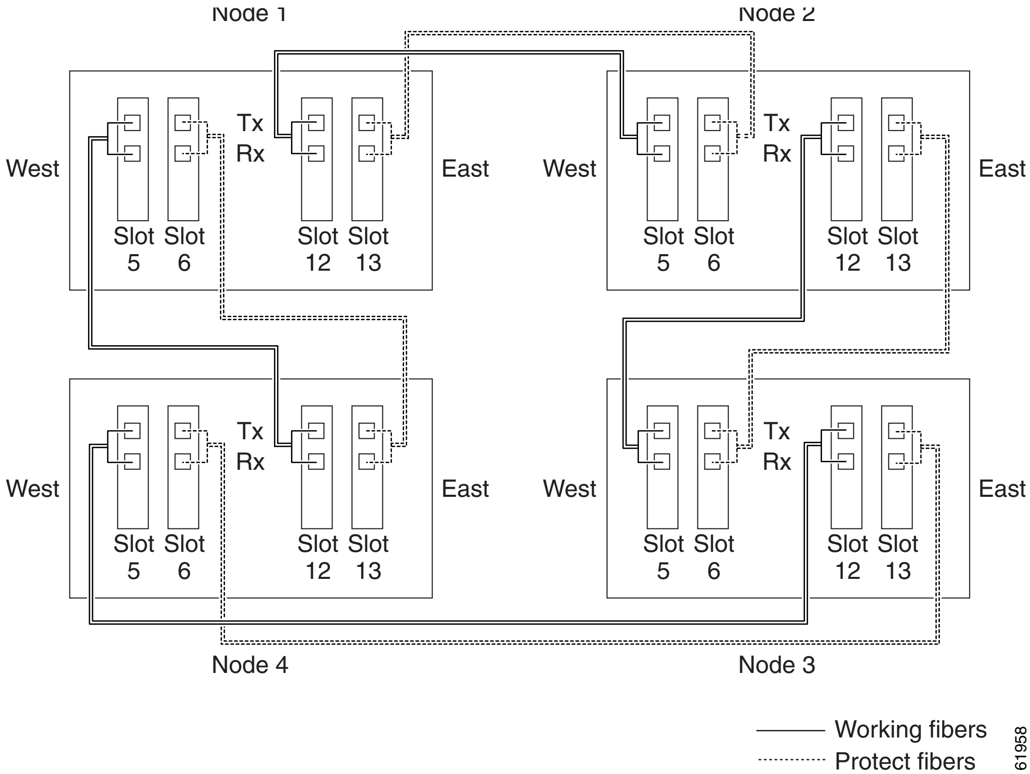
Plan your fiber connections and use the same plan for all BLSR nodes. For example, make the East port the farthest slot to the right and the West port the farthest left. Plug fiber connected to an East port at one node into the West port on an adjacent node. Figure 2-58 shows fiber connections for a two-fiber BLSR with trunk cards in Slot 5 (West) and Slot 12 (East).

Figure 2-58 Connecting Fiber to a Four-Node, Two-Fiber BLSR



For four-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 2-59 shows fiber connections for a four-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 2-59 Connecting Fiber to a Four-Node, Four-Fiber BLSR



Subtending Rings

An ONS 15454 with redundant TCC2/TCC2P cards can supports up to 68 SONET DCCs. Table 2-33 shows the number of SONET rings that can be created on each ONS 15454 node using redundant TCC2/TCC2P cards.

Table 2-33 Subtending Ring Capacities

Ring Type	Maximum Rings per Node
Two-Fiber BLSR	5
Two-Fiber BLSR and Four-Fiber BLSR	4 Two-Fiber BLSRs and 1 Four-Fiber BLSR
Path Protection Only	34
Path protection and Two-Fiber BLSR	29 path protections and 5 Two-Fiber BLSR
Path protection and Four-Fiber BLSR	32 path protection configurations and 1 Four-Fiber BLSR

Subtending rings from an ONS 15454 reduces the number of nodes and cards required and reduces external shelf-to-shelf cabling. Figure 2-60 shows an ONS 15454 network with multiple subtending rings.

Figure 2-60 ONS 15454 Network with Multiple Subtending Rings

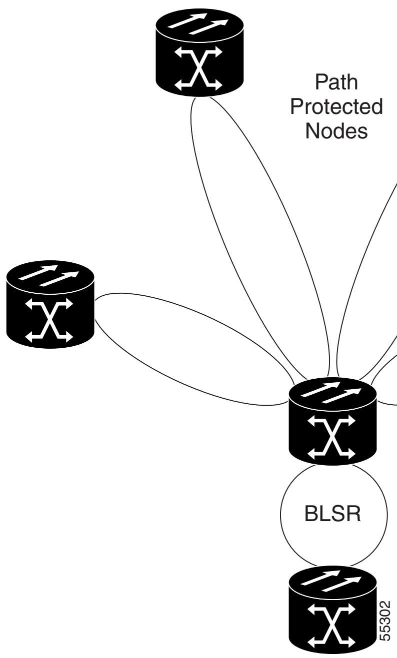
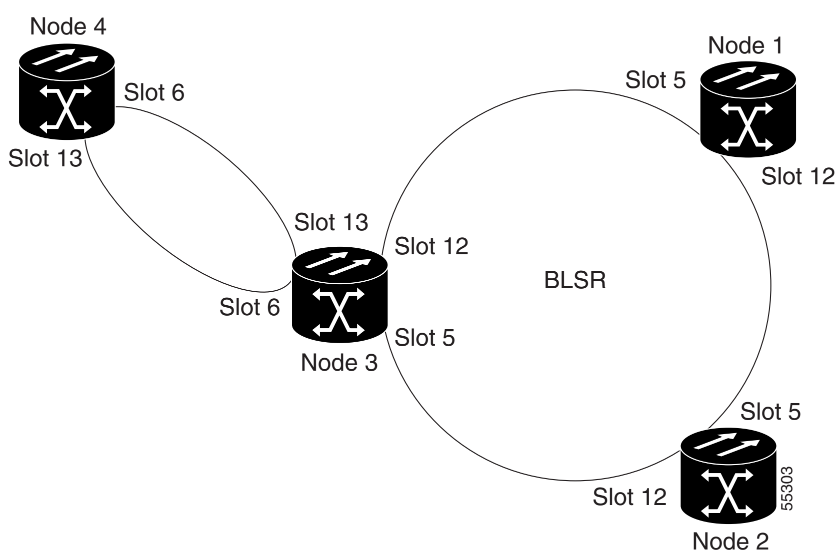


Figure 2-61 shows a path protection subtending from a BLSR. In this example, Node 3 is the only node serving both the BLSR and path protection. OC-N cards in Slots 5 and 12 serve the BLSR, and OC-N cards in Slots 6 and 13 serve the path protection.

Figure 2-61 Path Protection Subtending from a BLSR

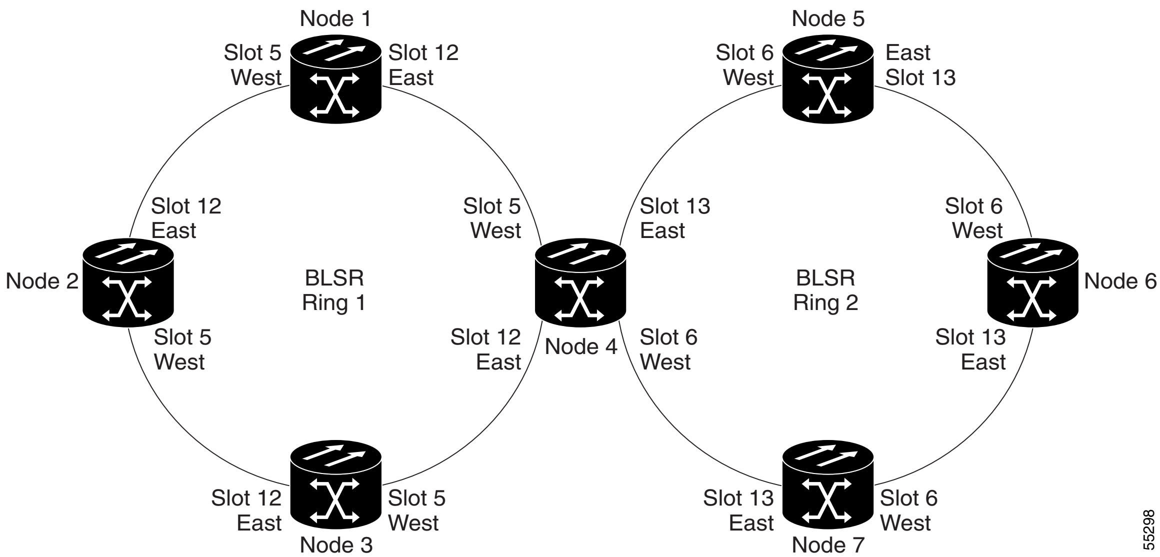


The ONS 15454 can support two BLSRs on the same node. This capability allows you to deploy an ONS 15454 in applications requiring SONET DCSs (digital cross-connect systems) or multiple SONET ADMs.

Figure 2-62 shows two BLSRs shared by one ONS 15454. 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.

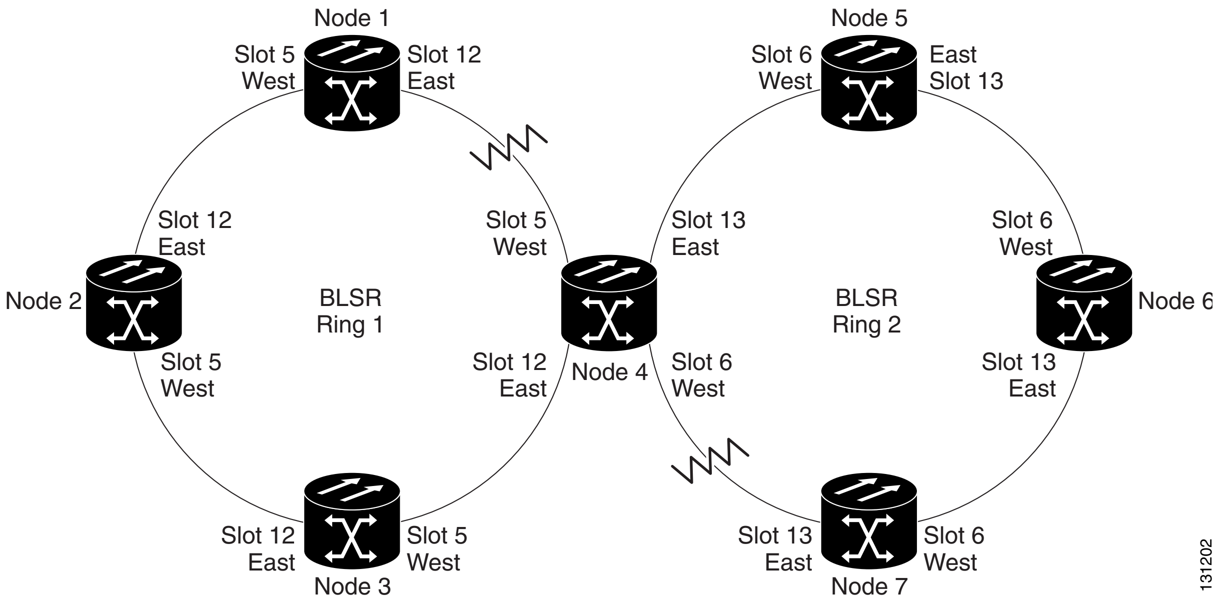
Although different node IDs are used for the two BLSRs shown in Figure 2-62, nodes in different BLSRs can use the same node ID.

Figure 2-62 BLSR Subtending from a BLSR



After subtending two BLSRs, you can route circuits from nodes in one ring to nodes in the second ring. For example in Figure 2-63, 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 between Nodes 1 and 4 and Nodes 4 and 7 as shown in Figure 2-63, traffic is rerouted around each ring to Nodes 2 and 3 in Ring 1 and Nodes 5 and 6 in Ring 2.

Figure 2-63 Two-Fiber Breaks in Subtending Rings



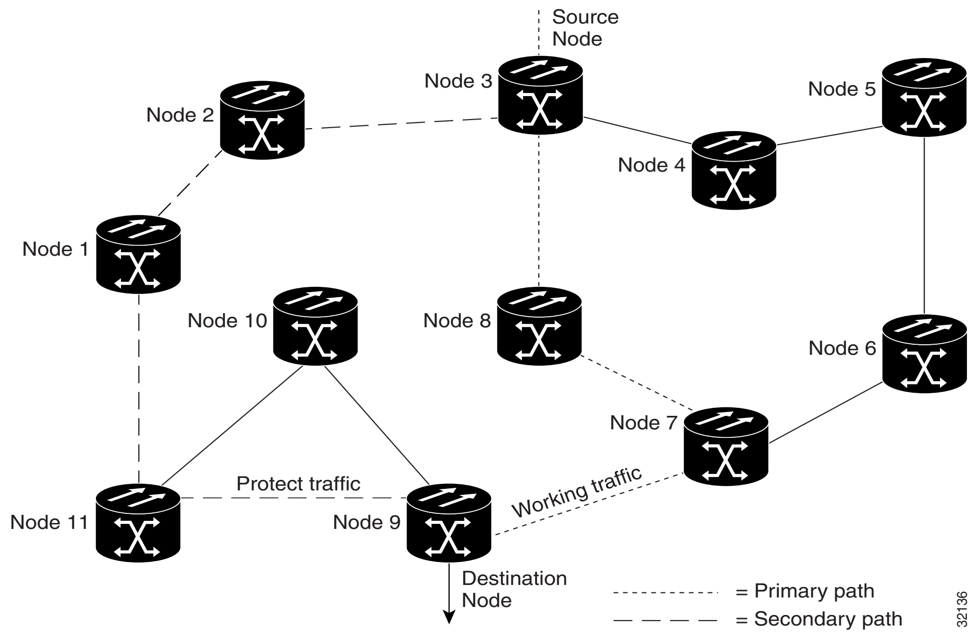
Path-Protected Meshed Networks

In addition to single BLSRs, path protection configurations and ADMs, you can extend ONS 15454 traffic protection by creating path-protected mesh networks (PPMNs). PPMNs include multiple ONS 15454 SONET topologies and extend the protection provided by a single path protection to the meshed architecture of several interconnecting rings. In a PPMN, circuits travel diverse paths through a network of single or multiple meshed rings. When you create circuits, you can have CTC automatically route circuits across the PPMN, or you can manually route them. You can also choose levels of circuit protection. For example, if you choose full protection, CTC creates an alternate route for the circuit in addition to the main route. The second route follows a unique path through the network between the source and destination and sets up a second set of cross-connections.

For example, in Figure 2-64, a circuit is created from Node 3 to Node 9. CTC determines that the shortest route between the two nodes passes through Node 8 and Node 7, shown by the dotted line, and automatically creates cross-connections at Nodes, 3, 8, 7, and 9 to provide the primary circuit path.

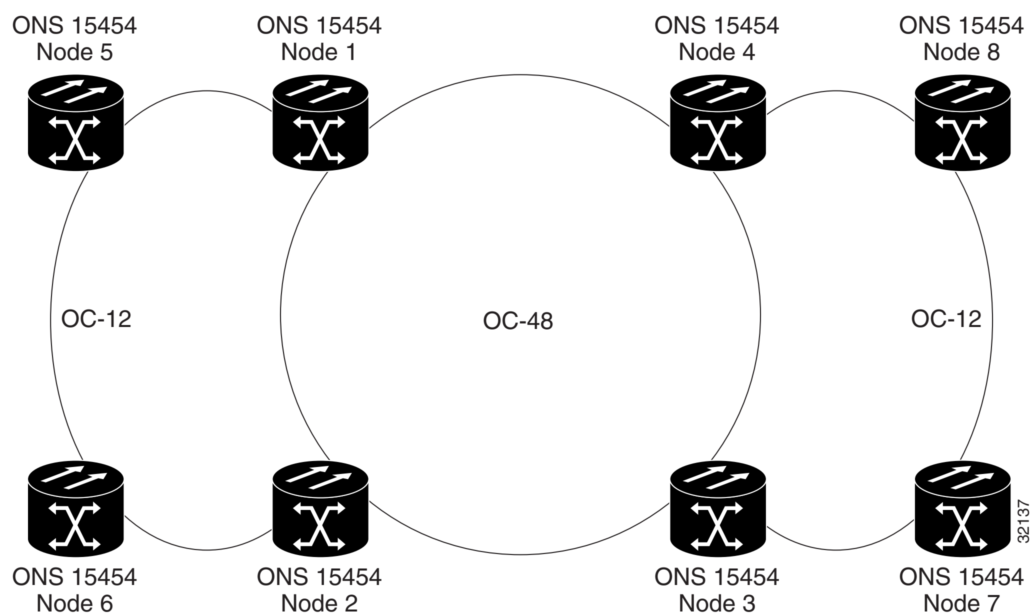
If full protection is selected, CTC creates a second unique route between Nodes 3 and 9 which, in this example, passes through Nodes 2, 1, and 11. Cross-connections are automatically created at Nodes 3, 2, 1, 11, and 9, shown by the dashed line. If a failure occurs on the primary path, traffic switches to the second circuit path. In this example, Node 9 switches from the traffic coming in from Node 7 to the traffic coming in from Node 11 and service resumes. The switch occurs within 50 ms.

Figure 2-64 Path-Protected Mesh Network



PPMN also allows spans of different SONET line rates to be mixed together in "virtual rings." Figure 2-65 shows Nodes 1, 2, 3, and 4 in a standard OC-48 ring. Nodes 5, 6, 7, and 8 link to the backbone ring through OC-12 fiber. The "virtual ring" formed by Nodes 5, 6, 7, and 8 uses both OC-48 and OC-12.

Figure 2-65 PPMN Virtual Ring



Inservice Topology Conversions

Caution An in-service topology conversion is potentially service-affecting, and generally allows a traffic hit of 50 ms or less. Traffic might not be protected during the upgrade.

Topology conversions can be performed in-service to convert a live network to a different topology. The following in-service topology conversions are supported:

- Unprotected point-to-point or linear ADM to path protection
- Point-to-point or linear ADM to two-fiber BLSR
- Path protection to two-fiber BLSR
- Two-fiber to four-fiber BLSR
- Node addition or removal from an existing topology

You can perform in-service topology conversions irrespective of the service state of the involved cross-connects or circuits, however a circuit must have a DISCOVERED status. For explanations on how to convert from one network topology to another, refer to the *Cisco ONS 15454 Procedure Guide*.

Circuit types supported for in-service topology conversions are:

- STS, VT, and VT tunnels
- Virtual concatenated circuits (VCAT)
- Unidirectional and bidirectional
- Automatically routed and manually routed
- CTC-created and TL1-created
- Ethernet (unstitched)
- Multiple source and destination (both sources should be on one node and both drops on one node)

You cannot upgrade stitched Ethernet circuits during topology conversions. For in-service topology conversion procedures, refer to the "Convert Network Configurations" chapter in the *Cisco ONS 15454 Procedure Guide*. For procedures to add or remove a node, refer to the "Add and Remove Nodes" chapter of the *Cisco ONS 15454 Procedure Guide*.

Note A database restore on all nodes in a topology returns converted circuits to their original topology.

Note Open-ended path protection and DRI configurations do not support in-service topology upgrades.

Unprotected Point-to-Point or Linear ADM to Path Protection

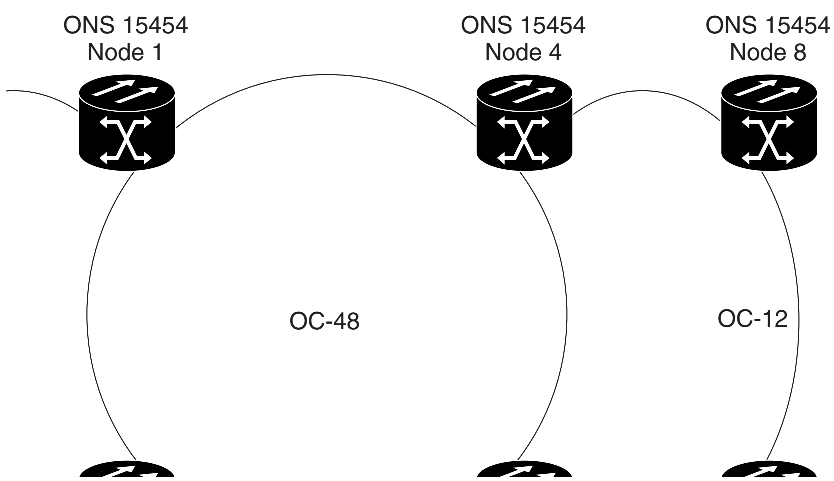
CTC provides a topology conversion wizard for converting an unprotected point-to-point or linear ADM topology to path protection. This conversion occurs at the circuit level. CTC calculates the additional path protection circuit route automatically or you can do it manually. When routing the path protection circuit, you can provision the USPR as go-and-return or unidirectional.

When performing an in-service topology conversion on a configuration with VCAT circuits, CTC allows you to select member circuits to upgrade individually. When upgrading VT tunnels, CTC does not convert the VT tunnel to path protection, but instead creates a secondary tunnel for the alternate path. The result is two unprotected VT tunnels using alternate paths.

To convert from point-to-point or linear ADM to a path protection, the topology requires an additional circuit route to complete the ring. When the route is established, CTC creates circuit connections on any intermediate nodes and modifies existing circuit connections on the original circuit path. The number and position of network spans in the topology remains unchanged during and after the conversion.

Figure 2-66 shows an unprotected point-to-point ADM configuration converted to a path protection. An additional circuit routes through Node 3 to complete the path protection.

Figure 2-66 Unprotected Point-to-Point ADM to Path Protection Conversion



Point-to-Point or Linear ADM to Two-Fiber BLSR

A 1+1 point-to-point or linear ADM to a two-fiber BLSR conversion is manual. You must remove the protect fibers from all nodes in the linear ADM and route them from the end node to the protect port on the other end node. In addition, you must delete the circuit paths that are located in the bandwidth that will become the protection portion of the two-fiber BLSR (for example, circuits in STS 25 or higher on an OC-48 BLSR) and recreate them in the appropriate bandwidth. Finally, you must provision the nodes as BLSR nodes.

To complete a conversion from an unprotected point-to-point or linear ADM to a two-fiber BLSR, use the CTC Convert Unprotected/path protection to BLSR wizard from the Tools > Topology Upgrade menu.

Path Protection to Two-Fiber BLSR

CTC provides a topology conversion wizard to convert a path protection to a two-fiber BLSR. A conversion from a path protection to a two-fiber BLSR changes path protection to line protection. A path protection can have a maximum of 16 nodes before conversion. Circuit paths must occupy the same time slots around the ring. Only the primary path through the path protection is needed; the topology conversion wizard removes the alternate path protection path during the conversion. Because circuit paths can begin and end outside of the topology, the conversion might create line-protected segments within path protection paths of circuits outside the scope of the ring. The physical arrangement of the ring nodes and spans remains the same after the conversion.

Two-Fiber BLSR to Four-Fiber BLSR

CTC provides a wizard to convert two-fiber OC-48 or OC-192 BLSRs to four-fiber BLSRs. To convert the BLSR, you must 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.

Add or Remove a Node from a Topology

You can add or remove a node from a linear ADM, BLSR, or path protection configuration. Adding or removing nodes from BLSRs is potentially service affecting, however adding and removing nodes from an existing 1+1 linear ADM or path protection configuration does not disrupt traffic. CTC provides a wizard for adding a node to a point-to-point or 1+1 linear ADM. This wizard is used when adding a node between two other nodes.

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
- Four-port OC-3 to eight-port OC-3
- Single-port OC-12 to OC-48
- Single-port OC-12 to OC-192
- OC-48 to OC-192

Table 2-34 lists permitted upgrades for Slots 5, 6, 12, and 13.

Table 2-34 Slot 5, 6, 12, and 13 Upgrade Options

Cards	Four-port OC-3	Eight-port OC-3	One-port OC-12	Four-port OC-12	OC-48	OC-192
Four-port OC-3	N/A	Not supported	Not supported	Not supported	Not supported	Not supported
Eight-port OC-3[1]	Not supported	N/A	Not supported	Not supported	Not supported	Not supported

Table 2-34 Slot 5, 6, 12, and 13 Upgrade Options (continued)

Cards	Four-port OC-3	Eight-port OC-3	One-port OC-12	Four-port OC-12	OC-48	OC-192
One-port OC-12	Not supported	Not supported	N/A	Not supported	Yes	Yes
Four-port OC-12[2]	Not supported	Not supported	Not supported	N/A	Not supported	Not supported
OC-48	Not supported	Not supported	Yes	Not supported	N/A	Yes
OC-192	Not supported	Not supported	Yes	Not supported	Yes	N/A

1. The eight-port OC-3 is not supported in Slots 5, 6, 12, and 13.
2. The four-port OC-12 is not supported in Slots 5, 6, 12, and 13.

Table 2-35 lists permitted upgrades for Slots 1 through 4 and 14 through 17.

Table 2-35 Upgrade Options for Slots 1 through 4 and 14 through 17

Cards	Four-port OC-3	Eight-port OC-3	One-port OC-12	Four-port OC-12	OC-48
Four-port OC-3	N/A	Yes	Not supported	Not supported	Not supported
Eight-port OC-3	Yes	N/A	Not supported	Not supported	Not supported
One-port OC-12	Not supported	Not supported	N/A	Yes	Yes
Four-port OC-12	Not supported	Not supported	Yes	N/A	Not supported
OC-48	Not supported	Not supported	Yes	Not supported	N/A

Note Since the four-port OC-3 to eight-port OC-3 cards and the single-port OC-12 to four-port OC-12 cards are the same speed, they are not considered span upgrades.

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, 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, 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.

Note Span upgrades do not upgrade SONET topologies, for example, a 1+1 group to a two-fiber BLSR.

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*:

- Perform a Manual Span Upgrade on a 2-Fiber BLSR
- Perform a Manual Span Upgrade on a 4-Fiber BLSR
- Perform a Manual Span Upgrade on a path protection
- Perform a Manual Span Upgrade on a 1+1 Protection Group
- Upgrade on an unprotected span

CHAPTER 3

SDH Transport Over SONET

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.

The following topics are covered in this chapter:

Provisioning OC-N Ports for SDH

All ports 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.

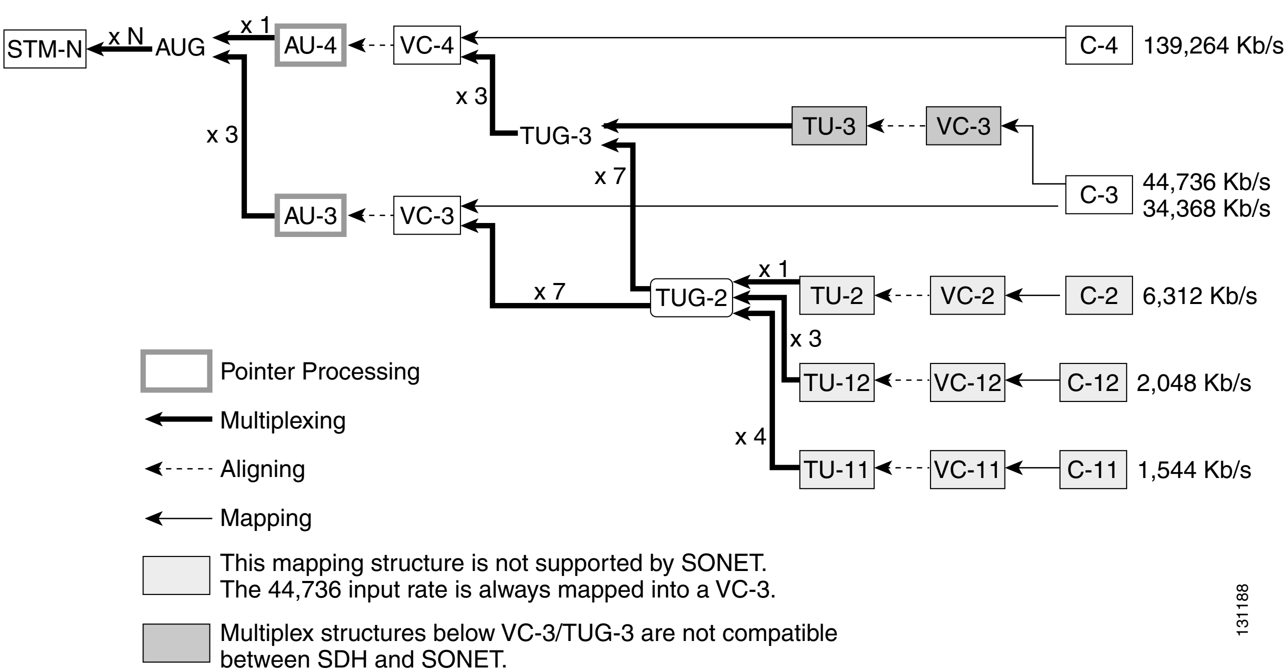
SDH to SONET Mapping

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, detailed in Table 3-1 and Table 3-2, 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 Au4 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

Table 3-2 SDH to SONET Circuit Type Mapping for Au3 SDH (continued)

Optical Card	Provisioned SDH Interface	SONET Circuit Type Mapping	Equivalent Au4 SDH Circuits
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 bidirectional 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

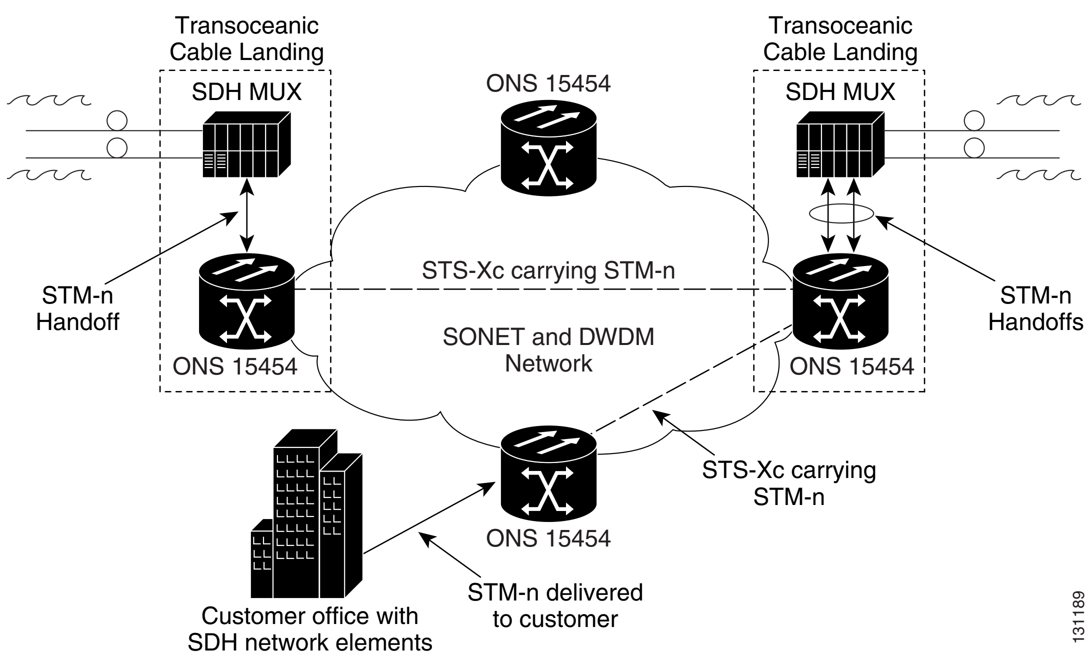
The SDH transport feature of the ONS 15454 addresses a variety of applications, with three applications depicted in Figures 3-1, 3-2 and 3-3:

- 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.

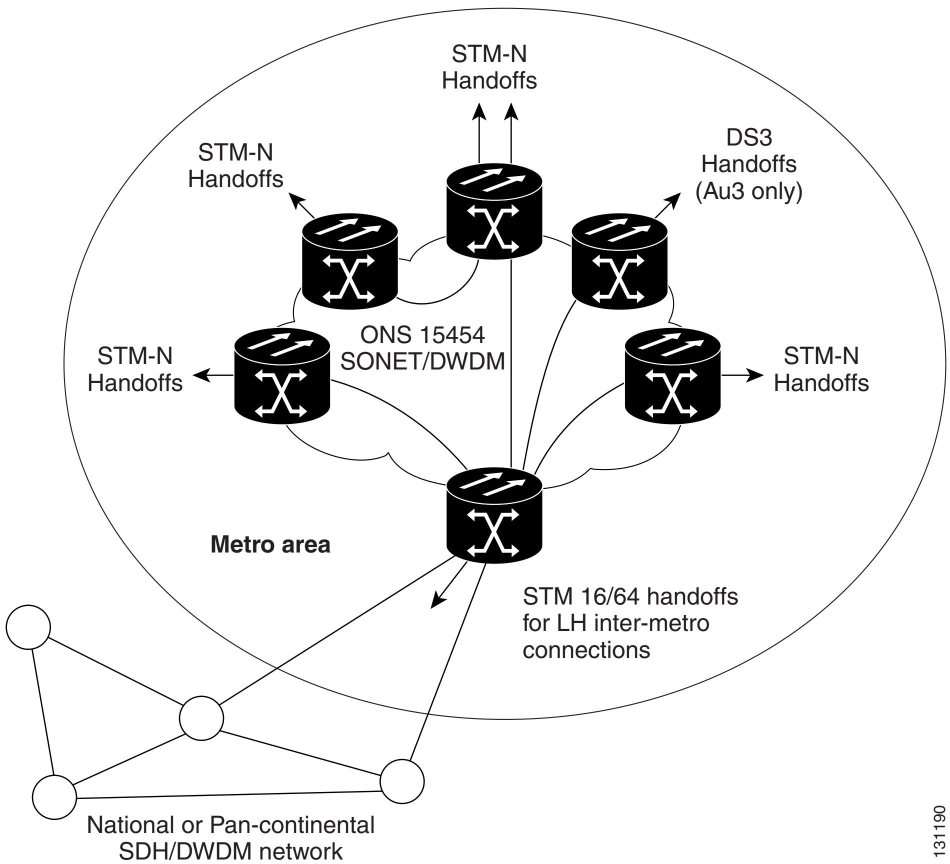
Figure 3-2 Transoceanic STM-N Handoff Application



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.

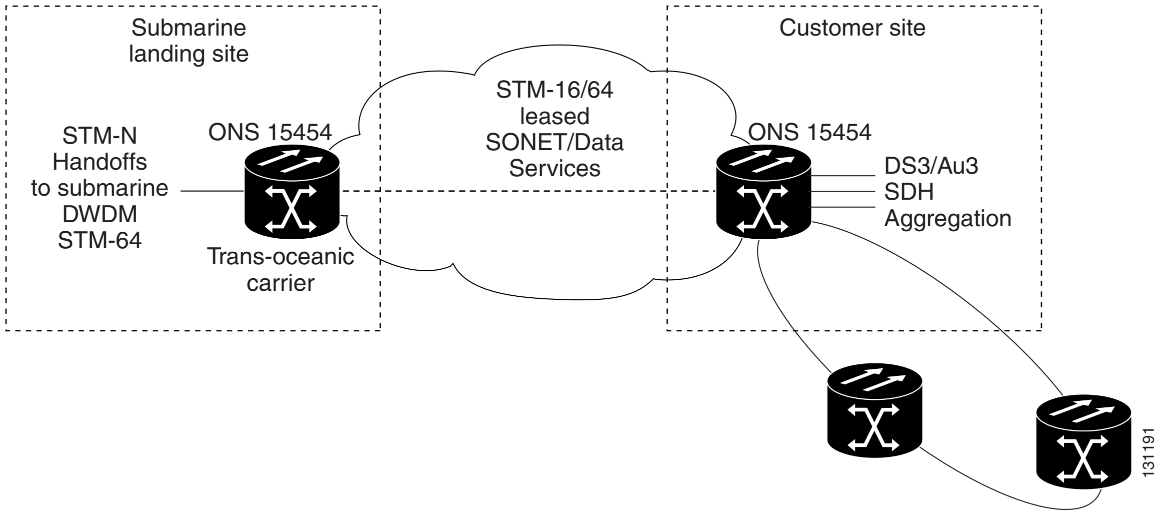
Figure 3-3 SDH Aggregation Applications



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 SDH and SONET Multiplexing Structures



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.

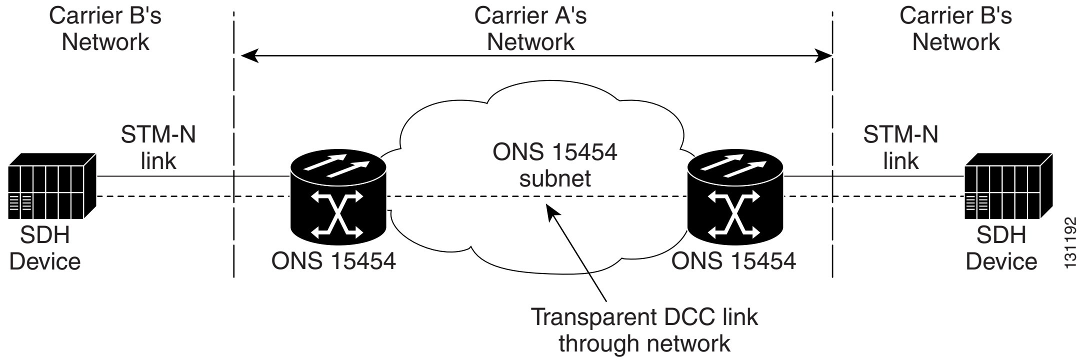
Table 3-3 SDH Hairpinning Compatibility Table

Optical Cards	STM-1	STM-16 HS	STM-16 AS	STM-64
OC-3/STM-1	Yes	Yes	Yes	Yes
OC-12/STM-4	Yes	Yes	Yes	No
OC-48/STM-16 High-Speed slot versions	Yes	Yes	No	No
OC-48/STM-16 Any-slot versions	Yes	No	No	Yes
OC-192/STM-64	Yes	No	No	Yes

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.

CHAPTER 4

DWDM

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.

This chapter provides general dense wavelength division multiplexing (DWDM) design guidelines and explains the various DWDM node configuration, topologies, optical performances, and features that are available for the ONS 15454. For information explaining installation, turn up, provisioning, and maintenance for Cisco's ONS 15454 DWDM systems, see the *Cisco ONS 15454 DWDM Installation and Operations Guide*. For an introduction to DWDM, see the DWDM Primer in Appendix C.

The following topics are covered in this chapter:

Design Guidelines

The ONS 15454 is a flexible platform that can be configured to support passive DWDM applications as a multi-service provisioning platform (MSPP) or provide DWDM aggregation and wavelength services as a multi-service transport platform (MSTP). Software Releases 4.6 and 5.0 fully integrate the passive DWDM MSPP and intelligent DWDM MSTP functions into one ONS 15454 system platform.

MSPP DWDM Applications

The multi-wavelength capabilities of the ONS 15454 MSPP allow it to easily interface with the WDM filters. Since these systems are transparent to the ONS 15454, you can support linear, mesh, and ring network architectures. For passive DWDM applications, use the OC48 and OC192 ITU-T optical cards described in this chapter.

MSTP Applications

With Software Release 4.5 and higher, the ONS 15454 MSTP supports a wide range of wavelength services and DWDM channel aggregation using the ONS 15454 DWDM cards below.

- Optical service channel cards provide bidirectional channels that connect all the ONS 15454 DWDM nodes and transport general-purpose information without affecting the client traffic. ONS 15454 optical service channel cards include the Optical Service Channel Module (OSCM) and the Optical Service Channel and Combiner/Separator Module (OSC-CSM).
- Optical amplifier cards are used in amplified DWDM nodes, including hub nodes, amplified OADM nodes, and line amplified nodes. Optical amplifier cards include the Optical Preamplifier (OPT-PRE) and Optical Booster (OPT-BST) amplifier.
- Dispersion compensation units are installed in the ONS 15454 dispersion compensation shelf when optical preamplifier cards are installed in the DWDM node. Each DCU module can compensate a maximum of 65 km of single-mode fiber (SMF-28) span. DCUs can be cascaded to extend the compensation to 130 km.
- Multiplexer and demultiplexer cards multiplex and demultiplex DWDM optical channels. ONS 15454 multiplexer and demultiplexer cards include the 32-Channel Multiplexer (32MUX-O), the 32-Channel Demultiplexers (32DMX-O and 32DMX), and the 4-Channel multiplexer/Demultiplexer (4MD-xx.x).
- Optical Add/Drop Multiplexer (OADM) cards are mainly divided into three groups: band OADM, channel OADM, and wavelength selective switch (WSS) cards. Band OADM cards add and drop one or four bands of adjacent channels; they include the 4-Band OADM (AD-4B-xx.x) and the 1-Band OADM (AD-1B-xx.x). Channel OADM cards add and drop one, two, or four adjacent channels; they include the 4-Channel OADM (AD-4C-xx.x), the 2-Channel OADM (AD-2C-xx.x) and the 1-Channel OADM (AD-1C-xx.x). Available in Release 5.0 and higher, the 32-Channel Wavelength Selective Switch (32WSS) card performs channel add/drop processing within the ONS 15454 DWDM node. The 32WSS works in conjunction with the 32DMX to implement reconfigurable optical add/drop (ROADM) functionality. Equipped with ROADM functionality, the ONS 15454 DWDM can be configured to add or drop individual optical channels using CTC, Cisco MetroPlanner, and CTM.
- Transponder and muxponder cards process multirate client signals into either 2.5 Gb/s or 10 Gb/s signals for transport into the core network. ONS 15454 transponder and muxponder cards include the following:
  - The 10 Gb/s Transponder–100 GHz–Tunable xx.xx-xx.xx card (TXP_MR_10G), which processes one 10 Gb/s signal (client side) into one 10 Gb/s, 100 GHz DWDM signal (trunk side).
  - The 10 Gb/s Transponder–100 GHz–Tunable xx.xx-xx.xx (TXP_MR_10E) card, which is a multirate transponder for the ONS 15454 platform.

- The 2.5 Gb/s Multirate Transponder–100 GHz–Tunable xx.xx-xx.xx (TXP_MR_2.5G and TXP_MRP_2.5G) card, which processes one 8 Mb/s to 2.488 Gb/s signal (client side) into one 8 Mb/s to 2.5 Gb/s, 100 GHz DWDM signal (trunk side). The P version indicates the option Protection.
- The 2.5 Gb/s–10 Gb/s Muxponder–100 GHz–Tunable xx.xx-xx.xx (MXP_2.5G_10G) card, which multiplexes/demultiplexes four 2.5 Gb/s signals (client side) into one 10 Gb/s, 100 GHz DWDM signal (trunk side).
- The 2.5 Gb/s–10 Gb/s Muxponder–100 GHz–Tunable xx.xx-xx.xx (MXP_2.5G_10E) card provides wavelength transmission service for the four incoming 2.5 Gb/s client interfaces.
- The 2.5 Gb/s Multirate Muxponder-100 GHz-Tunable 15xx.xx-15yy.yy (MXP_MR_2.5G) card aggregates a mix and match of client Storage Area Network (SAN) service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s OC-48 DWDM signal on the trunk side.
- The 2.5 Gb/s Multirate Muxponder–Protected–100 GHz–Tunable 15xx.xx-15yy.yy (MXPP_MR_2.5G) card aggregates various client SAN service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s OC-48 DWDM signal on the trunk side.

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 SDH to SONET Circuit Type Mapping for Au4 SDH

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
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
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[1]					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

1. These wavelengths are shorter lead-time cards and are recommended for deployment.

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 and higher 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

Channels/wavelengths can be added or deleted between ONS 15454 MSTP nodes via the CTC circuit creation wizard. Simply select OHCNC (optical channel connection) from the Circuit Type list, choose the wavelength you want to provision, and define the circuit attributes like you would for any CTC circuit. Refer to the *Cisco ONS 15454 DWDM Installation and Operation Guide* for step-by-step procedures.

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 0.25 mW by 18, which equals 0.0138 mW. This number (0.0138 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

Table 4-2 Maximum Power Per Channel (continued)

Full Loading—Number of Channels	Maximum per Channel Power (mW)	Maximum per Channel Power (dBm)
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 or Y-cable protection modules 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 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

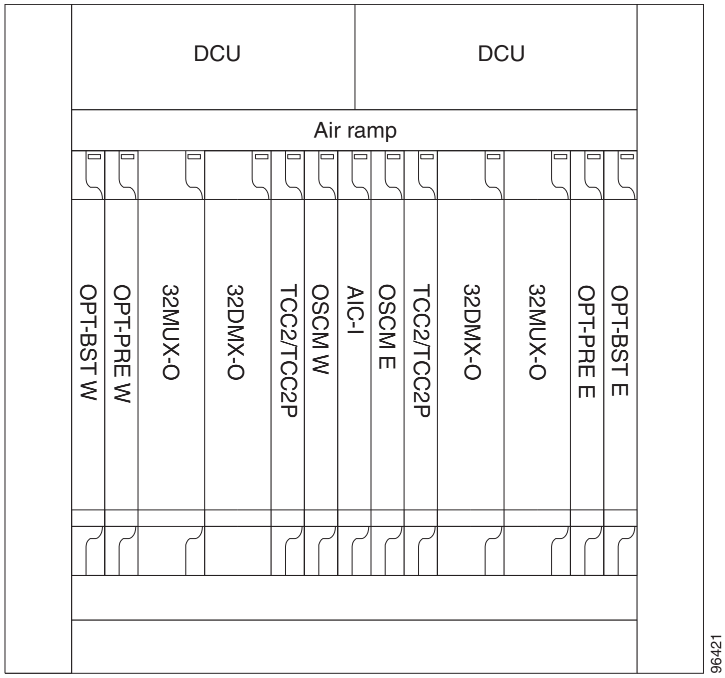
In a DWDM system, as wavelengths travel through fibers and various optical components (filters, amplifiers, etc.), dispersion or optical pulse widening occurs. Moreover, connectors and splices insert further loss and dispersion as light travels from one fiber to another. As dispersion increases, so does 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

You can install dispersion compensation units (DCUs) in the ONS 15454 dispersion compensation shelf when optical preamplifier cards are installed in the DWDM node. Each DCU module can compensate a maximum of 65 km of single-mode fiber (SMF-28) span. DCUs can be cascaded to extend the compensation to 130 km. Figure 4-1 shows a Hub node configuration with DCU cards installed.

Figure 4-1 Hub Node Configuration with DCU Cards Installed



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 100 GHz	OC48 200 GHz	OC192 100 GHz
Maximum Transmitter Output per Channel	0 dBm with BER 10^{-12}	0 dBm with BER 10^{-12}	0 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 ONS 15454 MSTP supports two optical EDFA amplifier cards: Preamplifier (OPT-PRE) and Optical Booster (OPT-BST). These cards are used in amplified DWDM nodes, including hub nodes, amplified OADM nodes, and line amplified nodes. If a DCU is not installed, a 5 dB attenuator loop must be installed between the OPT-PRE DC ports. Figure 4-2 shows a Hub node configuration with OPT-PRE and OPT-BST amplifier cards installed.

Figure 4-2 Hub Node Configuration with Amplifier Cards Installed

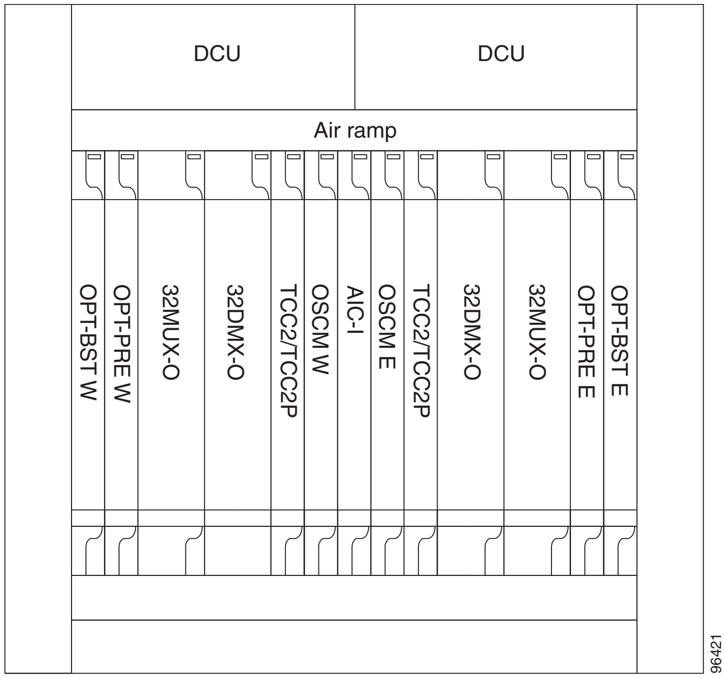
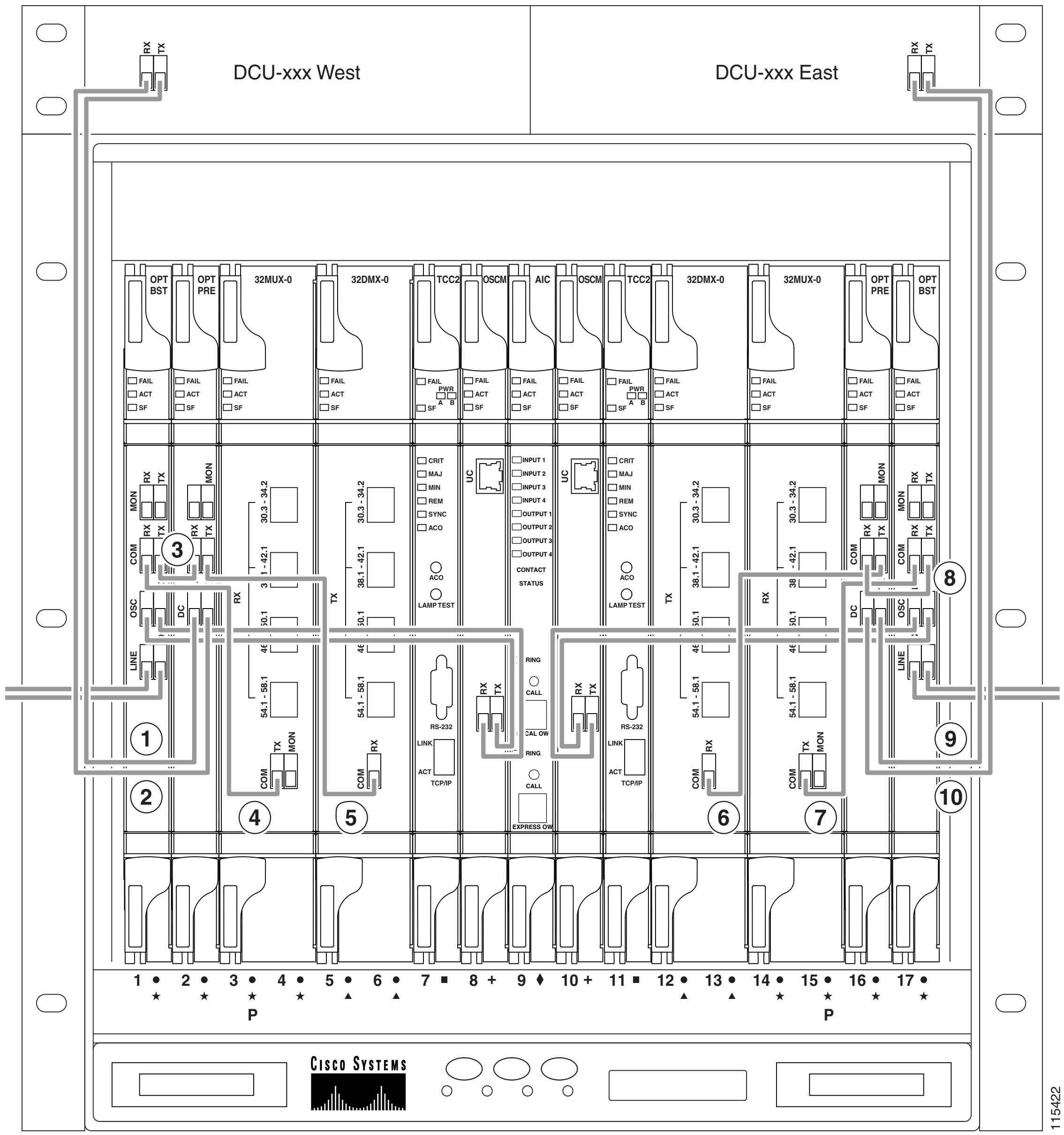


Figure 4-3 shows an example of how to cable a Hub node configured with DCU and amplifier cards.

Figure 4-3 Hub Node Wiring Example



1. West DCU TX to west OPT-PRE DC RX[1]
2. West DCU RX to west OPT-PRE DC TX[1]
3. West OPT-BST COM TX to west OPTPRE COM RX
4. West OPT-BST COM RX to west 32MUXO COM TX
5. West OPT-PRE COM TX to west 32DMXO COM RX
6. East 32DMX-O COM RX to east OPTPRE COM TX
7. East 32MUX-O COM TX to east OPTBSTCOM RX
8. East OPT-PRE COM RX to east OPTBST COM TX
9. East DCU TX to east OPT-PRE DC RX[1]
10. East DCU RX to east OPT-PRE DC TX[1]

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 23 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

No. of Spans	No. 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	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, multiplex/demultiplex, 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 multiplexed and demultiplexed 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

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

- Fixed Distance—Where network locations are already established.
- Variable Distance—where the designer chooses the network locations.

The following example provides a manual step-by-step approach to designing a Fixed Distance Metro DWDM network using ONS 15454 OC48 200 GHz ITU-T cards and Cisco's 200 GHz passive DWDM products. You can substitute the Cisco's DWDM products and specifications with third party passive DWDM equipment without affecting the steps listed below. For ONS 15454 MSTP Metro Core applications, Cisco recommends designing the DWDM network with MetroPlanner, Release 2.5 or higher. Cisco MetroPlanner prepares a shelf plan for each network node, and calculates the power and attenuation levels for the DWDM cards installed in the node. Cisco MetroPlanner exports the calculated parameters to an ASCII file called "NE Update." In CTC, you can import the NE Update file to automatically provision the node.

Caution Network ring designs including amplifiers must include at least one Multiplex/Demultiplex 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 Multiplex/Demultiplex. If the OADMs belonging to the channel that is patched through the multiplex/demultiplex 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 multiplex/demultiplex site are inserted so that they address the correct wavelengths.

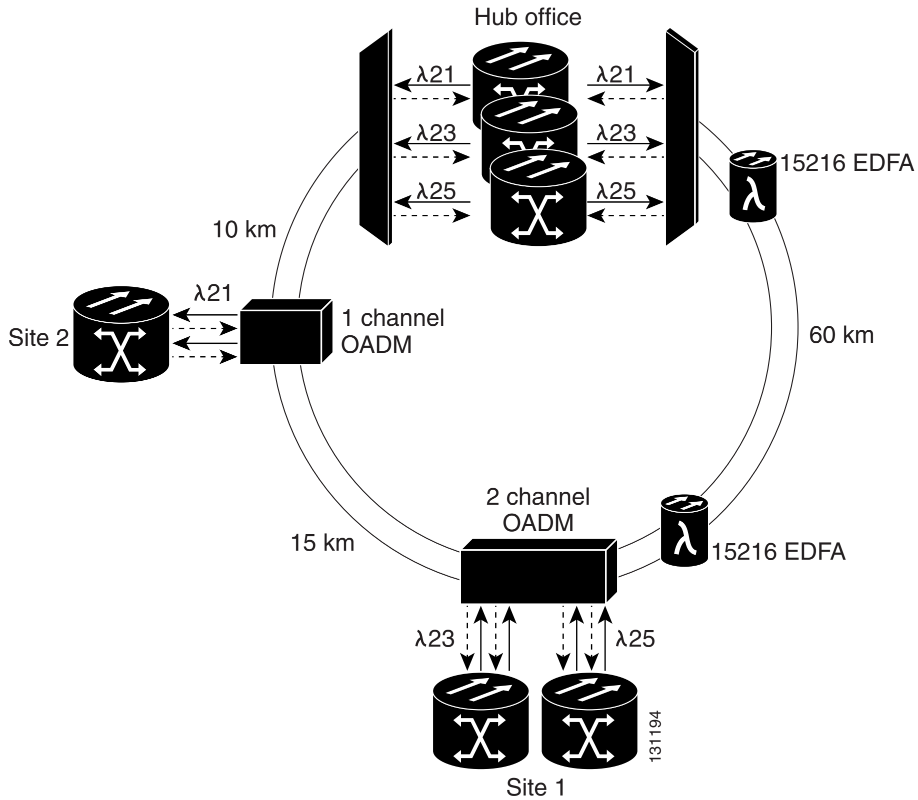
Note Additional loss is introduced to a channel when it passes through multiple Mux/Demultiplex filters due to effects of cascaded filters.

Step 1: Physical Parameters

Using Figure 4-4 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 4-4 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

No. of Channels (lambda)	Total Power (P)
1 lambda, P lambda= 0 dBm	P_{tot}= 0 dBm
2 lambda, P lambda= 0 dBm	P_{tot}= -3 dBm
4 lambda, P lambda= 0 dBm	P_{tot}= -6 dBm
8 lambda, P lambda= 0 dBm	P_{tot}= -9 dBm
16 lambda, P lambda= 0 dBm	P_{tot}= -12 dBm
32 lambda, P lambda= 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 $P_{in}=\Sigma P\lambda\iota$. 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

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

Table 4-15 EDFA Gain and OSNR (continued)

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

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:

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

Multiplex/Demultiplex 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

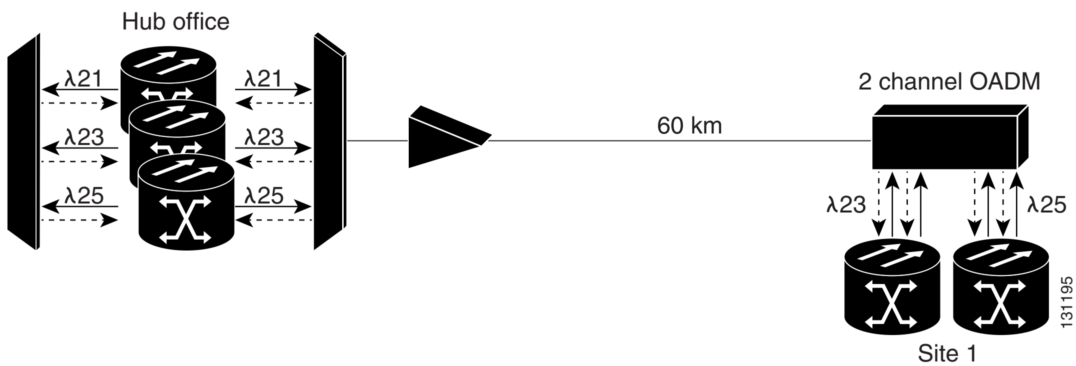
1-Channel OADM Characteristics:

- 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 4-5) the following calculations apply:

Figure 4-5 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

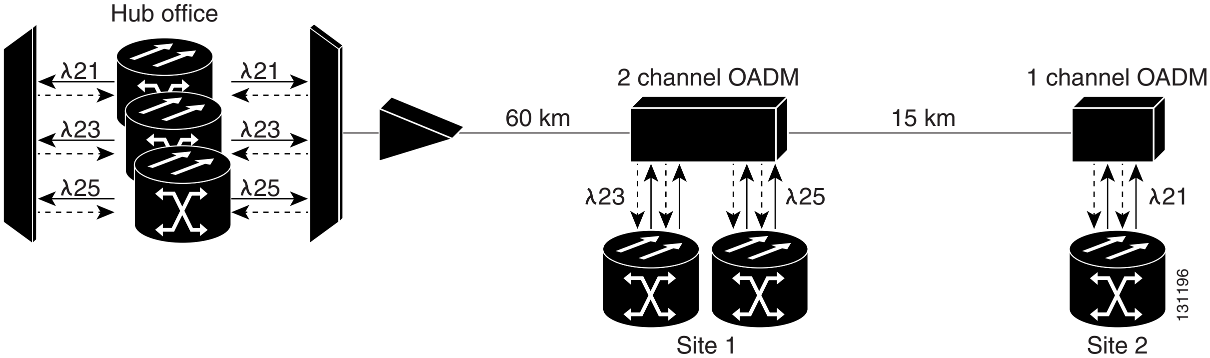
–2.6 dBm Drop loss for the 2-Channel OADM

<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 4-6) are as follows:

Figure 4-6 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

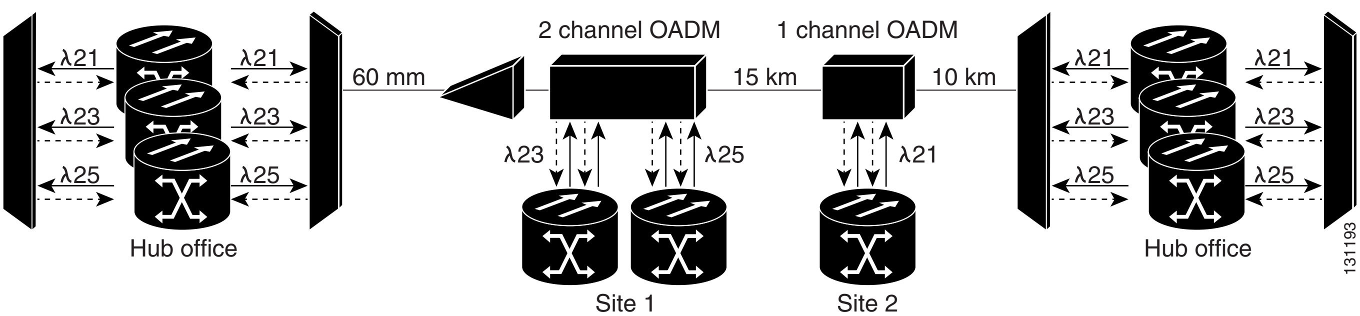
<u>–2.1 dB Drop loss for the 1-Channel OADM</u>

–14.4 dBm at the OC4 ITU-T receiver of Site 2

The passthrough channel power at Site 2: (–12.3 – 1.8) = –13.1 dBm

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



–13.1 dBm out of OADM-1

–4.5 dB For 15 km of span loss

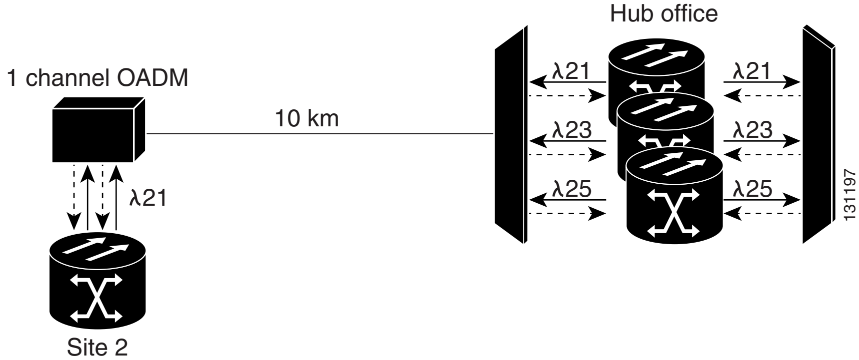
<u>–4.5 dB Drop loss for the Demux</u>

–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 4-8) are as follows:

Figure 4-8 ***Hub Office to Site 2***



–2.0 dBm ELR Output

<u>–4.5 dB Mux insertion loss</u>

–6.5 dBm Composite power

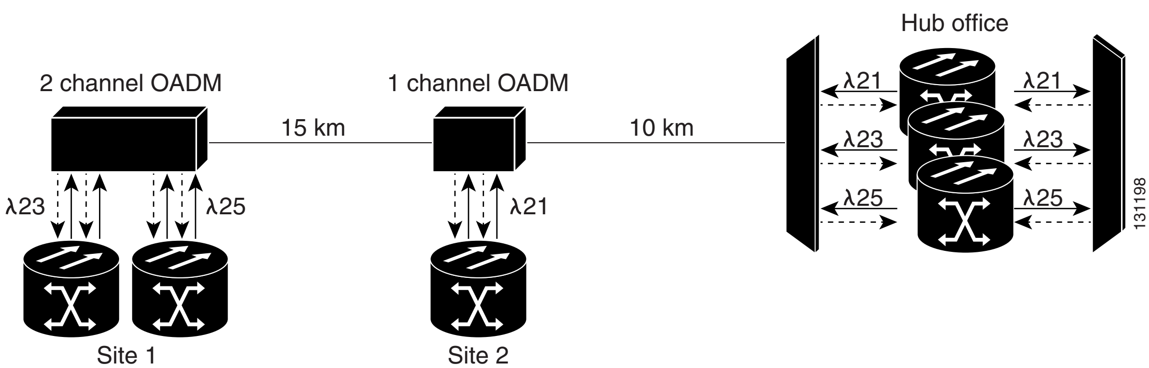
–3.0 dB for 10 km of span loss

<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 4-9) are as follows:

Figure 4-9 ***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

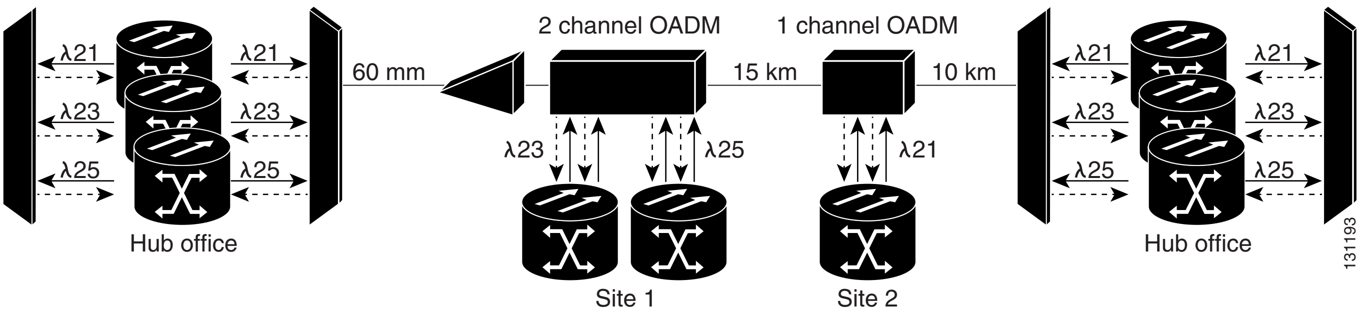
–4.5 dB for 15 km of span loss

<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 4-10) are as follows:

Figure 4-10 ***Hub Office to Site 1***



For the pass thru channel power at Site 1: (–16.1 – 2) = –18.1 dBm

–18.1 dBm out of the 2-Channel OADM

+22 dB Gain from the EDFA

+3.9 dBm Channel power out of the EDFA

–18.0 dB For 60 km of span loss

–4.5 dB Insertion loss of the Passive DWDM filter

–18.6 dBm at the OC48 ITU-T receiver of the Hub Office

DWDM Card Reference

The following common control cards are needed to support the functions of the DWDM, transponder, and muxponder cards:

- TCC2 or TCC2P
- AIC-I (optional)

DWDM Cards

Each DWDM card is marked with a symbol that corresponds to a slot (or slots) on the ONS 15454 shelf assembly. These cards can only be installed into slots displaying the same symbols.

ONS 15454 DWDM cards are grouped into the following categories:

- Optical service channel (OSC) cards, which provide bidirectional channels that connect all the ONS 15454 DWDM nodes and transport general-purpose information without affecting the client traffic. ONS 15454 optical service channel cards include the Optical Service Channel Module (OSCM) and the Optical Service Channel and Combiner/Separator Module (OSC-CSM).
- Optical EDFA cards, which are used in amplified DWDM nodes, including hub nodes, amplified OADM nodes, and line amplified nodes. Optical amplifier cards include the Optical Preamplifier (OPT-PRE) and Optical Booster (OPT-BST) amplifier.
- Dispersion compensation units, which are installed in the ONS 15454 dispersion compensation shelf when optical preamplifier cards are installed in the DWDM node. Each DCU module can compensate a maximum of 65 km of single-mode fiber (SMF-28) span. DCUs can be cascaded to extend the compensation to 130 km.

- Multiplexer and demultiplexer cards, which multiplex and demultiplex DWDM optical channels. The cards are composed of three main modules: optical plug-in, microprocessor, and the DC/DC converter. ONS 15454 multiplexer and demultiplexer cards include the 32-Channel Multiplexer (32MUX-O), the 32-Channel Demultiplexer (32DMX-O), the single-slot 32-Channel Demultiplexer and the 4-Channel Multiplexer/Demultiplexer (4MD-xx.x).
- Optical Add/Drop Multiplexer (OADM) cards, which are mainly divided into three groups: band OADM, channel OADM, and wavelength selective switch (WSS) cards. Band OADM cards add and drop one or four bands of adjacent channels; they include the 4-Band OADM (AD-4B-xx.x) and the 1-Band OADM (AD-1B-xx.x). Channel OADM cards add and drop one, two, or four adjacent channels; they include the 4-Channel OADM (AD-4C-xx.x), the 2-Channel OADM (AD-2C-xx.x) and the 1-Channel OADM (AD-1C-xx.x). The 32-Channel wavelength selective switch (32WSS) card is used with the 32DMX to implement Reconfigurable OADM (ROADM) functionality. These cards are composed of three main modules: optical plug-in, microprocessor, and the DC/DC converter.
- Transponder and Muxponder cards, which are divided into two groups:
  - Cards that are fully optically transparent, such as the TXP_MR_10E and MXP_2.5G_10E
  - Cards that are not fully optically transparent, such as the TXP_MR_10G, TXP_MR_2.5G, TXPP_MR_2.5G, MXP_MR_2.5G, MXPP_MR_2.5G and MXP_2.5G_10G

Table 4-16 describes the Cisco ONS 15454 DWDM cards available for MSTP applications.

Table 4-16 ONS 15454 DWDM Cards

Card	Part Number	Description
Optical Service Channel Modules		
OSCM	15454-OSCM=	The OSCM has one set of optical ports and one Ethernet port located on the faceplate. It operates in Slots 8 and 10. An optical service channel (OSC) is a bidirectional channel connecting all the nodes in a ring. The channel transports OSC overhead that is used to manage ONS 15454 DWDM networks. The OSC uses the 1510 nm wavelength and does not affect client traffic. The primary purpose of this channel is to carry clock synchronization and orderwire channel communications for the DWDM network. It also provides transparent links between each node in the network. The OSC is an OC-3 formatted signal. The OSCM is used in amplified nodes that include the OPT-BST booster amplifier. The OPT-BST includes the required OSC wavelength combiner and separator component. The OSCM cannot be used in nodes where you use OC-N cards, electrical cards, or cross-connect cards. The OSCM uses slots 8 and 10 when the ONS 15454 is configured as an MSTP.

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
OSC-CSM	15454-OSC-CSM=	The OSC-CSM has three sets of optical ports and one Ethernet port located on the faceplate. It operates in Slots 1 to 6 and 12 to 17. The OSC-CSM is identical to the OSCM, but also contains a combiner and separator module in addition to the OSC module. The OSC-CSM is used in unamplified nodes. This means that the booster amplifier with the OSC wavelength combiner and separator is not required for OSC-CSM operation. The OSC-CSM can be installed in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.
Optical Amplifiers		
OPT-PRE	15454-OPT-PRE=	The OPT-PRE is designed to support 64 channels at 50-GHz channel spacing, but Software R4.6 only supports 32 channels at 100 GHz. The OPT-PRE is a C-band DWDM, two-stage erbium-doped fiber amplifier (EDFA) with mid-amplifier loss (MAL) for allocation to a dispersion compensation unit (DCU). To control the gain tilt, the OPT-PRE is equipped with a built-in VOA. The VOA can also be used to pad the DCU to a reference value. You can install the OPT-PRE in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.
OPT-BST	15454-OPT-BST=	The OPT-BST is designed to support 64 channels at 50-GHz channel spacing, but Software R4.6 supports 32 channels at 100 GHz. The OPT-BST is a C-band DWDM EDFA with OSC add-and-drop capability. When an ONS 15454 MSTP has an OPT-BST installed, it is only necessary to have the OSCM to process the OSC. To control the gain tilt, the OPT-BST is equipped with a built-in VOA. You can install the OPT-BST in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.
Multiplexer and Demultiplexer Cards		
32MUX-O	15454-32MUX-O=	The 32-channel multiplexer card (32 MUX-O) multiplexes 32 100 GHz-spaced channels identified in the channel plan. The 32 MUX-O card takes up two slots in an ONS 15454 MSTP and can be installed in slots 1 to 5 and 12 to 16.
32DMX-O	15454-32DMX-O=	The 32-Channel Demultiplexer (32 DMX-O) card demultiplexes 32 100 GHz-spaced channels identified in the channel plan. The 32 DMX-O takes up two slots in an ONS 15454 MSTP and can be installed in slots 1 to 5 and 12 to 16.

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
32DMX	15454-32DMX=	The 32-Channel Demultiplexer card (32DMX) is a single-slot optical demultiplexer. The card receives an aggregate optical signal on its COM RX port and demultiplexes it into to 32 100-GHz-spaced channels. The 32DMX card can be installed in Slots 1 to 6 and in Slots 12 to 17.
4MD-xx.x	15454-4MD-xx.x=	The 4-Channel Multiplexer/Demultiplexer (4MD-xx.x) card multiplexes and demultiplexes four 100 GHz-spaced channels identified in the channel plan. The 4MD-xx.x card is designed to be used with band OADMs (both AD-1B-xx.x and AD-4B-xx.x). There are eight versions of this card that correspond with the eight sub-bands specified in Table 4-17. The 4MD-xx.x can be installed in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.
Optical Add/Drop Multiplexer Cards		
AD-1C-xx.x	15454-AD-1C-xx.x=	The 1-Channel OADM (AD-1C-xx.x) card passively adds or drops one of the 32 channels utilized within the 100 GHz-spacing of the DWDM card system. There are thirty-two versions of this card, each designed only for use with one wavelength. Each wavelength version of the card has a different part number. The AD-1C-xx.x can be installed in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.
AD-2C-xx.x	15454-AD-2C-xx.x=	The 2-Channel OADM (AD-2C-xx.x) card passively adds or drops two adjacent 100 GHz channels within the same band. There are sixteen versions of this card, each designed for use with one pair of wavelengths. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. Each version of the card has a different part number. The AD-2C-xx.x cards are provisioned for the channel pairs in Table 4-18. In this table, channel IDs are given rather than wavelengths. The AD-2C-xx.x can be installed in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.
AD-4C-xx.x	15454-AD-4C-xx.x=	The 4-Channel OADM (AD-4C-xx.x) card passively adds or drops all four 100 GHz-spaced channels within the same band. There are eight versions of this card, each designed for use with one band of wavelengths. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. There are eight versions of this card with eight part numbers. The AD-4C-xx.x cards are provisioned for the channel pairs in Table 4-19. In this table, channel IDs are given rather than wavelengths. The AD-4C-xx.x can be installed in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
AD-1B-xx.x	15454-AD-1B-xx=	The 1-Band OADM (AD-1B-xx.x) card passively adds or drops a single band of four adjacent 100 GHz-spaced channels. There are eight versions of this card with eight different part numbers, each version designed for use with one band of wavelengths. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. This card can be used when there is asymmetric adding and dropping on each side (east or west) of the node; a band can be added or dropped on one side but not on the other. The AD-1B-xx.x can be installed in slots 1 to 6 and 12 to17 when the ONS 15454 is configured as an MSTP.
AD-4B-xx.x	15454-AD-4B-xx=	The 4-Band OADM (AD-4B-xx.x) card passively adds or drops four bands of four adjacent 100 GHz-spaced channels. There are two versions of this card with different part numbers, each version designed for use with one set of bands. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. This card can be used when there is asymmetric adding and dropping on each side (east or west) of the node; a band can be added or dropped on one side but not on the other. The AD-4B-xx.x cards are provisioned for the channel pairs in Table 4-20. In this table, channel IDs are given rather than wavelengths. The AD1B-xx.x can be installed in slots 1 to 6 and 12 to 17 when the ONS 15454 is configured as an MSTP.
32WSS	15454-32WSS=	The 32WSS card has seven sets of ports located on the faceplate. The card takes up two slots and can operates in Slots 1-2, 3-4, 5-6, or in Slots 12-13, 14-15, or 16-17. The 32-Channel Wavelength Selective Switch (32WSS) card performs channel add/drop processing within the ONS 15454 DWDM node. The 32WSS works in conjunction with the 32DMX to implement ROADM functionality. Equipped with ROADM functionality, the ONS 15454 DWDM can be configured to add or drop individual optical channels using CTC, Cisco MetroPlanner, and CTM. A ROADM network element utilizes two 32WSS cards (two slots each) and two 32DMX cards (one slot each), for a total of six slots in the chassis.

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
Transponder and Muxponder Cards		
TXP_MR_10G	15454-10T-L1-30.3= 15454-10T-L1-31.9= 15454-10T-L1-34.2= 15454-10T-L1-35.8= 15454-10T-L1-38.1= 15454-10T-L1-39.7= 15454-10T-L1-42.1= 15454-10T-L1-43.7= 15454-10T-L1-46.1= 15454-10T-L1-47.7= 15454-10T-L1-50.1= 15454-10T-L1-51.7= 15454-10T-L1-54.1= 15454-10T-L1-55.7= 15454-10T-L1-58.1= 15454-10T-L1-59.7=	The TXP_MR_10G card has two sets of ports located on the faceplate and can be in Slots 1 to 6 and 12 to 17. The 10 Gbps Transponder–100 GHz–Tunable xx.xx-xx.xx card (TXP_MR_10G) processes one 10 Gb/s signal (client side) into one 10-Gb/s, 100 GHz DWDM signal (trunk side). It provides one 10 Gb/s port per card that can be provisioned for an STM64/OC-192 short reach (1310nm) signal, compliant with ITU-T G.707, G.709, ITU-T G.691, Telcordia GR-253-CORE, or to 10 GE BASE-LR, compliant to IEEE 802.3. The TXP_MR_10G card is tunable over two neighboring wavelengths in the 1550nm, ITU 100 GHz range. It is available in sixteen different versions, covering thirty-two different wavelengths in the 1550nm range.
TXP_MR_10E	15454-10E-L1-30.3= 15454-10E-L1-34.2= 15454-10E-L1-38.1= 15454-10E-L1-42.1= 15454-10E-L1-46.1= 15454-10E-L1-50.1= 15454-10E-L1-54.1= 15454-10E-L1-58.1=	The TXP_MR_10E card has two sets of ports located on the faceplate and can be installed in Slots 1 to 6 and Slots 12 to 17. The 10 Gb/s Transponder–100 GHz–Tunable xx.xx-xx.xx (TXP_MR_10E) card is a multirate transponder for the ONS 15454 platform. It processes one 10 Gb/s signal (client side) into one 10 Gb/s, 100 GHz DWDM signal (trunk side) that is tunable on four wavelength channels (ITU-T 100 GHz grid). You can provision this card in a linear configuration, BLSR, path protection, or a regenerator. The card can be used in the middle of BLSR or 1+1 spans when the card is configured for transparent termination mode. The TXP_MR_10E port features a 1550nm laser for the trunk port and an ONS-XC-10G-S1 XFP module for the client port and contains two transmit and receive connector pairs (labeled) on the card faceplate. The TXP_MR_10E card is tunable over four wavelengths in the 1550nm ITU 100-GHz range. They are available in eight versions of the card, covering thirty-two different wavelengths in the 1550nm range

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
TXP_MR_2.5G	15454-MR-L1-30.3= 15454-MR-L1-34.2= 15454-MR-L1-38.1= 15454-MR-L1-42.1= 15454-MR-L1-46.1= 15454-MR-L1-50.1= 15454-MR-L1-54.1= 15454-MR-L1-58.1=	The TXP_MR_2.5G card has two sets of ports located on the faceplate and can be installed in Slots 1 to 6 and Slots 12 to 17. The 2.5 Gb/s Multirate Transponder–100 GHz–Tunable xx.xx-xx.xx (TXP_MR_2.5G) card processes one 8 Mb/s to 2.488 Gb/s signal (client side) into one 8 Mb/s to 2.5 Gb/s, 100 GHz DWDM signal (trunk side). It provides one long-reach STM-16/OC-48 port per card, compliant with ITU-T G.707, ITU-T G.709, ITU-T G.957, and Telcordia GR-253-CORE. The TXP_MR_2.5G card is tunable over four wavelengths in the 1550nm ITU 100-GHz range. They are available in eight versions of the card, covering thirty-two different wavelengths in the 1550nm range. The TXP_MR_2.5G card support 2R and 3R modes of operation where the client signal is mapped into a ITU-T G.709 frame.
TXPP_MR_2.5G	15454-MRP-L1-30.3= 15454-MRP-L1-34.2= 15454-MRP-L1-38.1= 15454-MRP-L1-42.1= 15454-MRP-L1-46.1= 15454-MRP-L1-50.1= 15454-MRP-L1-54.1= 15454-MRP-L1-58.1=	The TXPP_MR_2.5G card has three sets of ports located on the faceplate and can be installed in Slots 1 to 6 and Slots 12 to 17. The 2.5 Gb/s Multirate Transponder–Protected–100 GHz–Tunable xx.xxxx. xx (TXPP_MR_2.5G) card processes one 8 Mb/s to 2.488 Gb/s signal (client side) into two 8 Mb/s to 2.5 Gb/s, 100 GHz DWDM signals (trunk side). It provides two long-reach STM-16/OC-48 ports per card, compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The TXPP_MR_2.5G card is tunable over four wavelengths in the 1550nm ITU 100-GHz range. They are available in eight versions of the card, covering thirty-two different wavelengths in the 1550nm range. The TXPP_MR_2.5G card support 2R and 3R modes of operation where the client signal is mapped into a ITU-T G.709 frame.

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
MXP_2.5G_10G	15454-10M-L1-30.3= 15454-10M-L1-31.9= 15454-10M-L1-34.2= 15454-10M-L1-35.8= 15454-10M-L1-38.1= 15454-10M-L1-39.7= 15454-10M-L1-42.1= 15454-10M-L1-43.7= 15454-10M-L1-46.1= 15454-10M-L1-47.7= 15454-10M-L1-50.1= 15454-10M-L1-51.7= 15454-10M-L1-54.1= 15454-10M-L1-55.7= 15454-10M-L1-58.1= 15454-10M-L1-59.7=	The MXP_2.5G_10G card has 9 sets of ports located on the faceplate and can be installed in Slots 1 to 6 and Slots 12 to 17. The 2.5 Gb/s–10 Gb/s Muxponder–100 GHz–Tunable xx.xx-xx.xx (MXP_2.5G_10G) card multiplexes/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.709, ITU-T G.957, and Telcordia GR-253-CORE) and four intermediate- or short-range OC-48/STM-16 ports per card on the client side. The port operates at 9.95328 Gb/s over unamplified distances up to 80 km (50 miles) with different types of fiber such as C-SMF or dispersion compensated fiber limited by loss and/or dispersion. The port can also operate at 10.70923 Gb/s in ITU-T G.709 Digital Wrapper/FEC mode. Client ports on the MXP_2.5G_10G card are also interoperable with OC-1 (STS-1) fiber optic signals defined in Telcordia GR-253-CORE. An OC-1 signal is the equivalent of one DS3 channel transmitted across optical fiber. OC-1 is primarily used for trunk interfaces to phone switches in the United States. The MXP_2.5G_10G card is tunable over two neighboring wavelengths in the 1550nm, ITU 100 GHz range. It is available in sixteen different versions, covering thirty-two different wavelengths in the 1550nm range.

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
MXP_2.5G_10E	15454-10ME-30.3= 15454-10ME-34.2= 15454-10ME-38.1= 15454-10ME-42.1= 15454-10ME-46.1= 15454-10ME-50.1= 15454-10ME-54.1= 15454-10ME-58.1=	The MXP_2.5G_10E card has 9 sets of ports located on the faceplate and can be installed in Slots 1 to 6 and 12 to 17. The 2.5 Gb/s–10 Gb/s Muxponder–100 GHz–Tunable xx.xx-xx.xx (MXP_2.5G_10E) card is a DWDM muxponder for the ONS 15454 platform that supports full optical transparency on the client side. The card multiplexes four 2.5 Gb/s client signals (4 x OC48/STM-16 SFP) into a single 10 Gb/s DWDM optical signal on the trunk side. The MXP_2.5G_10E provides wavelength transmission service for the four incoming 2.5 Gbps client interfaces. The MXP_2.5G_10E muxponder passes all SONET overhead bytes transparently. The MXP_2.5G_10E works with Optical Transparent Network (OTN) devices defined in ITU-T G.709. The card supports Optical Data Channel Unit 1 (ODU1) to Optical Channel Transport Unit (OTU2) multiplexing, an industry standard method for asynchronously mapping a SONET/SDH payload into a digitally wrapped envelope. The MXP_2.5G_10E card is tunable over four neighboring wavelengths in the 1550nm, ITU 100 GHz range. It is available in eight different versions, covering thirty-two different wavelengths in the 1550nm range. The MXP_2.5G_10E card is not compatible with the MXP_2.5G_10G card, which does not supports full optical transparency. The faceplate designation of the card is “4x2.5G 10E MXP.”

Table 4-16 ONS 15454 DWDM Cards (continued)

Card	Part Number	Description
MXP_MR_2.5G	15454-DM-L1-30.3= 15454-DM-L1-34.2= 15454-DM-L1-38.1= 15454-DM-L1-42.1= 15454-DM-L1-46.1= 15454-DM-L1-50.1= 15454-DM-L1-54.1= 15454-DM-L1-58.1=	The MXP_MR_2.5G card has 9 sets of ports located on the faceplate and can be installed in Slots 1 to 6 and Slots 12 to 17. The 2.5 Gb/s Multirate Muxponder-100 GHz-Tunable 15xx.xx-15yy.yy (MXP_MR_2.5G) card aggregates a mix and match of client Storage Area Network (SAN) service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s STM-16/OC-48 DWDM signal on the trunk side. It provides one long-reach STM-16/OC-48 port per card and is compliant with Telcordia GR-253-CORE. The client interface supports the following payload types: • GE • 1G FC • 2G FC • 1G FICON • 2G FICON Because the card is tunable to one of four adjacent grid channels on a 100 GHz spacing, this card is available in eight versions covering thirty-two different wavelengths in the 1550nm range.
MXPP_MR_2.5G	15454-DMP-L1-30.3= 15454-DMP-L1-34.2= 15454-DMP-L1-38.1= 15454-DMP-L1-42.1= 15454-DMP-L1-46.1= 15454-DMP-L1-50.1= 15454-DMP-L1-54.1= 15454-DMP-L1-58.1=	The MXPP_MR_2.5G card has 10 sets of ports located on the faceplate and can be installed in Slots 1 to 6 and Slots 12 to 17. The 2.5 Gb/s Multirate Muxponder–Protected–100 GHz–Tunable 15xx.xx- 15yy.yy (MXPP_MR_2.5G) card aggregates various client SAN service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s STM-16/OC-48 DWDM signal on the trunk side. It provides two long-reach STM-16/OC-48 ports per card and is compliant with ITU-T G.957 and Telcordia GR-253-CORE. The client interface supports the following payload types: • GE • 1G FC • 2G FC • 1G FICON • 2G FICON Because the card is tunable to one of four adjacent grid channels on a 100 GHz spacing, this card is available in eight versions covering thirty-two different wavelengths in the 1550nm range.

Table 4-17 shows the band IDs and the add/drop channel IDs for the 4MD-xx.x card.

Table 4-17 4MD-xx.x Channel Sets

Band IDs	Add/Drop Channel IDs	Add/Drop Wavelengths (nm)
Band 30.3 (A)	30.3, 31.2, 31.9, 32.6	1530.33, 1531.12, 1531.90, 1532.68
Band 34.2 (B)	34.2, 35.0, 35.8, 36.6	1534.25, 1535.04, 1535.82, 1536.61
Band 38.1 (C)	38.1, 38.9, 39.7, 40.5	1538.19, 1538.98, 1539.77, 1540.56
Band 42.1 (D)	42.1, 42.9, 43.7, 44.5	1542.14, 1542.94, 1543.73, 1544.53
Band 46.1 (E)	46.1, 46.9, 47.7, 48.5	1546.12, 1546.92, 1547.72, 1548.51
Band 50.1 (F)	50.1, 50.9, 51.7, 52.5	1550.12, 1550.92, 1551.72, 1552.52
Band 54.1 (G)	54.1, 54.9, 55.7, 56.5	1554.13, 1554.94, 1555.75, 1556.55
Band 58.1 (H)	58.1, 58.9, 59.7, 60.6	1558.17, 1558.98, 1559.79, 1560.61

Table 4-18 AD-2C-xx.x Channel Pairs

Band IDs	Add/Drop Channel IDs	Add/Drop Wavelengths (nm)
Band 30.3 (A)	30.3, 31.2 and 31.9, 32.6	1530.33, 1531.12 and 1531.90, 1532.68
Band 34.2 (B)	34.2, 35.0, and 35.8, 36.6	1534.25, 1535.04 and 1535.82, 1536.61
Band 38.1 (C)	38.1, 38.9 and 39.7, 40.5	1538.19, 1538.98 and 1539.77, 1540.56
Band 42.1 (D)	42.1, 42.9 and 43.7, 44.5	1542.14, 1542.94 and 1543.73, 1544.53
Band 46.1 (E)	46.1, 46.9 and 47.7, 48.5	1546.12, 1546.92 and 1547.72, 1548.51
Band 50.1 (F)	50.1, 50.9 and 51.7, 52.5	1550.12, 1550.92 and 1551.72, 1552.52
Band 54.1 (G)	54.1, 54.9 and 55.7, 56.5	1554.13, 1554.94 and 1555.75, 1556.55
Band 58.1 (H)	58.1, 58.9 and 59.7, 60.6	1558.17, 1558.98 and 1559.79, 1560.61

Table 4-19 AD-4C-xx.x Channel Sets

Band IDs	Add/Drop Channel IDs	Add/Drop Wavelengths (nm)
Band 30.3 (A)	30.3, 31.2, 31.9, 32.6	1530.33, 1531.12, 1531.90, 1532.68
Band 34.2 (B)	34.2, 35.0, 35.8, 36.6	1534.25, 1535.04, 1535.82, 1536.61
Band 38.1 (C)	38.1, 38.9, 39.7, 40.5	1538.19, 1538.98, 1539.77, 1540.56
Band 42.1 (D)	42.1, 42.9, 43.7, 44.5	1542.14, 1542.94, 1543.73, 1544.53
Band 46.1 (E)	46.1, 46.9, 47.7, 48.5	1546.12, 1546.92, 1547.72, 1548.51
Band 50.1 (F)	50.1, 50.9, 51.7, 52.5	1550.12, 1550.92, 1551.72, 1552.52
Band 54.1 (G)	54.1, 54.9, 55.7, 56.5	1554.13, 1554.94, 1555.75, 1556.55
Band 58.1 (H)	58.1, 58.9, 59.7, 60.6	1558.17, 1558.98, 1559.79, 1560.61

Table 4-20 AD-4B-xx.x Channel Sets

Band IDs	Add/Drop Channel IDs	Add/Drop Wavelengths (nm)
Band 30.3 (A)	B30.3	1530.33
Band 34.2 (B)	B34.2	1534.25
Band 38.1 (C)	B38.1	1538.19
Band 42.1 (D)	B42.1	1542.14
Band 46.1 (E)	B46.1	1546.12
Band 50.1 (F)	B50.1	1550.12
Band 54.1 (G)	B54.1	1554.13
Band 58.1 (H)	B58.1	1558.17

Multiplexer, Demultiplexer, and OADM Card Interface Classes

The 32MUX-O, 32WSS, 32DMX, 32DMX-O, 4MD-xx.x, AD-1C-xx.x, AD-2C-xx.x, and AD-4C-xx.x cards have different input and output power values depending upon the optical power of the interface card where the input signal originates. The client interfaces for these cards have been grouped in classes listed in Table 4-21. The subsequent tables list the optical performances and output power of each interface class.

Table 4-21 ONS 15454 DWDM Client Interfaces Assigned to Input Power Classes

Input Power Class	DWDM Client Interfaces
A	10 Gb/s multi-rate transponder with forward error correction (FEC) enabled (TXP_MR_10G or TXP_MR_10E) or 10 Gb/s muxponder with FEC enabled (MXP_2.5G_10G or MXP_2.5G_10E).
B	10 Gb/s multi-rate transponder without FEC (TXP_MR_10G) or 10 Gb/s muxponder (MXP_2.5G_10G) with FEC disabled.
C	OC-192 LR ITU, TXP_MR_10E without FEC.
D	2.5 Gb/s multi-rate transponder (TXP_MR_2.5G), both protected and unprotected, with FEC enabled
E	2.5 Gb/s multi-rate transponder (TXP_MR_2.5G), both protected and unprotected, without FEC enabled and reshape, regenerate, and retime (3R) mode enabled, or OC-48 100 GHz DWDM muxponder (MXP_MR_2.5G).
F	2.5 Gb/s multi-rate transponder (TXP_MR_2.5G), both protected and unprotected, in regenerate and reshape (2R) mode
G	OC-48 ELR 100 GHz
H	2 and 4 port GE Transponder (GBIC WDM 100GHz).
I	TXP_MR_10E with extended FEC (E-FEC) or MXP_2.5G_10E with EFEC.

10 Gbps cards that provide signal input to OADM cards have the optical performances listed in Table 4-22.

Table 4-22 10 Gbps Interface Optical Performances

Parameter	**Class A**		**Class B**		**Class C**	**Class I**	
Type	**Power Limited**	**OSNR Limited**	**Power Limited**	**OSNR Limited**	**OSNR Limited**	**Power Limited**	**OSNR Limited**
Optical signal to noise ratio (OSNR) sensitivity	23 dB	9 dB	23 dB	19 dB	19 dB	20 dB	8 dB
Power sensitivity	–24 dBm	–18 dBm	–20 dBm	–20 dBm	–22 dBm	–26 dBm	–18 dBm
Dispersion power penalty	2 dB	0 dB	3 dB	4 dB	2 dB	2 dB	0 dB
Dispersion OSNR penalty	0 dB	2 dB	0 dB	0 dB	0 dB	0 dB	2 dB
Dispersion compensation tolerance	+/– 800 ps/nm		+/– 1000 ps/nm		+/– 1000 ps/nm	+/– 800 ps/nm	
Maximum bit rate	10 Gb/s		10 Gb/s		10 Gbps	10 Gbps	
Regeneration	3R[1]		3R		3R	3R	
FEC	Yes		No		No	Yes (E0FEC)	
Threshold	Optimum		Average		Average	Optimum	
Maximum BER[2]	10^{-15}		10^{-12}		10^{-12}	10^{-15}	
Power overload	–8 dBm		–8 dBm		–9 dBm	–9 dBm	–8 dBm
Transmitted power range[3]							
10 Gb/s multirate Transponder with FEC (TXP_MR_10G)	+2.5 to 3.5 dBm		+2.5 to 3.5 dBm		—	—	
OC-192 LR ITU	—		—		+3.0 to 6.0 dBm	—	
10 Gb/s multirate Transponder with FEC (TXP_MR_10E)	+3.0 to 6.0 dBm		+3.0 to 6.0 dBm			+3.0 to 6.0 dBm	

1. 3R = retime, reshape, regenerate
2. BER = biter error rate
3. These values, decreased by patch cord and connector losses, are also the input power values for the OADM cards.

Table 4-23 2.5 Gb/s Interface Optical Performances—Part One

Parameter	**Class D**		**Class E**		**Class F**	**Class G**	
Type	**Power Limited**	**OSNR Limited**	**Power Limited**	**OSNR Limited**	**OSNR Limited**	**Power Limited**	**OSNR Limited**
Optical signal to noise ratio (OSNR) sensitivity	14 dB	6 dB	14 dB	10 dB	15 dB	14 dB	11 dB
Power sensitivity	–31 dBm	–25 dBm	–30 dBm	–23 dBm	–24 dBm	–27 dBm	–33 dBm
Dispersion power penalty	2 dB	0 dB	3 dB	4 dB	3 dB		2 dB

Table 4-23 2.5 Gb/s Interface Optical Performances—Part One (continued)

Parameter	Class D		Class E		Class F	Class G	
Type	Power Limited	OSNR Limited	Power Limited	OSNR Limited	OSNR Limited	Power Limited	OSNR Limited
Dispersion OSNR penalty	0 dB	2 dB	0 dB	2 dB	0 dB	0 dB	0 dB
Dispersion compensation tolerance	–1,200 to +5,400 ps/nm		–1,200 to +5,400 ps/nm		–1,200 to +3,300 ps/nm	–1,200 to +3,300 ps/nm	
Maximum bit rate	2.5 Gb/s		2.5 Gb/s		2.5 Gb/s	2.5 Gb/s	
Regeneration	3R[1]		3R		2R[2]	3R	
FEC	Yes		No		No	No	
Threshold	Average		Average		Average	Average	
Maximum BER[3]	10^{-15}		10^{-12}		10^{-12}	10^{-12}	
Power overload	–9 dBm		–9 dBm		–9 dBm	–9 dBm	
Transmitted power range[4]							
TXP_MR_2.5G	–1.0 to 1.0 dBm		–1.0 to 1.0 dBm		1.0 to 1.0 dBm	–2.0 to 0 dBm	
TXPP_MR_2.5G	–4.5 to –2.5 dBm		–4.5 to –2.5 dBm		–4.5 to –2.5 dBm	–2.0 to 0 dBm	
MXP_MR_2.5G	—		+2.0 to +4.0 dBm		—	–2.0 to 0 dBm	
MXPP_MR_2.5G	—		–1.5 to +0.5 dBm		—	–2.0 to 0 dBm	

1. 3R = retime, reshape, regenerate
2. 2R = reshape and regenerate
3. BER = biter error rate
4. These values, decreased by patch cord and connector losses, are also the input power values for the OADM cards.

2.5 Gbps card interface performances are listed in Table 4-23 and Table 4-24.

Table 4-24 2.5 Gbps Interface Optical Performances—Part Two

Parameter	Class H		Class J
Type	Power Limited	OSNR Limited	Power Limited
Optical signal to noise ratio (OSNR) sensitivity	13 dB	8 dB	12 dB
Power sensitivity	–28 dBm	–18 dBm	12 dBm
Dispersion compensation tolerance	–1,000 to +3,600 ps/nm		–1,000 to +3,200 ps/nm
Maximum bit rate	1.25 Gbps		2.5 Gbps
Regeneration	3R		3R
FEC	No		No
Threshold	Average		Average

Table 4-24 2.5 Gbps Interface Optical Performances—Part Two (continued)

Parameter	Class H	Class J
Maximum BER	10^{-12}	10^{-12}
Power overload	–7 dBm	–17 dBm
Transmitted power range[1]		
2 and 4 port GE Transponder (GBIC WDM 100 GHz)	+2.5 to 3.5 dBm	—

1. These values, decreased by patch cord and connector losses, are also the input power values for the OADM cards.

DWDM Node Configurations

The ONS 15454 supports the following DWDM node configurations:

- Hub
- Terminal
- OADM
- ROADM
- Anti-ASE
- Line Amplifier
- OSC Regeneration Line

Note The MetroPlanner tool creates a plan for amplifier placement and proper node equipment.

Hub Node

A hub node is a single ONS 15454 node equipped with two TCC2/TCC2P cards and one of the following combinations:

- Two 32MUX-O (32-Channel Multiplexer) and two 32DMX-O (32-Channel Demultiplexer) or 32DMX cards
- Two 32WSS (32-Channel Wavelength Selective Switch) and two 32DMX or 32DMX-O cards

Note The 32WSS and 32DMX are normally installed in reconfigurable OADM (ROADM) nodes, but they can be installed in hub and terminal nodes. If the cards are installed in a hub node, the 32WSS express (EXP RX and EXP TX) ports are not cabled.

A dispersion compensation unit (DCU) can also be added, if necessary. The hub node does not support both DWDM and TDM applications since the DWDM slot requirements do not leave room for TDM cards. Figure 4-11 shows a hub node configuration with the 32MUX-O and 32DMX-O cards installed.

Note The OADM AD-xC-xx.x or AD-xB-xx.x cards are not part of a hub node because the 32MUXO and 32DMX-O cards drop and add all 32 channels; therefore, no other cards are necessary.

Figure 4-11 Hub Node Configuration Example

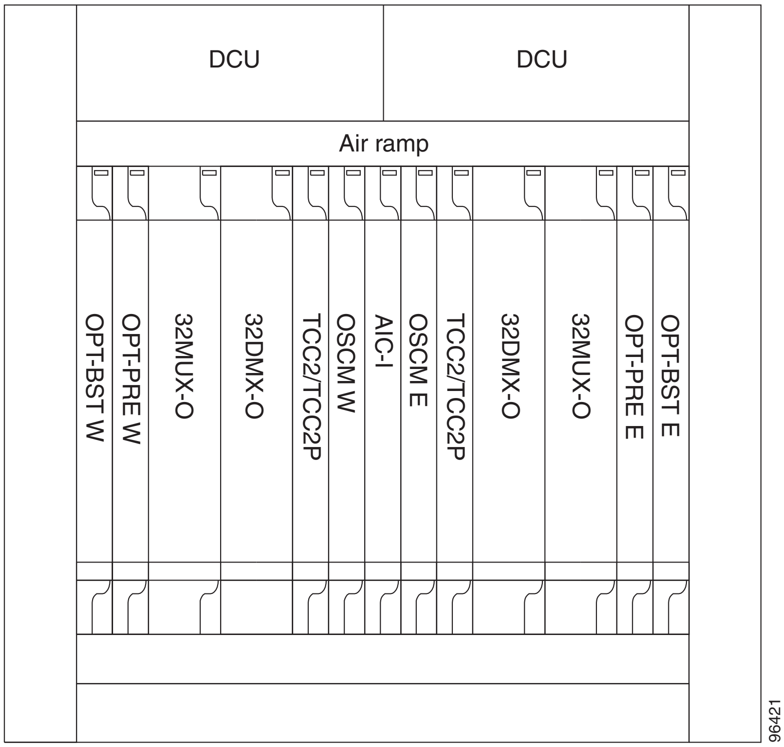
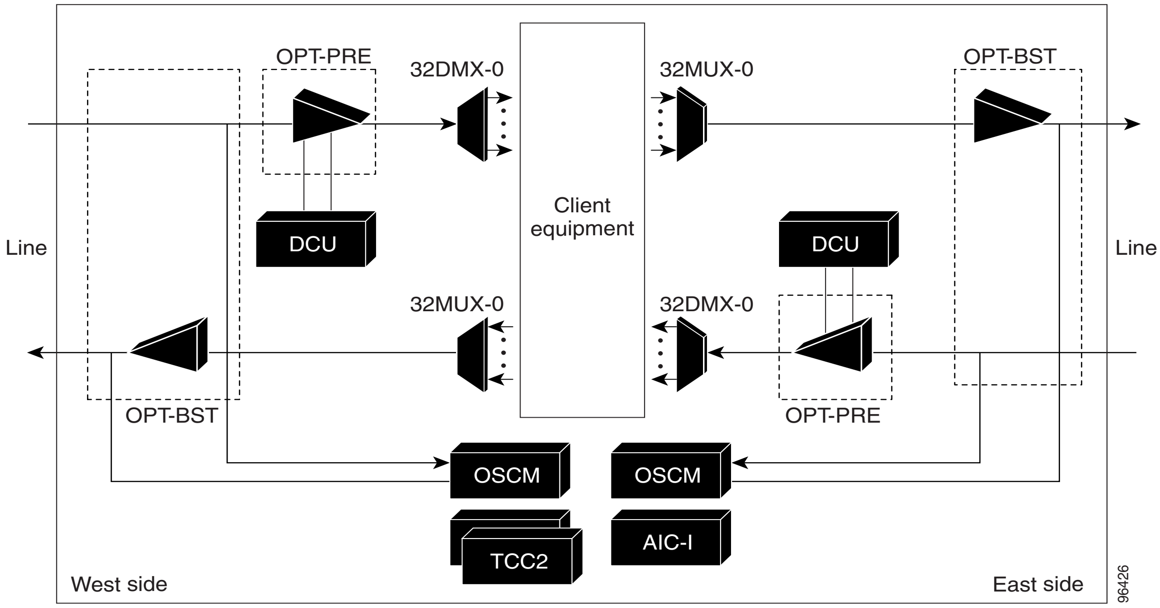


Figure 4-12 shows the channel flow for a hub node. Up to 32-channels from the client ports are multiplexed and equalized onto one fiber using the 32MUX-O card. Then, multiplexed channels are transmitted on the line in the eastward direction and fed to the Optical Booster (OPT-BST) amplifier. The output of this amplifier is combined with an output signal from the optical service channel modem (OSCM) card, and transmitted toward the east line.

Received signals from the east line port are split between the OSCM card and an Optical Preamplifier (OPT-PRE). Dispersion compensation is applied to the signal received by the OPTPRE amplifier, and it is then sent to the 32DMX-O card, which demultiplexes and attenuates the input signal. The west receive fiber path is identical through the west OPT-BST amplifier, the west OPT-PRE amplifier, and the west 32DMX-O card.

Figure 4-12 Hub Node Channel Flow Example



Terminal Node

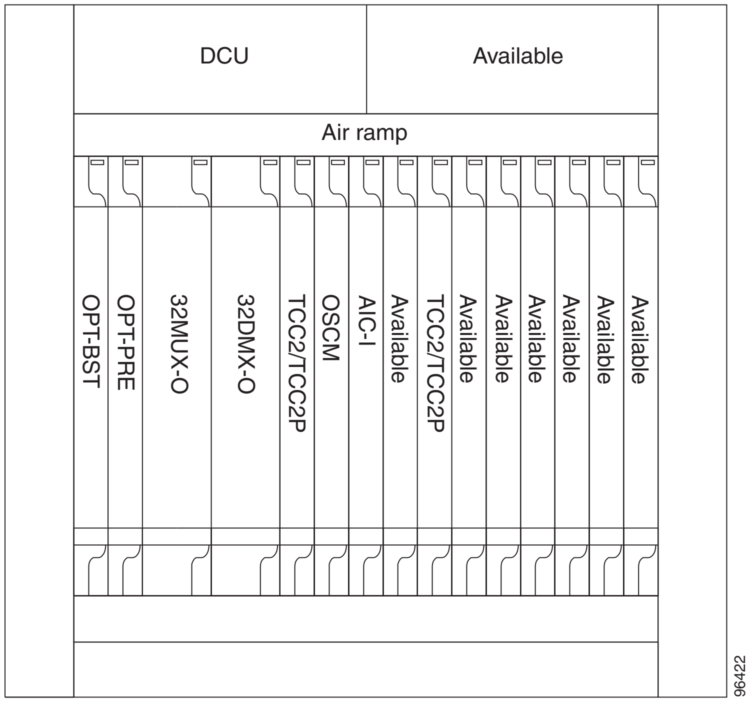
A terminal node is a single ONS 15454 node equipped with two TCC2/TCC2P cards and one of the following combinations:

- One 32MUX-O card and one 32DMX-O card
- One 32WSS and either a 32DMX or a 32DMX-O cards

Terminal nodes can be either east or west. In west terminal nodes, the cards are installed in the east slots (Slots 1 through 6). In east terminal nodes, cards are installed in the west slots (Slots 12 through 17). A hub node can be changed into a terminal node by removing either the east or west cards. Figure 4-13 shows an example of an east terminal configuration with a 32MUX-O and 32DMX-O cards installed. The channel flow for a terminal node is the same as the hub node (see Figure 4-12).

Note AD-xC-xx.x or AD-xB-xx.x cards are not part of a terminal node because pass-through connections are not allowed. However the AD-4C-xx.x card does support linear end nodes (terminals) in Software Release 4.6.

Figure 4-13 Terminal Node Configuration Example



OADM Node

An OADM node is a single ONS 15454 node equipped with at least one AD-xC-xx.x card or one AD-xB-xx.x card and two TCC2/TCC2P cards. The 32MUX-O or 32DMX-O cards cannot be provisioned. In an OADM node, channels can be added or dropped independently from each direction, passed through the reflected bands of all OADMs in the DWDM node (called express path), or passed through one OADM card to another OADM card without using a TDM ITU line card (called optical pass through) if an external patchcord is installed.

Unlike express path, an optical pass-through channel can be converted later to an add/drop channel in an altered ring without affecting another channel. OADM amplifier placement and required card placement is determined by the MetroPlanner tool or your site plan.

There are different categories of OADM nodes, such as amplified, passive, and anti-ASE. For anti-ASE node information, see the “Anti-ASE Node” section in this chapter. Figure 4-14 shows an example of an amplified OADM node configuration.

Figure 4-14 OADM Node Configuration Example

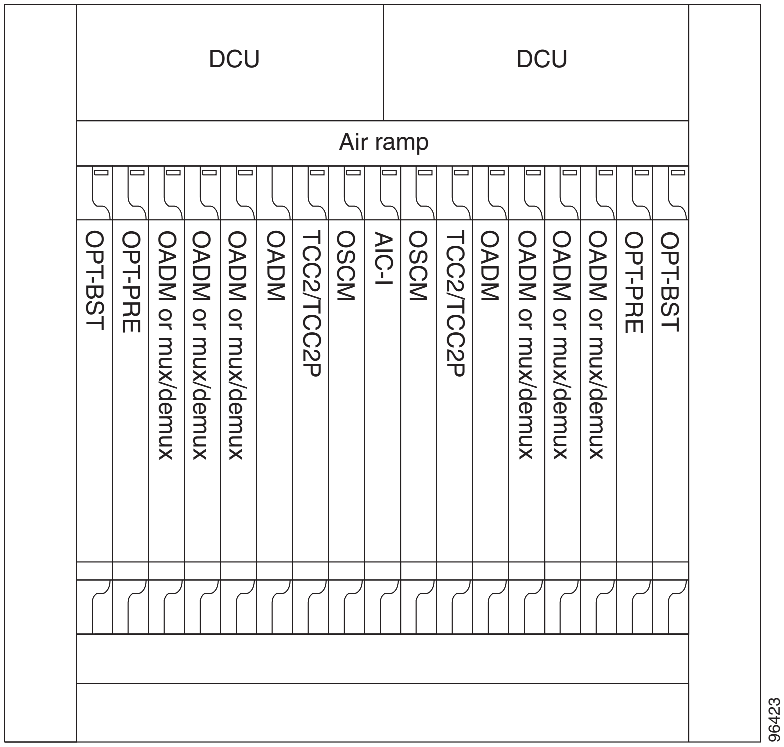


Figure 4-15 shows an example of the channel flow on the amplified OADM node. Since the 32-wavelength plan is based on eight bands (each band contains four channels), optical adding and dropping can be performed at the band level and/or at the channel level (meaning individual channels can be dropped).

Figure 4-15 Amplified OADM Node Channel Flow Example

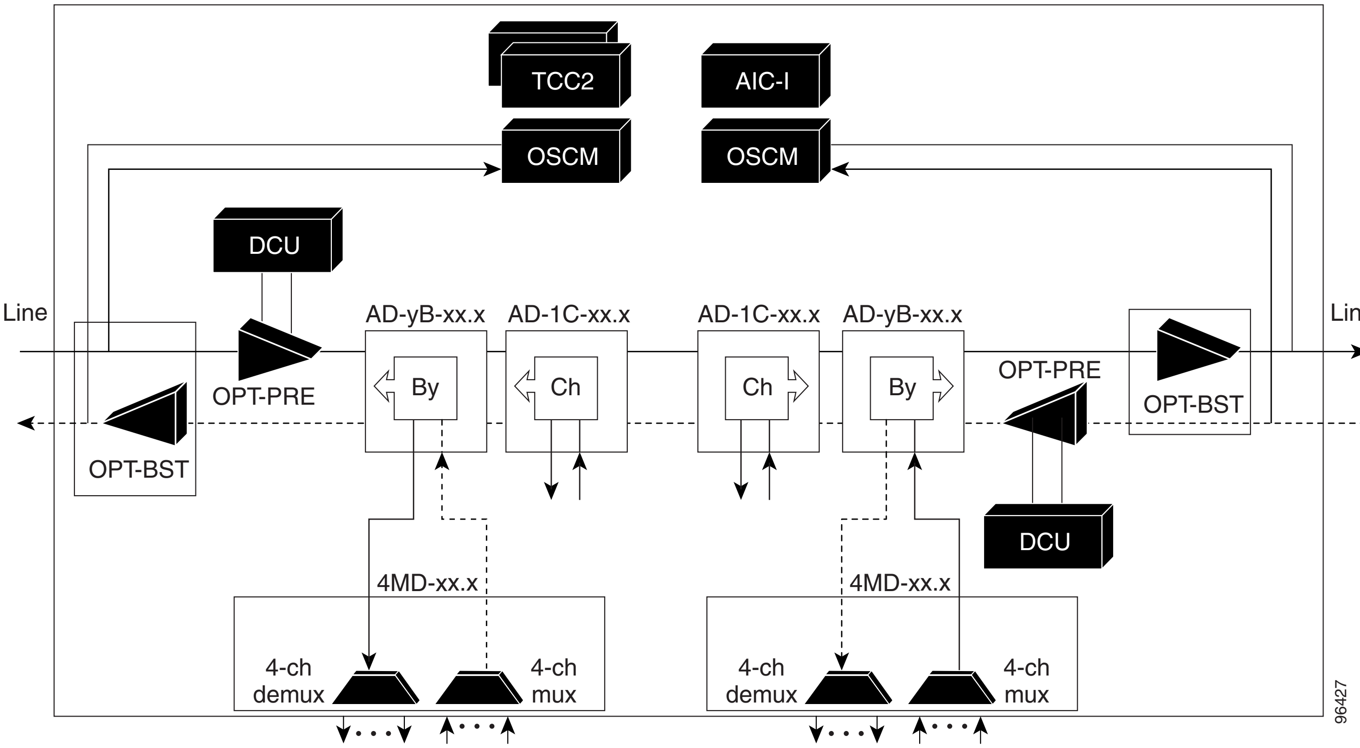


Figure 4-16 shows an example of a passive OADM node configuration. The passive OADM node is equipped with a band filter, one four-channel multiplexer/demultiplexer, and a channel filter on each side of the node.

Figure 4-16 Passive OADM Node Configuration Example

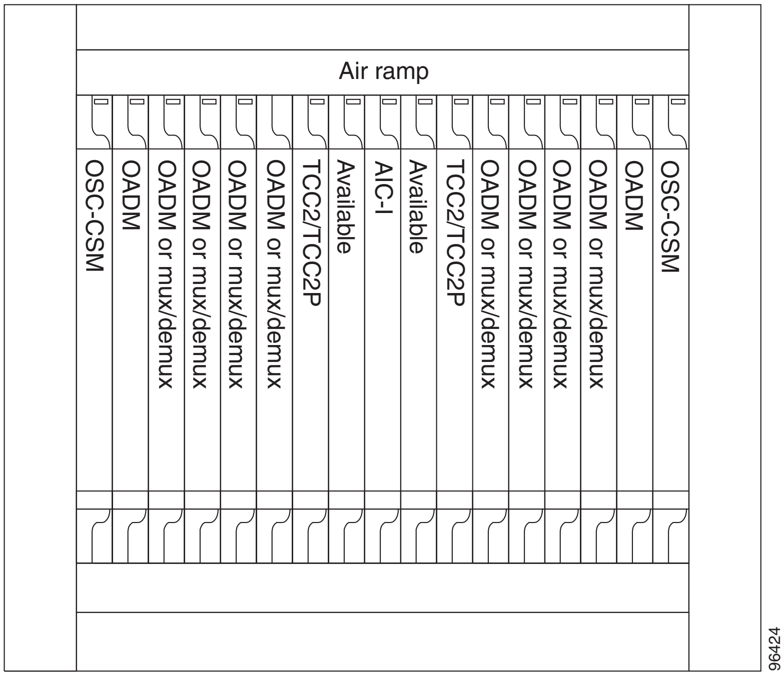
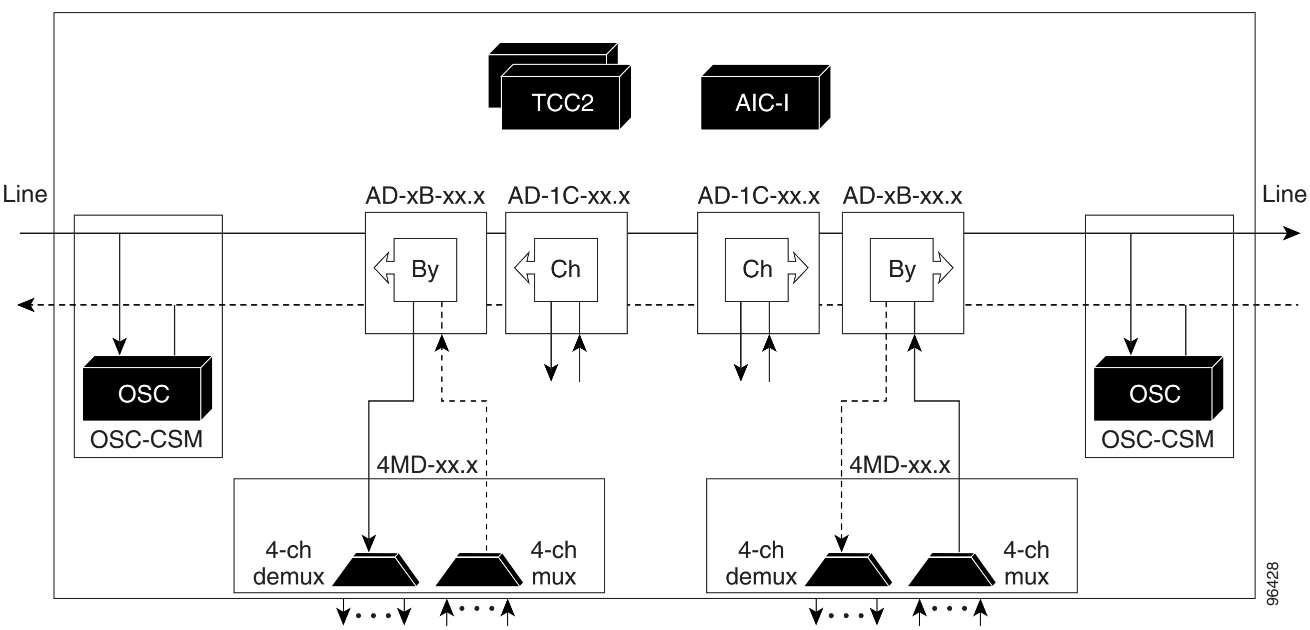


Figure 4-17 shows an example of traffic flow on the passive OADM node. The signal flow of the channels is the same as that described in Figure 4-15 except that the Optical Service Channel and Combiner/Separator Module (OSC-CSM) card is being used instead of the OPT-BST amplifier and the OSCM card.

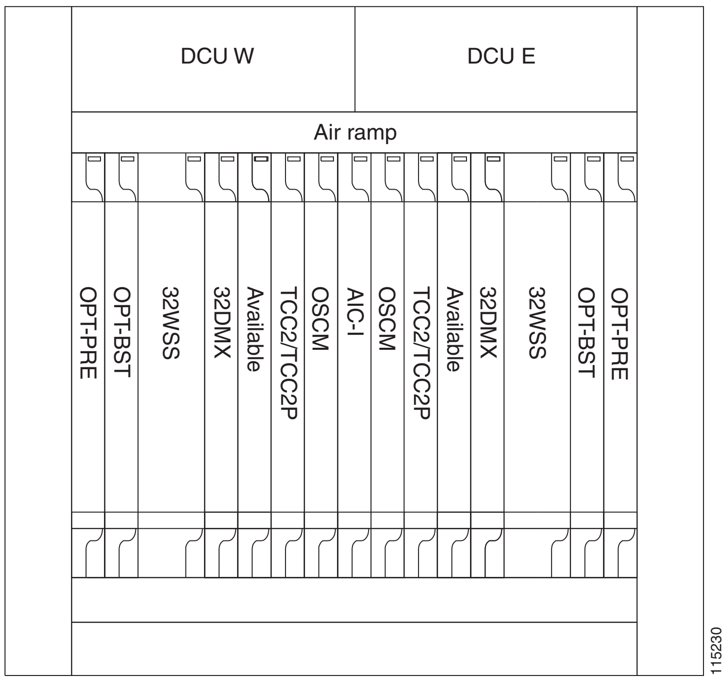
Figure 4-17 Passive OADM Node Channel Flow Example



ROADM Node

A reconfigurable OADM (ROADM) node allows you to add and drop wavelengths without changing the physical fiber connections. ROADM nodes are equipped with two 32WSS cards. 32DMX or 32DMX-O demultiplexers are typically installed, but are not required. Transponders (TXPs) and muxponders (MXPs) can be installed in Slots 6 and 12 and, if amplification is not used, in any open slot. Figure 4-18 shows an example of an amplified ROADM node configuration.

Figure 4-18 ROADM Node with BST-PRE, OPT-BST, and 32DMX Cards Installed



If the ROADM node receives a tilted optical signal, you can replace the single-slot 32DMX card with the double-slot 32DMX-O card to equalize the signal at the optical channel layer instead of the transport section layer. However, if 32DMX-O cards are installed, Slots 6 and 12 cannot be used for TXP or MXP cards.

Figure 4-19 shows an example of an ROADM with 32DMX-O cards installed.

Figure 4-19 ROADM Node with BST-PRE, OPT-BST, and 32DMX-O Cards Installed

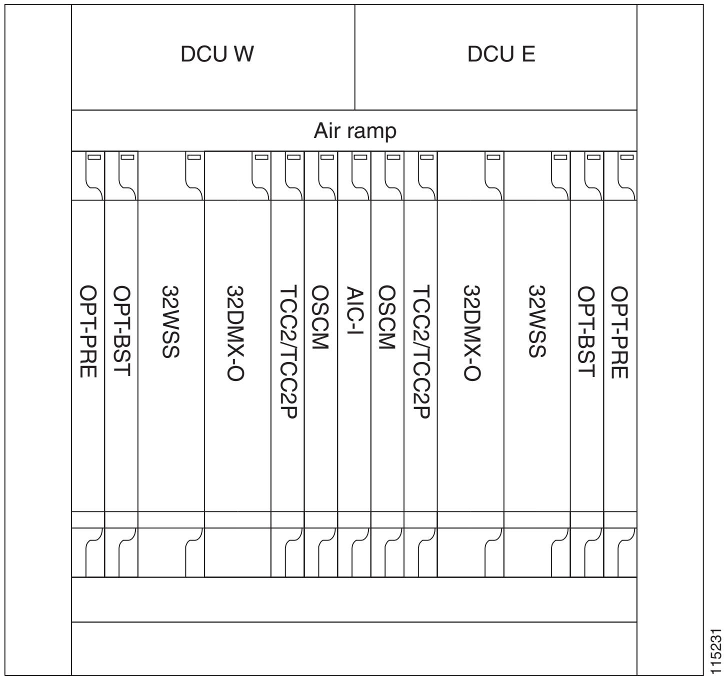
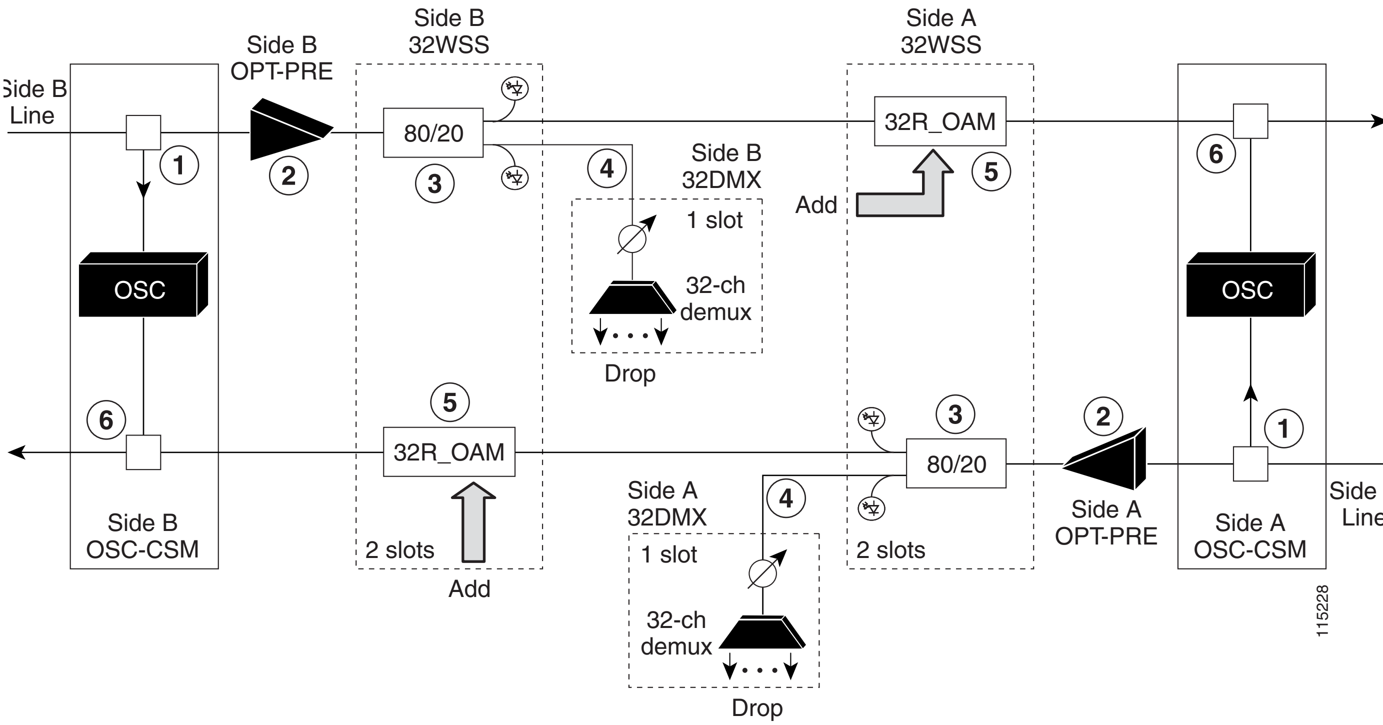


Figure 4-20 shows an example of a reconfigurable OADM east-to-west optical signal flow. The west-to-east optical signal flow follows an identical path through the west OSC-CSM and west 32WSS modules. In this example, OSC-CSM modules are installed so OPT-BST modules are not needed.

Figure 4-20 ROADM East to West Optical Signal Flow Example



1. The OSC-CSM receives the optical signal. It separates the optical service channel from the optical payload and sends the payload to the OPT-PRE module.
2. The OPT-PRE compensates for chromatic dispersion, amplifies the optical payload, and sends it to the 32WSS.
3. The 32WSS splits the signal into two components, one is sent to the DROP-TX port and the other is sent to the EXP-TX port.
4. The drop component goes to the 32DMX where it is attenuated, de-multiplexed, and dropped.
5. The express wavelength set goes to the 32WSS on the other side where it is demultiplexed. Channels are stopped or forwarded based upon their switch states. Forwarded wavelengths are multiplexed and sent to the OSC-CSM module.
6. The OSC-CSM combines the multiplexed payload with the OSC and sends the signal out the transmission line.

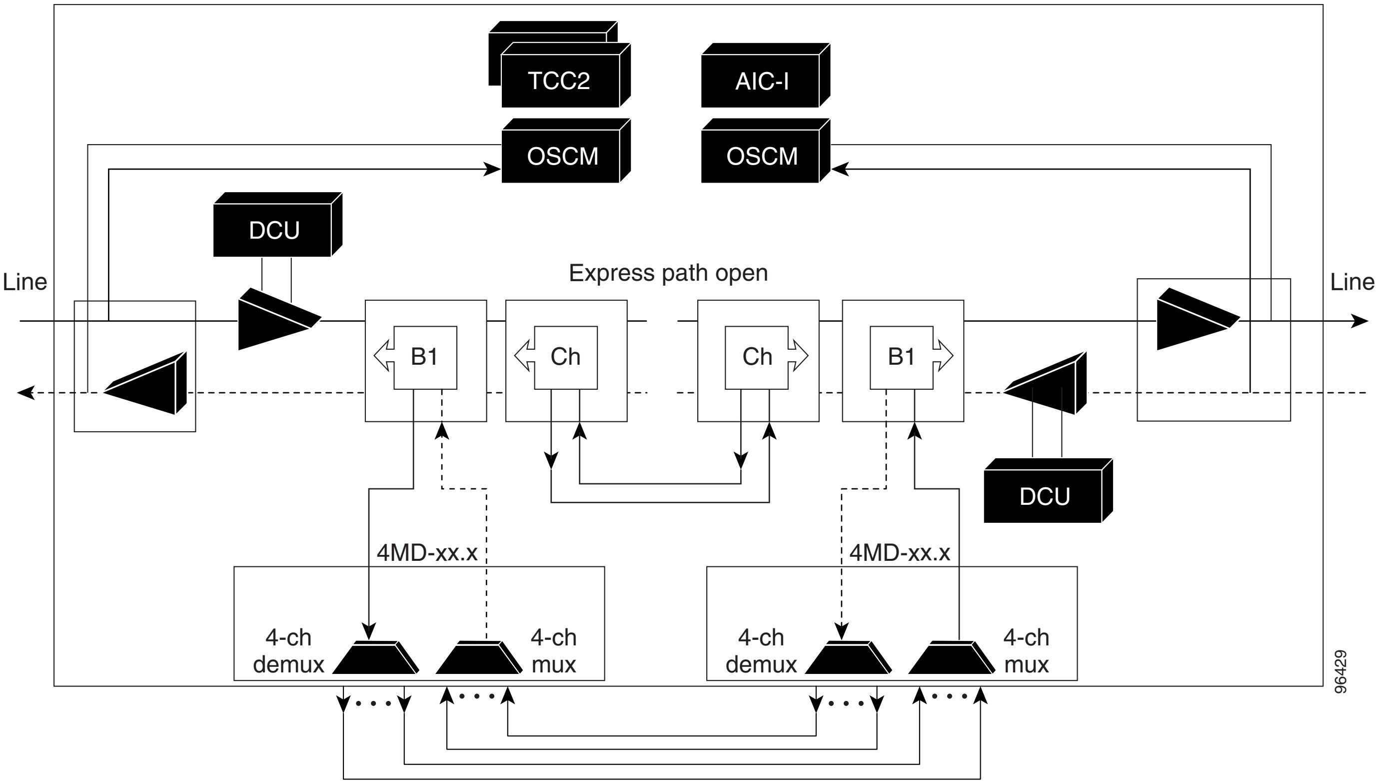
Anti-ASE Node

In a meshed ring network, the ONS 15454 requires a node configuration that prevents amplified spontaneous emission (ASE) accumulation and lasing. An anti-ASE node can be created by configuring a hub node or an OADM node with some modifications. No channels can travel through the express path, but they can be demultiplexed and dropped at the channel level on one side and added and multiplexed on the other side.

The hub node is the preferred node configuration when some channels are connected in passthrough mode. For rings that require a limited number of channels, combine AD-xB-xx.x and 4MD-xx.x cards, or cascade AD-xC-xx.x cards.

Figure 4-21 shows an example of traffic flow on an anti-ASE node that uses all wavelengths in the pass-through mode. Use MetroPlanner or another network planning tool to determine the best configuration for anti-ASE nodes.

Figure 4-21 Anti-ASE Node Channel Flow Example

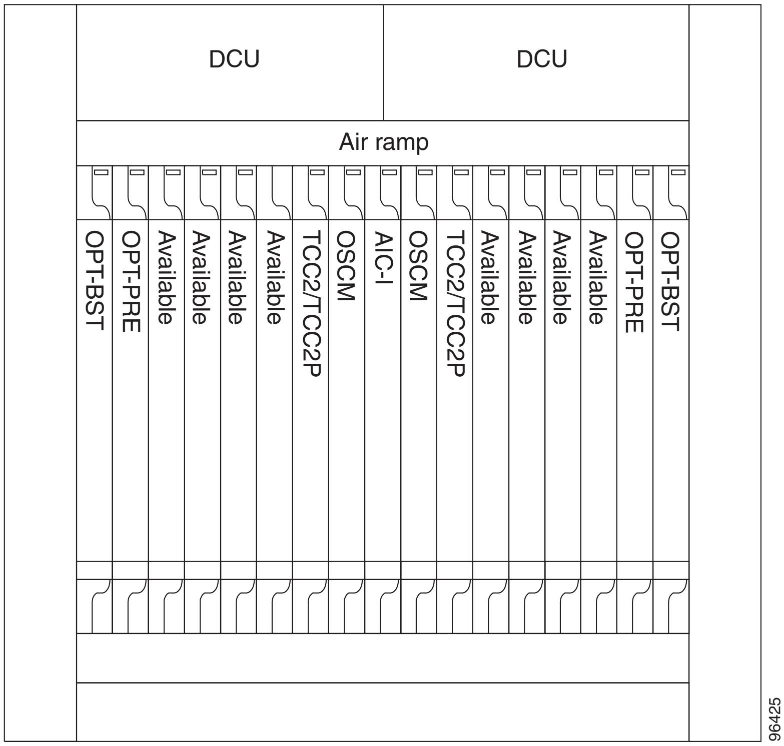


Line Amplifier Node

A line node is a single ONS 15454 node equipped with OPT-PRE amplifiers or OPT-BST amplifiers and TCC2/TCC2P cards. Attenuators might also be required between each preamplifier and booster amplifier to match the optical input power value and to maintain the amplifier gain tilt value.

Two OSCM cards are connected to the east or west ports of the booster amplifiers to multiplex the optical service channel (OSC) signal with the pass-though channels. If the node does not contain OPT-BST amplifiers, you must use OSC-CSM cards rather than OSCM cards in your configuration. Figure 4-22 shows an example of a line node configuration.

Figure 4-22 Line Node Configuration Example



OSC Regeneration Node

The OSC regeneration node is added to the DWDM networks for two purposes:

- To electrically regenerate the OSC channel whenever the span links are 37 dB or longer and payload amplification and add/drop capabilities are not present. Cisco MetroPlanner places an OSC regeneration node in spans longer than 37 dB. 31 dB is the longest span between the OSC regeneration node and the next DWDM network site.
- To add data communications network (DCN) capability wherever needed within the network.

OSC regeneration nodes require two OSC-CSM cards, as shown in Figure 4-23.

Figure 4-23 OSC Regeneration Line Node Configuration Example

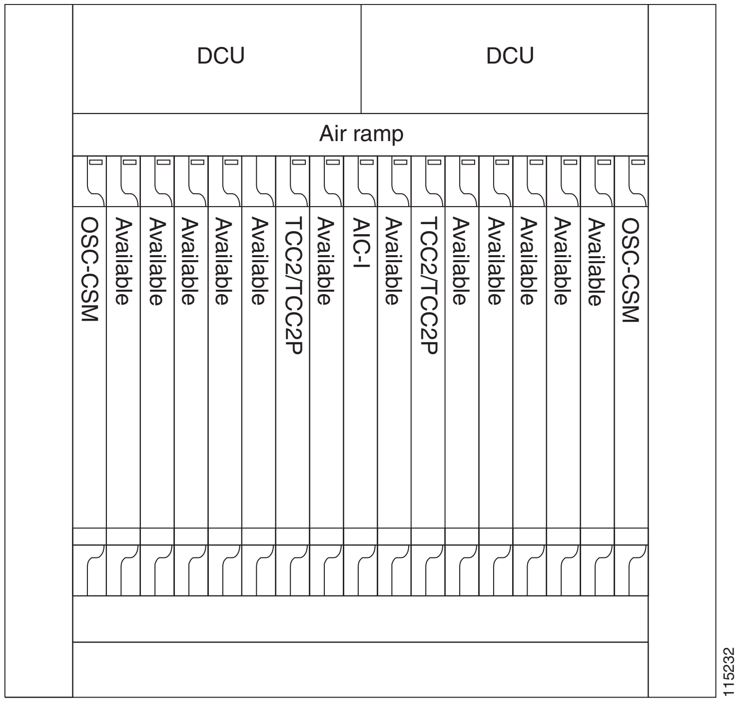
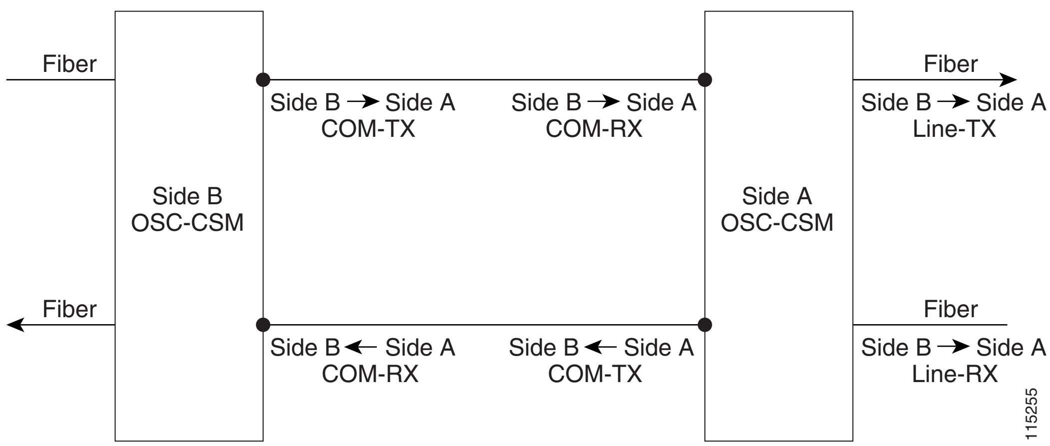


Figure 4-24 shows the OSC regeneration node OSC signal flow.

Figure 4-24 OSC Regeneration Line Site Example



DWDM and TDM Hybrid Node Configurations

The node configuration is determined by the type of card that is installed in an ONS 15454 hybrid node. The ONS 15454 supports the following DWDM and TDM hybrid node configurations:

- 1+1 Protected Flexible Terminal
- Scalable Terminal

- Hybrid Terminal
- Hybrid OADM
- Hybrid Line Amplifier
- Amplified TDM

Note The MetroPlanner tool creates a plan for amplifier placement and proper equipment for DWDM node configurations. Although TDM cards can be used with DWDM node configurations, the MetroPlanner tool does not create a plan for TDM card placement. MetroPlanner will support TDM configurations in a future release.

1+1 Protected Flexible Terminal Node

The 1+1 protected flexible terminal node is a single ONS 15454 node equipped with a series of OADM cards acting in a hub node configuration. This configuration uses a single hub or OADM node connected directly to the far-end hub or OADM node through four fiber links. This node configuration is used in a ring configured with two point-to-point links. The advantage of the 1+1 protected flexible terminal node configuration is that it provides path redundancy for 1+1 protected TDM networks (two transmit paths and two receive paths) using half of the DWDM equipment that is usually required. In the example shown in Figure 4-25, one node transmits traffic to the other node on both east and west sides of the ring for protection purposes. If the fiber is damaged on one side of the ring, traffic still arrives safely through fiber on the other side of the ring.

Figure 4-25 Double Terminal Protection Configuration

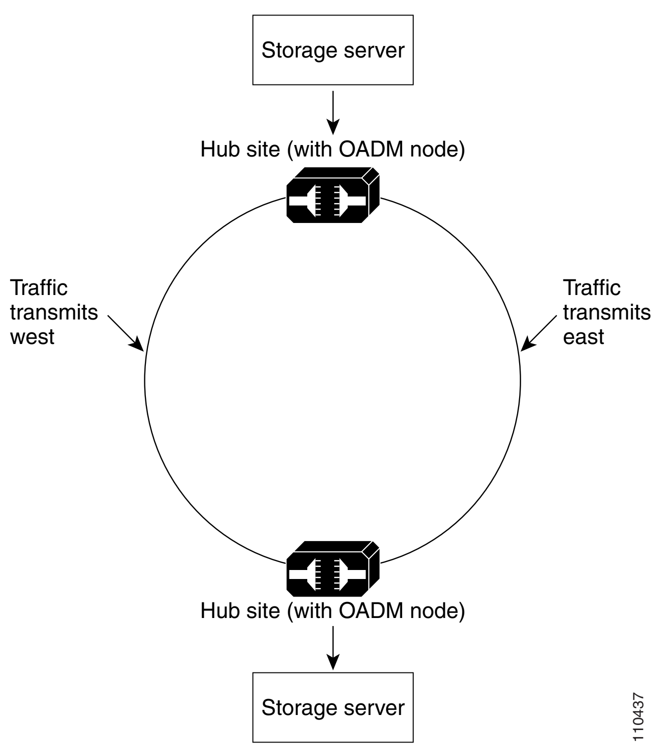


Figure 4-26 shows a 1+1 protected single-span link with hub nodes. 1+1 protected single-span link with hub nodes cannot be used in a hybrid configurations.

Figure 4-26 1+1 Protected Single-Span Link with Hub Nodes

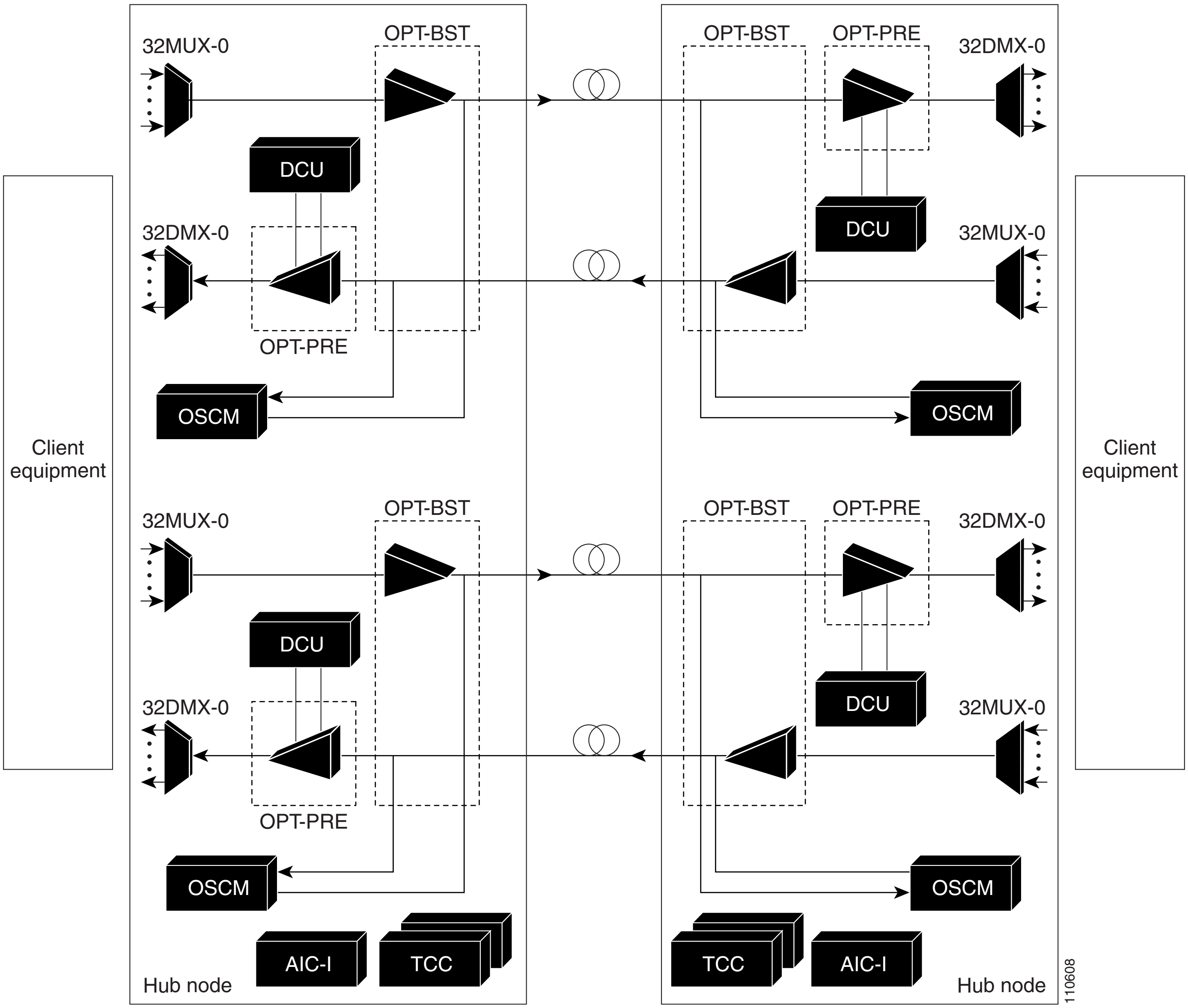
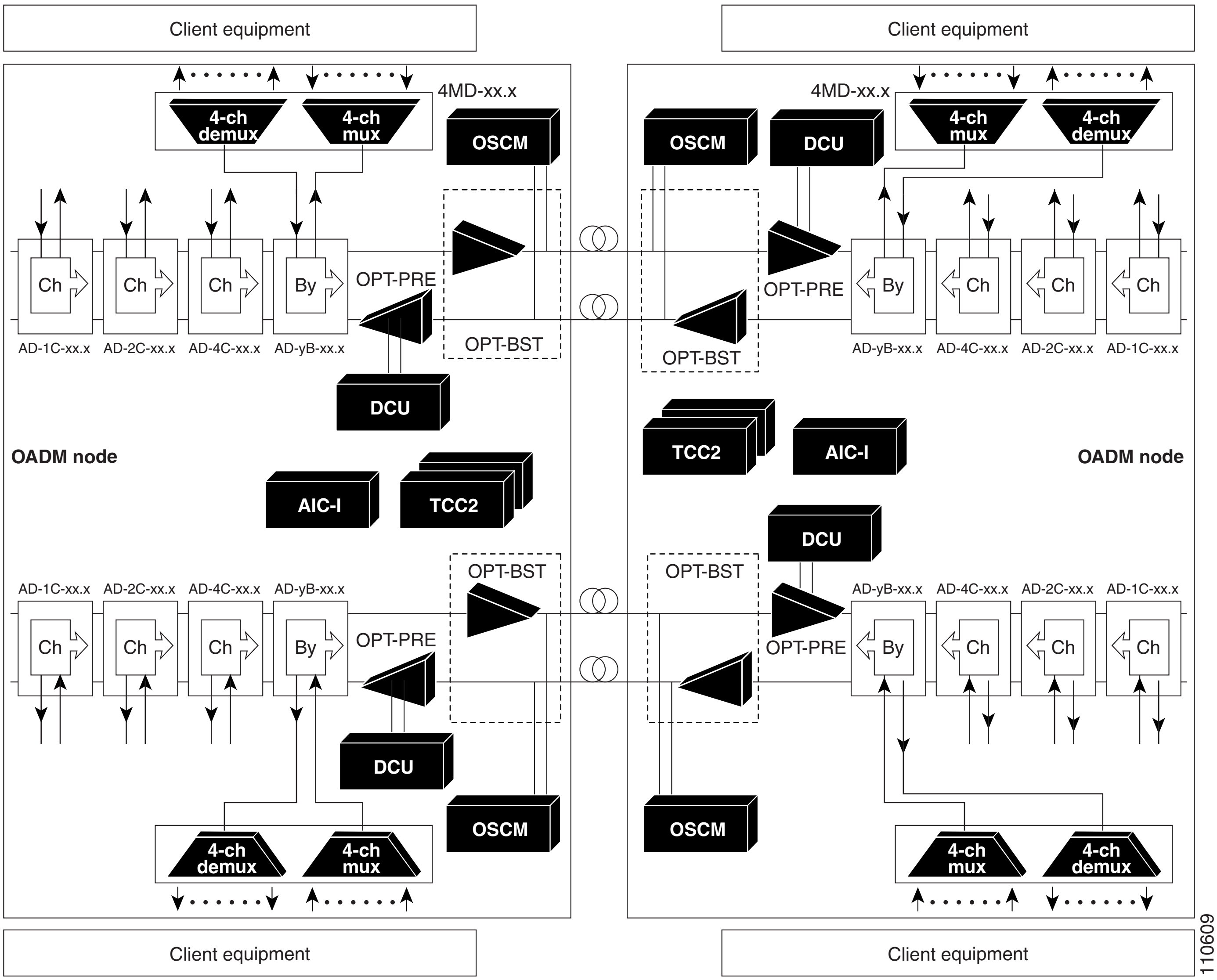


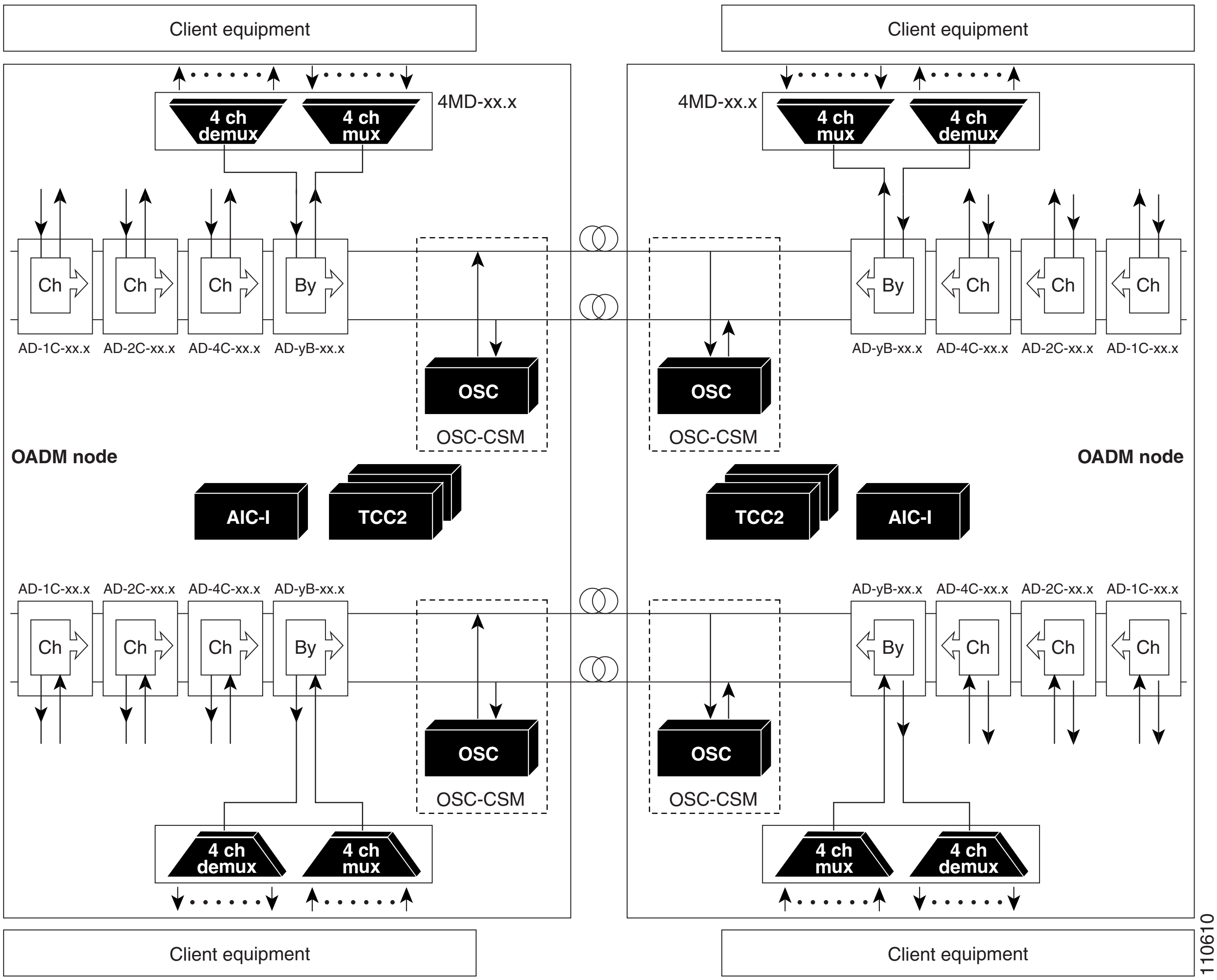
Figure 4-27 shows a 1+1 protected single-span link with active OADM nodes. 1+1 protected single-span link with active OADM nodes can be used in a hybrid configurations.

Figure 4-27 1+1 Protected Single-Span Link with Active OADM Nodes



[Figure 4-28](#) shows a 1+1 protected single-span link with passive OADM nodes. 1+1 protected single-span link with passive OADM nodes can be used in a hybrid configurations.

Figure 4-28 1+1 Protected Single-Span Link with Passive OADM Nodes



Scalable Terminal Node

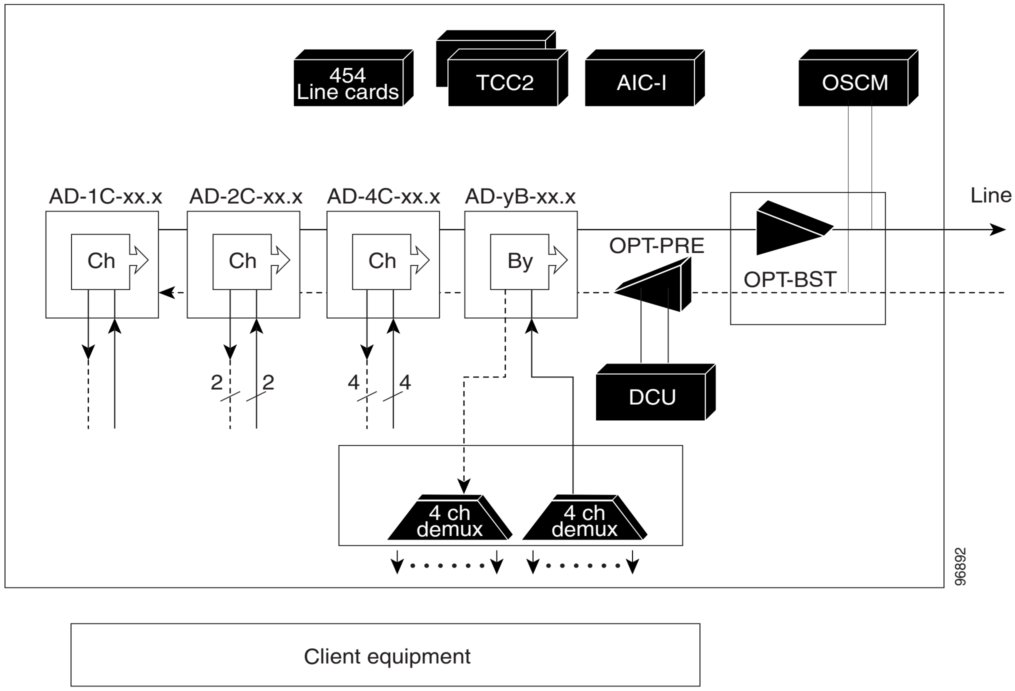
The scalable terminal node is a single ONS 15454 node equipped with a series of OADM cards and amplifier cards. This node type is more cost effective if a maximum of 16 channels are used (see Table 4-25). This node type does not support a terminal configuration exceeding 16 channels, because the 32-channel terminal site is more cost effective for 17 channels and beyond.

Table 4-25 Typical AD Configurations for Scalable Terminal Nodes

Number of Channels	Terminal Configuration Options	
	Option 1	**Option 2**
1	AD-1C-xx.x	—
2	AD-2C-xx.x	—
3	AD-4C-xx.x	AD-1B-xx.x + 4MD-xx.x
4	AD-4C-xx.x	AD-1B-xx.x + 4MD-xx.x
5	AD-1C-xx.x + AD-4C-xx.x	AD-1C-xx.x + AD-1B-xx.x + 4MD-xx.x
6	AD-2C-xx.x + AD-4C-xx.x	AD-2C-xx.x + AD-1B-xx.x + 4MD-xx.x
7	2 x AD-4C-xx.x	2 x (AD-1B-xx.x + 4MD-xx.x)
8	2 x AD-4C-xx.x	2 x (AD-1B-xx.x + 4MD-xx.x)
9	AD-1C-xx.x + (2 x AD-4C-xx.x)	AD-1C-xx.x + 2 x (AD-1B-xx.x + 4MD-xx.x)
10	AD-2C-xx.x + (2 x AD-4C-xx.x)	AD-2C-xx.x + 2 x (AD-1B-xx.x + 4MD-xx.x)
11	3 x AD-4C-xx.x	AD-4B-xx.x + (3 x 4MD-xx.x)
12	3 x AD-4C-xx.x	AD-4B-xx.x + (3 x 4MD-xx.x)
13	AD-4B-xx.x + (3 x 4MD-xx.x) + AD-1C-xx.x	AD-4B-xx.x + (3 x 4MD-xx.x)
14	AD-4B-xx.x + (3 x 4MD-xx.x) + AD-1C-xx.x	AD-4B-xx.x + (3 x 4MD-xx.x)
15	—	AD-4B-xx.x + (3 x 4MD-xx.x)
16	—	AD-4B-xx.x + (3 x 4MD-xx.x)

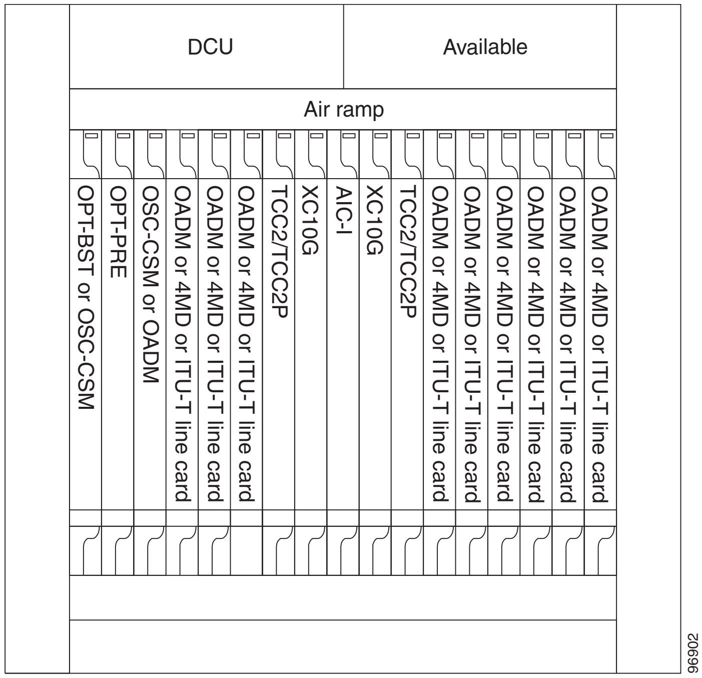
The OADM cards that can be used in this type of configuration are: AD-1C-xx.x, AD-2C-xx.x, AD-4C-xx.x, and AD-1B-xx.x. You can also use AD-4B-xx.x and up to four 4MD-xx.x cards. The OPT-PRE and/or OPT-BST amplifiers can be used. The OPT-PRE or OPT-BST configuration depends on the node loss and the span loss. When the OPT-BST is not installed, the OSC-CSM must be used instead of the OSCM card. Figure 4-29 shows a channel flow example of a scalable terminal node configuration.

Figure 4-29 Scalable Terminal Channel Flow Example



A scalable terminal node can be created by using band and/or channel OADM filter cards. This node type is the most flexible of all node types, because the OADM filter cards can be configured to accommodate node traffic. If the node does not contain amplifiers, it is considered a passive hybrid terminal node. Figure 4-30 shows an example of a scalable terminal node configuration. This node type can be used without add or drop cards.

Figure 4-30 Scalable Terminal Example



Hybrid Terminal Node

A hybrid terminal node is a single ONS 15454 node equipped with at least one 32MUX-O card, one 32DMX-O card, two TCC2/TCC2P cards, and TDM cards. If the node is equipped with OPT-PRE or OPT-BST amplifiers, it is considered an amplified terminal node. The node becomes passive if the amplifiers are removed. The hybrid terminal node type is based on the DWDM terminal node type described previously in this chapter. Figure 4-31 shows an example of an amplified hybrid terminal node configuration.

Figure 4-31 Amplified Hybrid Terminal Example

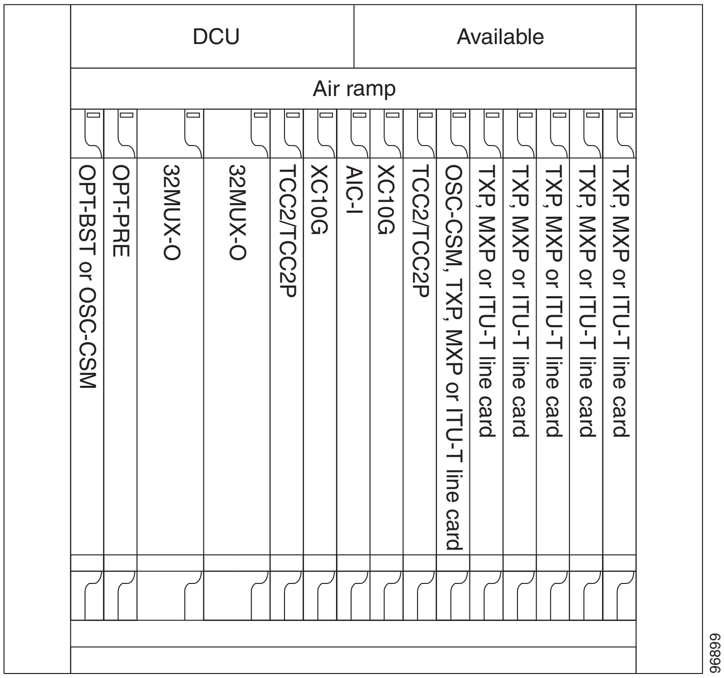
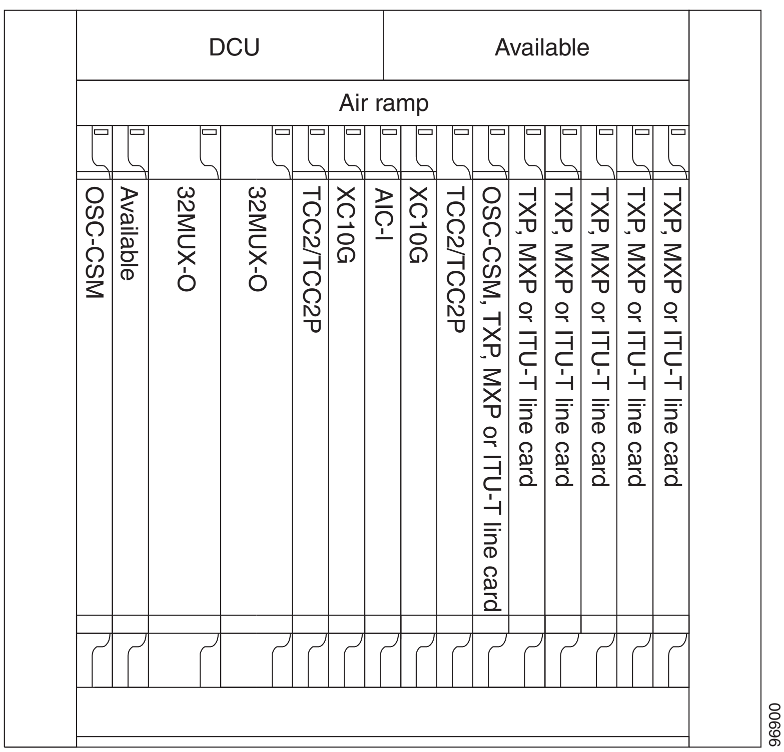


Figure 4-32 shows an example of a passive hybrid terminal node configuration.

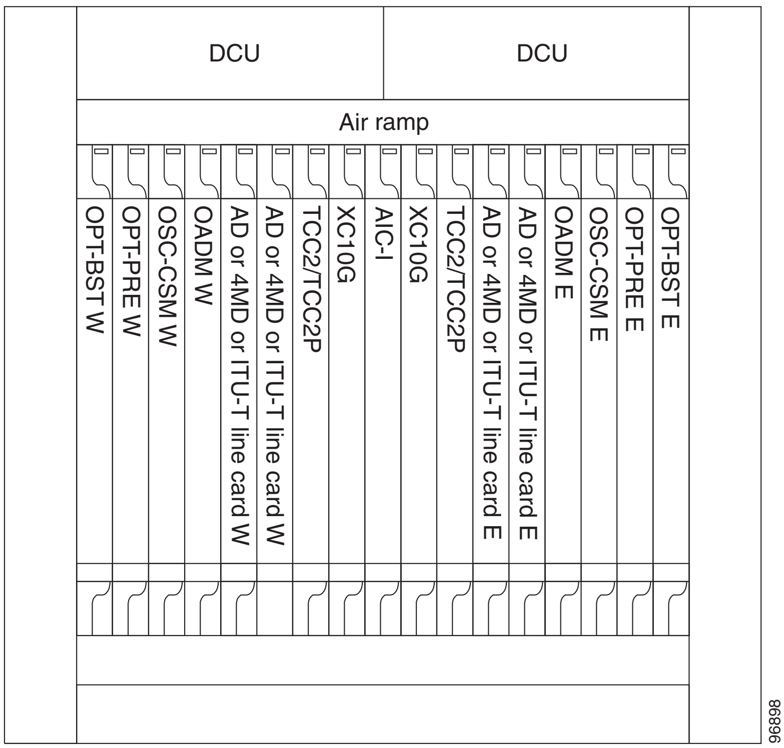
Figure 4-32 Passive Hybrid Terminal Example



Hybrid OADM Node

A hybrid OADM node is a single ONS 15454 node equipped with at least one AD-xC-xx.x card or one AD-xB-xx.x card, and two TCC2/TCC2P cards. The hybrid OADM node type is based on the DWDM OADM node type previously described in this chapter. TDM cards can be installed in any available multi-speed slot. Review the plan produced by MetroPlanner to determine slot availability.Figure 4-33 shows an example of an amplified hybrid OADM node configuration. The hybrid OADM node can also become passive by removing the amplifier cards.

Figure 4-33 Hybrid Amplified OADM Example

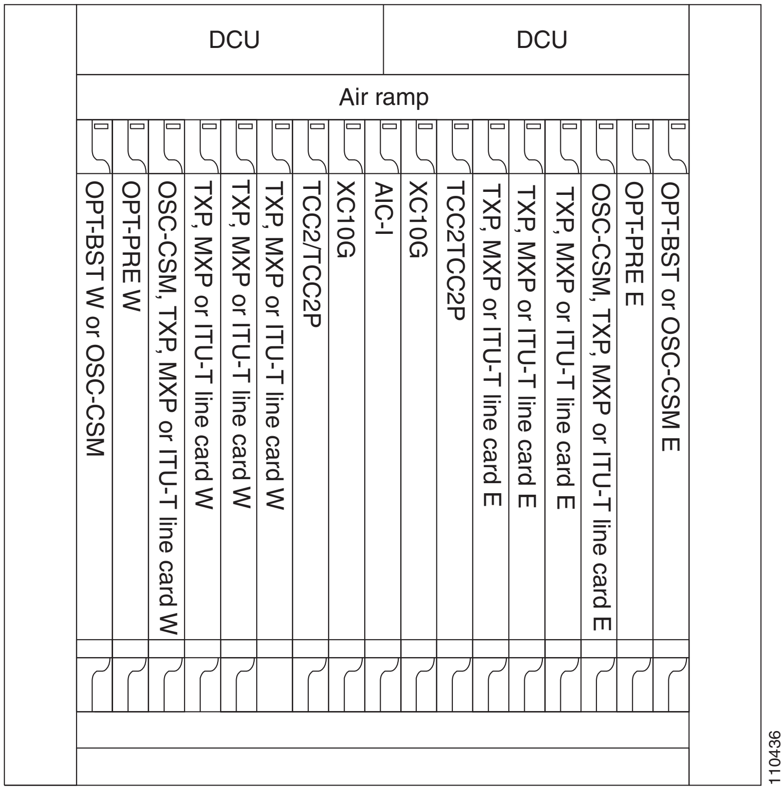


Hybrid Line Amplifier Node

A hybrid line amplifier node is a single ONS 15454 node with open slots for both TDM and DWDM cards. Figure 4-34 shows an example of a hybrid line amplifier node configuration.

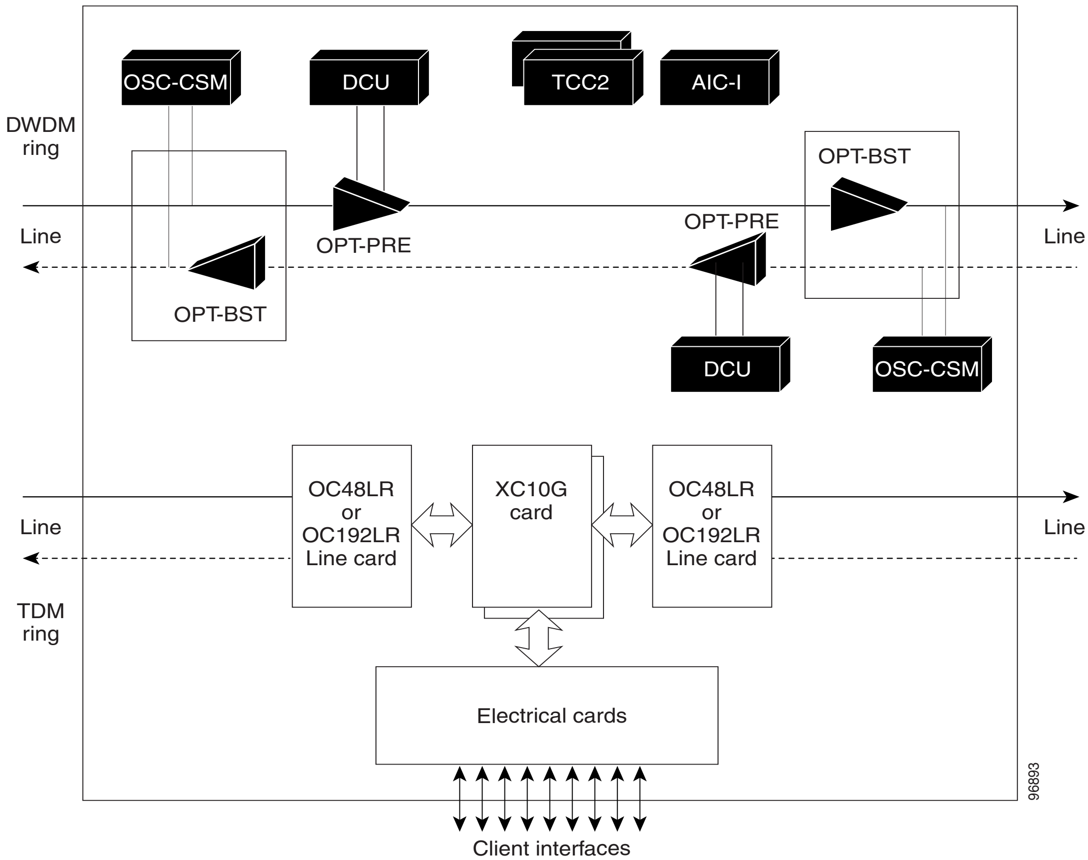
Note For DWDM applications, if the OPT-BST is not installed within the node, the OSC-CSM card must be used instead of the OSCM card.

Figure 4-34 Hybrid Line Amplifier Example



A hybrid line node is another example of the hybrid line amplifier OADM node. A hybrid line node is single ONS 15454 node equipped with OPT-PRE amplifiers, OPT-BST amplifiers, and TCC2/TCC2P cards for each line direction. Both types of amplifiers can be used or just one type of amplifier. Attenuators might also be required between each preamplifier and booster amplifier to match the optical input power value and to maintain the amplifier gain tilt value. TDM cards can be installed in any available multi-speed slot. Review the plan produced by MetroPlanner to determine slot availability. Figure 4-35 shows a channel flow example of a hybrid line node configuration. Since this node contains both TDM and DWDM rings, both TDM and DWDM rings should be terminated even if no interactions are present between them.

Figure 4-35 Hybrid Line Amplifier Channel Flow Example



Amplified TDM Node

An amplified TDM node is a single ONS 15454 node that increases the span length between two ONS 15454 nodes that contain TDM cards and optical amplifiers. There are three possible configurations for an amplified TDM node:

- Configuration 1 uses client cards and OPT-BST amplifiers.
- Configuration 2 uses client cards, OPT-BST amplifiers, OPT-PRE amplifiers, and FlexLayer filters.
- Configuration 3 uses client cards, OPT-BST amplifiers, OPT-PRE amplifiers, AD-1Cxx.x cards, and OSC-CSM cards.

The client cards that can be used in an amplified TDM node are:

- TXP_MR_10G
- MXP_2.5G_10G
- TXP_MR_2.5G
- TXPP_MR_2.5G
- OC-192 LR/STM 64 ITU 15xx.xx
- OC-48 ELR/STM 16 EH 100 GHz

Figure 4-36 shows the first amplified TDM node scenario with an OPT-BST amplifier.

Figure 4-36 Amplified TDM Example with an OPT-BST Amplifier

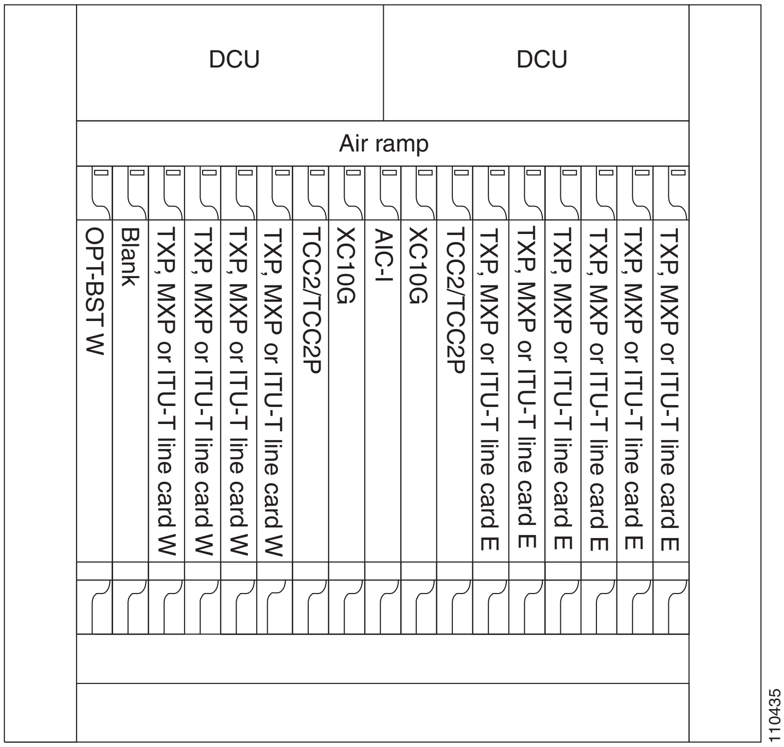


Figure 4-37 shows the first amplified TDM node channel flow configuration with OPT-BST amplifiers.

Figure 4-37 Amplified TDM Channel Flow Example With OPT-BST Amplifiers

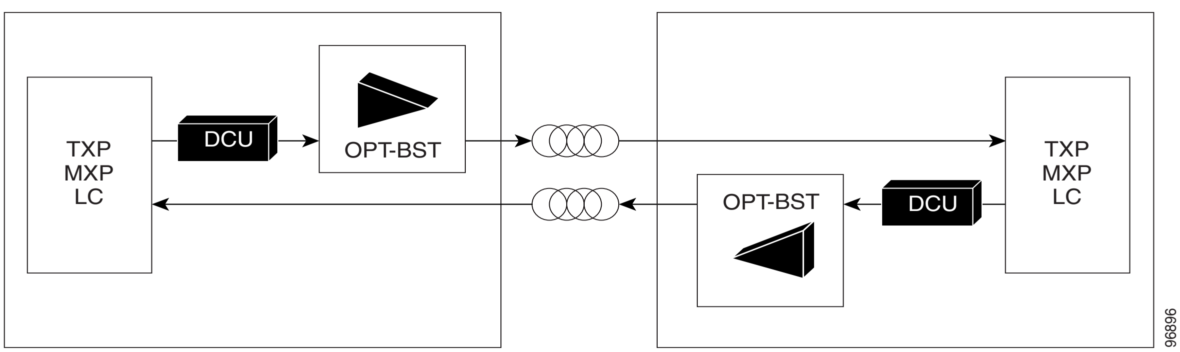


Figure 4-38 shows the second amplified TDM node configuration with client cards, AD-1C-xx.x cards, OPT-BST amplifiers, OPT-PRE amplifiers, and FlexLayer filters.

Figure 4-38 Amplified TDM Example with FlexLayer Filters

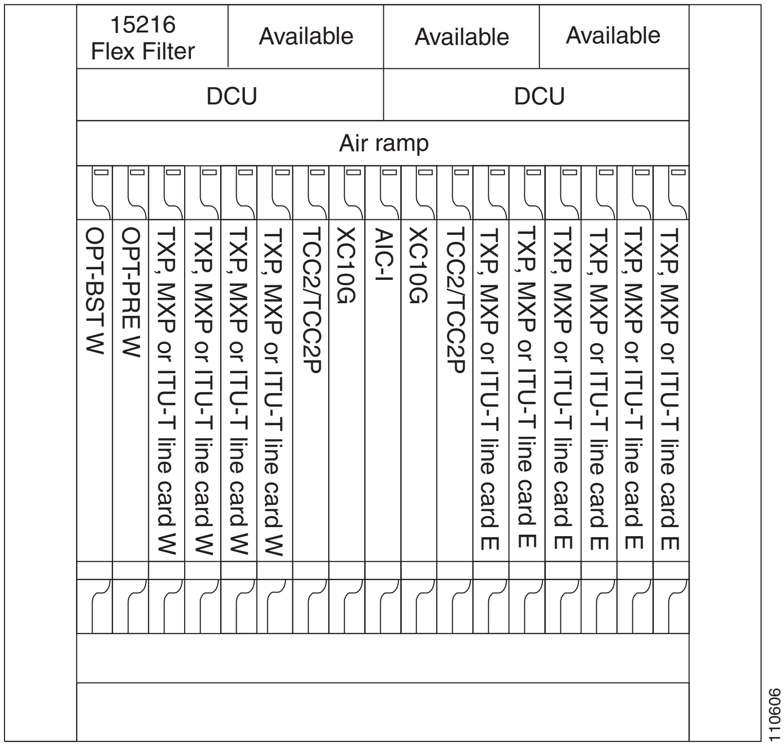


Figure 4-39 shows the second amplified TDM node channel flow configuration with client cards, OPT-BST amplifiers, OPT-PRE amplifiers, and FlexLayer filters.

Figure 4-39 Amplified TDM Channel Flow Example With FlexLayer Filters

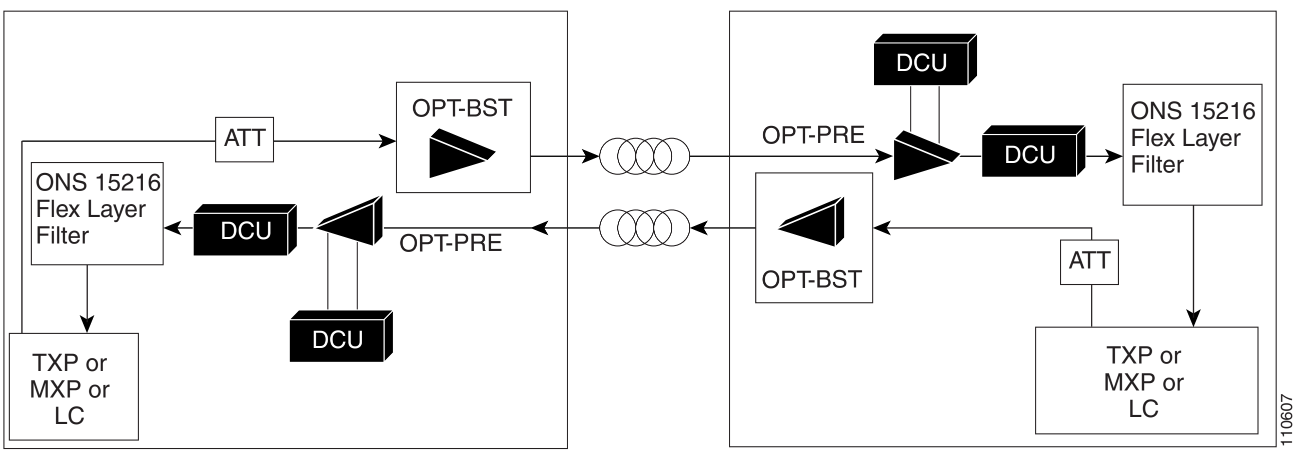
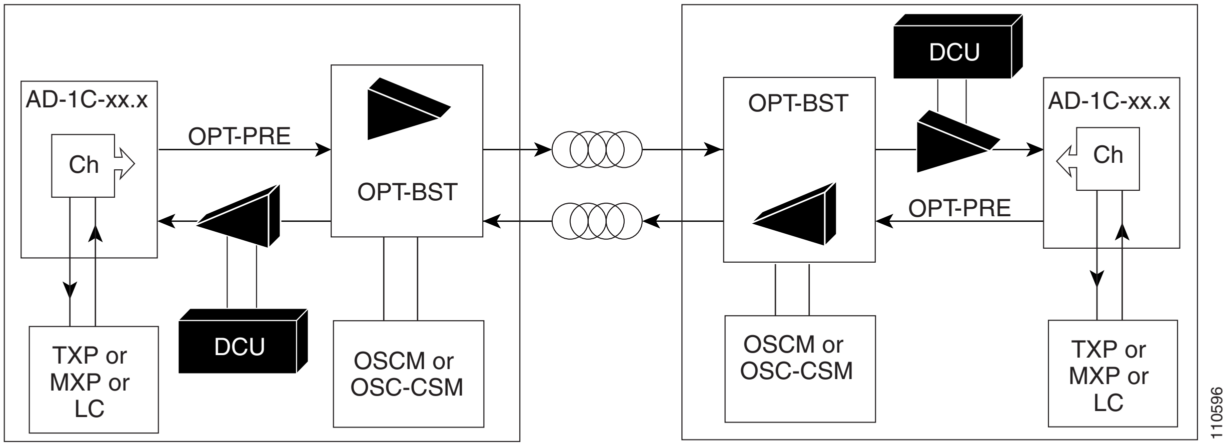


Figure 4-40 shows the third amplified TDM channel flow configuration with client cards, OPT-BST amplifiers, OPT-PRE amplifiers, AD-1C-xx.x cards, and OSC-CSM cards.

Figure 4-40 Amplified TDM Channel Flow Example With Amplifiers, AD-1C-xx.x Cards, and OSC-CSM Cards



DWDM Topologies

There are two main DWDM network types: metro core, where the channel power is equalized and dispersion compensation is applied, and metro access, where the channels are not equalized and dispersion compensation is not applied. Metro Core networks often include multiple spans and amplifiers, thus making optical signal-to-noise ratio (OSNR) the limiting factor for channel performance. Metro Access networks often include a few spans with very low span loss; therefore, the signal link budget is the limiting factor for performance. The DWDM network topologies supported by the ONS 15454 are:

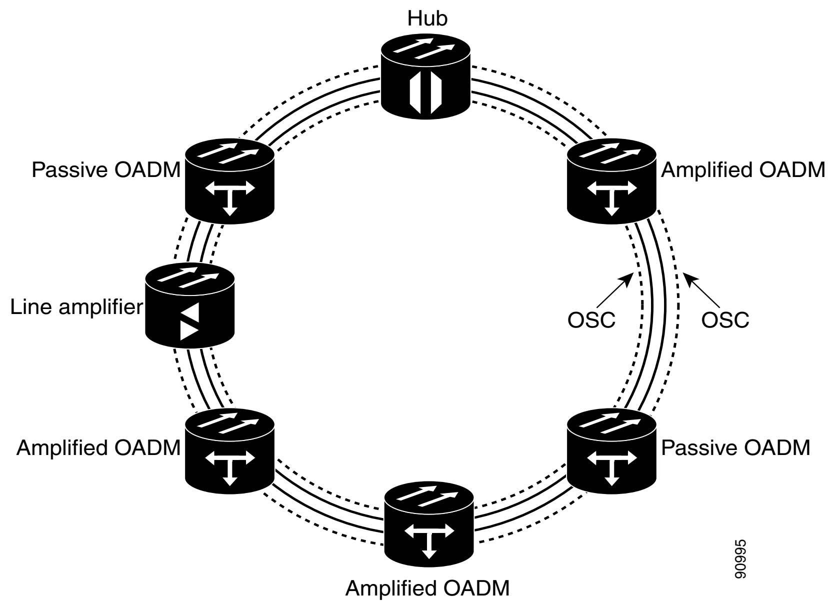
- Hubbed Rings
- Multi-hubbed Rings
- Any-to-Any Rings
- Meshed Rings
- Linear Configurations
- Single-span Links
- Hybrid Networks

Hubbed Rings

In the hubbed ring topology (Figure 4-41), a hub node terminates all the DWDM channels. A channel can be provisioned to support protected traffic between the hub node and any node in the ring. Both working and protected traffic use the same wavelength on both sides of the ring. Protected traffic can also be provisioned between any pair of OADM nodes, except that either the working or the protected path must be regenerated in the hub node.

Protected traffic saturates a channel in a hubbed ring, that is, no channel reuse is possible. However, the same channel can be reused in different sections of the ring by provisioning unprotected multi-hop traffic. From a transmission point of view, this network topology is similar to two bidirectional point-to-point links with OADM nodes.

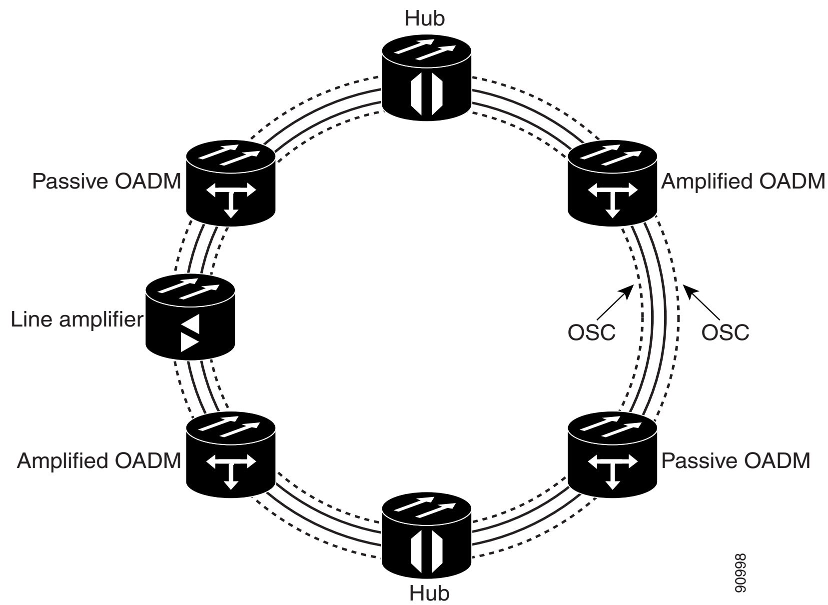
Figure 4-41 Hubbed Ring



Multi-hubbed Rings

A multi-hubbed ring (Figure 4-42) is based on the hubbed ring topology, except that two or more hub nodes are added. Protected traffic can only be established between the two hub nodes. Protected traffic can be provisioned between a hub node and any OADM node only if the allocated wavelength channel is regenerated through the other hub node. Multi-hop traffic can be provisioned on this ring. From a transmission point of view, this network topology is similar to two or more point-to-point links with OADM nodes.

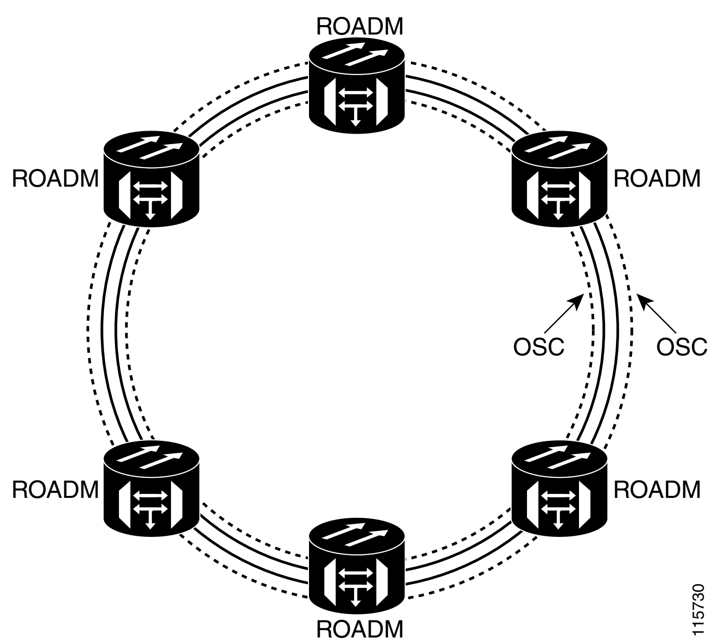
Figure 4-42 Multi-hubbed Ring



Any-to-Any Rings

The any-to-any ring topology shown in Figure 4-43 contains only reconfigurable OADM (ROADM) nodes, or ROADM nodes with Optical Service Channel (OSC) regeneration or amplifier nodes. This topology potentially allows you to route every wavelength from any source to any destination node inside the network.

Figure 4-43 Any-to-Any Ring

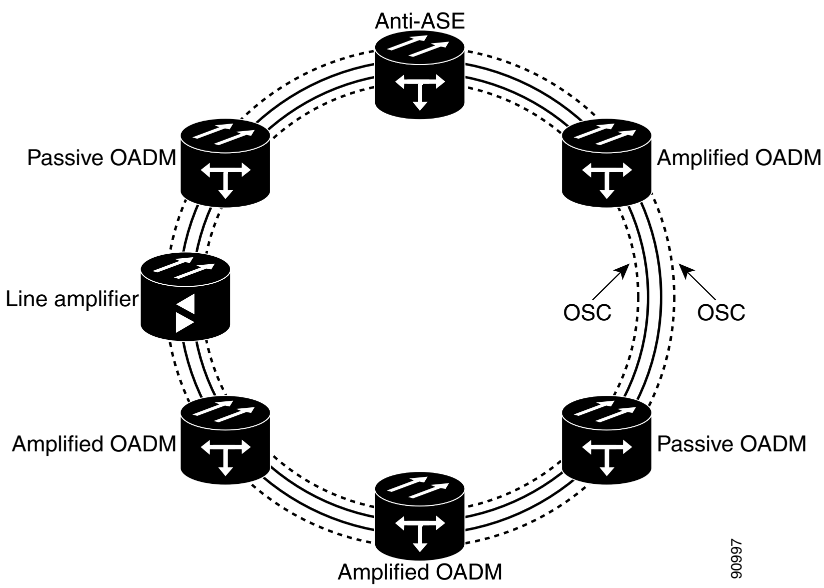


Meshed Rings

The meshed ring topology (Figure 4-44 does not use hubbed nodes; only amplified and passive OADM nodes are present. Protected traffic can be provisioned between any two nodes; however, the selected channel cannot be reused in the ring. Unprotected multi-hop traffic can be provisioned in the ring. A meshed ring must be designed to prevent ASE lasing. This is done by configuring a particular node as an anti-ASE node. An anti-ASE node can be created in two ways:

- Equip an OADM node with 32MUX-O cards and 32DMX-O cards. This solution is adopted when the total number of wavelengths deployed in the ring is higher than ten. OADM nodes equipped with 32MUX-O cards and 32DMX-O cards are called full OADM nodes.
- When the total number of wavelengths deployed in the ring is lower than ten, the anti-ASE node is configured by using an OADM node where all the channels that are not terminated in the node are configured as "optical pass-through." In other words, no channels in the anti-ASE node can travel through the express path of the OADM node.

Figure 4-44 Meshed Ring



Linear Configurations

Linear configurations are characterized by the use of two terminal nodes (west and east). The terminal nodes must be equipped with a 32MUX-O card and a 32DMX-O card, or a 32WSS card with a 32DMX or 32DMX-O card. OADM or line amplifier nodes can be installed between the two terminal nodes. Only unprotected traffic can be provisioned in a linear configuration. Figure 4-45 shows five ONS 15454 nodes in a linear configuration with an OADM node.

Figure 4-45 Linear Configuration with an OADM Node

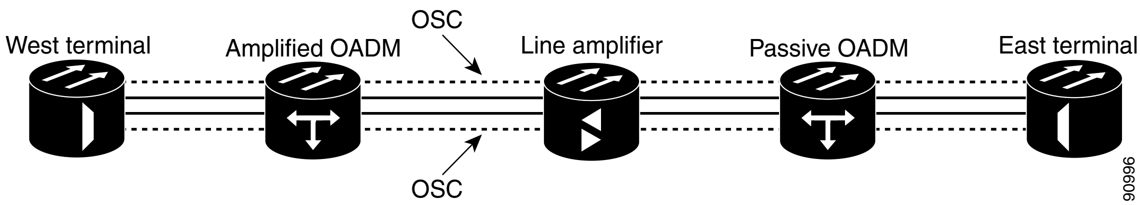
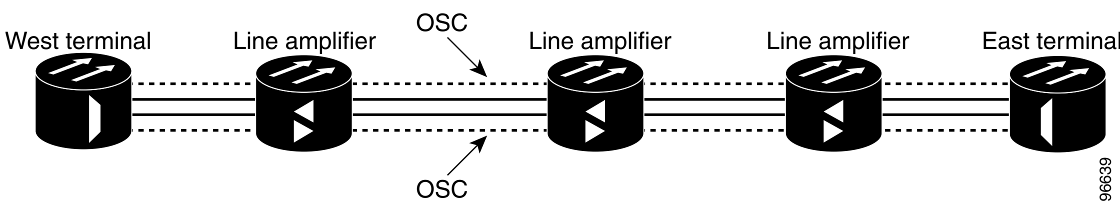


Figure 4-46 shows five ONS 15454 nodes in a linear configuration without an OADM node.

Figure 4-46 Linear Configuration without an OADM Node

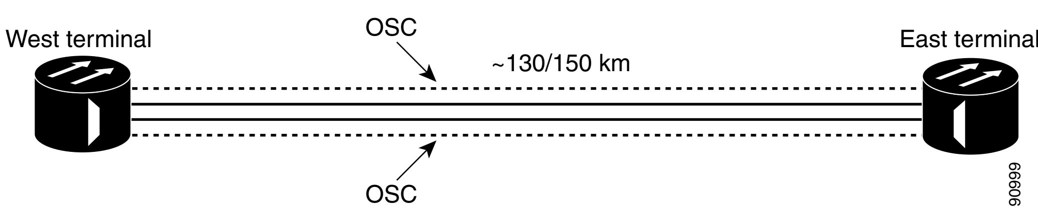


Single-Span Link

Single-span link is a type of linear configuration characterized by a single-span link with preamplification and post-amplification. A span link is also characterized by the use of two terminal nodes (west and east). The terminal nodes are usually equipped with a 32MUX-O card and a 32DMX-O card. However, a 32WSS card and a 32DMX or a 32DMX-O card can be installed. Software R4.6 and higher also supports single-span links with AD-4C-xx.x cards. Only unprotected traffic can be provisioned on a single-span link.

Figure 4-47 shows ONS 15454s in a single-span link. Eight channels are carried on one span. Single-span link losses apply to OC-192 LR ITU cards. The optical performance values are valid assuming that the sum of the OADM passive nodes insertion losses and the span losses does not exceed 35 dB.

Figure 4-47 Single-Span Link

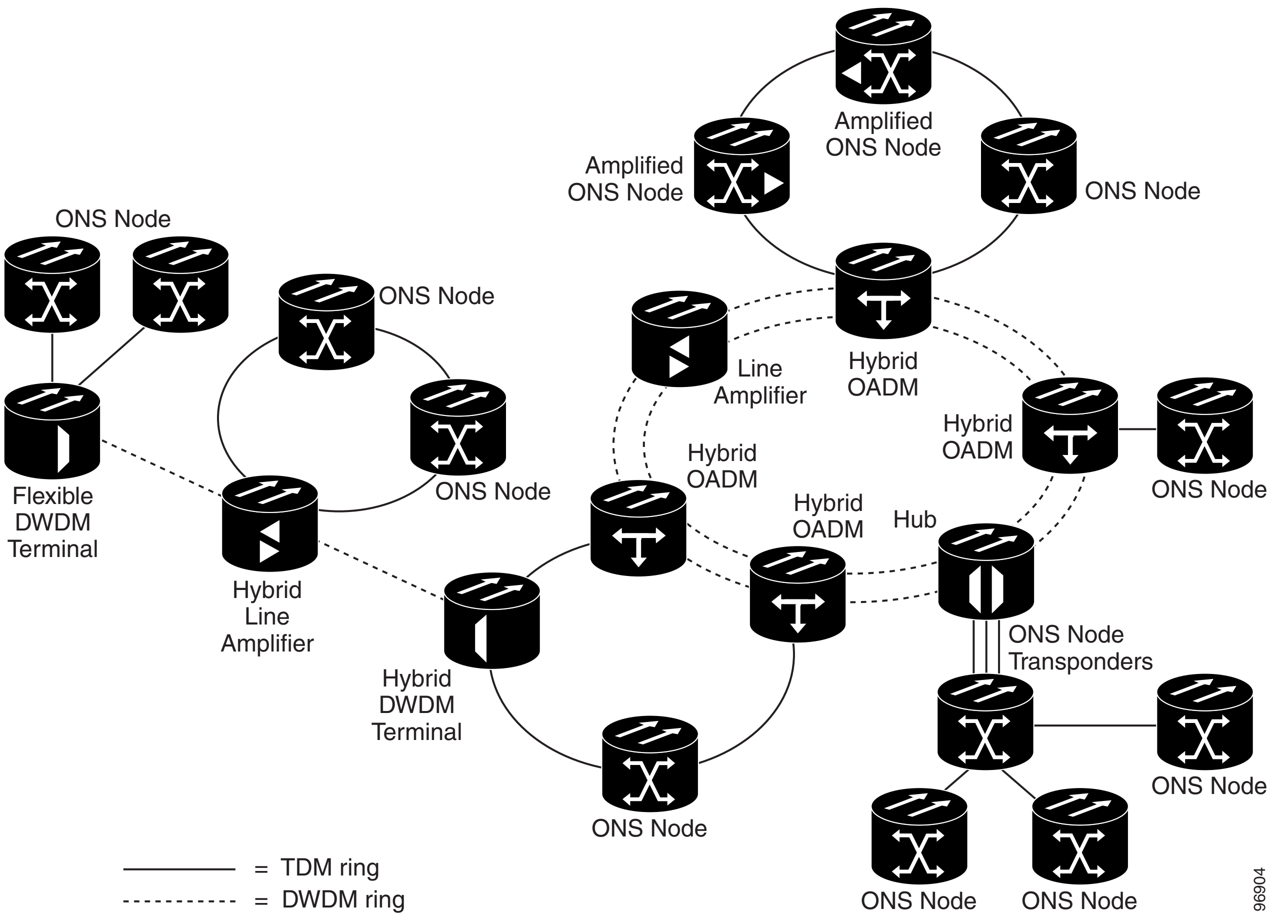


Hybrid Networks

The hybrid network configuration is determined by the type of node that is used in an ONS 15454 network. Along with TDM nodes, the ONS 15454 supports the following hybrid node types: 1+1 protected flexible terminal, scalable terminal, hybrid terminal, hybrid OADM, hybrid line amplifier, and amplified TDM.

Figure 4-48 shows ONS 15454s in a hybrid TDM and DWDM configurations.

Figure 4-48 Hybrid Network Example



DWDM and TDM layers can be mixed in the same node; however they operate and are provisioned independently. The following TDM configurations can be added to a hybrid network:

- Point-to-Point
- Linear ADM
- BLSR
- Path protection

Figure 4-49 shows ONS 15454s in a hybrid point-to-point configuration.

Figure 4-49 ***Hybrid Point-to-Point Network Example***

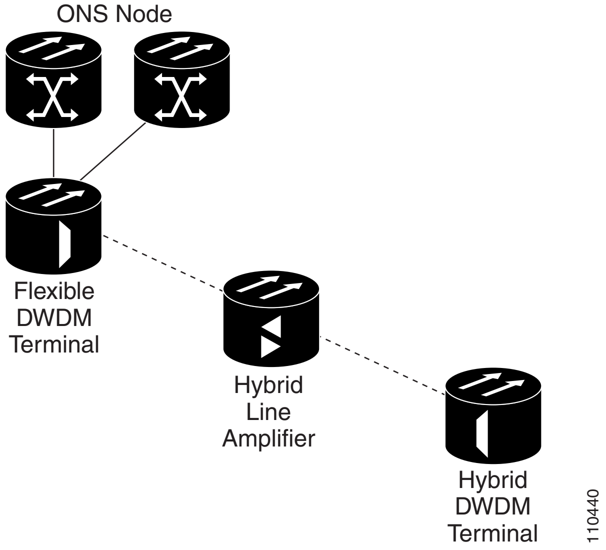


Figure 4-50 shows ONS 15454s in a hybrid linear ADM configuration.

Figure 4-50 ***Hybrid Linear ADM Network Example***

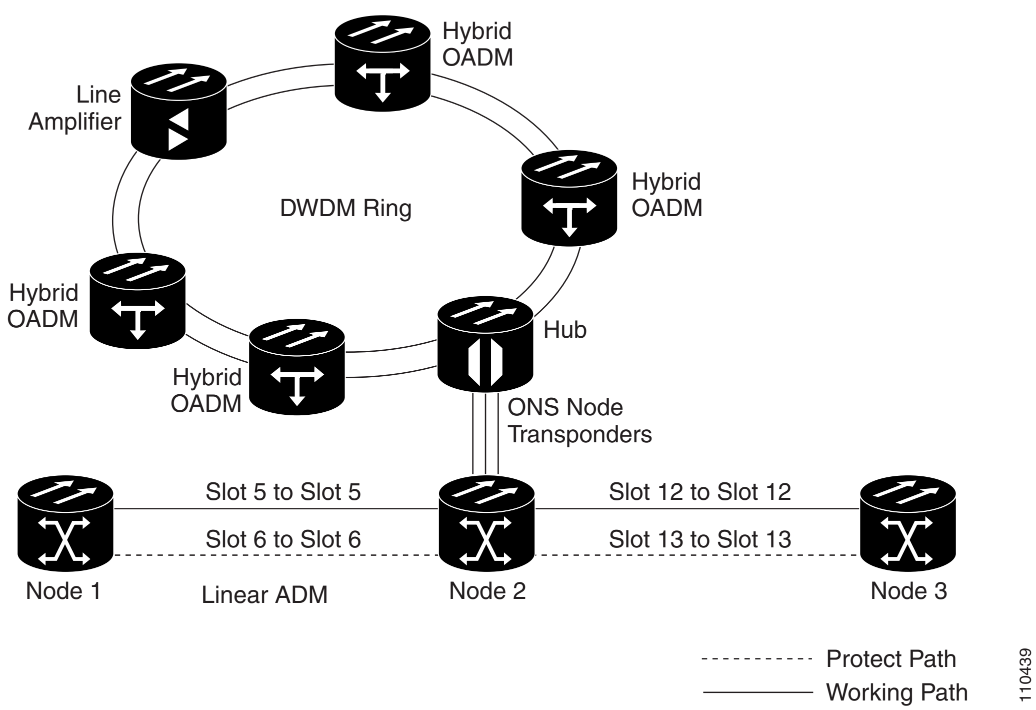


Figure 4-51 shows ONS 15454s in a hybrid BLSR configuration.

Figure 4-51 Hybrid BLSR Network Example

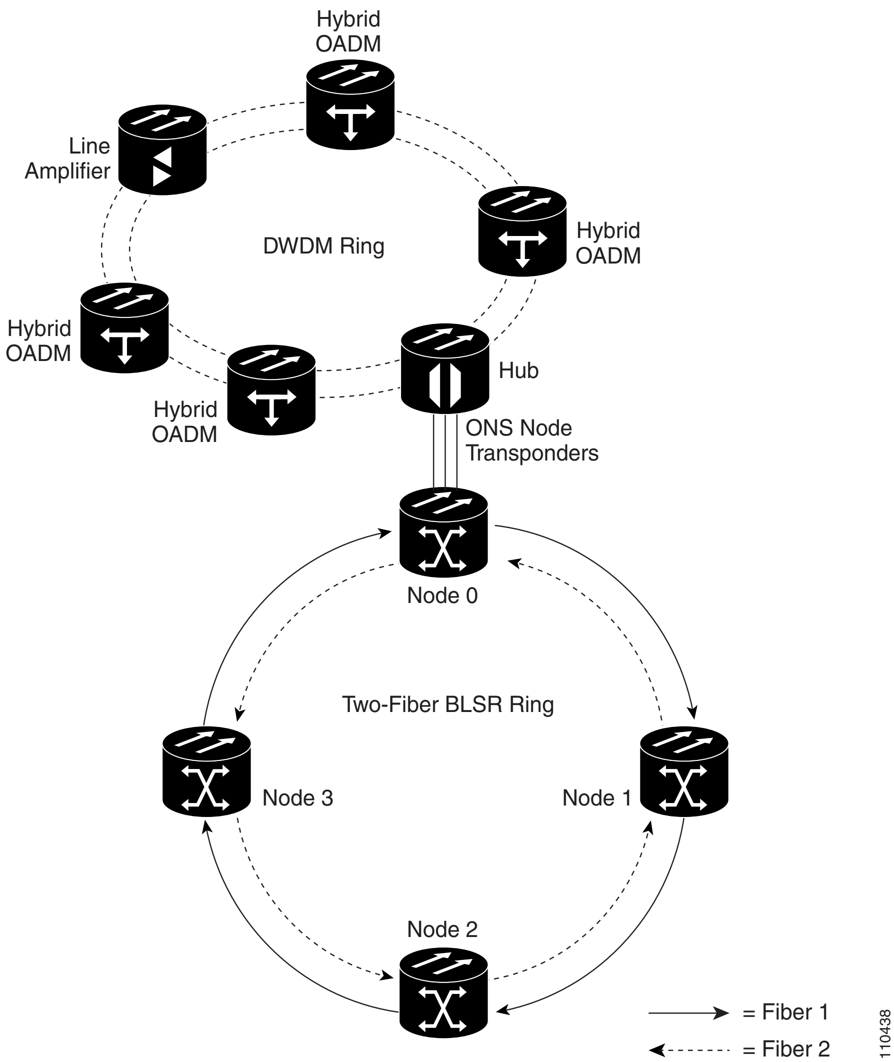
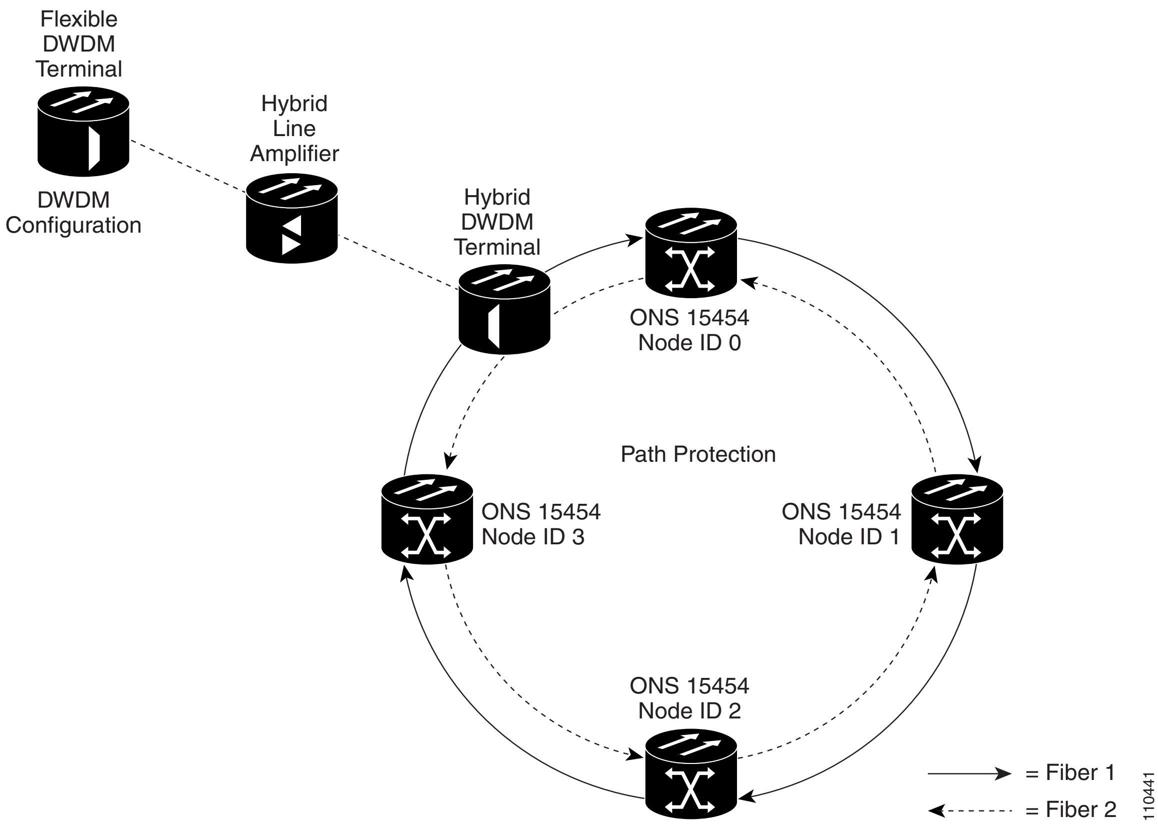


Figure 4-52 shows ONS 15454s in a hybrid path protection configuration.

Figure 4-52 Hybrid Path Protection Network Example



DWDM Network Topology Discovery

Each ONS 15454 DWDM node has a network topology discovery function that can:

- Identify other ONS 15454 DWDM nodes in an ONS 15454 DWDM network.
- Identify the different types of DWDM networks.
- Identify when the DWDM network is complete and when it is incomplete.

ONS 15454 DWDM nodes use node services protocol (NSP) to automatically update nodes whenever a change in the network occurs. NSP uses two information exchange mechanisms: hop-by-hop message protocol and broadcast message protocol. Hop-by-hop message protocol elects a master node and exchanges information between nodes in a sequential manner simulating a token ring protocol as follows:

- Each node that receives a hop-by-hop message passes it to the next site according to the ring topology and the line direction from which the token was received.
- The message originator always receives the token after it has been sent over the network.
- Only one hop-by-hop message can run on the network at any one time.

NSP broadcast message protocol distributes information that is to be shared by all ONS 15454 DWDM nodes on the same network. Broadcast message delivery is managed in an independent way from delivery of the two tokens. Moreover, no synchronization among broadcast messages is required; every node is authorized to send a broadcast message any time it is necessary.

Optical Performance

This section provides optical performance information for ONS 15454 DWDM networks. The performance data is a general guideline based upon the network topology, node type, client cards, fiber type, number of spans, and number of channels. The maximum number of nodes that can be in an ONS 15454 DWDM network is 16. The DWDM topologies and node types covered in this section are shown in Table 4-26.

Table 4-26 Supported Topologies, and Node Types

Number of Channels	Fiber Type	Topologies	Node Type
32	SMF-28[1] E-LEAF[2] TW-RS[3]	Ring Linear Linear without OADM	Hub Active OADM Passive OADM Terminal Line OSC regeneration
16	SMF-28	Ring Linear Linear without OADM	Hub Active OADM Passive OADM Terminal Line OSC regeneration
8	SMF-28	Linear without OADM	Terminal Line

1. SMF-28 = single-mode fiber 28
2. E-LEAF = enhanced large effective area fiber
3. TW-RS = TrueWave reduced slope fiber

The following tables provide optical performance estimates for open and closed ONS 15454 rings and linear networks with OADM nodes.

Table 4-27 shows the optical performance for a 32-channel hubbed ring SMF fiber. Span losses shown in the table assume:

- OADM nodes have a loss of 16 dB and equal span losses.
- Optical Preamplifier (OPT-PRE) and Optical Booster (OPT-BST) amplifiers are installed in all nodes.
- The OPT-PRE amplifier switches to control power whenever the span loss is higher than 27 dB.

Table 4-27 Span Loss for 32-Channel Ring and Linear Networks with OADM Nodes Using SMF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	Class A	Class B	Class C	Class I	Class D	Class E	Class F	Class G	Class H	Class J
1	34 dB	26 dB	26 dB	36 dB	37 dB	33 dB	30 dB	32 dB	34 db	30 dB
2	28 dB	21 dB	20 dB	30 dB	31 dB	28 dB	25 dB	27 Db	29 dB	25 dB
3	26 dB	17 dB	15 dB	28 dB	29 dB	26 dB	23 dB	25 dB	26 dB	23 dB
4	24 dB	—	—	25 dB	26 dB	23 dB	20 dB	22 dB	24 dB	20 dB
5	22 dB	—	—	24 dB	25 dB	22 dB	16 dB	20 dB	23 dB	16 dB
6	20 dB	—	—	22 dB	24 dB	19 dB	—	17 dB	21 dB	—
7	18[1] dB	—	—	21 dB	23 dB	16 dB	—	—	19 dB	—

1. 0.5 dB of OSNR impairment recovered by FEC margin @ BER > 10-6

Table 4-28 shows the optical performance for 16-channel networks using SMF fiber. Span loss values assume the following:

- OADM nodes have a loss of 16 dB and equal span losses.
- All nodes have OPT-PRE and OPT-BST amplifiers installed.
- The OPT-PRE amplifier switches to control power whenever the span loss is higher than 27 dB.

Table 4-28 Span Loss for 16-Channel Ring and Linear Networks with OADM Nodes Using SMF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	Class A	Class B	Class C	Class I	Class D	Class E	Class F	Class G	Class H	Class J
1	37dB	29 dB	29 dB	37 dB	37 dB	36 dB	33 dB	35 dB	37 db	33 dB
2	21 dB	25 dB	24 dB	33dB	34 dB	31 dB	28 dB	30 Db	32 dB	28 dB
3	28 dB	22 dB	21 dB	30 dB	31 dB	28 dB	26 dB	27 dB	29 dB	26 dB
4	26 dB	19 dB	17 dB	28 dB	29 dB	26 dB	24dB	25 dB	27 dB	24 dB
5	25 dB	—	—	26 dB	27 dB	25 dB	22 dB	24 dB	25 dB	22 dB
6	24 dB	—	—	25 dB	26 dB	24 dB	21 dB	23 dB	24 dB	21 dB
7	23 dB	—	—	25 dB	25 dB	23 dB	19 dB	22 dB	24 dB	19 dB

Table 4-29 shows the optical performance for 32-channel networks using TW-RS fiber. Span loss values assume the following:

- OADM nodes have a loss of 16 dB and equal span losses.
- All nodes have OPT-PRE and OPT-BST amplifiers installed.
- The OPT-PRE amplifier switches to control power whenever the span loss is higher than 27 dB.

Table 4-29 Span Loss for 32-Channel Ring and Linear Networks with OADM Nodes Using TW-RS Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	**Class A**	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	37dB	29 dB	29 dB	37 dB	37 dB	36 dB	33 dB	35 dB	37 db	33 dB
2	21 dB	25 dB	24 dB	33dB	34 dB	31 dB	28 dB	30 Db	32 dB	28 dB
3	28 dB	22 dB	21 dB	30 dB	31 dB	28 dB	26 dB	27 dB	29 dB	26 dB
4	26 dB	19 dB	17 dB	28 dB	29 dB	26 dB	24dB	25 dB	27 dB	24 dB
5	25 dB	—	—	26 dB	27 dB	25 dB	22 dB	24 dB	25 dB	22 dB
6	24 dB	—	—	25 dB	26 dB	24 dB	21 dB	23 dB	24 dB	21 dB
7	23 dB	—	—	25 dB	25 dB	23 dB	19 dB	22 dB	24 dB	19 dB

Table 4-30 shows the optical performance for 32-channel networks using E-LEAF fiber. Span loss values assume the following:

- OADM nodes have a loss of 16 dB and equal span losses.
- All nodes have OPT-PRE and OPT-BST amplifiers installed.
- The OPT-PRE amplifier switches to control power whenever the span loss is higher than 27 dB.

Table 4-30 Span Loss for 32-Channel Ring and Linear Networks with OADM Nodes Using E-LEAF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	**Class A**	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	34dB	26 dB	26 dB	36 dB	34 dB	33 dB	30 dB	32 dB	34 db	30 dB
2	29 dB	21 dB	20 dB	31 dB	32 dB	29 dB	26 dB	28 dB	30 dB	26 dB
3	27 dB	17 dB	15 dB	29 dB	30 dB	26 dB	23 dB	25 dB	27 dB	23 dB
4	23 dB	—	—	25 dB	28 dB	23 dB	20 dB	22 dB	24 dB	20 dB
5	21 dB	—	—	23 dB	26 dB	22 dB	16 dB	20 dB	23 dB	16 dB
6	18 dB	—	—	21 dB	24 dB	19 dB	—	17 dB	21 dB	—
7	15 dB	—	—	19 dB	23 dB	16 dB	—	—	19 dB	—

Optical Performance for Linear Networks Without OADM Nodes

The following tables list the reference optical performances for linear networks without OADM nodes. Table 4-31 shows the optical performance for 32-channel linear networks using SMF fiber. Span loss values assume the following:

- No OADM nodes are installed
- Only OPT-PRE amplifiers are installed
- Span losses are equal

Table 4-31 Span Loss for 32-Channel Ring and Linear Networks without OADM Nodes Using SMF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	Class A	Class B	Class C	Class I	Class D	Class E	Class F	Class G	Class H	Class J
1	34 dB	26 dB	26 dB	36 dB	37 dB	33 dB	30 dB	32 dB	32 dB	30 dB
2	27 dB	21 dB	20 dB	29 dB	30 dB	27 dB	24 dB	27 dB	26 dB	24 dB
3	24 dB	18 dB	18 dB	26 dB	26 dB	24 dB	21 dB	25 dB	23 dB	21 dB
4	23 dB	17 dB	16 dB	24 dB	24 dB	22 dB	20 dB	22 dB	21 dB	20 dB
5	21 dB	—	—	22 dB	23 dB	20 dB	19 dB	20 dB	20 dB	19 dB
6	20 dB	—	—	21 dB	22 dB	20 dB	18 dB	17 dB	19 dB	18 dB
7	19 dB	—	—	20 dB	21 dB	19 dB	17 dB	—	18 dB	17 dB

Table 4-32 shows the optical performance for 32-channel linear networks using TW-RS fiber. Span loss values assume the following:

- No OADM nodes are installed.
- Only OPT-PRE amplifiers are installed.
- Span losses are equal.

Table 4-32 Span Loss for 32-Channel Ring and Linear Networks without OADM Nodes Using TW-RS Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	Class A	Class B	Class C	Class I	Class D	Class E	Class F	Class G	Class H	Class J
1	34 dB	26 dB	26 dB	36 dB	34 dB	33 dB	30 dB	32 dB	34 dB	30 dB
2	28 dB	21 dB	21 dB	30 dB	31 dB	28 dB	25 dB	27 dB	28 dB	25 dB
3	26 dB	18 dB	18 dB	27 dB	28 dB	25 dB	23 dB	24 dB	26 dB	23 dB
4	24 dB	17 dB	16 dB	26 dB	26 dB	24 dB	21 dB	23 dB	24 dB	21 dB
5	23 dB	—	—	24 dB	25 dB	23 dB	19 dB	22 dB	23 dB	19 dB
6	23 dB	—	—	24 dB	24 dB	22 dB	18 dB	21 dB	23 dB	18 dB
7	21 dB	—	—	23 dB	23 dB	20 dB	17 dB	19 dB	21 dB	15 dB

Table 4-33 shows the optical performance for 32-channel linear networks using E-LEAF fiber. Span loss values assume the following:

- No OADM nodes are installed.
- Only OPT-PRE amplifiers are installed.
- Span losses are equal.

Table 4-33 Span Loss for 32-Channel Ring and Linear Networks without OADM Nodes Using E-LEAF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	**Class A**	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	34 dB	26 dB	26 dB	36 dB	34 dB	33 dB	30 dB	32 dB	34 dB	30 dB
2	28 dB	21 dB	21 dB	30 dB	31 dB	28 dB	25 dB	27 dB	28 dB	25 dB
3	26 dB	18 dB	18 dB	27 dB	28 dB	25 dB	23 dB	24 dB	26 dB	23 dB
4	24 dB	17 dB	16 dB	26 dB	26 dB	24 dB	21 dB	23 dB	24 dB	21 dB
5	23 dB	—	—	24 dB	25 dB	23 dB	19 dB	22 dB	23 dB	19 dB
6	21 dB	—	—	23 dB	24 dB	22 dB	18 dB	21 dB	23 dB	18 dB
7	20 dB	—	—	21 dB	23 dB	20 dB	17 dB	19 dB	21 dB	15 dB

Table 4-34 shows the optical performance for 16-channel linear networks using SMF fiber. Span loss values assume the following:

- No OADM nodes are installed
- Only OPT-PRE amplifiers are installed
- Span losses are equal
- The minimum channel power is 4 dBm
- Wavelengths are picked up without any restriction from Bands 4 and 5 (1542.14 to 1545.51 nm).

Table 4-34 Span Loss for 16-Channel Ring and Linear Networks without OADM Nodes Using SMF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	**Class A**	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	37 dB	29 dB	29 dB	37 dB	37 dB	36 dB	33 dB	35 dB	37 dB	33 dB
2	32 dB	24 dB	24 dB	33 dB	34 dB	31 dB	28 dB	30 dB	32 dB	28 dB
3	28 dB	21 dB	21 dB	30 dB	31 dB	27 dB	25 dB	27 dB	28 dB	25 dB
4	26 dB	20 dB	19 dB	28 dB	28 dB	25 dB	23 dB	24 dB	26 dB	23 dB
5	25 dB	19 dB	18 dB	26 dB	27 dB	24 dB	22 dB	23 dB	25 dB	22 dB
6	24 dB	18 dB	17 dB	25 dB	26 dB	23 dB	21 dB	22 dB	24 dB	21 dB
7	22 dB	16 dB	15 dB	24 dB	24 dB	22 dB	20 dB	21 dB	22 dB	20 dB

Table 4-35 shows the optical performance for 8-channel linear networks using SMF fiber. Span loss values assume the following:

- No OADM nodes are installed
- Only OPT-PRE amplifiers are installed
- Span losses are equal.

Table 4-35 Span Loss for 8-Channel Ring and Linear Networks without OADM Nodes Using SMF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	**Class A**	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	37 dB	31 dB	31 dB	37 dB	37 dB	37 dB	35 dB	37 dB	37 dB	35 dB
2	34 dB	27 dB	26 dB	36 dB	37 dB	33 dB	30 dB	32 dB	34 dB	30 dB
3	31 dB	24 dB	23 dB	33 dB	34 dB	30 dB	27 dB	29 dB	31 dB	27 dB
4	29 dB	—	—	31 dB	31 dB	28 dB	25 dB	27 dB	29 dB	25 dB
5	27 dB	—	—	29 dB	30 dB	27 dB	24 dB	26dB	27 dB	24 dB
6	—	—	—	28 dB	—	—	—	—	—	—

Optical Performance for ROADM Rings and Linear Networks

The following tables list the reference optical performances for ROADM rings and linear networks. Table 4-36 shows the optical performance for 32-channel linear or ring networks using SMF fiber with only ROADM nodes installed. Span loss values assume the following:

- All nodes in the ring or linear network are ROADM
- OPT-PRE and OPT-BST amplifiers are installed
- Span losses are equal

Table 4-36 Span Loss for 32-Channel Ring or Linear Networks with all ROADM Nodes Using SMF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	**Class A**	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	34 dB	26 dB	26 dB	36 dB	37 dB	33 dB	27 dB	32 dB	34 dB	—
2	29dB	21 dB	21 dB	32 dB	33 dB	29 dB	27 dB	28 dB	30 dB	—
3	28 dB	19 dB	18 dB	30 dB	31 dB	27 dB	25 dB	26 dB	27 dB	—
4	29 dB	—	—	28 dB	29 dB	25 dB	23 dB	24 dB	26 dB	—
5	25 dB	—	—	27 dB	28 dB	24 dB	22 dB	22 dB	24 dB	—
6	24 dB	—	—	26 dB	27 dB	22 dB	21 dB	21 dB	23 dB	—
7	23 dB	—	—	25 dB	26 dB	21 dB	20 dB	20 dB	22 dB	—
8	22 dB	—	—	24 dB	25 dB	20 dB	NA	18 dB	20 dB	—
9	21 dB	—	—	23 dB	24 dB	19 dB	27 dB	17 dB	19 dB	—
10	20 dB	—	—	23 dB	23 dB	18 dB	25 dB	14 dB	18 dB	—
11	19 dB	—	—	22 dB	23 dB	16 dB	23 dB	—	19 dB	—
12	16 dB	—	—	21 dB	22 dB	14 dB	22 dB	—	18 dB	—
13	—	—	—	21 dB	22 dB	—	21 dB	—	—	—
14	—	—	—	20 dB	21 dB	—	20 dB	—	—	—
15	—	—	—	20 dB	20 dB	—	20 dB	—	—	—

Table 4-37 shows the optical performance for 32-channel linear or ring network with ROADM and OADM nodes using SMF fiber. Span loss values assume the following:

- All nodes in the ring or linear network are ROADM or OADM
- OPT-PRE and OPT-BST amplifiers are installed
- Span losses are equal

Table 4-37 Span Loss for 32-Channel Ring and Linear Networks with ROADM and OADM Nodes Using SMF Fiber

	10 Gb/s				2.5 Gb/s					
Number of Spans	**Class A**	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	30 dB	23 dB	24 dB	31 dB	34 dB	31 dB	28 dB	29 dB	30 dB	28 dB
2	26 dB	19 dB	19 dB	27dB	27 dB	26 dB	23 dB	26 dB	27 dB	23 dB
3	23 dB	—	—	25 dB	26 dB	23 dB	21 dB	23 dB	24 dB	21 dB
4	21 dB	—	—	23 dB	24 dB	22 dB	18 dB	21 dB	22 dB	18 dB
5	20 dB	—	—	22 dB	23 dB	20 dB	13 dB	20 dB	21 dB	13 dB
6	17 dB	—	—	19 dB	22 dB	18 dB	—	17 dB	18 dB	—
7	15[1] dB	—	—	17 dB	21 dB	16 dB	—	15[1] dB	16 dB	—

1. 0.5 dB of OSNR impairment recovered by FEC margin @ BER > 10-6

The following tables show the pass/fail criteria for eight and sixteen ROADM nodes. Table 4-38 shows the pass/fail criteria for eight ROADM nodes (seven spans) required for any-to-any node circuit reconfigurations:

- All nodes in the ring are ROADM.
- Span losses are equal.

Table 4-38 Pass/Fail Criteria for 32-Channel, 8-Node ROADM Rings Using SMF Fiber

Span Loss (dB)	**Amplifiers Installed**	10 Gb/s				2.5 Gb/s					
		Class A	**Class B**	**Class C**	**Class I**	**Class D**	**Class E**	**Class F**	**Class G**	**Class H**	**Class J**
1	OPT-PRE	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
2	OPT-PRE	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
3	OPT-PRE	Yes	<7	<7	Yes	Yes	Yes	<7	Yes	Yes	—
4	OPT-PRE	Yes	<7	<7	Yes	Yes	Yes	<7	Yes	Yes	—
5	OPT-PRE	Yes	<7	<7	Yes	Yes	Yes	<7	Yes	Yes	—
6	OPT-PRE	Yes	<7	<7	Yes	Yes	Yes	<7	Yes	Yes	—
7	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	<7	Yes	Yes	—
8	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
9	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—

Table 4-38 Pass/Fail Criteria for 32-Channel, 8-Node ROADM Rings Using SMF Fiber (continued)

Span Loss (dB)	Amplifiers Installed	10 Gb/s				2.5 Gb/s					
		Class A	Class B	Class C	Class I	Class D	Class E	Class F	Class G	Class H	Class J
10	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
11	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
12	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
13	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
14	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—
15	OPT-PRE OPT-BST	Yes	<7	<7	Yes	Yes	Yes	Yes	Yes	Yes	—

Table 4-39 shows the pass/fail criteria for 16 ROADM nodes (15 spans) required for any-to-any node circuit reconfigurations.

- All nodes in the ring are ROADM.
- Span losses are equal.

Table 4-39 Pass/Fail Criteria for 32-Channel, 16-Node ROADM Rings Using SMF Fiber

Span Loss (dB)	Amplifiers Installed	10 Gbps				2.5 Gbps					
		Class A	Class B	Class C	Class I	Class D	Class E	Class F	Class G	Class H	Class J
1	OPT-PRE	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
2	OPT-PRE	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
3	OPT-PRE	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
4	OPT-PRE	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
5	OPT-PRE	<15[1]	<15[1]	<15[1]	Yes	Yes	<15	<15	<15	<15	—
6	OPT-PRE	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
7	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
8	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
9	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
10	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
11	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—

Table 4-39 Pass/Fail Criteria for 32-Channel, 16-Node ROADM Rings Using SMF Fiber (continued)

Span Loss (dB)	Amplifiers Installed	10 Gbps				2.5 Gbps					
		Class A	Class B	Class C	Class I	Class D	Class E	Class F	Class G	Class H	Class J
12	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
13	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
14	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—
15	OPT-PRE OPT-BST	<15[1]	<15[1]	<15[1]	Yes	Yes	<15[1]	<15[1]	<15[1]	<15[1]	—

1. Cisco MetroPlanner calculates the maximum ring circumference and number of nodes that can be supported.

Optical Performance for Single-Span Networks

Table 4-40 lists the span loss for a single-span link configuration with eight channels. The optical performance for this special configuration is given only for Classes A and C. This configuration assumes a maximum channel capacity of eight channels (8 dBm nominal channel power) used without any restrictions on the 32 available channels.

Table 4-40 Span Loss for Single-Span Link with Eight Channels

Node Config	Number of Spans	10 Gb/s			2.5 Gb/s			
		Class A	Class B	Class C	Class D	Class E	Class F	Class G
With OSCM	1	37 dB	—	37 dB	—	—	—	—
With OSC-CSM	1	35 dB	—	35 dB	—	—	—	—

Table 4-41 lists the span loss for a single-span link configuration with 16 channels. The optical performance for this special configuration is given only for Class A and Class C. This configuration assumes a maximum channel capacity of 16 channels (5 dBm nominal channel power) used without any restrictions on the 32 available channels.

Table 4-41 Span Loss for Single-Span Link with 16 Channels

Node Config	Number of Spans	10 Gb/s			2.5 Gb/s			
		Class A	Class B	Class C	Class D	Class E	Class F	Class G
With OSCM or OSC-CSM cards	1	35 dB	—	35 dB	—	—	—	—

Table 4-42 lists the span loss for a single-span link configuration with AD-1C-x.xx cards, OPTPRE amplifiers, and OPT-BST amplifiers. The single-span link with a flexible channel count is used both for transmitting and receiving. If dispersion compensation is required, a DCU can be used with an OPT-PRE amplifier. The optical performance for this special configuration is given for Classes A through G (8 dBm nominal channel power) used without any restrictions on the 32 available channels.

Table 4-42 Span Loss for Single-Span Link with AD-1C-xx.x Cards, OPT-PRE Amplifiers, and OPT-BST Amplifiers

Node Config	Number of Spans	10 Gb/s			2.5 Gb/s			
		Class A	Class B	Class C	Class D	Class E	Class F	Class G
With OSCM cards[1]	1	37 dB	31 dB	31 dB	37 dB	37 dB	37 dB	37 dB
Hybrid with OSC-CSM cards[2]	1	35 dB	31 dB	31 dB	35 dB	35 dB	35 dB	35 dB

1. OSCM sensitivity limits the performance to 37 dB.
2. OSC-CSM sensitivity limits the performance to 35 dB when it replaces the OSCM.

Table 4-43 lists the span loss for a single-span link configuration with one channel and OPT-BST amplifiers. The optical performance for this special configuration is given for Classes A through G. Classes A, B, and C use 8 dBm nominal channel power. Classes D, E, F, and G use 12 dBm nominal channel power. There are no restriction on the 32 available channels. That is, a line card, transponder, or muxponder wavelength can be extracted from the 32 available wavelengths. Also, the optical service channel is not required.

Table 4-43 Span Loss for Single-Span Link with One Channel and OPT-BST Amplifiers

Number of Spans	10 Gb/s			2.5 Gb/s			
	Class A	Class B	Class C	Class D	Class E	Class F	Class G
1	20 to 30 dB	17 to 26 dB	17 to 28 dB	Unprotected from 29 to 41 dB Protected from 25 to 41 dB	Unprotected from 28 to 37 dB Protected from 24 to 40 dB	Unprotected from 21 to 34 dB Protected from 18 to 34 dB	From 23 to 36 dB

Automatic Power Control

Each ONS 15454 DWDM node has an automatic power control (APC) feature that performs the following functions:

- Increases optical network resilience by keeping the per channel power constant for both expected and unexpected variations in the number of channels.
- Compensates for optical network degradation (aging effects).
- Simplifies the installation and upgrade of DWDM optical networks by automatically calculating amplifiers set-points.

Note These functions are performed by software algorithms performed on the OPT-BST, OPT-PRE, and the TCC2/TCC2P cards.

Amplifier software uses a control gain loop with fast transient suppression in order to keep the channel power constant regardless of any variation in the number of channels. Amplifiers monitor the input power variation and change the output power according to the calculated gain set point. Shelf controller software emulates the control output power loop to adjust for fiber degradation. To perform this function, the TCC2/TCC2P needs to know the channel distribution, which is provided by a signaling protocol, and the expected per channel power, which is provisioned by user. Using this method, the TCC2/TCC2P is able to compare the actual amplifier output power with the expected amplifier output power that is matched by modifying the set points if there are any discrepancies.

APC at the Amplifier

In constant gain mode, the amplifier power out control loop performs the following input and output power calculations, where G represents the gain and t represents time:

P_{out} (t) = G * P_{in} (t) (mW)

P_{out} (t) = G + P_{in} (t) (dB)

In a power equalized optical system the total input power is proportional to the number of channels. Amplifier software compensates for any variation of the input power as a variation in the number of channels carried by the incoming signal.

Amplifier software identifies changes in the read input power in two different instances, t1 and t2 as a change in the carried traffic. The letters m and n below represent two different channel numbers. Pin/ch represents the per channel input power as follows:

P_{in} (t1) = nP_{in}/ch

P_{in} (t2) = mP_{in}/ch

Amplifier software applies the variation in the input power to the output power with a reaction time that is a fraction of a millisecond. This keeps the power constant on each channel at the output amplifier, even during a channel upgrade or a fiber cut.

Amplifier parameters are configured using east and west conventions for ease of use. Selecting west provisions parameters for the preamplifier receiving from the west and the booster amplifier transmitting to the west. Selecting east provisions parameters for the preamplifiers receiving from the east and the booster amplifier transmitting to the east.

Starting from the expected per channel power, the amplifiers are automatically able to calculate the gain set-point when the first channel is provisioned. An amplifier gain set-point is calculated in order to make it equal to the loss of the span preceding the amplifier itself. Once the gain is calculated, the set point is no longer changed by the amplifier. Amplifier gain is recalculated every time the number of provisioned channels returns to zero. If you need to force a recalculation of the gain, move the number of channels back to zero.

APC at the Node

The amplifier calculates gain set points to compensate for span loss on the preceding node. Changing network conditions that affect span loss (aging fiber, aging components, or changes in operating conditions) makes the gain calculation invalid. The goal of APC at the node layer is to recalculate the gain to make it equal to the span loss.

APC corrects the gain or express variable optical attenuator (VOA) set points by calculating the difference between the power value read by the photodiodes and the expected power value calculated using the following parameters:

- Provisioned per channel power value
- Channel distribution (the number of express, add, and drop channels in the node)
- ASE estimation

Channel distribution is determined by the sum of provisioned and failed channels. Information about provisioned wavelengths is sent to APC on the applicable nodes during the circuit creation phase. Information about failed channels is collected through a signaling protocol that monitors alarms on ports in the applicable nodes and distributes that information to all the other nodes in the network.

ASE calculations purify the noise from the power level reported from the photodiode. Each amplifier can compensate for its own noise (SNR) but cascaded amplifiers cannot compensate for ASE generated by preceding nodes. The ASE effect increases when the number of channels decreases; therefore, a correction factor must be calculated in each amplifier of the ring to compensate for ASE build-up.

APC is a network-level feature. The APC algorithm designates a master node that is responsible for starting APC hourly or every time a new circuit is provisioned or removed. Every time the master node signals for APC to start, gain and VOA set points are evaluated on all nodes in the network. If corrections are needed in different nodes, they are always performed sequentially following the optical paths starting from the master node.

APC corrects the power level only if the variation exceeds the hysteresis thresholds of +/–0.5 dB. Any power level fluctuation within the threshold range is skipped since it is considered negligible. Since APC is designed to follow slow time events, APC skips corrections greater than 3 dB that is the total typical aging margin provisioned by the user during the network design phase. When the first channel is provisioned or amplifiers are turned up for the first time, APC does not apply the 3 dB rule. In this case APC corrects all the power differences to turn-up the node.

Note Software R4.6 and higher does not report corrections that are not performed and exceed the 3 dB correction factor to management interfaces (CTC, CTM, and TL1).

To avoid large power fluctuations, APC adjusts power levels incrementally. The maximum power correction applied each iteration is +/–0.5 dB until the optimal power level is reached. For example a gain deviation of 2 dB is corrected in four steps. Each of the four steps requires a complete APC check on every node in the network. APC can correct up to a maximum of 3 dB on an hourly basis. If degradation occurs in a longer time period, APC will compensate for it by using all margins provisioned by the user during installation.

When no margin is available adjustments cannot be made because set points exceed ranges and APC communicates the event to CTC, CTM, and TL1 through an APC Fail condition. APC will clear the APC fail condition when set-points return to the allowed ranges.

APC cannot be started or disabled by the user. APC automatically disables itself when:

- A HW FAIL alarm is raised by any card in any of the network nodes.
- An MEA (Mismatch Equipment Alarm) is raised by any card in any of the network nodes.
- An Improper Removal alarm is raised by any card in any of the network nodes.
- Gain Degrade, Power Degrade, and Power Fail Alarms are raised by the output port of any amplifier card in any of the network nodes.
- A VOA degrade or Fail alarm is raised by any of the cards in any of the network nodes.

The APC state (Enable/Disable) is located on every node and can be retrieved by the CTC or TL1 interface. If an event that disables APC occurs in one of the network nodes, APC will be disabled on all the others and the APC state changes to DISABLE - INTERNAL. The DISABLE state is raised only by the node where the problem occurred to simplify troubleshooting.

APC raises the following standing conditions at the port level in CTC, TL1, and SNMP:

APC Out of Range – APC cannot assign a new setpoint for a parameter this is allocated to a port because the new setpoint exceeds the parameter range.

APC Correction Skipped – APC skipped a correction to one parameter allocated to a port because the difference between the expected and current values exceeds the +/– 3 dB security range.

After the error condition is cleared, signaling protocol enables APC on the network and the APC DISABLE - INTERNAL condition is cleared. Because APC is required after channel provisioning to compensate for ASE effects, all optical channel network connection (OCHNC) circuits that you provision during the disabled APC state are kept in the Out-of-Service and Autonomous, Automatic In-Service (OOS-AU,AINS [ANSI]) or Unlocked-disabled,automaticInService (ETSI) service state until APC is enabled. OCHNCs automatically go into the In-Service and Normal (ISNR [ANSI]) or Unlocked-enabled (ETSI) service state only after APC is enabled.

Managing APC

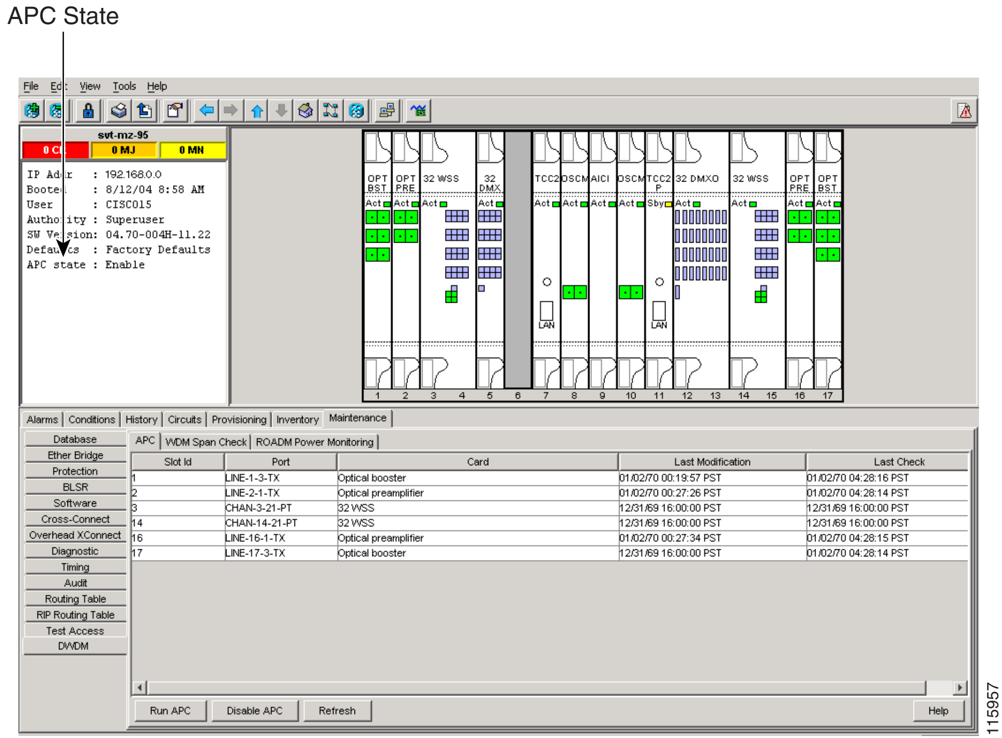
The automatic power control status is indicated by the following four APC states shown in the node view status area:

- Enable—APC is enabled.
- Disable – Internal—APC has been automatically disabled for an internal cause.
- Disable – User—APC was disabled manually by a user.
- Not Applicable—The node is provisioned to Metro Access or Not DWDM, which do not support APC.

You can view the automatic power control information and disable and enable APC manually on the Maintenance > DWDM > APC subtab shown in Figure 4-53.

Caution When APC is disabled, aging compensation is not applied and circuits cannot be activated. Do not disable APC unless it is required for specific maintenance or troubleshooting tasks. Always enable APC as soon as the tasks are completed.

Figure 4-53 Automatic Power Control



The APC subtab provides the following information:

- Slot ID—The ONS 15454 slot number for which APC information is shown.
- Port—The port number for which APC information is shown.
- Card—The card for which power control information is shown.
- Last Modification—Date and time APC last modified a setpoint for the parameters shown in Table 4-44.
- Last Check—Date and time APC last verified the setpoints for the parameters shown in Table 15-2.

Table 4-44 APC-Managed Parameters

Card	Port	Parameters
OPT-BST	LINE-3-TX	Gain Total Signal Output Power
OPT-PRE	LINE-1-TX	Gain Total Signal Output Power
AD-xB-xx.x	LINE-1-TX BAND-i-TX	VOA Target Attenuation
AD-1C-xx.x AD-2C-xx.x	LINE-1-TX	VOA Target Attenuation

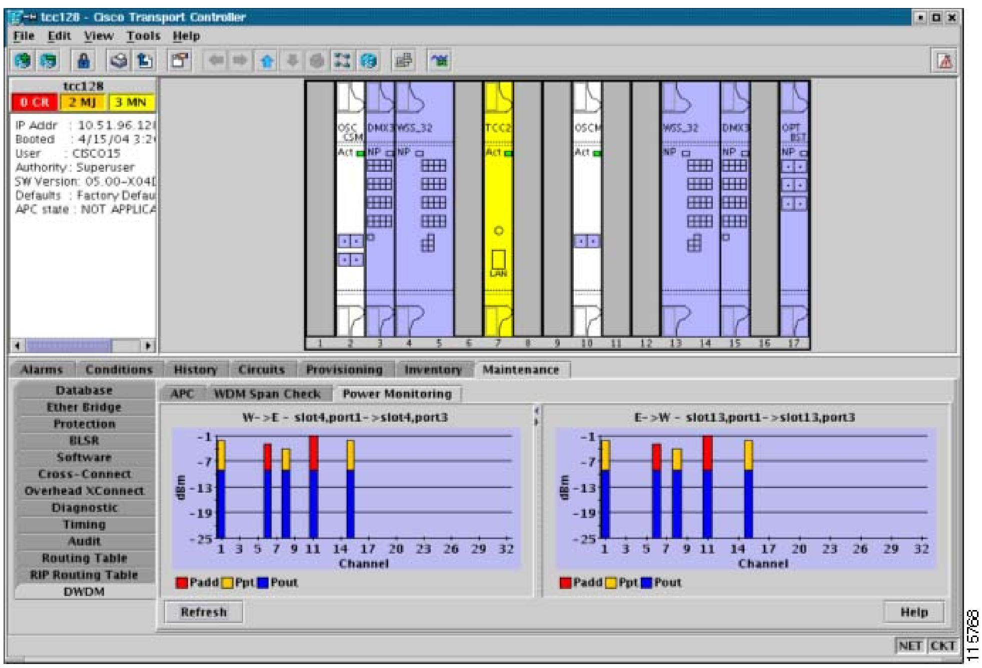
Table 4-44 APC-Managed Parameters (continued)

Card	Port	Parameters
AD-4C-xx.x	LINE-1-TX CHAN-i-TX	VOA Target Attenuation
32DMX	LINE-1-TX	VOA Target Attenuation

ROADM Power Equalization Monitoring

Reconfigurable OADM (ROADM) nodes allow you to monitor the 32WSS card equalization functions on the Maintenance > DWDM > Power Monitoring subtab as shown in Figure 4-54. The tab shows the input channel power (Padd), the express or pass-through (Ppt) power and the power level at output (Pout).

Figure 4-54 Power Monitoring Subtab



Span Loss Verification

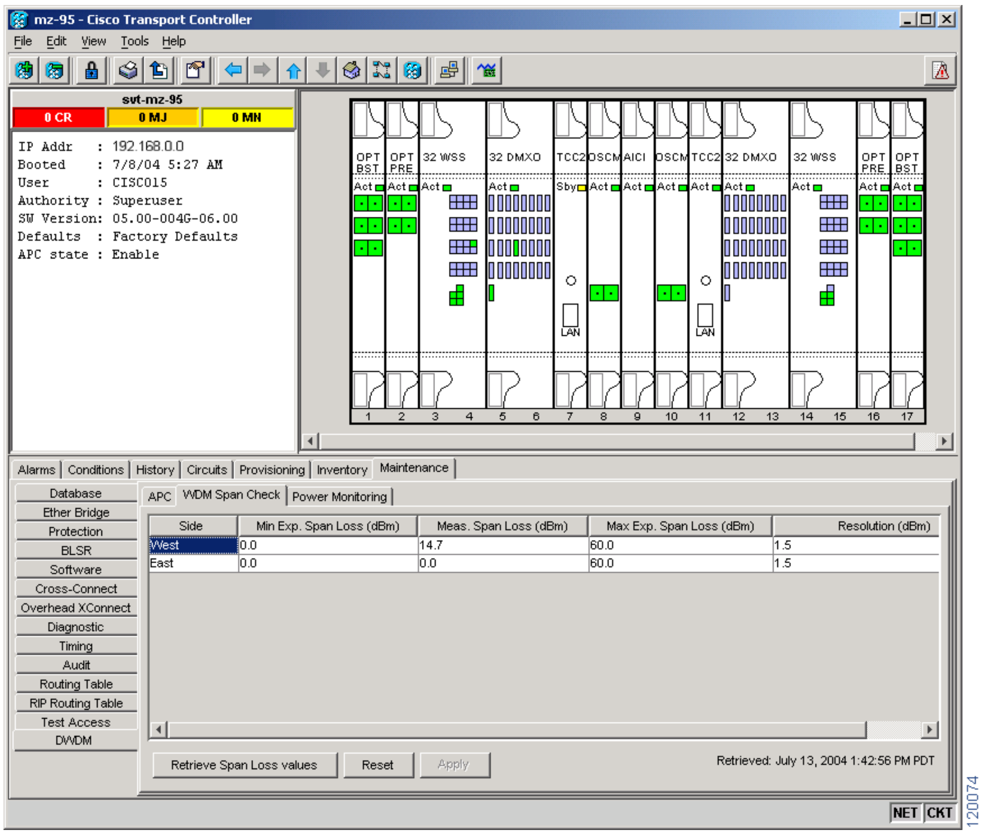
Span loss measurements can be performed from the Maintenance > DWDM > WDM Span Check subtab as shown in Figure 4-55. The CTC span check compares the far-end OSC power with the near-end OSC power. A “Span Loss Out of Range” condition is raised when the measured span loss is higher than the maximum expected span loss. It is also raised when the measured span loss is lower than the minimum expected span loss and the difference between the minimum and maximum span loss values is greater than 1 dB. The minimum and maximum expected span loss values are calculated by Cisco MetroPlanner for the network and imported into CTC. However, you can manually change the minimum and expected span loss values.

CTC span loss measurements provide a quick span loss check and are useful whenever changes to the network occur, for example after you install equipment or repair a broken fiber. CTC span loss measurement resolutions are:

- +/– 1.5 dB for measured span losses between 0 and 25 dB
- +/– 2.5 dB for measured span losses between 25 and 38 dB

For ONS 15454 span loss measurements with higher resolutions, an optical time domain reflectometer (OTDR) must be used.

Figure 4-55 Span Loss Verification



Automatic Node Setup

Automatic node setup (ANS) is a TCC2/TCC2P function that adjusts values of the VOAs on the DWDM channel paths to equalize the per-channel power at the amplifier input. This power equalization means that at launch, all the channels have the same amplifier power level, independent from the input signal on the client interface and independent from the path crossed by the signal inside the node. This equalization is needed for two reasons:

1. Every path introduces a different penalty on the signal that crosses it.
2. Client interfaces add their signal to the ONS 15454 DWDM ring with different power levels.

To support ANS, the integrated VOAs and photodiodes are provided in the following ONS 15454 DWDM cards:

- OADM band cards (AD-xB-xx.x) express and drop path
- OADM channel cards (AD-xC-xx.x) express and add path
- 4-Channel Terminal Multiplexer/Demultiplexer (4MD-xx.x) input port
- 32-Channel Terminal Multiplexer (32MUX-O) input port
- 32-Channel Wavelength Selective Switch (32WSS) input port
- 32-Channel Terminal Demultiplexer (32DMX-O and 32DMX) output port

Optical power is equalized by regulating the VOAs. Based on the expected per-channel power, ANS automatically calculates the VOA values by:

- Reconstructing the different channels paths
- Retrieving the path insertion loss (stored in each DWDM transmission element)

VOAs operate in one of three working modes:

- Automatic VOA Shutdown – In this mode, the VOA is set at maximum attenuation value. Automatic VOA shutdown mode is set when the channel is not provisioned to ensure system reliability in the event that power is accidentally inserted.
- Constant Attenuation Value – In this mode, the VOA is regulated to a constant attenuation independent from the value of the input signal. Constant attenuation value mode is set on the following VOAs:
  - OADM band card VOAs on express and drop paths (as operating mode)
  - OADM channel card VOAs during power insertion startup
  - The multiplexer/demultiplexer card VOAs during power insertion startup
  - AD-xC cards on EXP-TX ports
  - AD-4C cards on CHAN-TX ports
  - AD-xB cards on all port where a VOA is present
  - 32DMX cards on COM-RX
- Constant Power Value – In this mode, the VOA values are automatically regulated to keep a constant output power when changes occur to the input power signal. This working condition is set on OADM channel card VOAs as "operating" and on 32MUXO, 32WSS, 32DMX-O, and 32DMX card VOAs as "operating mode."

In the normal operating mode, OADM band card VOAs are set to a constant attenuation, while OADM channel card VOAs are set to a constant power. ANS requires the following VOA provisioning parameters to be specified:

- Target attenuation (OADM band card VOA and OADM channel card startup)
- Target power (channel VOA)

To allow you to modify ANS values based on your DWDM deployment, provisioning parameters are divided into two contributions:

- Reference Contribution (read only) – Set by ANS.
- Calibration Contribution (read and write) – Set by user.

The ANS equalization algorithm requires knowledge of the DWDM transmission element layout as follows:

- The order in which the DWDM elements are connected together on the express paths
- Channels that are dropped and added

- Channels or bands that have been configured as pass through

ANS assumes that every DWDM port has a line direction parameter that is either West to East (W-E) or East to West (E-W). ANS automatically configures the mandatory optical connections according to following main rules:

- Cards equipped in Slots 1 to 6 have a drop section facing west.
- Cards equipped in Slots 12 to 17 have a drop section facing east.
- Contiguous cards are cascaded on the express path.
- 4MD-xx.x and AD-xB-xx.x are always optically coupled.
- A 4MD-xx.x absence forces an optical pass-through connection.
- Transmit (Tx) ports are always connected to receive (Rx) ports.

Optical patch cords are passive devices that are not autodiscovered by ANS. However, optical patch cords are used to build the alarm correlation graph. ANS uses CTC and TL1 as the user interfaces to:

- Calculate the default connections on the NE.
- Retrieve the list of existing connections.
- Retrieve the list of free ports.
- Create new connections or modify existing ones.
- Launch ANS.

After you launch ANS, the following statuses are provided for each ANS parameter:

- Success – Changed – The parameter setpoint was recalculated successfully.
- Success – Unchanged – The parameter setpoint did not need recalculation.
- Not Applicable – The parameter setpoint does not apply to this node type.
- Fail - Out of Range – The calculated setpoint is outside the expected range.
- Fail - Port in IS State – The parameter could not be calculated because the port is in service.

Optical connections are identified by the two termination points, each with an assigned slot and port. ANS checks that a new connection is feasible (according to embedded connection rules) and returns a denied message in the case of a violation.

ANS requires provisioning of the expected wavelength. When provisioning the expected wavelength, the following rules apply:

- The card name is generically characterized by the card family, and not the particular wavelengths supported (for example, AD-2C for all 2-channel OADMs).
- At the provisioning layer, you can provision a generic card for a specific slot using CTC or TL1.
- Wavelength assignment is done at the port level.
- An equipment mismatch alarm is raised when a mismatch between the identified and provisioned value occurs. The default value for the provisioned attribute is AUTO.

Automatic Node Setup Parameters

All ONS 15454 ANS parameters are calculated by Cisco MetroPlanner for nodes configured for metro core networks. (Parameters must be configured manually for metro access nodes.) Cisco MetroPlanner exports the calculated parameters to an ASCII file called "NE Update." In CTC, you can import the NE Update file to automatically provision the node. Table 4-45 shows ANS parameters arranged in east and west, transmit and receive groups.

Table 4-45 ANS Parameters

Direction	ANS Parameters
West Side – Receive	• West Side Rx Min Expected Span Loss • West Side Rx Amplifier Working Mode • West Side Rx Amplifier Ch Power • West Side Rx Amplifier Gain • West Side Rx Amplifier Tilt • West Side OSC LOS Threshold • West Side Channel LOS Threshold • West Side Rx Amplifier Input Power Fail Th • West Side Add and Drop Stage Input Power • West Side Add and Drop Stage Drop Power • West Side Add and Drop Stage Band (i) Drop Power (i = 1 through 8) • West Side Add and Drop Stage Channel (i) Drop Power (i = 1 through 32)
East Side – Receive	• East Side Rx Max Expected Span Loss • East Side Rx Min Expected Span Loss • East Side Rx Amplifier Working Mode • East Side Rx Amplifier Ch Power • East Side Rx Amplifier Gain • East Side Rx Amplifier Tilt • East Side OSC LOS Threshold • East Side Channel LOS Threshold • East Side Rx Amplifier Input Power Fail Th • East Side Add and Drop Stage Input Power • East Side Add and Drop Stage Drop Power • East Side Add and Drop Stage Band (i) Drop Power (i = 1 through 8 • East Side Add and Drop Stage Channel (i) Drop Power (i = 1 through 32)

Table 4-45 ANS Parameters (continued)

Direction	ANS Parameters
West Side – Transmit	• West Side Tx Amplifier Working Mode • West Side Tx Amplifier Ch Power • West Side Tx Amplifier Gain • West Side Tx Amplifier Tilt • West Side Fiber Stage Input Threshold • West Side Add and Drop Stage Output Power • West Side Add and Drop Stage By-Pass Power
East Side - Transmit	• East Side Tx Amplifier Working Mode • East Side Tx Amplifier Ch Power • East Side Tx Amplifier Gain • East Side Tx Amplifier Tilt • East Side Fiber Stage Input Threshold • East Side Add and Drop Stage Output Power • East Side Add and Drop Stage By-Pass Power

Viewing and Provisioning ANS Parameters

All ANS parameters can be viewed and provisioned from the node view Provisioning > WDMANS > Provisioning subtab, shown in Figure 4-56. The WDM-ANS > Provisioning > Provisioning subtab presents the parameters in the following tree view:

- root
- +/– East
  - +/– Receiving
    - •+/– Amplifier
    - •+/– Power
    - •+/– Threshold
- +/– Transmitting
    - •+/– Amplifier
    - •+/– Power
    - •+/– Threshold
- +/– West
  - +/– Receiving
    - •+/– Amplifier
    - •+/– Power
    - •+/– Threshold
  - +/– Transmitting

- +/– Amplifier
- +/– Power
- +/– Threshold

Figure 4-56 WDM-ANS Provisioning

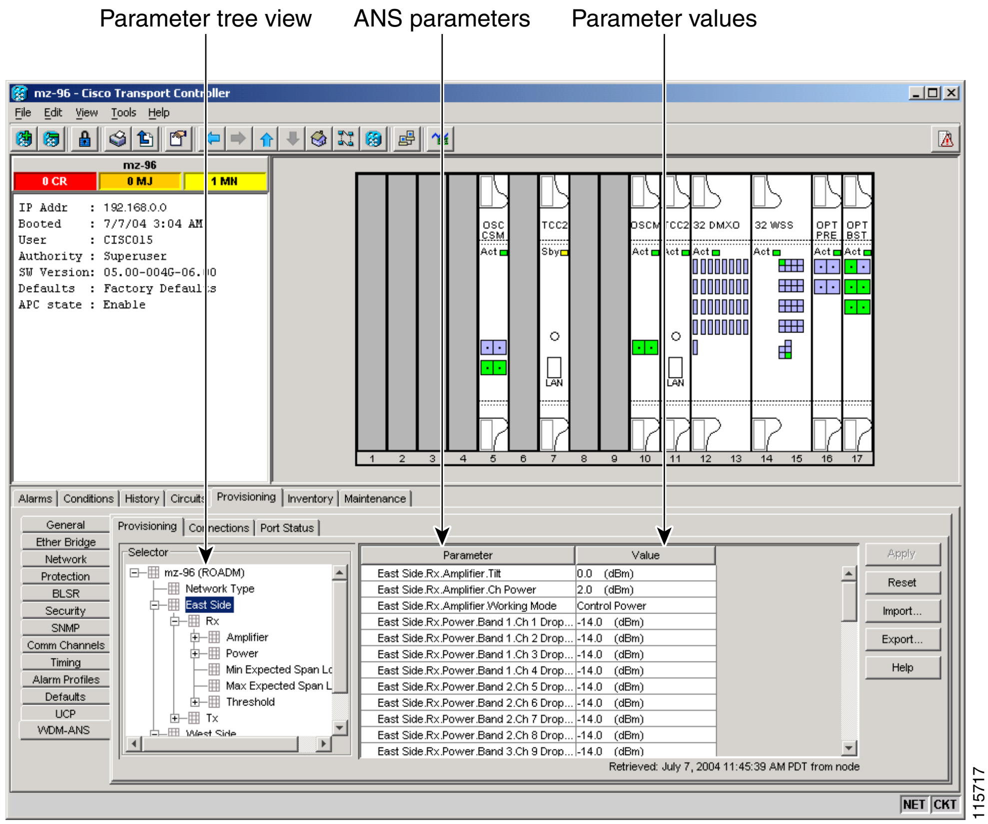


Table 4-46 ANS-WDM > Provisioning Subtab Parameters

Tree Element	Parameters
root	Network Type (dwdm)
root +/– East +/– Receiving	East Side Rx Max Expected Span Loss East Side Rx Min Expected Span Loss
root +/– East +/– Receiving +/– Amplifier	East Side Rx Amplifier Working Mode East Side Rx Amplifier Ch Power East Side Rx Amplifier Gain East Side Rx Amplifier Tilt
root +/– East +/– Receiving +/– Power	East Side Add and Drop Input Power East Side Add and Drop Drop Power East Side Band n Drop Power (n = 1-8) East Side Channel n Drop Power East (n = 1-32)

Table 4-46 ANS-WDM > Provisioning Subtab Parameters (continued)

Tree Element	Parameters
root +/– East +/– Receiving +/– Thresholds	East Side OSC LOS Threshold East Side Channel LOS Threshold East Side Rx Amplifier In Power Fail Threshold
root +/– East +/– Transmitting +/– Amplifier	East Side Tx Amplifier Working Mode East Side Tx Amplifier Ch Power East Side Tx Amplifier Gain East Side Tx Amplifier Tilt
root +/– East +/– Transmitting +/– Power	East Side Add and Drop Output Power East Side Add and Drop By-Pass Power
root +/– East +/– Transmitting +/– Thresholds	East Side Fiber Stage Input Threshold
root +/– West +/– Receiving	West Side Rx Max Expected Span Loss West Side Rx Min Expected Span Loss
root +/– West +/– Receiving +/– Amplifier	West Side Rx Amplifier Working Mode West Side Rx Amplifier Ch Power West Side Rx Amplifier Gain West Side Rx Amplifier Tilt
root +/– West +/– Receiving +/– Power	West Side Add and Drop Input Power West Side Add and Drop Drop Power West Side Band n Drop Power (n = 1-8) West Side Channel n Drop Power (n = 1-32)
root +/– West +/– Receiving +/– Thresholds	West Side OSC LOS Threshold West Side Channel LOS Threshold West Side Rx Amplifier In Power Fail Threshold
root +/– West +/– Transmitting +/– Amplifier	West Side Tx Amplifier Working Mode West Side Tx Amplifier Ch Power West Side Tx Amplifier Gain West Side Tx Amplifier Tilt
root +/– East +/– Transmitting +/– Power	West Side Add and Drop Output Power West Side Add and Drop By-Pass Power
root +/– West +/– Transmitting +/– Thresholds	West Side Fiber Stage Input Threshold

The ANS parameters that appear in the WDM-ANS > Provisioning subtab depend on the node type. Table 4-47 shows the DWDN node configurations and their ANS parameters.

Table 4-47 ANS Parameters By Node Configuration

Node Configuration	Parameter Group	Parameter
Hub	Network	Network Type
	Span Loss	East and West Expected Span Loss
	Amplifier Tx	East and West Side Transmit Amplifier Working Mode East and West Side Transmit Amplifier Channel Power East and West Side Transmit Amplifier Gain East and West Side Transmit Amplifier Tilt
	Amplifier Rx	East and West Side Receive Amplifier Working Mode East and West Side Receive Amplifier Channel Power East and West Side Receive Amplifier Gain East and West Side Receive Amplifier Tilt
	Thresholds Tx	East and West Side Fiber Stage Input Threshold
	Thresholds Rx	East and West Side Osc Los Threshold East and West Side Channel Los Threshold East and West Side Receive Amplifier Input Power Fail
	Power	East and West Side Add and Drop Input Power East and West Side Add and Drop Output Power East and West Side Add and Drop By-Pass Power East and West Side Channel (n) Drop Power
Terminal	Network	Network Type
	Span Loss	East and West Expected Span Loss
	Amplifier Tx	East and West Side Transmit Amplifier Working Mode East and West Side Transmit Amplifier Channel Power East and West Side Transmit Amplifier Gain East and West Side Transmit Amplifier Tilt
	Amplifier Rx	East and West Side Receive Amplifier Working Mode East and West Side Receive Amplifier Channel Power East and West Side Receive Amplifier Gain East and West Side Receive Amplifier Tilt
	Thresholds Tx	East and West Side Fiber Stage Input Threshold
	Thresholds Rx	East and West Side Osc Los Threshold East and West Side Channel Los Threshold East and West Side Receive Amplifier Input Power Fail
	Power	East and West Side Add and Drop Input Power East and West Side Add and Drop Output Power East or West Side Channel (n) Drop Power (n = 1-32)

Table 4-47 ANS Parameters By Node Configuration (continued)

Node Configuration	Parameter Group	Parameter
Flexible Channel Count Terminal	Network	Network Type
	Span Loss	East and West Expected Span Loss
	Amplifier Tx	East and West Side Transmit Amplifier Working Mode East and West Side Transmit Amplifier Channel Power East and West Side Transmit Amplifier Gain East and West Side Transmit Amplifier Tilt
	Amplifier Rx	East and West Side Receive Amplifier Working Mode East and West Side Receive Amplifier Channel Power East and West Side Receive Amplifier Gain East and West Side Receive Amplifier Tilt
	Thresholds Tx	East and West Side Fiber Stage Input Threshold
	Thresholds Rx	East and West Side Osc Los Threshold East and West Side Channel Los Threshold East and West Side Receive Amplifier Input Power Fail
	Power	East and West Side Add and Drop Input Power East and West Side Add and Drop Output Power East or West Side Channel (n) Drop Power (n = 1-8)
OADM	Network	Network Type
	Span Loss	East and West Expected Span Loss
	Amplifier Tx	East and West Side Transmit Amplifier Working Mode East and West Side Transmit Amplifier Channel Power East and West Side Transmit Amplifier Gain East and West Side Transmit Amplifier Tilt
	Amplifier Rx	East and West Side Receive Amplifier Working Mode East and West Side Receive Amplifier Channel Power East and West Side Receive Amplifier Gain East and West Side Receive Amplifier Tilt
	Thresholds Tx	East and West Side Fiber Stage Input Threshold
	Thresholds Rx	East and West Side Osc Los Threshold East and West Side Channel Los Threshold East and West Side Receive Amplifier Input Power Fail
	Power	East and West Side Add and Drop Input Power East and West Side Add and Drop Output Power East or West Side Channel (n) Drop Power (n = 1-8)

Table 4-47 ANS Parameters By Node Configuration (continued)

Node Configuration	Parameter Group	Parameter
Line Amplifier	Network	Network Type
	Span Loss	East and West Expected Span Loss
	Amplifier Tx	East and West Side Transmit Amplifier Working Mode East and West Side Transmit Amplifier Channel Power East and West Side Transmit Amplifier Gain East and West Side Transmit Amplifier Tilt
	Amplifier Rx	East and West Side Receive Amplifier Working Mode East and West Side Receive Amplifier Channel Power East and West Side Receive Amplifier Gain East and West Side Receive Amplifier Tilt
	Thresholds Tx	East and West Side Fiber Stage Input Threshold
	Thresholds Rx	East and West Side Osc Los Threshold East and West Side Channel Los Threshold East and West Side Receive Amplifier Input Power Fail
ROADM	Network	Network Type
	Span Loss	East and West Expected Span Loss
	Amplifier Tx	East and West Side Transmit Amplifier Working Mode East and West Side Transmit Amplifier Channel Power East and West Side Transmit Amplifier Gain East and West Side Transmit Amplifier Tilt
	Amplifier Rx	East and West Side Receive Amplifier Working Mode East and West Side Receive Amplifier Channel Power East and West Side Receive Amplifier Gain East and West Side Receive Amplifier Tilt
	Thresholds Tx	East and West Side Fiber Stage Input Threshold
	Thresholds Rx	East and West Side Osc Los Threshold East and West Side Channel Los Threshold East and West Side Receive Amplifier Input Power Fail
	Power	East and West Side Add and Drop Input Power (if 32DMX East/West is installed) East and West Side Add and Drop Output Power East and West Side Add and Drop Drop Power (if 32DMX East/West is installed) East and West Side Channel (n) Drop Power (if 32DMXO East/West is installed)

Table 4-48 shows the following information for all ONS 15454 ANS parameters:

- Min – Minimum value in decibels.
- Max – Maximum value in decibels.
- Def – Default value in decibels. Other defaults include MC (metro core), CG (control gain), U (unknown).
- Group – Group(s) to which the parameter belongs: ES (east side), WS (west side), Rx (receive), Tx (transmit), Amp (amplifier), P (power), DB (drop band), DC (drop channel), A (attenuation), Th (threshold).
- Network Type – Parameter network type: MC (metro core), MA (metro access), ND (not DWDM)
- Optical Type – Parameter optical type: TS (32 channel terminal), FC (flexible channel count terminal), O (OADM), H (hub), LS (line amplifier), R (ROADM), U (unknown)

Table 4-48 ANS Parameters Summary

Name	Min	Max	Default	Group	Network Type	Optical Type
Network Type	—	—	MC	Root	MC, MA, ND	U, TS, FC, O, H, LS, R
West Side Rx Max Expected Span Loss	0	60	60	WS, Rx	MC, MA	TS, FC, O, H, LS, R
East Side Rx Max Expected Span Loss	0	60	60	ES, Rx	MC, MA	TS, FC, O, H, LS, R
West Side Rx Min Expected Span Loss	0	60	60	WS, Rx	MC, MA	TS, FC, O, H, LS, R
East Side Rx Min Expected Span Loss	0	60	60	ES, Rx	MC, MA	TS, FC, O, H, LS, R
West Side Tx Amplifier Working Mode	0	—	CG	WS, Tx, Amp	MC, MA, ND	TS, FC, O, H, LS, R
East Side Tx Amplifier Working Mode	0	—	CG	ES, Rx	MC, MA	TS, FC, O, H, LS, R
West Side Rx Amplifier Working Mode	0	—	CG	WS, Tx, Amp	MC, MA, ND	TS, FC, O, H, LS, R
East Side Rx Amplifier Working Mode	0	—	CG	ES, Rx	MC, MA	TS, FC, O, H, LS, R
West Side Tx Amplifier Ch Power	–10	17	2	WS, Tx, Amp	MC, MA, ND	TS, FC, O, H, LS, R
East Side Tx Amplifier Ch Power	–10	17	2	WS, Tx, Amp	MC, MA, ND	TS, FC, O, H, LS, R
West Side Rx Amplifier Ch Power	–10	17	2	WS, Tx, Amp	MC, MA, ND	TS, FC, O, H, LS, R
East Side Rx Amplifier Ch Power	–10	17	2	WS, Tx, Amp	MC, MA, ND	TS, FC, O, H, LS, R
West Side Tx Amplifier Gain	0	30	0	WS, Tx, Amp	MA	TS, FC, O, H, LS, R
East Side Tx Amplifier Gain	0	30	0	WS, Tx, Amp	MA	TS, FC, O, H, LS, R

Table 4-48 ANS Parameters Summary (continued)

Name	Min	Max	Default	Group	Network Type	Optical Type
West Side Rx Amplifier Gain	0	30	0	WS, Tx, Amp	MA	TS, FC, O, H, LS, R
East Side Rx Amplifier Gain	0	30	0	WS, Tx, Amp	MA	TS, FC, O, H, LS, R
West Side Tx Amplifier Tilt	0	30	0	WS, Tx, Amp	MC, MA	TS, FC, O, H, LS, R
East Side Tx Amplifier Tilt	0	30	0	WS, Tx, Amp	MC, MA	TS, FC, O, H, LS, R
West Side Rx Amplifier Tilt	0	30	0	WS, Rx, Amp	MC, MA	TS, FC, O, H, LS, R
East Side Rx Amplifier Tilt	0	30	0	WS, Rx, Amp	MC, MA	TS, FC, O, H, LS, R
West Side OSC LOS Threshold	–50	30	U	WS, Rx, Th	MC, MA	TS, FC, O, H, LS, R
East Side OSC LOS Threshold	–50	30	U	WS, Rx, Th	MC, MA	TS, FC, O, H, LS, R
West Side Channel LOS Threshold	–50	30	U	WS, Rx, Th	MC, MA	TS, FC, O, H, LS, R
East Side Channel LOS Threshold	–50	30	U	ES, Rx, Th	MC, MA, ND	TS, FC, O, H, LS, R
West Side Fiber State Input Threshold	–50	30	U	WS, Tx, Th	MC, MA, ND	TS, FC, O, H, LS, R
East Side Fiber State Input Threshold	–50	30	U	ES, Tx, Th	MC, MA, ND	TS, FC, O, H, LS, R
West Side Add and Drop Output Power	–50	30	–14	WS, Tx, P	MC	TS, FC, O, H, R
East Side Add and Drop Output Power	–50	30	–14	ES, Tx, P	MC	TS, FC, O, H, R
West Side Add and Drop Input Power	–50	30	–14	WS, Tx, P	MC	TS, FC, O, H, R
East Side Add and Drop Input Power	–50	30	–14	ES, Tx, P	MC	TS, FC, O, H, R
West Side Add and Drop By-Pass Power	–50	30	–14	WS, Tx, P	MC	H
East Side Add and Drop By-Pass Power	–50	30	–14	ES, Tx, P	MC	H
West Side Add and Drop Drop Power	–50	30	–14	WS, Tx, P	MC	R
East Side Add and Drop Drop Power	–50	30	–14	ES, Tx, P	MC	R
West Side Band 1...8 Drop Power	–50	30	–14	WS, Rx, P, DB	MC	FC, O

Table 4-48 ANS Parameters Summary (continued)

Name	Min	Max	Default	Group	Network Type	Optical Type
East Side Band 1...8 Drop Power	–50	30	–14	ES, Rx, P, DB	MC	FC, O
West Side Channel 1...32 Drop Power	–50	30	–14	WS, Rx, P, DC, B1	MC, MA	TS, H, R
East Side Channel 1...32 Drop Power	–50	30	–14	ES, Rx, P, DC, B1	MC, MA	TS, H, R

CHAPTER 5

Ethernet Features and Functions

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.

This chapter describes the Ethernet features and functions 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 you to over-subscribe and efficiently pack your networks with data services, while also maintaining the flexibility to offer dedicated Ethernet Private Line (EPL) and Ethernet Private Ring (EPR) services. With ML-Series cards, efficient Ethernet transport and TDM can coexist on same card, thus enabling low cost interconnectivity for hubs and routers.

The following topics are covered in this chapter:

E-Series Overview

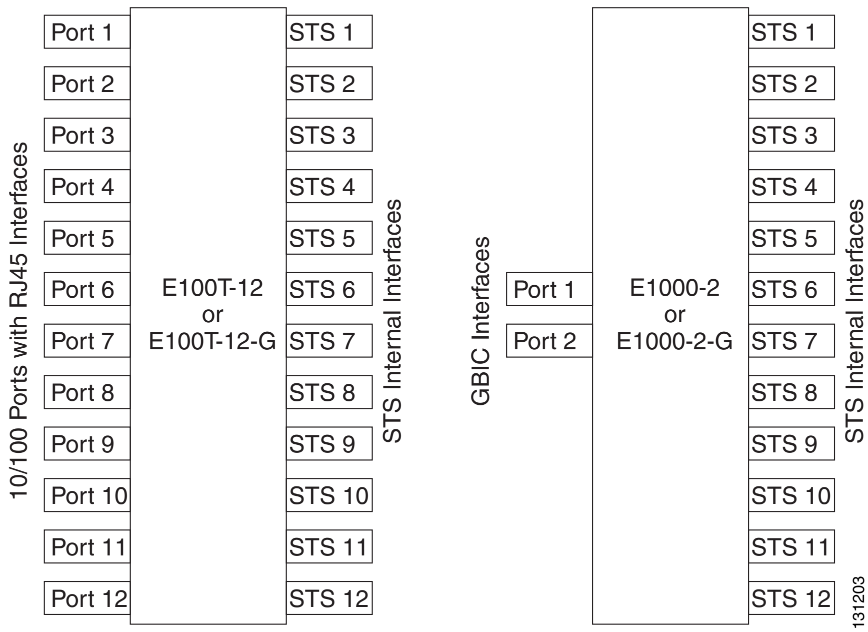
The E-Series cards incorporate layer 2 switching, while the CE- and G-series cards are layer 1 mapper cards. The ONS 15454 E-Series include the following Ethernet cards:

- 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. Each E100T-12 and E100T-G 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 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 (E100T-G or E1000-2-G) of the E-Series Ethernet cards.

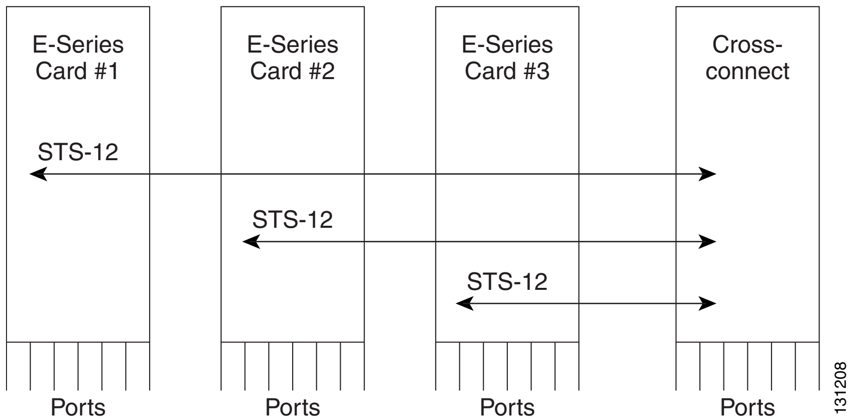
E-Series cards support VLAN, IEEE 802.1Q, spanning tree, and IEEE 802.1D. These cards conform to the general specifications of RFC 1619, but uses Cisco's proprietary HDLC encapsulation protocol. HDLC encapsulation adds 5 overhead bytes to the payload (1 byte = flag, 1 byte = address, 1 byte = control, 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 operates in one of three modes: single-card EtherSwitch, multi-card EtherSwitch group, or 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 inTable 5-1.

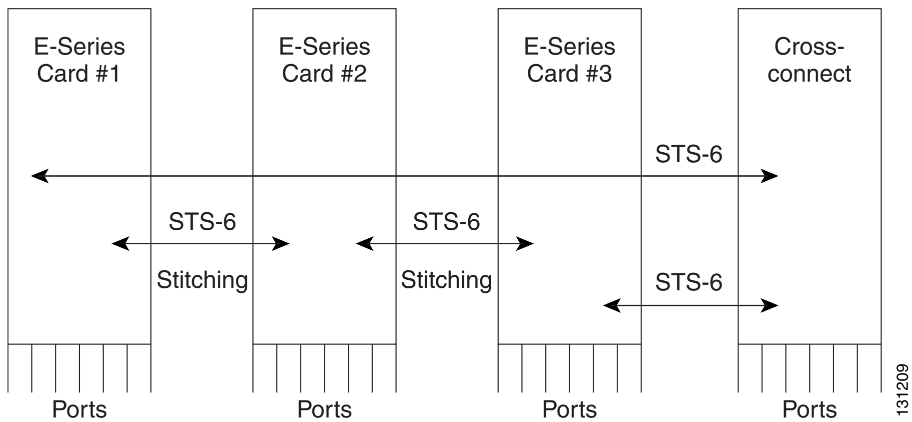
Table 5-1 EtherSwitch Circuit Combinations

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

E-Series Multicard EtherSwitch Group

Multicard 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 multicard EtherSwitch group can co-exist with multiple single-card EtherSwitches in the same node. Multicard EtherSwitch group mode is required when provisioning shared packet ring circuits, but it can also be used for point-to-point circuits.

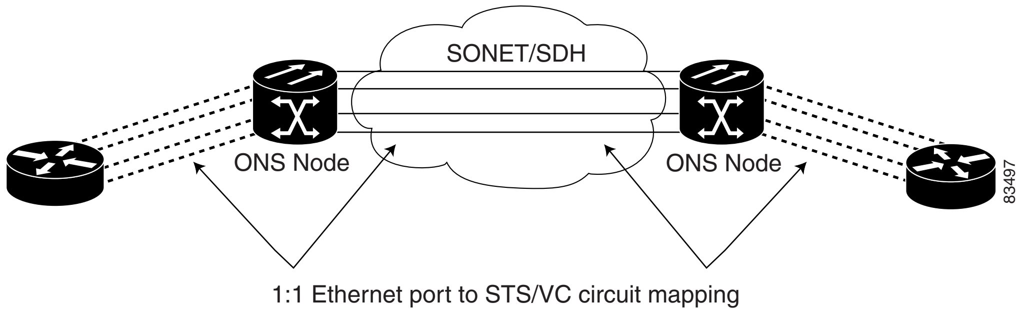
Figure 5-3 Multi-card EtherSwitch Group Operation



E-Series Port-Mapped (Linear Mapper)

System Release 4.0 introduced the E-Series port-mapped mode, also referred to as linear mapper. Port-mapped mode configures the E-Series card to map a specific E-Series Ethernet port to one of the card's specific STS circuits (see Figure 5-4). Port-mapped mode ensures that Layer 1 transport has low latency for unicast, multicast, and mixed traffic. Ethernet and Fast Ethernet on the E100T-G or E10/100-4 card (ONS 15327) operate at line-rate speed. Gigabit Ethernet transport is limited to a maximum of 600 Mb/s because the E1000-2-G card has a maximum bandwidth of STS-12c. Ethernet frame sizes up to 1522 bytes are also supported, which allow transport of IEEE 802.1Q tagged frames. The larger maximum frame size of Q-in-Q frames (IEEE 802.1Q in IEEE 802.1Q wrapped frames) is not supported.

Figure 5-4 E-Series Mapping Ethernet Ports to STS/VC Circuits



Port-mapped mode disables Layer 2 functions supported by the E-Series in single-card and multicard mode, including STP, VLANs, and MAC address learning. It significantly reduces the service-affecting time for cross-connect and TCC card switches.

Port-mapped mode does not support VLANs in the same manner as multicard and single-card mode. The ports of E-Series cards in multicard and single-card mode can join specific VLANs. E-Series cards in port-mapped mode do not have this Layer 2 capability and only transparently transport external VLANs over the mapped connection between ports. An E-Series card in port-mapped mode does not inspect the tag of the transported VLAN, so a VLAN range of 1 through 4096 can be transported in port-mapped mode.

Port-mapped mode does not perform any inspection or validation of the Ethernet frame header. The Ethernet CRC is validated, and any frame with an invalid Ethernet CRC is discarded.

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, 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.

Port-mapped mode also allows the creation of STS circuits between any two E-Series cards, including the E100T-G, E1000-2-G, and the E10/100-4 card on the ONS 15327. Port-mapped mode does not allow ONS 15454 E-Series cards to connect to the ML-Series or G-Series cards, but does allow an ONS 15327 E10/100-4 card provisioned with LEX encapsulation to connect to the ML-Series card.

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 TCC or cross-connect card protection 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 5-5 Multicard EtherSwitch Point-to-Point Circuit

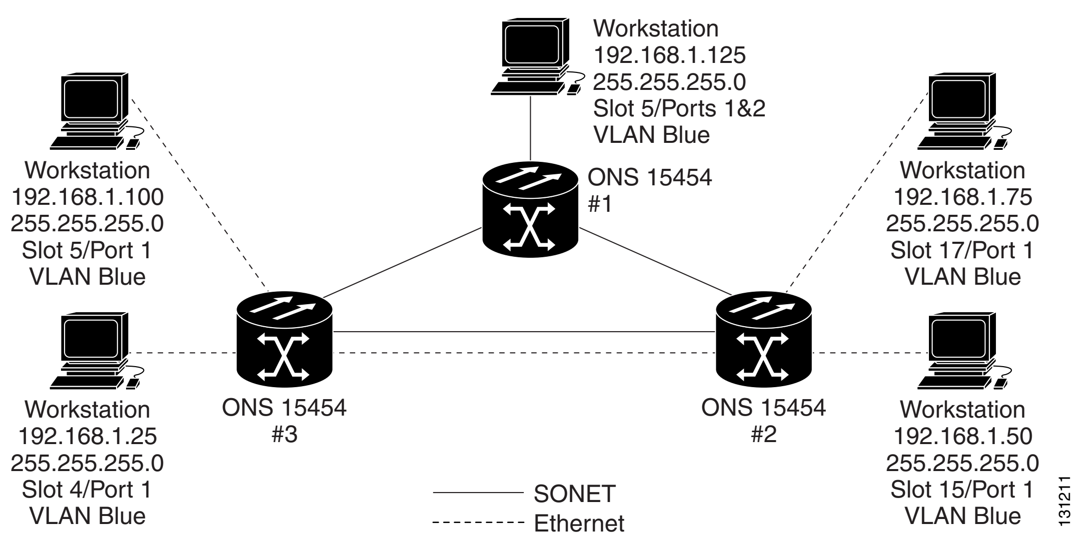


Figure 5-6 Single-card EtherSwitch Point-to-Point Circuit

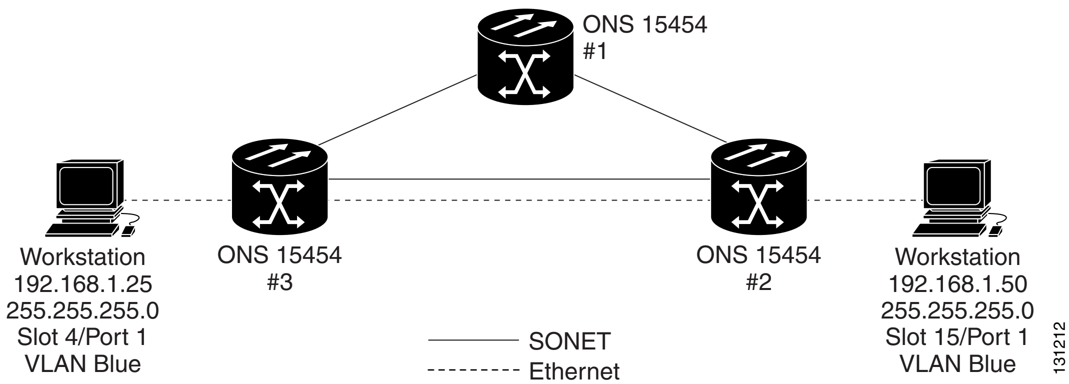
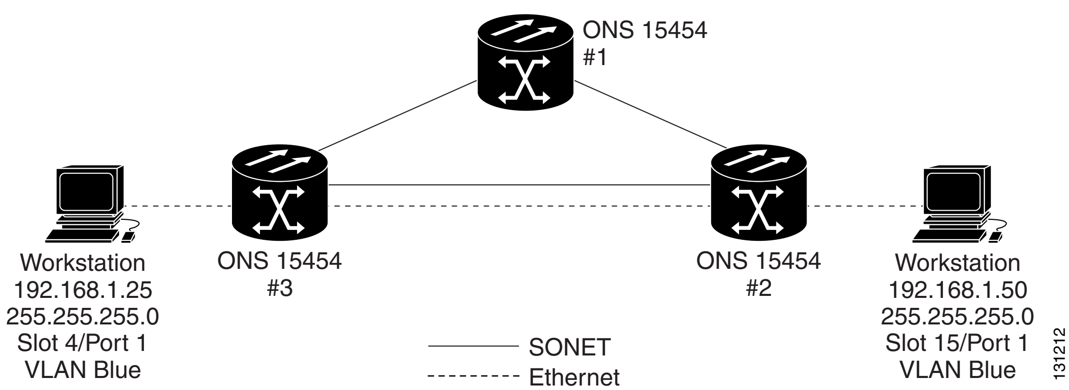


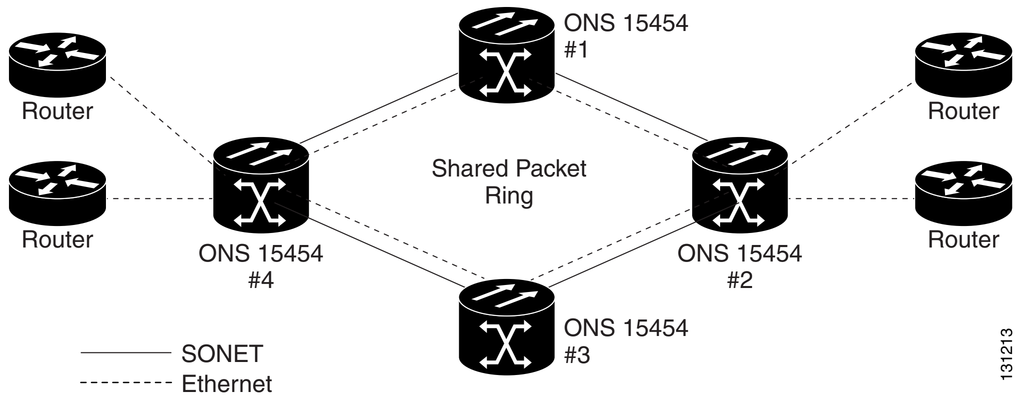
Figure 5-7 Port-mapped Point-to-Point Circuit



E-Series Shared Packet Ring Ethernet Circuits

A shared packet ring allows additional nodes (besides the source and destination nodes) access to an Ethernet STS circuit. The E-Series card ports on the additional nodes can share the circuit's VLAN and bandwidth. Figure 5-8 illustrates a shared packet ring.

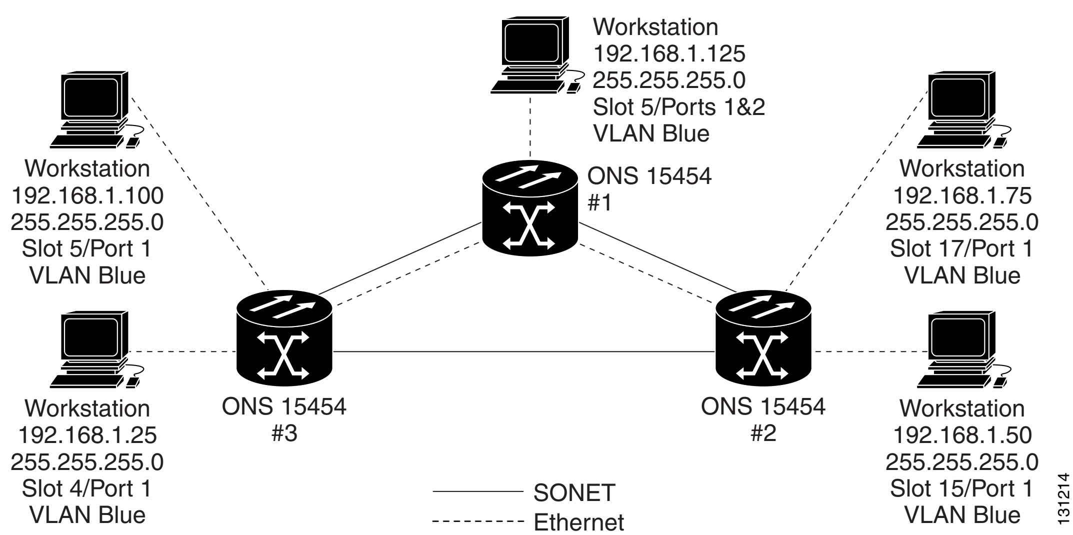
Figure 5-8 Shared Packet Ring Ethernet Circuit



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 5-9 illustrates a sample hub-and- spoke ring.

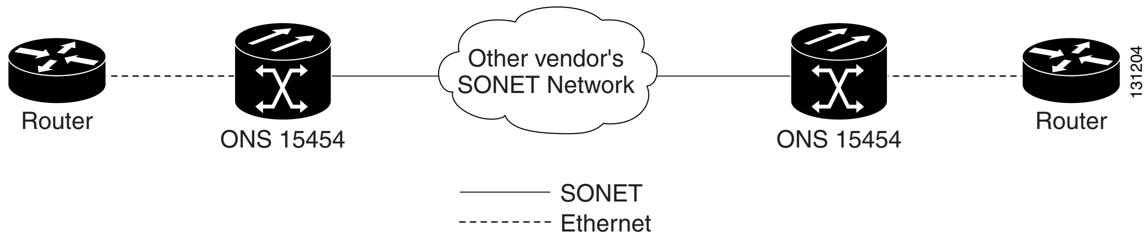
Figure 5-9 Hub and Spoke Ethernet Circuit



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, as shown in Figure 5-10, 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 5-10 Ethernet Manual Cross-Connects



Available Circuit Sizes For E-Series Modes

Table 5-2 shows the circuit sizes available for E-Series modes on the ONS 15454.

Table 5-2 ONS 15454 E-Series Ethernet Circuit Sizes

E-Series Mode	Available Circuit Sizes
Port-Mapped and Single-Card EtherSwitch	STS-1
	STS-3c
	STS-6c
	STS-12c
Multicard EtherSwitch	STS-1
	STS3c
	STS-6c

Total Bandwidth Available For E-Series Modes

Table 5-3 shows the total bandwidth available for E-Series modes on the ONS 15454.

Table 5-3 E-Series Total Bandwidth Available

E-Series Mode	Combined Total Bandwidth
Port-Mapped and Single-Card EtherSwitch	STS-12c
Multicard EtherSwitch	STS-6c

E-Series Circuit Protection

Different combinations of E-Series circuit configurations and SONET network topologies offer different levels of E-Series circuit protection. Table 5-4 details the available protection.

Table 5-4 Protection for E-Series Circuit Configurations

Configuration	Path protection	BLSR	1+1
Point-to-point multicard EtherSwitch	None	SONET	SONET
Point-to-point single-card EtherSwitch	SONET	SONET	SONET
Point-to-point port-mapped mode	SONET	SONET	SONET
Shared packet ring multicard EtherSwitch	STP		
Common control card switch	STP	STP	STP

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 does not increment). 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 802.3z Flow Control

The E100T-G or E10/100-4 (operating in any mode) and the E1000-2-G (operating port-mapped mode) support IEEE 802.3z symmetrical flow control and propose symmetric flow control when autonegotiating with attached Ethernet devices. For flow control to operate, both the E-Series port and the attached Ethernet device must be set to autonegotiation (AUTO) mode. The attached Ethernet device might also need to have flow control enabled. The flow-control mechanism allows the E-Series to respond to pause frames sent from external devices and send pause frames to external devices.

For the E100T-G or E10/100-4 (operating in any mode) and the E1000-2-G (operating port- mapped mode), flow control matches the sending and receiving device throughput to that of the bandwidth of the STS circuit. For example, a router might transmit to the Gigabit Ethernet port on the E-Series in port-mapped mode. The data rate transmitted by the router might occasionally exceed 622 Mbps, but the ONS 15454 circuit assigned to the E-Series port in port-mapped mode is a maximum of STS-12c (622.08 Mbps). In this scenario, the ONS 15454 sends out a pause frame and requests that the router delay its transmission for a certain period of time.

IEEE 802.3z flow control and frame buffering to reduces 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 802.3z 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 802.3z "pause frames" connected to 802.3z compliant stations. E-Series Ethernet cards will not issue 802.3z "pause frames" to end stations.

Note To enable flow control between an E-Series in port-mapped mode and a SmartBits test set, manually set Bit 5 of the MII register to 0 on the SmartBits test set. To enable flow control between an E-Series in port-mapped mode and an Ixia test set, select Enable the Flow Control in the Properties menu of the attached Ixia port.

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:

Table 5-5 Average Latency

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

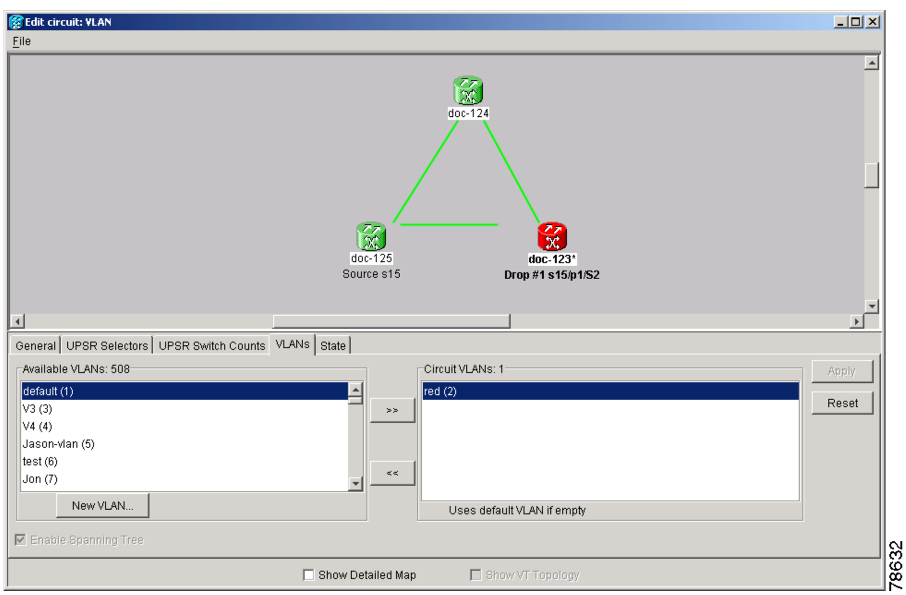
You can provision up to 509 VLANs. Specific sets of ports define the broadcast domain for the ONS 15454. The definition of VLAN ports includes all Ethernet and packet-switched SONET port types. All VLAN IP address discovery, flooding, and forwarding is limited to these ports.

The IEEE 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.

Note Port-mapped mode does not support VLANs.

The number of VLANs used by circuits and the total number of VLANs available for use appears in CTC on the VLAN counter as shown in Figure 5-11.

Figure 5-11 Edit Circuit Dialog Box Listing Available VLANs



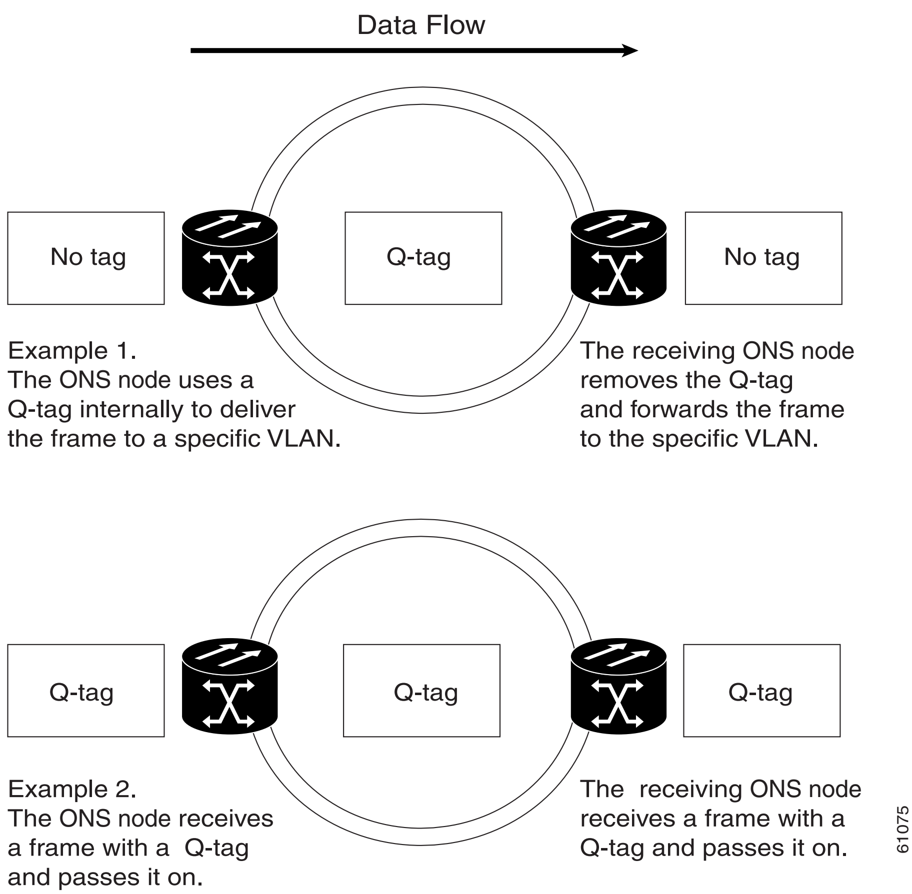
E-Series Q-Tagging (IEEE 802.1Q)

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 5-12 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 inFigure 5-12 illustrates the handling of packets that both enter and exit the ONS 15454 network with a Q-tag.

Figure 5-12 Q-tag Moving Through a VLAN



E-Series Priority Queuing (IEEE 802.1Q)

Note IEEE 802.1Q was formerly IEEE 802.1P.

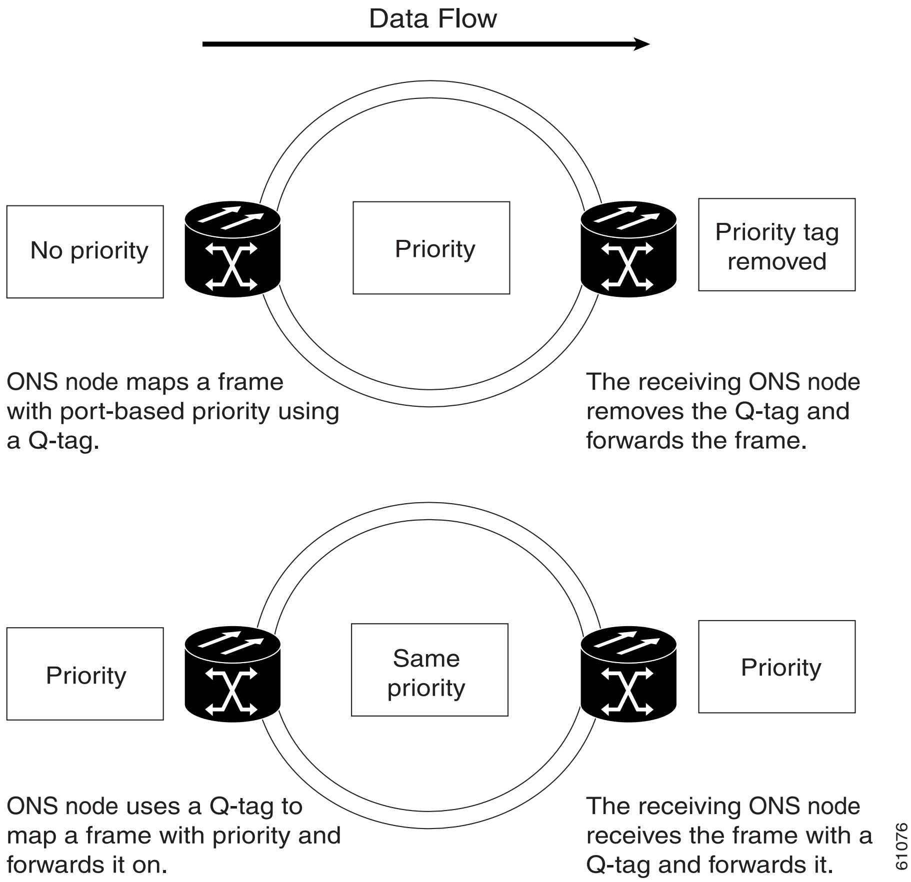
Networks without priority queuing handle all packets on a first-in-first-out basis. Priority queuing reduces the impact of network congestion by mapping Ethernet traffic to different priority levels. The ONS 15454 supports priority queuing. The ONS 15454 takes the eight priorities specified in IEEE 802.1Q and maps them to two queues shown in Table 5-6. Q-tags carry priority queuing information through the network.

Table 5-6 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 5-13 illustrates the priority queuing process.

Figure 5-13 Priority Queuing Process



E-Series Spanning Tree (IEEE 802.1D)

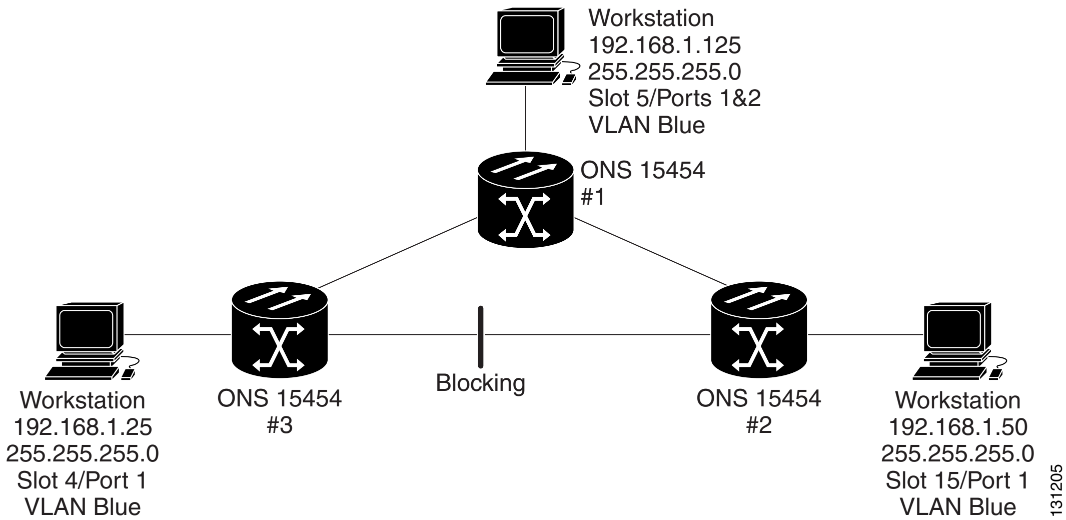
The Cisco ONS 15454 operates spanning tree protocol (STP) according to IEEE 802.1D when an E-Series Ethernet card is installed. The spanning tree algorithm places each Ethernet port into either a forwarding state or blocking state. All the ports in the forwarding state are considered to be in the current 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 5-14. The single path eliminates possible bridge loops. This is crucial for shared packet rings, which naturally include a loop.

Figure 5-14 ONS 15454 Network with STP



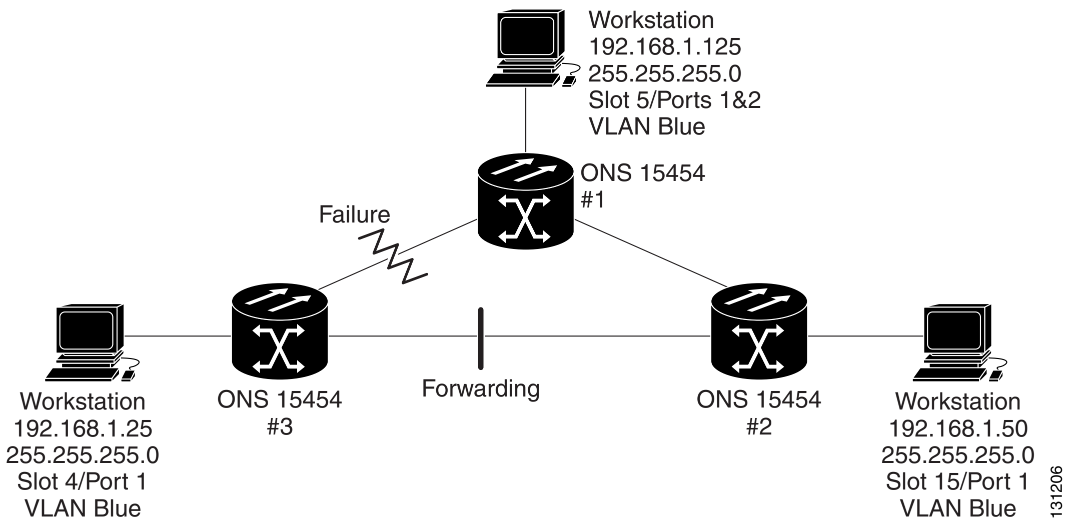
Now when the Workstation connected to ONS 15454 #1 sends a frame to the Workstation connected to ONS 15454 #3, the frame does not loop. ONS 15454 #1 sends a copy to ONS 15454 #3, but ONS 15454 #3 cannot forward it to ONS 15454 #2 out its Ethernet port because it is blocking.

To remove loops, STP defines a tree that spans all the switches in an extended network. STP forces certain redundant data paths into a standby (blocked) state. If one network segment in the STP becomes unreachable, the STP algorithm reconfigures the STP topology and reactivates the blocked path to reestablish the link. STP operation is transparent to end stations, which do not discriminate between connections to a single LAN segment or to a switched LAN with multiple segments.

The ONS 15454 supports one STP instance per circuit and a maximum of eight STP instances per ONS node.

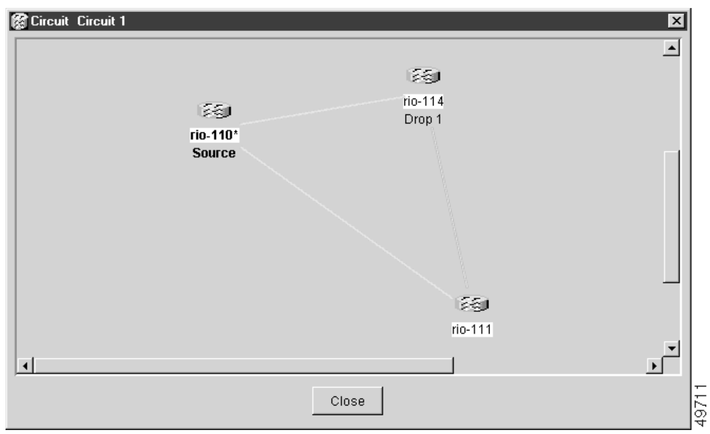
If the link between ONS 15454 #1 and ONS 15454 #3 fails, STP would reconverge so that ONS 15454 #3 would no longer block. For example, in Figure 5-15, that link has failed and STP has changed. Typically STP takes about 30-50 seconds to reconverge. However, since the ONS 15454 has SONET protection, the 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.

Figure 5-15 ONS 15454 Network with STP After Link Failure



The Circuit window shows forwarding spans and blocked spans on the spanning tree map (Figure 5-16).

Figure 5-16 Spanning Tree Map on Circuit Window



Note Green represents forwarding spans and purple represents blocked (protect) spans. If you have a packet ring configuration, at least one span should be purple.

Caution Multiple circuits with STP protection enabled will incur blocking if the circuits traverse a common card and use the same VLAN.

Note E-Series port-mapped mode does not support STP (IEEE 802.1D).

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 5-7 are appropriate for most situations, but can be modified as required.

Table 5-7 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

Table 5-7 Spanning Tree Parameters (continued)

Parameter	Description	Default	Range
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	10	0–65535 seconds
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 5-8 lists the maximum Bit rate by circuit size.

Table 5-8 maxRate for STS Circuits

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

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 bidirectional) per port up to 2.5 Gb/s (5 Gb/s bidirectional) per card. The ONS 15454 G-Series include the following Ethernet cards:

- G1000-4
- G1K-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 (GE) circuits can be protected using SONET switching, path protection, 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 GE circuits can also be operated over unprotected OC-N spans.

The G1K-4 card is a high density GE card. It provides four GBIC interfaces, and supports ethernet frames up to 10,000 bytes. The G1K-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 G1K-4 and G1000-4 cards can be installed in any multipurpose I/O slot when interoperating with the XC-10G cross-connect card. These constraints do not apply to a G-Series card configured for Gigabit Ethernet Transponder Mode. The G1K-4 card is backward compatible to System Release 3.2 software.

Software R4.0 and later identifies G1K-4 cards at physical installation. Software R3.4 and earlier identifies both G1000-4 and G1K-4 cards as G1000-4 cards at physical installation.

The following GBIC modules are available as separate orderable products:

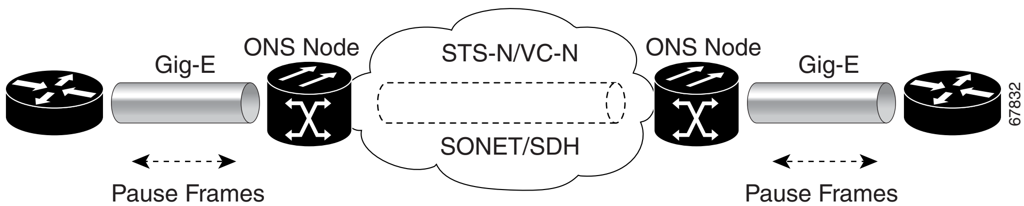
- IEEE 1000Base-SX compliant 850nm optical module
- IEEE 1000Base-LX compliant 1300nm optical module
- IEEE 1000Base-Zx 1550nm optical modules

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 5-17 shows an example of a G-Series Ethernet application. In this example, data traffic from the GE port of a high-end router travels across the ONS 15454 point-to-point circuit to the GE port of another high-end router.

Figure 5-17 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 GE fiber into a standard Cisco GBIC on a G1000-4 or G1K-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 GE 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 64-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.

IEEE 802.3z Flow Control and Frame Buffering

The G-Series Ethernet cards supports IEEE 802.3z 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 IEEE 802.3z 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 5-17 illustrates pause frames being sent from the ONS 15454s to the sources of the data.

The G-Series cards have symmetric flow control. Symmetric flow control allows the G-Series cards to respond to pause frames sent from external devices and to send pause frames to external devices. Prior to Software R4.0, flow control on the G-Series cards was asymmetric, meaning that the cards sent pause frames and discarded received pause frames.

Software Release 5.0 and later features separate CTC provisioning of autonegotiation and flow control. A failed autonegotiation results in a link down.

When both autonegotiation and flow control are enabled, the G-Series card proposes symmetrical flow control to the attached Ethernet device. Flow control may be used or not depending on the result of the autonegotiation.

If autonegotiation is enabled but flow control is disabled, then the G-Series proposes no flow control during the autonegotiation. This negotiation succeeds only if the attached device agrees to no flow control.

If autonegotiation is disabled, then the attached device's provisioning is ignored. The G-Series card's flow control is enabled or disabled based solely on the G-Series card's provisioning.

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 GE port on the G1000-4. This particular data rate may occasionally exceed 622 Mb/s, but the ONS 15454 circuit assigned to the G1000-4 port may be only STS-12c (622.08 Mb/s). 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.

The G-Series cards have flow control threshold provisioning, which allows you to select one of three watermark (buffer size) settings: default, low latency, or custom. Default is the best setting for general use and was the only setting available prior to Software R4.1. Low latency is good for sub-rate applications, such as voice-over-IP (VoIP) over an STS-1. For attached devices with insufficient buffering, best effort traffic, or long access line lengths, set the G-Series to a higher latency.

The custom setting allows you to specify an exact buffer size threshold for Flow Ctrl Lo and Flow Ctrl Hi. The flow control high setting is the watermark for sending the Pause On frame to the attached Ethernet device; this frame signals the device to temporarily stop transmitting. The flow control low setting is the watermark for sending the Pause Off frame, which signals the device to resume transmitting. With a G-Series card, you can only enable flow control on a port if autonegotiation is enabled on the device attached to that port.

External Ethernet devices with autonegotiation configured to interoperate with G-Series cards running releases prior to Software R4.0 do not need to change autonegotiation settings when interoperating with G-Series cards running Software R4.0 and later.

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

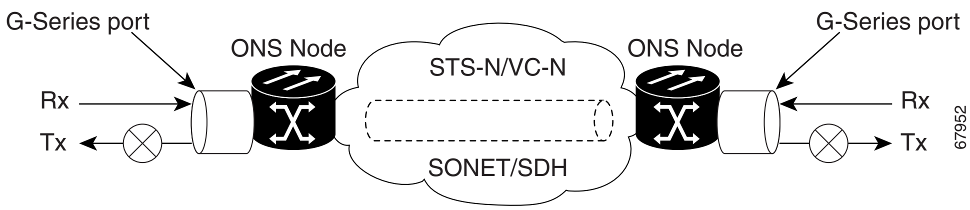
- Flow control is now symmetric. Previous to System Release 4.0, the G1000-4 card only supported asymmetric flow control, where flow control frames were sent to the external equipment but no response from the external equipment is necessary or acted upon.
- Received flow control frames are quietly discarded. 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 5-18, a failure at any point of the path 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 G1K-4 operates in the same manner.

Figure 5-18 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.

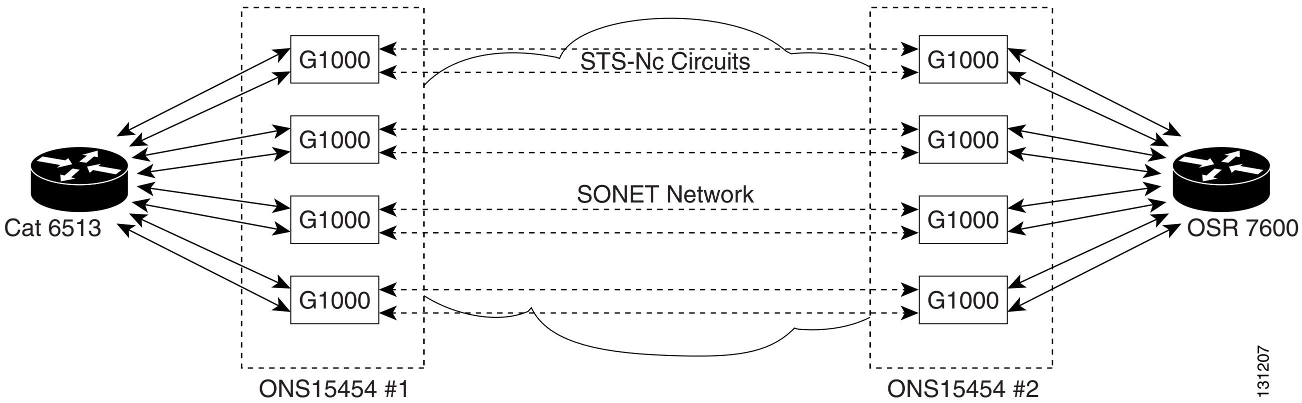
Note Enabling or disabling port level flow control on the test set or other Ethernet device attached to the GE port can affect the transmit (Tx) laser of the G-Series Ethernet card. This can result in unidirectional traffic flow, if flow control is not enabled on the test set or other Ethernet device.

Gigabit EtherChannel/IEEE 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 5-19 illustrates G-Series GEC support.

Figure 5-19 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 GE parallel circuit sizes can be used to support GEC throughput.

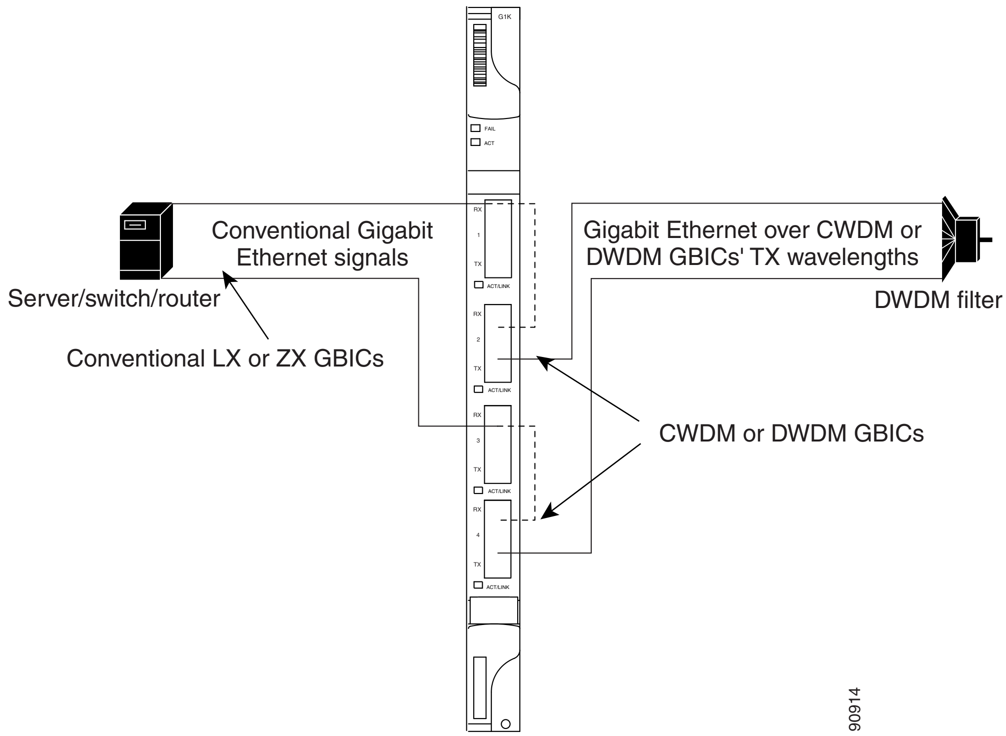
GEC provides line-level active redundancy and protection (1:1) for attached Ethernet equipment. It can also bundle parallel GE data links together to provide more aggregated bandwidth. STP operates as if the bundled links are one link and permits GEC to utilize these multiple parallel paths. Without 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.

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

G-Series Gigabit Ethernet Transponder Mode

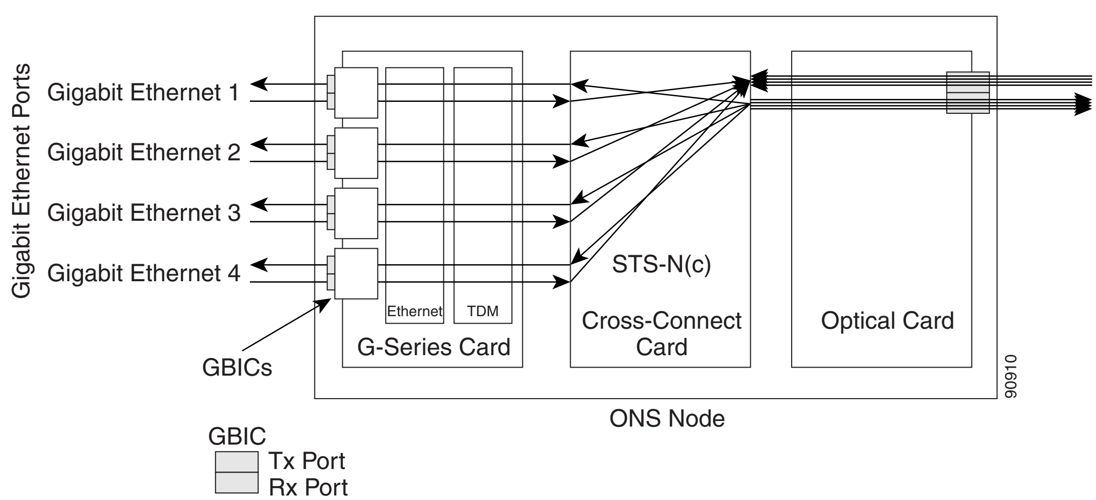
Starting with Software Release 4.1, the G-Series card can be configured as a transponder. Transponder mode can be used with any G-Series supported GBIC (SX, LX, Zx, CWDM, or DWDM). Figure 5-20 shows a card level overview of a transponder mode application.

Figure 5-20 Card Level Overview of G-Series One-Port Transponder Mode Application



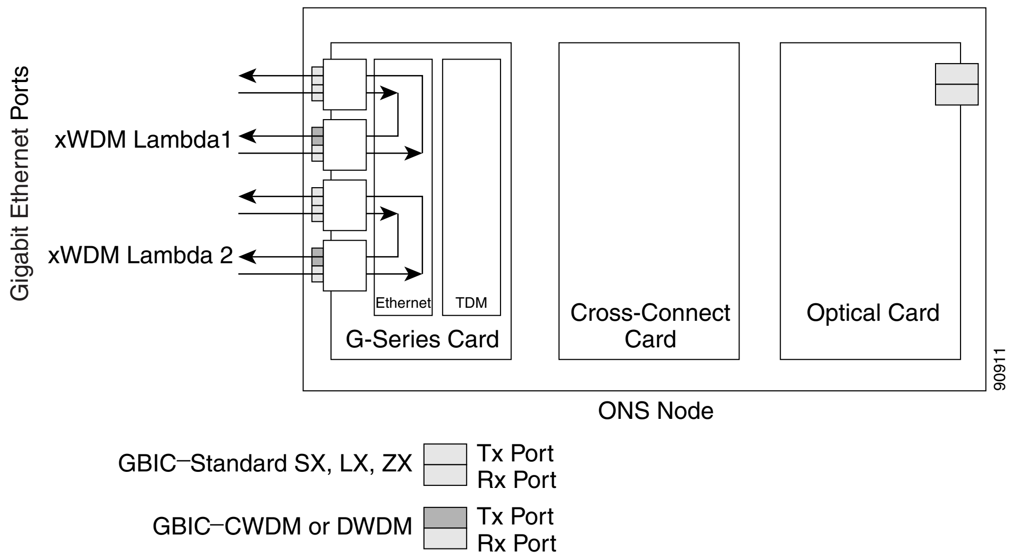
A G-Series card configured as a transponder operates quite differently than a G-Series card configured for SONET. In SONET configuration, the G-Series card receives and transmits Gigabit Ethernet traffic out the Ethernet ports and GBICs on the front of the card. This Ethernet traffic is multiplexed on and off the SONET network through the cross-connect card and the OC-N card (see Figure 5-21).

Figure 5-21 G-Series in Default SONET Mode



In transponding mode, the G-Series Ethernet traffic never comes into contact with the cross-connect card or the SONET network, it stays internal to the G-Series card and is routed back to a GBIC on that card (see Figure 5-22).

Figure 5-22 G-Series Card in Transponder Mode (Two-Port Bidirectional)



A G-Series card can either be configured for transponding mode or as the SONET default. When any port is provisioned in transponding mode, the card is in transponding mode and no SONET circuits can be configured until every port on the card goes back to SONET mode. Refer to the *Cisco ONS 15454 Procedure Guide* for detailed instructions on how to provision G-Series ports for transponder mode.

All SONET circuits must be deleted before a G-Series card can be configured in transponding mode. An ONS 15454 can host the card in any or all of the twelve traffic slots on the ONS 15454 and supports a maximum of 24 bidirectional or 48 unidirectional lambdas.

A G-Series card configured as a transponder can be in one of three modes:

- Two-port bidirectional transponding mode
- One-port bidirectional transponding mode
- Two-port unidirectional transponding mode

Two-Port Bidirectional Transponder

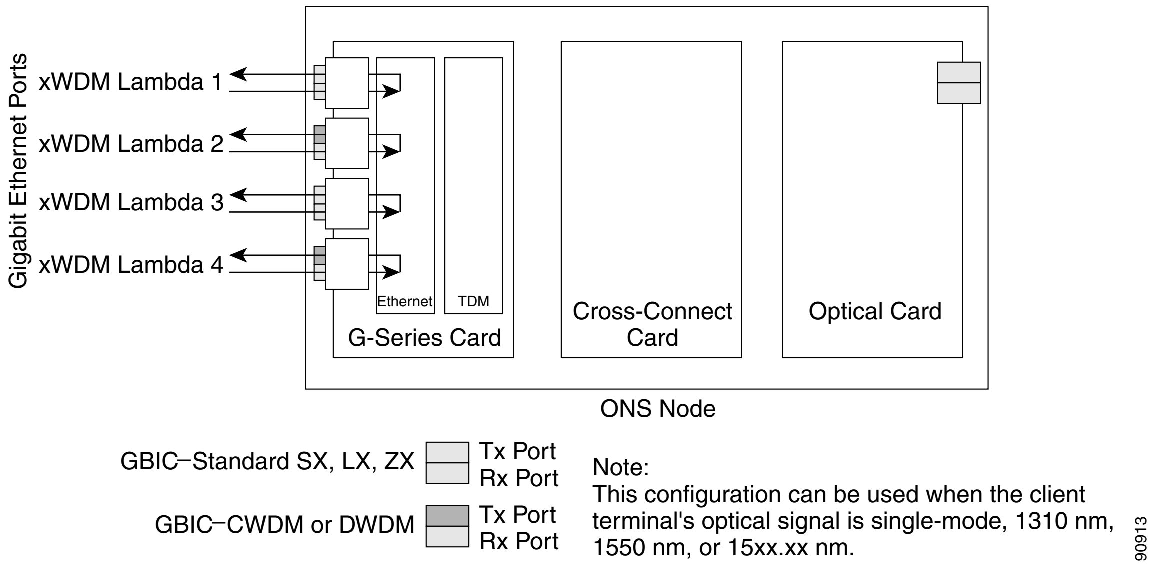
Two-port bidirectional transponder mode maps the transmitted and received Ethernet frames of one G-Series card port into the transmit and receive of another port (see Figure 5-22). Transponder bidirectional port mapping can be any port to any port on the same card.

One-Port Bidirectional Transponder

One-port bidirectional transponder mode shown in Figure 5-23 maps the Ethernet frames received at a port out the transmitter of the same GBIC. This mode is similar to two-port bidirectional transponder mode except that a receive port is mapped only to the transmit port on the same GBIC. Although the data path of the one-port bidirectional transponder mode is identical to that of a facility loopback. The transponding mode is not a maintenance mode and does not suppress non-SONET alarms, like loss of carrier (CARLOSS).

This mode can be used for intermediate DWDM signal regeneration and to take advantage of the wide band capability of the CWDM and DWDM GBICs, which allows you to receive on multiple wavelengths but transmit on a fixed wavelength.

Figure 5-23 One-Port Bidirectional Transponding Mode

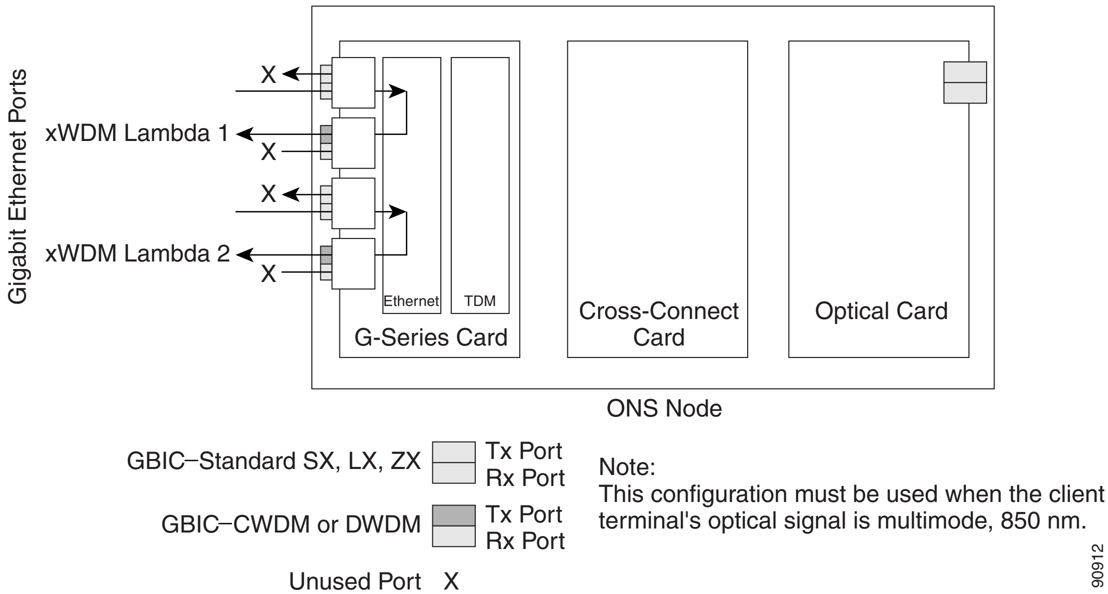


Two-Port Unidirectional Transponder

Ethernet frames received at one port's receiver will be transmitted out the transmitter of another port. This mode is similar to two-port bidirectional transponder mode except only one direction is used (Figure 5-24). One port has to be provisioned as unidirectional transmit only and the other port as unidirectional receive. The port configured as unidirectional transmit ignores any lack of signal on the receive port, so the receive port fiber does not need not be connected. The port configured as unidirectional receive does not turn on the transmit laser, and so the transmit port fiber does not need to be connected.

This mode can be used when only one direction needs to be transmitted over CWDM/DWDM, for example certain VOD applications.

Figure 5-24 Two-Port Unidirectional Transponder



The operation of a G-Series card in transponder mode differs from a G-Series card in SONET mode in the following ways:

- A G-Series card set to transponder mode will not show up in the CTC list of provisionable cards when the user is provisioning a SONET circuit.
- G-Series cards set to transponder mode do not require cross-connect cards (XC, XCVT or XC10G), but do require timing communications and control cards (TCC2/TCC2P).
- G-Series ports configured as transponders do not respond to flow control pause frames and pass the pause frames transparently through the card. In SONET mode, ports can respond to pause frames and do not pass the pause frames through the card.
- There is no TL1 provisioning support for configuring transponding mode. However, transponding mode and port information can be retrieved in the results for the TL1 command RTRV-G1000.
- All SONET related alarms are suppressed when a card is set in transponding mode.
- There are no slot number or cross-connect restrictions for G1000-4 or G1K-4 cards in transponder mode.
- Facility and terminal loopbacks are not fully supported in unidirectional transponding mode, but are supported in both bidirectional transponding modes.
- Ethernet autonegotiation is not supported and cannot be provisioned in unidirectional transponding mode. Autonegotiation is supported in both bidirectional transponding modes.
- No end-to-end link integrity function is available in transponding mode.

Note In normal SONET mode the G-Series cards supports an end-to-end link integrity function. This function causes an Ethernet or SONET failure to disable and turn the transmitting laser off the corresponding mapped Ethernet port. In transponder mode, the loss of signal on an Ethernet port has no impact on the transmit signal of the corresponding mapped port.

The operation of a G-Series card in transponder mode is also similar to the operation of a G-Series card in SONET mode as follows:

- G-Series Ethernet statistics are available for ports in both modes.
- Ethernet port level alarms and conditions are available for ports in both modes.
- Jumbo frame and non-jumbo frame operation is the same in both modes.
- Collection, reporting, and threshold crossing conditions for all existing counters and PM parameters are the same in both modes.
- SNMP and RMON support is the same in both modes.

Enhanced State Model for Gigabit Ethernet Ports

For Release 5.0 and higher, the G-Series supports the Enhanced State Model (ESM) for the Gigabit Ethernet ports, as well as for the SONET circuit.

The Gigabit Ethernet ports can be set to the ESM service states including the automatic in-service administrative state (IS, AINS). IS, AINS initially puts the port in the out of service, automatic in-service (OOS-AU, AINS) state. In this service state, alarm reporting is suppressed, but traffic is carried and loopbacks are allowed. After the soak period passes, the port changes to in-service, not reported (IS-NR). Raised fault conditions, whether their alarms are reported or not, can be retrieved on the CTC Conditions tab or by using the TL1 RTRV-COND command.

Two Ethernet port alarms/conditions, CARLOSS and TPTFAIL, can prevent the port from going into service. This occurs even though alarms are suppressed when a G-Series circuit is provisioned with the Gigabit Ethernet ports set to IS, AINS state. Because the G-Series link integrity function is active and ensures that the Tx transmit lasers at either end are not enabled until all SONET and Ethernet errors along the path are cleared. As long as the link integrity function keeps the end-to-end path down both ports will have at least one of the two conditions needed to suppress the AINS to IS transition so the ports will remain in the AINS state with alarms suppressed.

ESM also applies to the SONET circuits of the G-Series card. If the SONET circuit had been setup in IS, AINS state and the Ethernet error occurs before the circuit transitions to IS, then link integrity will also prevent the circuit transition to the IS state until the Ethernet port errors are cleared at both ends. Service state will be OOS-AU,AINS as long as the admin state is IS,AINS. Once there are no Ethernet or SONET errors link integrity enables the Gigabit Ethernet TX transmit lasers at each end. Simultaneously, the AINS countdown begins as normal. If no additional conditions occur during the time period each port transitions to the IS, NR state. During the AINS countdown the soak time remaining is available in CTC and TL1. The AINS soaking logic restarts from the beginning if a condition re-appears during the soak period.

A SONET circuit provisioned in the IS, AINS state remains in the initial OOS state until the Gigabit Ethernet ports on either end of the circuit transition to the IS, NR state. The SONET circuit transports Ethernet traffic and count statistics when link integrity turns on the Gigabit Ethernet port Tx transmit lasers, regardless of whether this AINS to IS transition is complete.

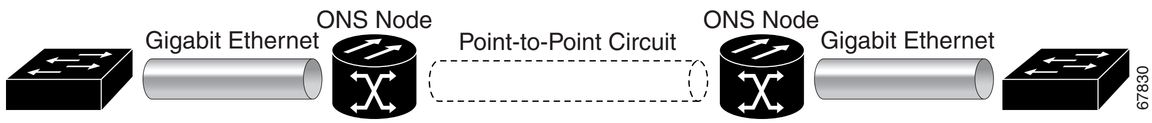
G-Series Ethernet Circuit Configurations

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 can terminate on another G-Series card or an ML-series card.

Point-to-Point Ethernet Circuits

Figure 5-25 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 5-25 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-24c circuits 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.

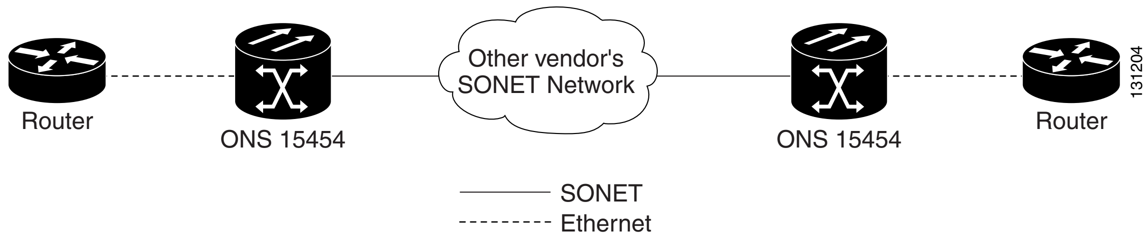
Note All SONET side STS circuits must be contiguous.

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 5-26. This allows an Ethernet circuit to run from ONS 15454 node to ONS 15454 node utilizing the other vendors' network.

Note In this section, "cross-connect" and "circuit" have the following meanings: Cross-connect refers to the connections that occur within a single ONS node to allow a circuit to enter and exit an ONS node. Circuit refers to the series of connections from a traffic source (where traffic enters the ONS node network) to the drop or destination (where traffic exits an ONS node network).

Figure 5-26 G-Series Manual Cross-Connects



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 G1K-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:

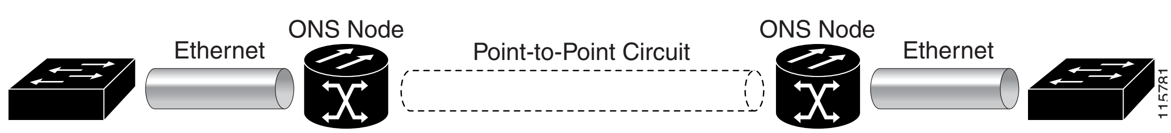
((inOctets + outOctets) + (inPkts + outPkts) * 20)) * 8 / 100% interval * maxBaseRate * 2.

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.

CE-100T-8 Overview

The CE-100T-8, supported in R5.0.2 and later, is a Layer 1 mapper card with eight 10/100 Ethernet ports. It maps each port to a unique SONET circuit in a point-to-point configuration. Figure 5-27 illustrates a sample CE-100T-8 application. In this example, data traffic from the Fast Ethernet port of a switch travels across the point-to-point circuit to the Fast Ethernet port of another switch.

Figure 5-27 CE-100T-8 Point-to-Point Circuit



The CE-100T-8 cards allow you to provision and manage an Ethernet private line service like a traditional SONET line. CE-100T-8 card applications include providing carrier-grade Ethernet private line services and high-availability transport.

The CE-100T-8 card carries any Layer 3 protocol that can be encapsulated and transported over Ethernet, such as IP or IPX. The Ethernet frame from the data network is transmitted on the Ethernet cable into the standard RJ-45 port on a CE-100T-8 card. The CE-100T-8 card transparently maps Ethernet frames into the SONET payload using packet-over-SONET (POS) encapsulation. The POS circuit with its encapsulated Ethernet inside is then multiplexed onto an OC-N card like any other SONET STS. When the payload reaches the destination node, the process is reversed and the data is transmitted from the standard RJ-45 port in the destination CE-100T-8 card onto the Ethernet cable and data network.

The CE-100T-8 card supports ITU-T G.707 and Telcordia GR-253 based standards for SONET. It offers a carrier-class level of features and reliability. This includes errorless (0-msec impact on traffic) reprovisioning. When circuit or port provisioning takes place, this operation does not affect the performance of other ports and circuit configurations that are already established on the card.

Software upgrades are errorless. However when the CE-100T-8 firmware is upgraded, the upgrade has an effect on traffic similar to the effect of a hard reset on the CE-100T-8. A software upgrade or a firmware upgrade does not affect the existing provisioning of the ports and circuits on the CE-100T-8 card.

Span upgrades are hitless. Protection and maintenance switches are also hitless.

The CE-100T-8 offers full TL1-based provisioning capability.

CE-100T-8 Ethernet Features

The CE-100T-8 card has eight front-end Ethernet ports which use standard RJ-45 connectors for 10BASE-T Ethernet/100BASE-TX Ethernet media. Ethernet Ports 1 through 8 each map to a POS port with a corresponding number. The console port on the CE-100T-8 card is not functional.

The CE-100T-8 cards forward valid Ethernet frames unmodified over the SONET network. Information in the headers is not affected by the encapsulation and transport. For example, included IEEE 802.1Q information will travel through the process unaffected.

The ONS 15454 CE-100T-8 supports maximum Ethernet frame sizes of 1548 bytes including the CRC. The MTU size is not configurable and is set at a 1500 byte maximum (standard Ethernet MTU). Baby giant frames in which the standard Ethernet frame is augmented by 802.1 Q tags or MPLS tags are also supported. Full Jumbo frames are not supported.

The CE-100T-8 cards discard certain types of erroneous Ethernet frames rather than transport them over SONET. Erroneous Ethernet frames include corrupted frames with cyclic redundancy check (CRC) errors and undersized frames that do not conform to the minimum 64-byte length Ethernet standard.

Autonegotiation, Flow Control, and Frame Buffering

On the CE-100T-8, Ethernet link autonegotiation is on by default. You can also set the link speed, duplex, and flow control manually under the card-level Provisioning tab of CTC.

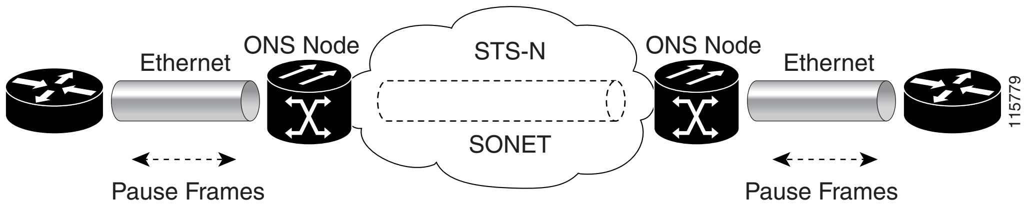
The CE-100T-8 supports IEEE 802.3x flow control and frame buffering to reduce data traffic congestion. Flow control is on by default.

To prevent over-subscription, buffer memory is available for each port. When the buffer memory on the Ethernet port nears capacity, the CE-100T-8 uses IEEE 802.3x flow control to transmit a pause frame to the attached Ethernet device. Flow control and autonegotiation frames are local to the Fast Ethernet interfaces and the attached Ethernet devices. These frames do not continue through the POS ports.

The CE-100T-8 card has symmetric flow control and proposes symmetric flow control when autonegotiating flow control with attached Ethernet devices. Symmetric flow control allows the CE-100T-8 cards to respond to pause frames sent from external devices and to send pause frames to external devices.

The pause frame instructs the source to stop sending packets for a specific period of time. The sending station waits the requested amount of time before sending more data. Figure 5-28 illustrates pause frames being sent and received by CE-100T-8 cards and attached switches.

Figure 5-28 Flow Control



This flow-control mechanism matches the sending and receiving device throughput to that of the bandwidth of the STS circuit. For example, a router might transmit to the Ethernet port on the CE-100T-8 card. This particular data rate might occasionally exceed 51.84 Mbps, but the SONET circuit assigned to the CE-100T-8 port might be only STS-1 (51.84 Mbps). In this example, the CE-100T-8 sends out a pause frame and requests that the router delay its transmission for a certain period of time. With flow control and a substantial per-port buffering capability, a private line service provisioned at less than full line rate capacity (STS-1) is efficient because frame loss can be controlled to a large extent.

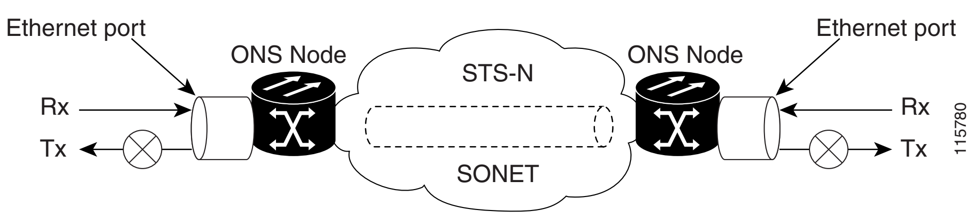
Ethernet Link Integrity Support

The CE-100T-8 supports end-to-end Ethernet link integrity (Figure 5-29). This capability is integral to providing an Ethernet private line service and correct operation of Layer 2 and Layer 3 protocols on the attached Ethernet devices.

End-to-end Ethernet link integrity means that if any part of the end-to-end path fails, the entire path fails. It disables the Ethernet port on the CE-100T-8 card if the remote Ethernet port is unable to transmit over the SONET network or if the remote Ethernet port is disabled.

Failure of the entire path is ensured by turning off the transmit pair at each end of the path. The attached Ethernet devices recognize the disabled transmit pair as a loss of carrier and consequently an inactive link or link fail.

Figure 5-29 End-to-End Ethernet Link Integrity Support



Note Some network devices can be configured to ignore a loss of carrier condition. If a device configured to ignore a loss of carrier condition attaches to a CE-100T-8 card at one end, alternative techniques (such as use of Layer 2 or Layer 3 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.

IEEE 802.1Q CoS and IP ToS Queuing

The CE-100T-8 references IEEE 802.1Q class of service (CoS) thresholds and IP type of service (ToS) (IP Differentiated Services Code Point [DSCP]) thresholds for priority queueing. CoS and ToS thresholds for the CE-100T-8 are provisioned on a per port level. This allows you to provide priority treatment based on open standard quality of service (QoS) schemes already existing in the data network attached to the CE-100T-8. The QoS treatment is applied to both Ethernet and POS ports.

Any packet or frame with a priority greater than the set threshold is treated as priority traffic. This priority traffic is sent to the priority queue instead of the normal queue. When buffering occurs, packets on the priority queue preempt packets on the normal queue. This results in lower latency for the priority traffic, which is often latency-sensitive traffic, such as voice-over-IP (VoIP).

Because these priorities are placed on separate queues, the priority queuing feature should not be used to separate rate-based CIR/EIR marked traffic (sometimes done at a Metro Ethernet service provider edge). This could result in out-of-order packet delivery for packets of the same application, which would cause performance issues with some applications.

For an IP ToS-tagged packet, the CE-100T-8 can map any of the 256 priorities specified in IP ToS to priority or best effort. You can configure a different ToS on CTC at the card-level view under the Provisioning > Ether Ports tabs. Any ToS class higher than the class specified in CTC is mapped to the priority queue, which is the queue geared towards low latency. By default, the ToS is set to 255, which is the highest ToS value. This results in all traffic being treated with equal priority by default.

Table 5-9 shows which values are mapped to the priority queue for sample IP ToS settings. (ToS settings span the full 0 to 255 range, but only selected settings are shown.)

Table 5-9 IP ToS Priority Queue Mappings

ToS Setting in CTC	ToS Values Sent to Priority Queue
255 (default)	None
250	251-255
150	151-255
100	101-255
50	51-255
0	1-255

For a CoS-tagged frame, the CE-100T-8 can map the eight priorities specified in CoS to priority or best effort. You can configure a different CoS on CTC at the card-level view under the Provisioning > Ether Ports tabs. Any CoS class higher than the class specified in CTC is mapped to the priority queue, which is the queue geared towards low latency. By default, the CoS is set to 7, which is the highest CoS value. This results in all traffic being treated with equal priority by default.

Table 5-10 shows which values are mapped to the priority queue for CoS settings.

Table 5-10 CoS Priority Queue Mappings

CoS Setting in CTC	CoS Values Sent to Priority Queue
7 (default)	None
6	7
5	6, 7

Table 5-10 CoS Priority Queue Mappings (continued)

CoS Setting in CTC	CoS Values Sent to Priority Queue
4	5, 6, 7
3	4, 5, 6, 7
2	3, 4, 5, 6, 7
1	2, 3, 4, 5, 6, 7
0	1, 2, 3, 4, 5, 6, 7

Ethernet frames without VLAN tagging use ToS-based priority queueing if both ToS and CoS priority queueing is active on the card. The CE-100T-8 card's ToS setting must be lower than 255 (default) and the CoS setting lower than 7 (default) for CoS and ToS priority queueing to be active. A ToS setting of 255 (default) disables ToS priority queueing, so in this case the CoS setting would be used.

Ethernet frames with VLAN tagging use CoS-based priority queueing if both ToS and CoS are active on the card. The ToS setting is ignored. CoS based priority queueing is disabled if the CoS setting is the 7 (default), so in this case the ToS setting would be used.

If the CE-100T-8 card's ToS setting is 255 (default) and the CoS setting is 7 (default), priority queueing is not active on the card, and data gets sent to the default normal traffic queue. Also if data is not tagged with a ToS value or a CoS value before it enters the CE-100T-8 card, it gets sent to the default normal traffic queue.

Note Priority queuing has no effect when flow control is enabled (default) on the CE-100T-8. Under flow control a 6 kilobyte single-priority first in first out (FIFO) buffer fills, then a PAUSE frame is sent. This results in the packet ordering priority becoming the responsibility of the external device, which is buffering as a result of receiving the PAUSE flow-control frames.

Note Priority queuing has no effect when the CE-100T-8 is provisioned with STS-3C circuits. The STS-3c circuit has more data capacity than Fast Ethernet, so CE-100T-8 buffering is not needed. Priority queuing only takes effect during buffering.

RMON and SNMP Support

The CE-100T-8 card features remote monitoring (RMON) that allows network operators to monitor the health of the network with a network management system (NMS).

The RMON contains the statistics, history, alarms, and events MIB groups from the standard RMON MIB. You can access RMON threshold provisioning through TL1 or CTC. For RMON threshold provisioning with CTC, see the *Cisco ONS 15454 Procedure Guide* (NTP-A279) and the *Cisco ONS 15454 Troubleshooting Guide*. For TL1 information, see the *Cisco ONS SONET TL1 Command Guide*.

CE-100T-8 SONET Circuits and Features

The CE-100T-8 has eight POS ports, numbered one through eight, which are exposed to management with CTC or TL1. Each POS port is statically mapped to a matching Ethernet port. By clicking the card-level Provisioning tab > POS Ports tab, you can configure the Administrative State, Framing Type, and Encapsulation Type. By clicking the card-level Performance tab > POS Ports tab, you can view the statistics, utilization, and history for the POS ports.

Each POS port terminates an independent contiguous SONET concatenation (CCAT) or virtual SONET concatenation (VCAT). The SONET circuit is created for these ports through CTC or TL1 in the same manner as a SONET circuit for a non-Ethernet line card. Table 5-11 shows the circuit sizes available for the CE-100T-8 on the ONS 15454.

Table 5-11 CE-100T-8 Supported Circuit Sizes

CCAT High Order	VCAT High Order	VCAT Low Order
STS-1	STS-1-1v	VT1.5-nV (n= 1 to 64)
STS-3c	STS-1-2v STS-1-3v	—

A single circuit provides a maximum of 100 Mb/s of throughput, even when an STS-3c circuit, which has a bandwidth equivalent of 155 Mb/s, is provisioned. This is due to the hardware restriction of the Fast Ethernet port. A VCAT circuit is also restricted in this manner. Table 5-12 shows the minimum SONET circuit sizes required for 10 Mb/s and 100 Mb/s wire speed service.

Table 5-12 SONET CIrcuit Sizes and Ethernet Services

Ethernet Wire Speed	CCAT High Order	VCAT High Order	VCAT Low Order
Line Rate 100BaseT	STS-3c	STS-1-3v, STS-1-2v[1]	—
Sub Rate 100BaseT	STS-1	STS-1-1v	VT1.5-xv (x=1-64)
Line Rate 10BaseT	STS-1	—	VT1.5-7v
Sub Rate 10BaseT	—	—	VT1.5-xv (x=1-6)

1. STS-1-2v provides a total transport capacity of 98 Mb/s.

The number of available circuits and total combined bandwidth for the CE-100T-8 depends on the combination of circuit sizes configured. Table 5-13 and Table 5-14 show the circuit size combinations available for the CE-100T-8.

Table 5-13 CCAT High Order Circuit Size Combinations

Number of STS-3c Circuits	Maximum Number of STS-1 Circuits
None	8
1	7
2	6
3	3
4	None

Table 5-14 VCAT High Order Circuit Combinations for STS-1-3v and STS-1-2v

Number of STS-1-3v Circuits	Maximum Number of STS-1-2v Circuits
None	4
1	3
2	2
3	1
4	None

The CE-100T-8 supports up to eight low order VCAT circuits. The available circuit sizes are VT1.5-Xv, where X is the range from 1 to 64. A maximum of four circuits are available at the largest low order VCAT circuit size, VT1.5-64v.

You can combine CCAT high order, VCAT high order and VCAT low order circuits. Table 5-15 details the maximum density service combinations.

Table 5-15 CE-100T-8 Maximum Service Densities

Service Combination	STS-3c or STS-1-3v	STS-1-2v	STS-1	VT1.5-xV (x=1-7)	Number of Active Service
1	4	0	0	0	4
2	3	1	1	0	5
3	3	0	3	0	6
4	3	0	0	4 (x=1-21)[1]	7[1]
5	2	2	2	0	6
6	2	1	4	0	7
7	2	1	1	4 (x=1-21)[1]	8[1]
8	2	0	6	0	8
9	2	0	3	3 (x=1-28)	8
10	2	0	0	6 (x=1-28)	8
11	1	3	3	0	7
12	1	2	5	0	8
13	1	2	2	3 (x=1-28)	8
14	1	1	1	5 (x=1-28)	8
15	1	0	7	0	8
16	1	0	3	4 (x=1-42)	8
17	1	0	0	7 (x=1-28)	8
18	0	4	4	0	8
19	0	3	3	2 (x=1-42)	8
20	0	0	8	0	8
21	0	0	4	4 (x=1-42)	8
22	0	0	0	8 (x=1-42)	8

1. This low order VCAT circuit combination is achievable if one of the first two circuits created on the card is an low order VCAT circuit. If the first two circuits created on the card are high order VCAT or CCAT, then a maximum of three low order VCAT circuits can be created on the card.

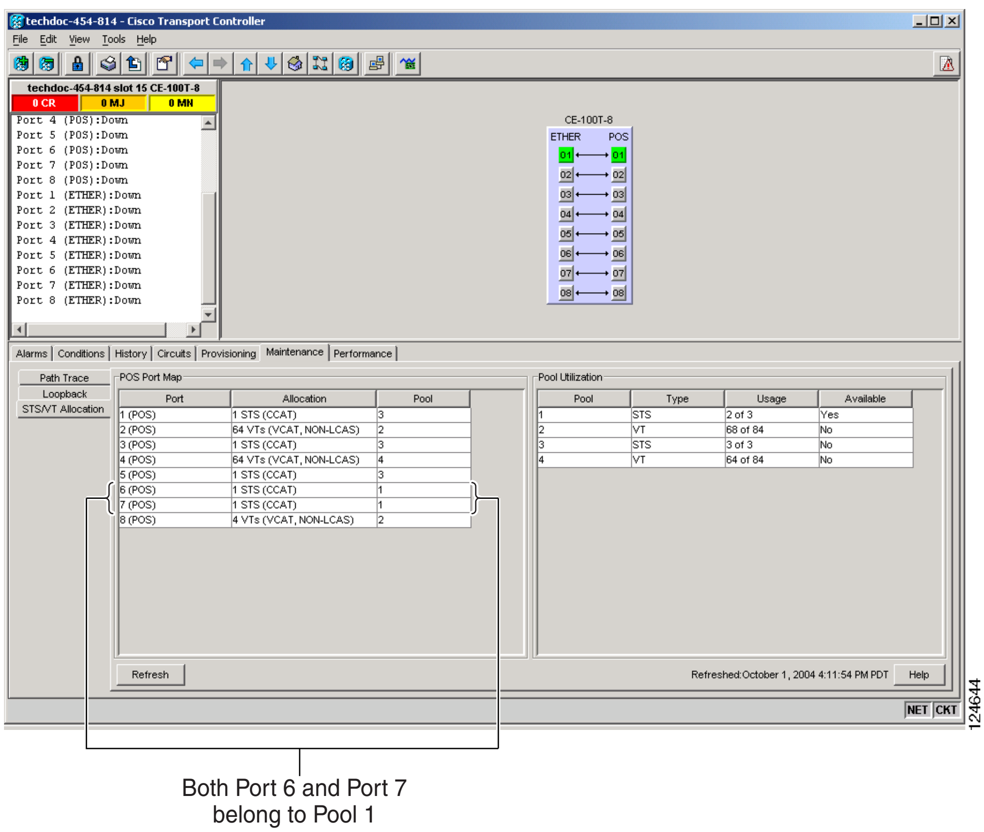
CE-100T-8 Pools and STS/VT Allocation Tab

The CE-100T-8 has four pools, each with a maximum capacity of three STSs. All VCAT circuit members must be from the same pool.

One of the four memory pools is reserved for the low order VCAT circuits, if sufficient bandwidth exists to support the high order circuits on the remaining three pools. The high order CCAT circuits use all the available capacity from a single memory pool before beginning to use the capacity of a new pool. The memory pools will be allocated alternatively for the first three high order VCAT circuits if the pools have the sufficient bandwidth to support the requested circuit size. To help prevent stranding bandwidth, provision your high order VCAT circuits first to distribute them evenly.

At the CTC card-level view under the Maintenance tab, the STS/VT Allocation tab (Figure 5-30) displays how the provisioned circuits populate the four pools. This information can be useful in freeing up the bandwidth required for provisioning a circuit, if there is not enough existing capacity on any one pool for provisioning the desired circuit. You can look at the distribution of the existing circuits among the four pools and decide which circuits to delete in order to free up space for the desired circuit.

Figure 5-30 CE-100T-8 STS/VT Allocation Tab



For example, to provision an STS-3c or STS-1-3v on the CE-100T-8 card shown in Figure 5-30, a STS-3c or STS-1-3v worth of bandwidth is not available from any of the four pools. You need to delete circuits from the same pool to free up bandwidth. If the bandwidth is available but scattered among the pools, the circuit cannot be provisioned. Looking at the POS Port Map table, you can determine which circuits belong to which pools. The Pool and Port columns in Figure 5-30 show that port 6 and port 7 are both drawn from Pool 1 and no other circuits are drawn from Pool 1. Deleting these two STS-1 circuits will free up an STS-3c or STS-1-3v worth of bandwidth from a single pool.

If you did not determine what circuits to delete from the table information, you could delete the STS-1 circuits on port 3, port 5 and port 6. This frees up an STS-3c or STS-1-3v worth of bandwidth, but the required bandwidth is not available from a single pool and the STS-3c or STS-1-3v circuit is not provisionable.

The POS Port table, shown in Figure 5-30, has a row for each port with three columns. Each row shows the port number, the circuit size and type, and the pool it is drawn from. The Pool Utilization table has four columns and shows the pool number, the type of circuits on that pool, how much of the pool's capacity is being used, and whether additional capacity is available.

CE-100T-8 VCAT Characteristics

The CE-100T-8 card has hardware-based support for the ITU-T G.7042 standard link capacity adjustment scheme (LCAS). This allows you to dynamically resize a VCAT circuit through CTC or TL1 without affecting other members of the VCAT group. The CE-100T-8 card is also compatible with the ML-Series card's software-based LCAS (SW-LCAS).

The CE-100T-8 card allows independent routing and protection preferences for each member of a VCAT circuit. You can also control the amount of VCAT circuit capacity that is fully protected or unprotected. If the circuit is on a bidirectional line switched ring (BLSR), you can use protection channel access (PCA).

Alarms are supported on a per-member as well as per virtual concatenation group (VCG) basis.

Note The maximum tolerable VCAT differential delay for the CE-100T-8 is 48 milliseconds. The VCAT differential delay is the relative arrival time measurement between members of a virtual concatenation group (VCG).

CE-100T-8 POS Encapsulation, Framing, and CRC

The CE-100T-8 uses Cisco EoS LEX (LEX). LEX is the primary encapsulation of ONS Ethernet cards. In this encapsulation the protocol field is set to the values specified in Internet Engineering Task Force (IETF) Request For Comments (RFC) 1841. You can provision GPF-F framing (default) or high-level data link control (HDLC) framing. With GFP-F framing, you can also configure a 32-bit CRC (the default) or no CRC (none). When LEX is used over GFP-F it is standard Mapped Ethernet over GFP-F according to ITU-T G.7041. HDLC framing provides a set 32-bit CRC.

The CE-100T-8 card supports GFP-F null mode. GFP-F CMFs are counted and discarded.

CE-100T-8 Loopback and J1 Path Trace Support

The CE-100T-8 card supports terminal and facility loopbacks. It also reports SONET alarms and transmits and monitors the J1 Path Trace byte in the same manner as OC-N cards. Support for path termination functions includes:

- H1 and H2 concatenation indication
- C2 signal label
- Bit interleaved parity 3 (BIP-3) generation
- G1 path status indication
- C2 path signal label read/write
- Path level alarms and conditions, including loss of pointer, unequipped, payload mismatch, alarm indication signal (AIS) detection, and remote defect indication (RDI)
- J1 path trace for high order paths
- J2 path trace for low order paths
- J2 path trace for low order VCAT circuits at the member level
- Extended signal label for the low order paths

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.

The ML-Series card features two virtual Packet-over-SONET/SDH (POS) ports, which function in a manner similar to OC-N card ports. The SONET/SDH circuits are provisioned through CTC in the same manner as standard OC-N card circuits. The ML-Series POS ports supports virtual concatenation (VCAT) of SONET/SDH circuits and a software link capacity adjustment scheme (SW-LCAS).

An ML-Series card can be installed in slots 1-6 and 12-17 of an ONS 15454 operating with the TCC2/TCC2P and XC-10G cross-connect cards. When operating with a TCC2/TCC2P and XC or XC-VT cards, the ML-Series cards can only be installed in 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. Cards shipped with Software prior to R5.0 come preloaded with Cisco IOS Release 12.1(14)EB. Cards shipped with Software R5.0 come preloaded with Cisco IOS Release 12.2(18)SO. The Cisco IOS command-line interface (CLI) is the primary user interface for the ML-Series card. Most configuration for the card, such as Ethernet port, bridging, and VLAN, can be done only via the Cisco IOS CLI. 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

CTC is used for ML-Series status information, SONET alarm management, Cisco IOS Telnet session initialization, Cisco IOS configuration file management, and SONET circuit provisioning. SONET cross-connects cannot be provisioned via the Cisco IOS CLI. They 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 TCC2/TCC2P 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 TCC2/TCC2P card 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 TCC2/TCC2P card. Caching the IOS image provides a significant time savings when a warm reset is performed.

Console Port and adaptor cable

Each ML-Series card includes a Console port labeled CONSOLE. This port is used to provide configuration access to just the associated ML-Series card's IOS features using the Cisco CLI. This port is an RJ-11 and an extension cable is available to be connected with standard Cisco console cables.

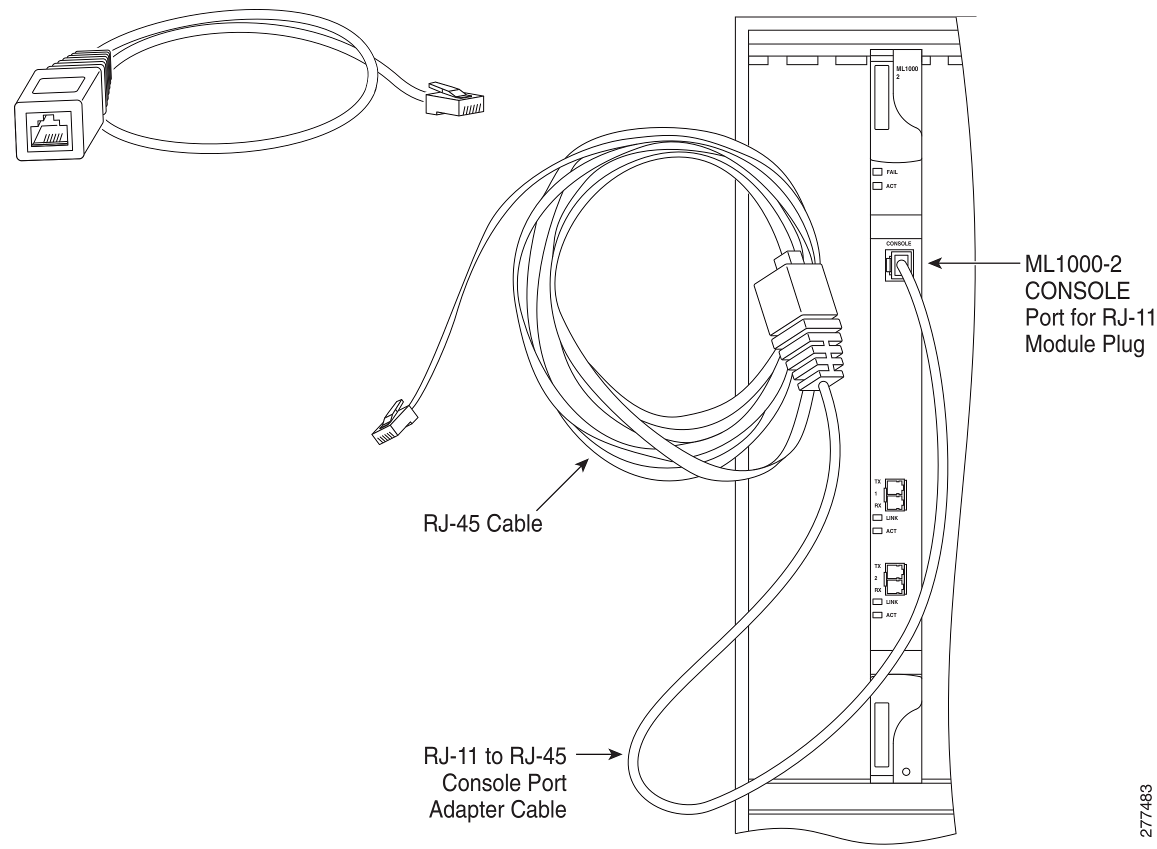
An RJ-11 to RJ-45 adaptor cable is shipped with each ML-Series card to adapt the ML-Series RJ-11 console port to any external management systems, which require RJ-45 connectors.

Figure 5-31 illustrates the console adaptor cable assembly and pin-mappings between the RJ-11 and RJ-45 ports.

The part number of the console cable for SONET is "15454-CONSOLE-02=" (Description is: RJ11 to RJ45 Console Cable Adapter, 22 Inches).

The part number of the console cable for SDH is "15454E-CONSOLE-02=" (Description is: RJ11 to RJ45 Console Cable Adapter, 22 Inches).

Figure 5-31 Console Port Adaptor Cable



ML-Series 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
- IEEE 802.3z (Gigabit Ethernet) and 802.3x (Fast Ethernet) Flow Control
- POS channel (with LEX encapsulation only)
- IRB on POS ports
- IEEE 802.1Q trunking support on POS ports card
- Bundling the two POS ports
- Two POS virtual ports with maximum bandwidth of STS-48c per
- High-level data link control (HDLC) or frame-mapped generic framing procedure (GFP-F) framing mechanism for POS (no VLAN trunking support)
- LEX, Cisco HDLC, Point-to-Point Protocol/Bridge Control Protocol (PPP/BCP) port encapsulation for POS (VLAN trunking supported via BCP)
- IRB on POS ports

- IEEE 802.1Q trunking support on POS ports
- G-Series card compatible (with LEX encapsulation only)
- VCAT with SW-LCAS (R4.6 and higher)

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
- IEEE 802.1Q-based VLAN routing and bridging
- 802.1D Spanning Tree and 802.1W Rapid Spanning Tree
- IEEE 802.1D STP instance per bridge group
- Resilient packet ring (RPR)
- Dual RPR Interconnect (DRPRI)
- Ethernet over Multiprotocol Label Switching (EoMPLS) (R4.6 and higher)
- VLAN-transparent and VLAN-specific services (Ethernet Relay Multipoint Service (ERMS))

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

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 40 IP multicast groups
- IRB routing mode support

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)

Additional Protocols:

- 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

Access List (ACL) Features:

- IP standard ACL
- IP extended ACL

QoS Features:

- Multicast priority queuing classes
- Service Level Agreements (SLAs) with 1-Mbps granularity
- Input policing
- Guaranteed bandwidth (weighted round-robin [WDRR] plus strict priority scheduling)
- Class of service (CoS) based on Layer 2 priority, VLAN ID, Layer 3 Type of Service/DiffServ Code Point (TOS)/(DSCP), and port
- CoS-based packet statistics (R4.6 and higher)
- Low latency queuing support for unicast VoIP

Management Features:

- Remote monitoring (RMON)
- Simple Network Management Protocol (SNMP)
- Transaction Language 1 (TL1)
- Cisco IOS
- CTC and CTM management interfaces

CTC Features:

- Framing Mode Provisioning
- Standard STS/STM and VCAT circuit provisioning for POS virtual ports
- SONET/SDH alarm reporting for path alarms and other ML-Series card specific alarms
- Raw port statistics
- Standard inventory and card management functions
- J1 Path Trace
- Cisco IOS CLI Telnet sessions from CTC
- Cisco IOS startup configuration file management from CTC

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-Mb/s full-duplex Fast Ethernet on the ML100-12.

Cisco's GEC technology provides bandwidth scalability by providing 2-Gb/s 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 5-16.

Table 5-16 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 5-32 shows an example of a VRF Lite configuration.

Figure 5-32 VRF Lite Example

Cisco IOS

Cisco IOS controls the data functions of the ML-Series card and comes preloaded on the ONS 15454 TCC2/TCC2P 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.

GFP-F Framing

GFP defines a standard-based mapping of different types of services onto SONET/SDH. The ML-Series and CE-Series support frame-mapped GFP (GFP-F), which is the PDU-oriented client signal adaptation mode for GFP. GFP-F maps one variable length data packet onto one GFP packet.

GFP is composed of common functions and payload specific functions. Common functions are those shared by all payloads. Payload-specific functions are different depending on the payload type. GFP is detailed in the ITU recommendation G.7041.

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:

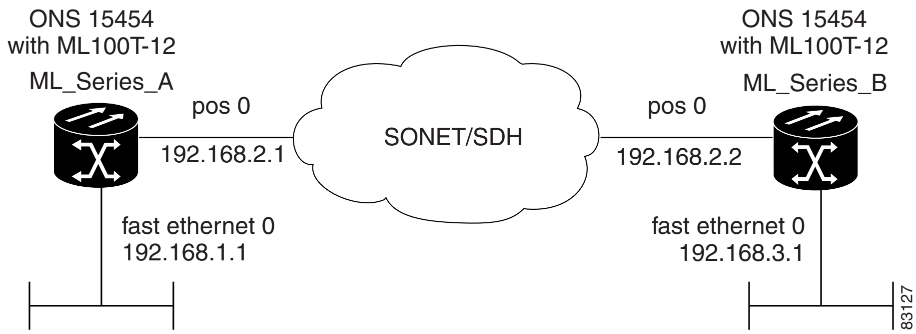
- All interfaces have a name which is comprised of an interface type (word) and a Port ID (number). For example, FastEthernet 2.
- Configure each interface with a bridge-group or IP address and IP subnet mask.
- VLANs are supported through the use of subinterfaces. The subinterface is a logical interface 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 5-33 illustrates a POS configuration between two ML-Series cards.

Figure 5-33 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:

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

In interface configuration mode:

- 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.

IEEE 802.1T Spanning Tree Extensions

The ML-Series cards support the IEEE 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 5-17, 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 5-17 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

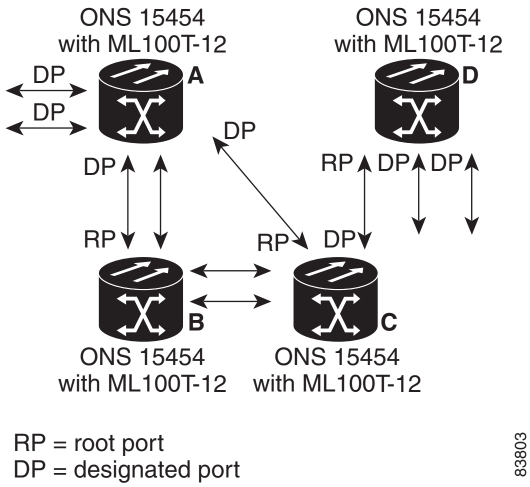
Spanning tree uses the extended system ID, the switch priority, and the allocated spanning tree MAC address to make the bridge ID unique for each VLAN.

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 5-34, 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 5-34 Spanning Tree Topology

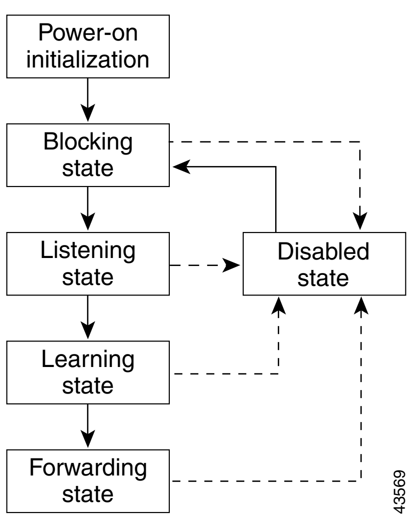


Spanning Tree Interface States

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 5-35 illustrates how an interface moves through the states.

Figure 5-35 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.

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 5-18 provides a comparison of 802.1D and RSTP port states.

Table 5-18 Port State Comparison

Operational Status	STP Port State	RSTP Port State	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 5-19 shows the RSTP flag fields.

Table 5-19 RSTP BPDU Flags

Bit	Function
0	Topology Change (TC)
1	Proposal
2-3:	Port Role:
00	Unknown
01	Alternate Port
10	Root Port
11	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 IEEE 802.1D in handling spanning tree topology changes.

- Detection: Unlike IEEE 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 IEEE 802.1D, which uses TCN BPDUs, the RSTP does not use them. However, for IEEE 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 IEEE 802.1D switch, it replies with an IEEE 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 IEEE 802.1D) is active on a root port connected to an IEEE 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 IEEE 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 IEEE 802.1D switches, RSTP selectively sends IEEE 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 IEEE 802.1D BPDU after the port's migration-delay timer has expired, it assumes that it is connected to an IEEE 802.1D switch and starts using only IEEE 802.1D BPDUs. However, if the RSTP ML-Series card is using IEEE 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 IEEE 802.1D STP

An ML-Series card running RSTP supports a built-in protocol migration mechanism that enables it to interoperate with legacy IEEE 802.1D switches. If this card receives a legacy IEEE 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 IEEE 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.

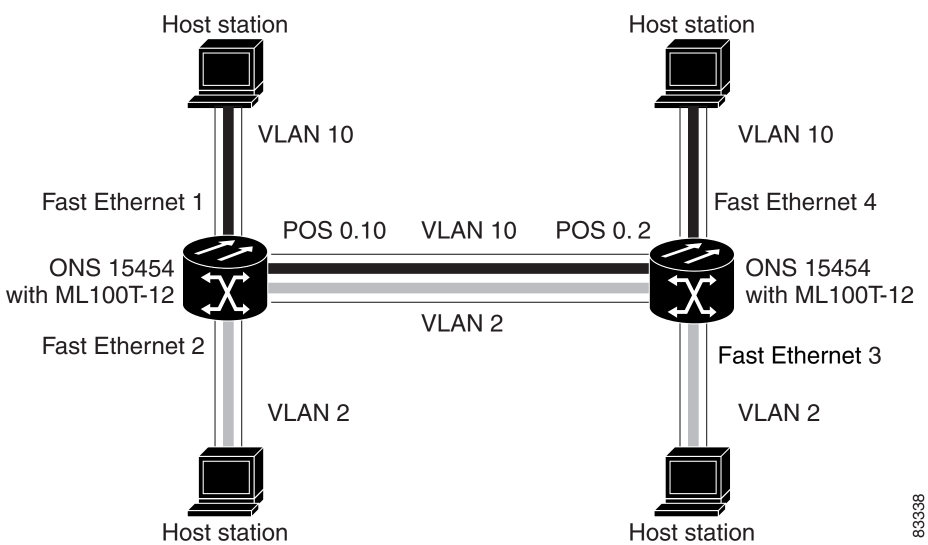
VLAN Support

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 5-36 shows a network topology in which two VLANs span two ONS 15454 nodes with ML-Series cards.

Figure 5-36 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

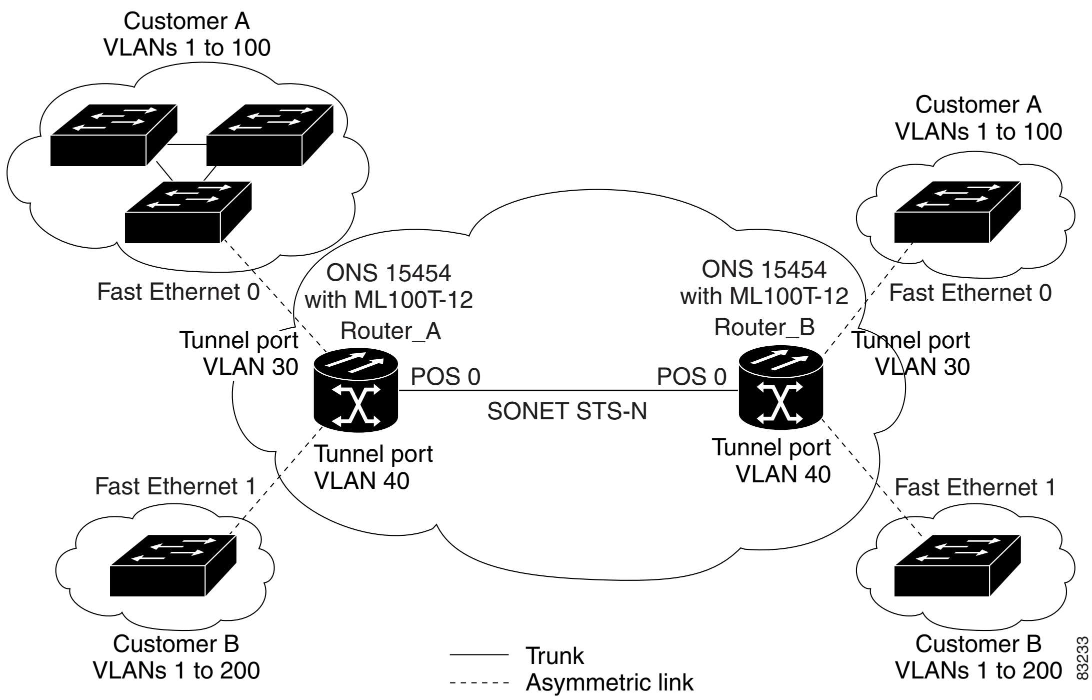
Virtual private networks (VPNs) provide enterprise-scale connectivity on a shared infrastructure, often Ethernet-based, with the same security, prioritization, reliability, and manageability requirements of private networks. Tunneling is a feature designed for service providers who carry traffic of multiple 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 5-37.

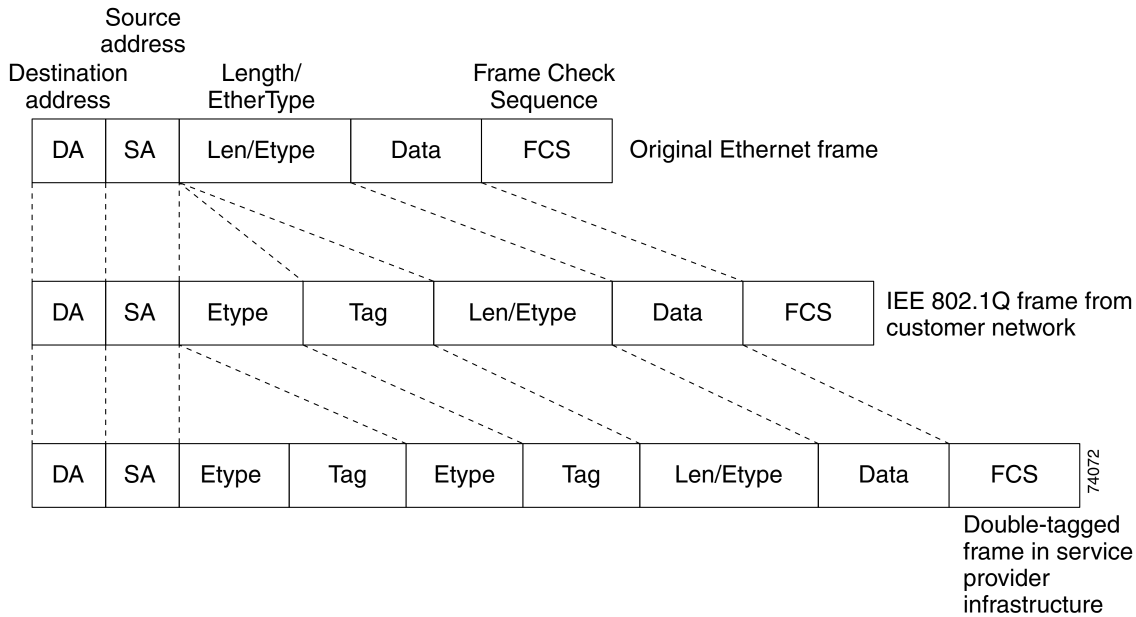
Figure 5-37 IEEE 802.1Q Tunnel Ports in a Service-Provider Network



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 5-38 shows the structure of the double-tagged packet.

Figure 5-38 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 5-37, 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 you 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.

Understanding CoS-based Packet Statistics (Software Release 4.6 and Later)

Enhanced performance monitoring displays per-CoS packet statistics on the ML-Series card interfaces when CoS accounting is enabled. Starting with software Release 4.6 per-CoS packet statistics are only supported for bridged services, not IP routing or MPLS. CoS-based traffic utilization is displayed at the FastEthernet or GigabitEthernet interface or subinterface (VLAN) level or the POS interface level but not at the POS subinterface level. RPR statistics are not available at the SPR interface level, but statistics are available for the individual POS ports that make up the SPR interface. EtherChannel (port-channel) and BVI statistics are available only at the member port level. Table 5-20 shows the types of statistics available at specific interfaces.

Table 5-20 Packet Statistics on ML-Series Card Interfaces

Statistics Collected	Gigabit/FastEthernet Interface	Gigabit/FastEthernet Subinterface (VLAN)	POS Interface	POS Subinterface
Input - Packets and Bytes	Yes	Yes	No	No
Output - Packets and Bytes	Yes	Yes	No	No
Drop Count - Packets and Bytes[1]	Yes	No	Yes	No

1. Drop counts only include discards caused by output congestion and are counted at the output interface.

CoS-based packet statistics are available through the Cisco IOS command-line interface (CLI) and simple network management protocol (SNMP), using an extension of the CISCO-PORT-QOS MIB. They are not available through Cisco Transport Controller (CTC).

Classification

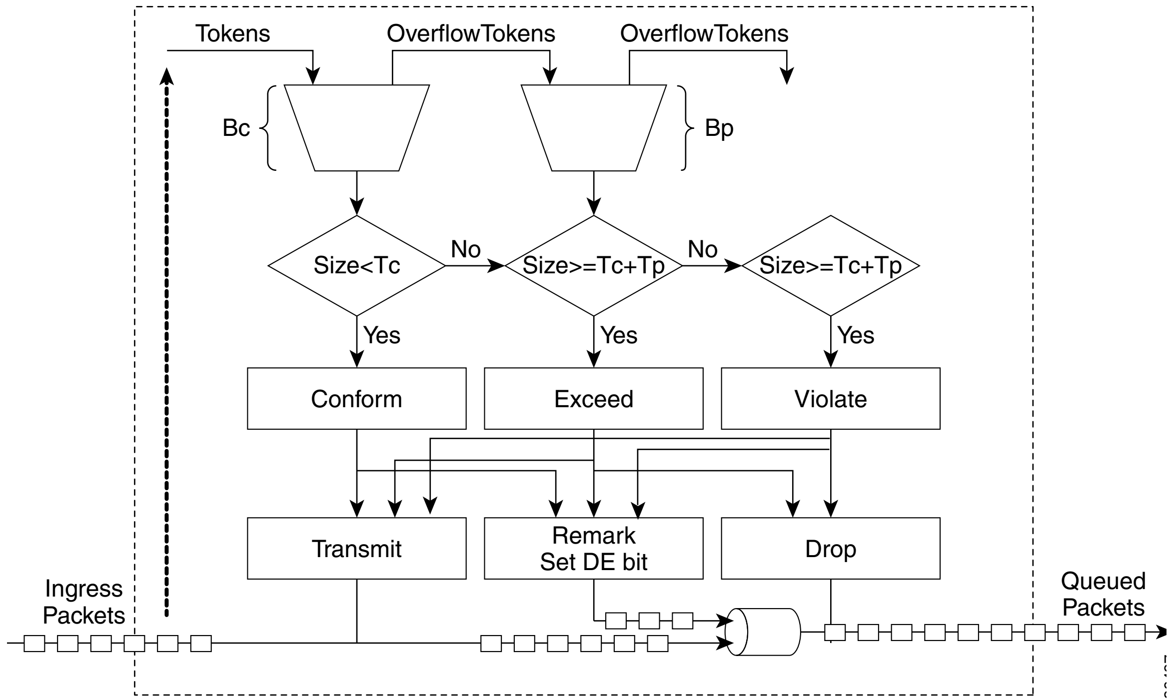
Classification can be based on any single packet classification criteria or a combination (logical And and OR). A total of 254 classes, not including the class default, can be defined on the card. Classification of packets is configured using the Modular CLI class-map command. For traffic transiting the resilient packet ring (RPR), only the Input Interface and/or the RPR-CoS can be used as classification criteria.

Policing

Dual leaky bucket policer is a process where the first bucket (CIR bucket) is filled with tokens at a known rate (CIR), which is a parameter that can be configured by the operator. Figure 5-39 illustrates the dual leaky bucket policer model. The tokens fill the bucket up to a maximum level, which is the amount of burstable committed (BC) traffic on the policer. The non-conforming packets of the first bucket are the overflow packets, which are passed to the second leaky bucket (the PIR bucket). The second leaky bucket is filled with these tokens at a known rate (PIR), which is a parameter that can be configured by the operator. The tokens fill the PIR bucket up to a maximum level (BP), which is the amount of peak burstable traffic on the policer. The non-conform packets of the second bucket are the overflow packets, which can be dropped or marked according to the policer definition.

On the dual leaky bucket policer, the packets conforming to the CIR are conform packets, the packets not conforming to CIR but conforming to PIR are exceed packets, and the packets not conforming to either the PIR or CIR are violate packets.

Figure 5-39 Dual Leaky Bucket Policer Model



Marking and Discarding

On the ML-Series card's policer, the conform packets can be transmitted or marked and transmitted. The exceed packets can be transmitted, marked and transmitted, or dropped. The violating packets can be transmitted, marked and transmitted, or dropped. The primary application of the dual-rate or three-color policer is to mark the conform packets with CoS bit 2l, mark the exceed packet with CoS bit 1, and discard the violated packets so all the subsequent network devices can implement the proper QoS treatment per frame/packet basis based on these priority marking without knowledge of each SLA.

If a marked packet has a provider-supplied Q-Tag inserted before transmission, the marking only affects the provider Q-Tag. If a Q-Tag was received, it will be re-marked. If a marked packet is transported over the RPR ring, the marking also affects the RPR-CoS bit.

If a Q-Tag is inserted (QinQ), the marking affects the added Q-Tag. If the ingress packet contains a Q-tag and is transparently switched, the existing Q-Tag is marked. In case of a packet without any Q-Tag, the marking does not have any significance.

The local scheduler treats all non-conforming packets as discard eligible regardless of their CoS setting or the global cos commit definition. For RPR implementation, the discard eligible (DE) packets are marked using the DE bit on the RPR header. The discard eligibility based on the CoS Commit or the policing action is local to the ML-Series card scheduler, but it is global for the RPR ring.

Queuing

ML-Series card queuing uses a shared buffer pool to allocate memory dynamically to different traffic queues. The ML-Series card uses a total of 12 MB memory for the buffer pool. Ethernet ports share 6 MB of the memory, and POS ports share the remaining 6 MBs of memory. Memory space is allocated in 1500-byte increments.

Each queue has an upper limit on the allocated number of buffers based on the class bandwidth assignment of the queue and the number of queues configured. This upper limit is typically 30% to 50% of the shared buffer capacity. Dynamic buffer allocation to each queue may be reduced based on the number of queues needing extra buffering. The dynamic allocation mechanism provides fairness in proportion to service commitments as well as optimization of system throughput over a range of system traffic loads.

The Low Latency Queue (LLQ) is defined by setting the weight to infinity or committing 100% bandwidth. When a LLQ is defined, a policer should also be defined on the ingress for that specific class to limit the maximum bandwidth consumed by the LLQ; otherwise there may be a potential risk of LLQ occupying the whole bandwidth and starving the other unicast queues.

The ML-Series includes support for 400 user-definable queues, which are assigned per the classification and bandwidth allocation definition. The classification used for scheduling classifies the frames/packet after the policing action, so if the policer is used to mark or change the CoS bits of the ingress frames/packet, the new values are applicable for the classification of traffic for queuing and scheduling. The ML-Series provides buffering for 4000 packets.

Scheduling

Scheduling is provided by a series of schedulers that perform a weighted deficit round robin (WDRR) as well as priority scheduling mechanisms from the queued traffic associated with each egress port.

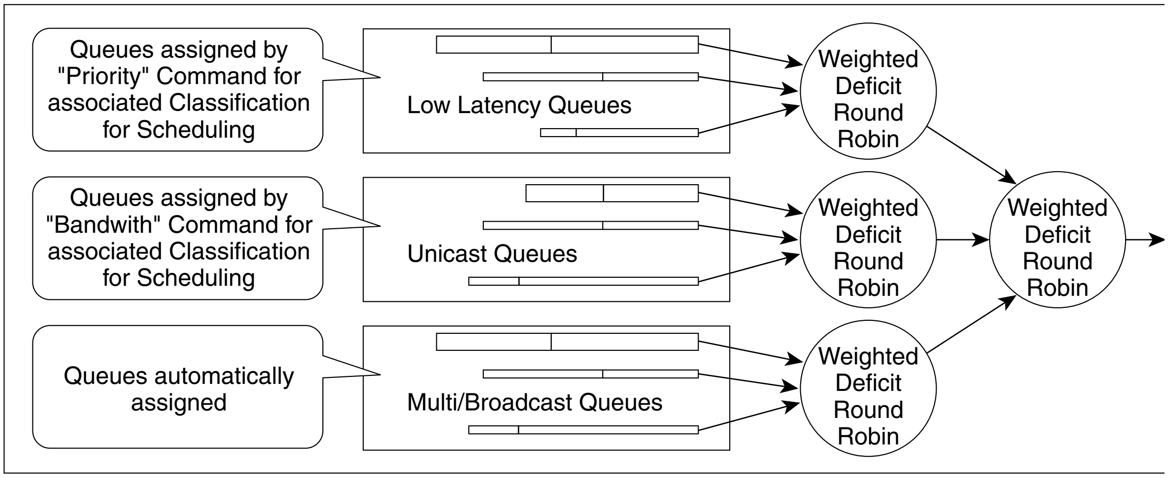
Though ordinary round robin servicing of queues can be done in constant time, the unfairness that occurs when different queues use different packet sizes. Deficit Round Robin (DRR) scheduling solves this problem. If a queue was not able to send a packet in its previous round because its packet size was too large, the remainder from the previous amount of credits a queue gets in each round (quantum) is added to the quantum for the next round.

WDRR extends the quantum idea from the DRR to provide weighted throughput for each queue. Different queues have different weights, and the quantum assigned to each queue in its round is proportional to the relative weight of the queue among all the queues serviced by that scheduler.

Weights are assigned to each queue as a result of the service provisioning process. When coupled with policing and policy mapping provisioning, these weights and the WDRR scheduling process ensure that QoS commitments are provided to each service flow.

Figure 5-40 illustrates the ML-Series card's queuing and scheduling.

Figure 5-40 Queuing and Scheduling Model



The weighting structure allows traffic to be scheduled at 1/2048 of the port rate. This equates to approximately 488 kbps for traffic exiting a Gigabit Ethernet port, approximately 293 kbps for traffic going exiting an OC-12c port, and approximately 49 kbps for traffic exiting a FastEthernet port.

The multicast/broadcast queue is automatically created on every egress port of the ML-Series card with a committed bandwidth of 10%. This queue is used for multicast/broadcast data traffic, control traffic, L2 protocol tunnelling, and flooding traffic of the unknown MAC during MAC learning. If the aggregate of multicast/broadcast traffic at any egress port exceeds 10% of the bandwidth those frames beyond 10% of the bandwidth, are treated as best effort by the scheduler.

The unicast queues are created as the output service policy implementation on the egress ports. Each unicast queue is assigned with a committed bandwidth and the weight of the queue is determined by the normalization of committed bandwidth of all defined unicast queues for that port. The traffic beyond the committed bandwidth on any queue is treated by the scheduler according to the relative weight of the queue.

The LLQ is created as the output service policy implementation on the egress ports. Each LLQ queue is assigned with a committed bandwidth of 100% and is served with lower latency. To limit the bandwidth usage by the LLQ, a strict policer needs to be implemented on the ingress for the LLQ traffic classes.

The discard eligibility (DE) allows some packets to be treated as committed and some as discard-eligible on the scheduler. For the Ethernet frames the CoS (802.1p) bits are used to identify committed and discard eligible packets, where the RPR-CoS and the DE bits are used for RPR traffic. When congestion occurs and a queue begins to fill, the discard-eligible packets hit a lower tail-drop threshold than the committed packets. Committed packets are not dropped until the total committed load exceeds the interface output. The tail-drop thresholds adjust dynamically in the card to maximize use of the shared buffer pool while guaranteeing fairness under all conditions.

Multicast QoS

On the ML-Series cards, multicast (including IP-multicast) and broadcast traffic forwarding is supported at line-rate; however the QoS implementation on multicast traffic varies from the unicast QoS. The difference is in the priority handling for the multicast traffic on the scheduler.

For unicast packets, the priority is defined by the bandwidth command, which creates a CIR for the unicast packets in a particular class.

The priority handling of multicast packets is not based on the bandwidth command. Instead, multicast frames are assigned to a queue that has a committed bandwidth of 10% of the port bandwidth. If the multicast and broadcast traffic exceeds 10% of the port bandwidth, frames exceeding 10% are given low priority (best effort). The10% committed bandwidth for multicast is applied to the aggregate traffic and does not allow the multicast traffic of one customer to be given higher priority than another customer, unlike the QoS model for unicast traffic.

The scheduler allocates 10% of the bandwidth for multicast and broadcast traffic. Any other QoS implementation is not applicable for multicast and broadcast traffic except the allocation of 10% bandwidth for all multicast/broadcast traffics. Buffers are allocated to queues dynamically from a shared resource pool.

Control Packets and L2 Tunneled Protocols

The control packets originated by the ML-Series card have a higher priority than data packets. The external Layer 2 and Layer 3 control packets are handled as data packets and assigned to broadcast queues. Bridge protocol data unit (BPDU) prioritization in the ML-Series card gives Layer 2-tunneled BPDU sent out the multicast/broadcast queue a higher discard value and therefore a higher priority than than other packets in the multicast/broadcast queue. The Ethernet CoS (802.1p) for Layer 2-tunneled protocols can be assigned by the ML-Series card.

Priority Marking

Priority marking allows the operator to assign the 802.1p CoS bits of packets that exit the card. This marking allows the operator to use the CoS bits as a mechanism for signaling to downstream nodes the QoS treatment the packet should be given. This feature operates on the outer-most 802.1p CoS field. When used with the QinQ feature, priority marking allows the user traffic (inner Q-Tag) to traverse the network transparently, while providing a means for the network to internally signal QoS treatment at Layer 2.

Priority marking follows the classification process, and therefore any of the classification criteria identified earlier can be used as the basis to set the outgoing 802.1p CoS field. For example, a specific CoS value can be mapped to a specific Bridge Group.

Priority marking is configured using the MQC set-cos command. If packets would otherwise leave the card without an 802.1q tag, then the set cos will have no effect on that packet. If an 802.1q tag is inserted in the packet (either a normal tag or a QinQ tag), the inserted tag will have the set cos priority. If an 802.1q tag is present on packet ingress and retained on packet egress, the priority of that tag will be modified. If the ingress interface is an Q-in-Q Access port, and the set cos policy-map classifies based on ingress tag priority, this will classify based on the user priority. This is a way to allow the user-tag priority to determine the Service Provider tag priority. When a packet does not match any set cos policy-map, the priority of any preserved tag is unchanged and the priority of any inserted 802.1q tag is set to 0.

The set-cos command on the output service policy is only applied to unicast traffic. Priority marking for multicast/broadcast traffic can only be achieved by the set cos action of the policing process on the input service policy.

QinQ Implementation

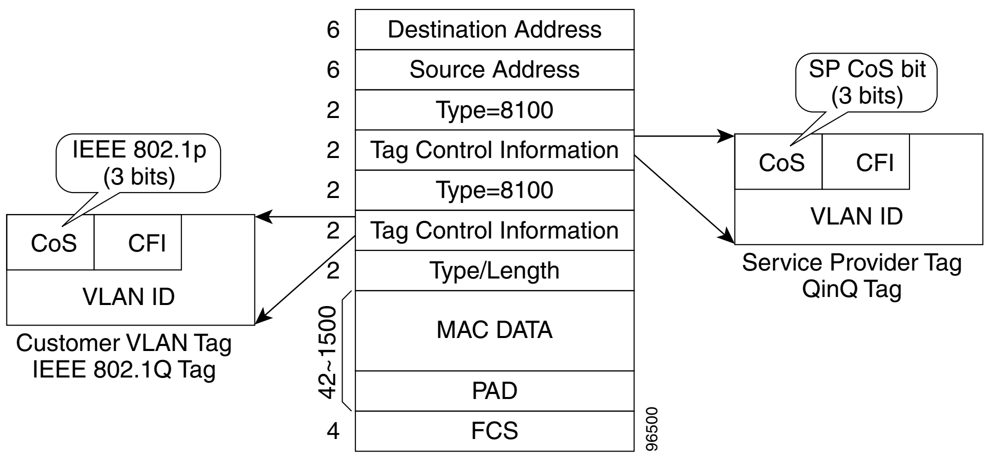
The hierarchical VLAN or IEEE 802.1Q tunneling feature enables the service provider to transparently carry the customer VLANs coming from any specific port (UNI) and transport them over the service provider network. This feature is also known as QinQ, which is performed by adding an additional 802.1Q tag on every customer frame.

Using the QinQ feature, service providers can use a single VLAN to support customers with multiple VLANs. QinQ preserves customer VLAN IDs and segregates traffic from different customers within the service-provider infrastructure, even when traffic from different customers originally shared the same VLAN ID. The QinQ also expands VLAN space by using a VLAN-in-VLAN hierarchy and tagging the tagged packets. When the service provider tag is added, the QinQ network typically loses any visibility to the IP header or the customer Ethernet 802.1Q tag on the QinQ encapsulated frames.

On the ML-Series cards, the QinQ access ports (802.1Q tunnel ports or QinQ UNI ports) have visibility to the customer CoS and the IP Precedence or IP DSCP values; therefore, the SP tag can be assigned with proper CoS bit which would reflect the customer IP Precedence, IP DSCP, or CoS bits. In the QinQ network, the QoS is then implemented based on the 802.1p bit of the service provider tag. The ML-Series cards do not have visibility into the customer CoS or IP Precedence or DSCP values after the packet is double-tagged (that is beyond the entry point of the QinQ service).

Figure 5-41 illustrates the QinQ implementation on the ML-Series card.

Figure 5-41 Q in Q



The ML-Series cards can be used as the 802.1Q tunneling device for the QinQ network and also provide the option to copy the customer frame's CoS bit into the CoS bit of the added QinQ tag. This way the service provider QinQ network can be fully aware of the necessary QoS treatment for each individual customer frames.

Flow Control Pause and QoS

If flow control and port-based policing are both enabled for an interface, flow control handles the bandwidth. If the policer gets non-compliant flow, then the policer drops or demarks the packets using the policer definition of the interface.

QoS on RPR

For VLAN bridging over RPR, all ML-Series cards on the ring must be configured with the base RPR and RPR QOS configuration. SLA and bridging configurations are only needed at customer RPR access points, where 802.1q VLAN CoS is copied to the RPR CoS. This 802.1q VLAN CoS copying can be overwritten with a set cos <action> command. The cos commit rule applies at RPR ring ingress. Transit RPR ring traffic is classified on CoS only.

If the packet does not have a VLAN header, the RPR CoS for non-VLAN traffic is set using the following rules:

1. The default CoS is 0.
2. If the packet comes in with an assigned CoS. The assigned CoS replaces the default, or if an IP packet originates locally, the IP Precedence setting replaces the CoS setting.
3. The input policy map has a set cos action.
4. The output policy map has a set cos action (except for broadcast or multicast packets).

The RPR header contains a CoS value and DE indicator. The RPR DE is set for non-committed traffic.

Resilient Packet Ring (RPR)

RPR is an emerging network architecture designed for metro fiber ring networks. This new MAC protocol is designed to overcome the limitations of IEEE 802.1D Spanning Tree Protocol (STP), IEEE 802.1W Rapid Spanning Tree Protocol (RSTP) and SONET in packet-based networks. RPR operates at the Layer 2 level and is compatible with Ethernet and SONET/SDH.

The ML-Series card's RPR relies on the QoS features of the ML-Series card for efficient bandwidth utilization with service level agreement (SLA) support. ML-Series card QoS mechanisms apply to all SONET traffic on the ML-Series card, whether passed-through, bridged, or stripped.

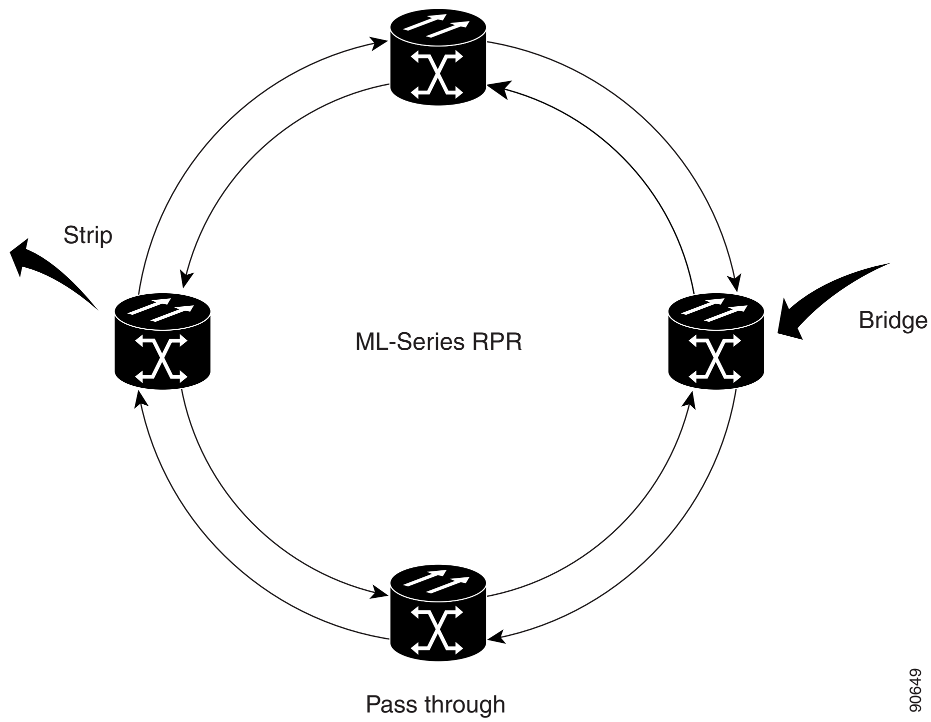
When an ML-Series card is configured with RPR and made part of a shared packet ring (SPR), the ML-Series card assumes it is part of a ring. If a packet is not destined for devices attached to the specific ML-Series, the ML-Series card simply continues to forward this transit traffic along the SONET circuit relying on the circular path of the ring architecture to guarantee the packet will eventually arrive at the destination. This eliminates the need to queue and forward the packet flowing through the non-destination ML-Series card. From a Layer 2 or Layer 3 perspective, the entire RPR looks like one shared network segment.

RPR supports operation over protected and unprotected SONET circuits. On unprotected SONET circuits RPR provides SONET -like protection without the redundant SONET protection path. Eliminating the need for a redundant SONET path frees bandwidth for additional traffic. RPR also incorporates spatial reuse of bandwidth through a hash algorithm for east/west packet transmission. RPR utilizes the entire ring bandwidth and does not need to block ring segments like STP or RSTP.

Packet Handling Operations

The RPR protocol, using the transmitted packet's header information, allows the interfaces to quickly determine the operation that needs to be applied to the packet. An ML-Series card configured with RPR is part of the ring and has three basic packet-handling operations: bridge, pass-through, or strip. Figure 5-42 illustrates these operations. Bridging connects and passes packets between the Ethernet ports on the ML-Series and the Packet over SONET/SDH (POS) circuit circling the ring. Pass-through lets the packets continue through the ML-Series card and along the ring, and stripping takes the packet off the ring and discards it. Because STP or RSTP is not in effect between nodes when RPR is configured, the transmitting RPR port strips its own packets after they return from circling the ring. A hash algorithm is used to determine the direction of the packet around the RPR.

Figure 5-42 RPR Packet Handling Operations



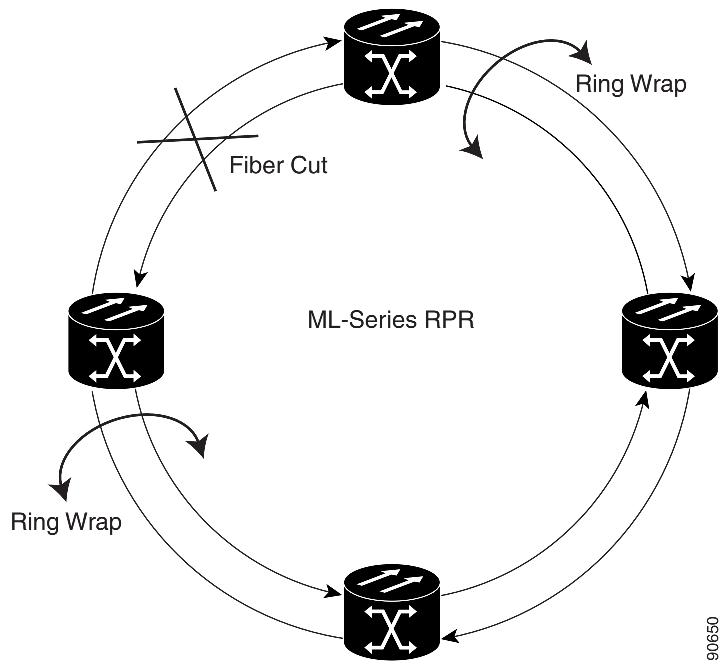
Ring Wrapping

RPR initiates ring wraps in the event of a fiber cut, node failure, node restoration, new node insertion, or other traffic problems. This protection mechanism redirects traffic to the original destination by sending it in the opposite direction around the ring after a link state change or after receiving SONET path level alarms. Ring wrapping on the ML-Series card allows sub 50-msec convergence times. RPR convergence times are comparable to SONET and much faster than STP or RSTP.

RPR on the ML-Series card survives both unidirectional and bidirectional transmission failures within the ring. Unlike STP or RSTP, RPR restoration is scalable, increasing the number of ML-Series cards in a ring does not increase the convergence time.

RPR will initiate ring wraps immediately (default) or delay the wrap with a configured carrier delay time. When configured to wrap traffic after the carrier delay, a POS trigger delay time should be added to the carrier delay time to estimate approximate convergence times. The default and minimum POS trigger delay time for the ML-Series Card is 200 ms. A carrier delay time of 200 ms (default) and a POS trigger delay time of 200 ms (default and minimum) combine for a total convergence time of approximately 400 ms. If the carrier delay is set to 0, then the convergence time would be approximately 200 ms. Figure 5-43 illustrates ring wrapping.

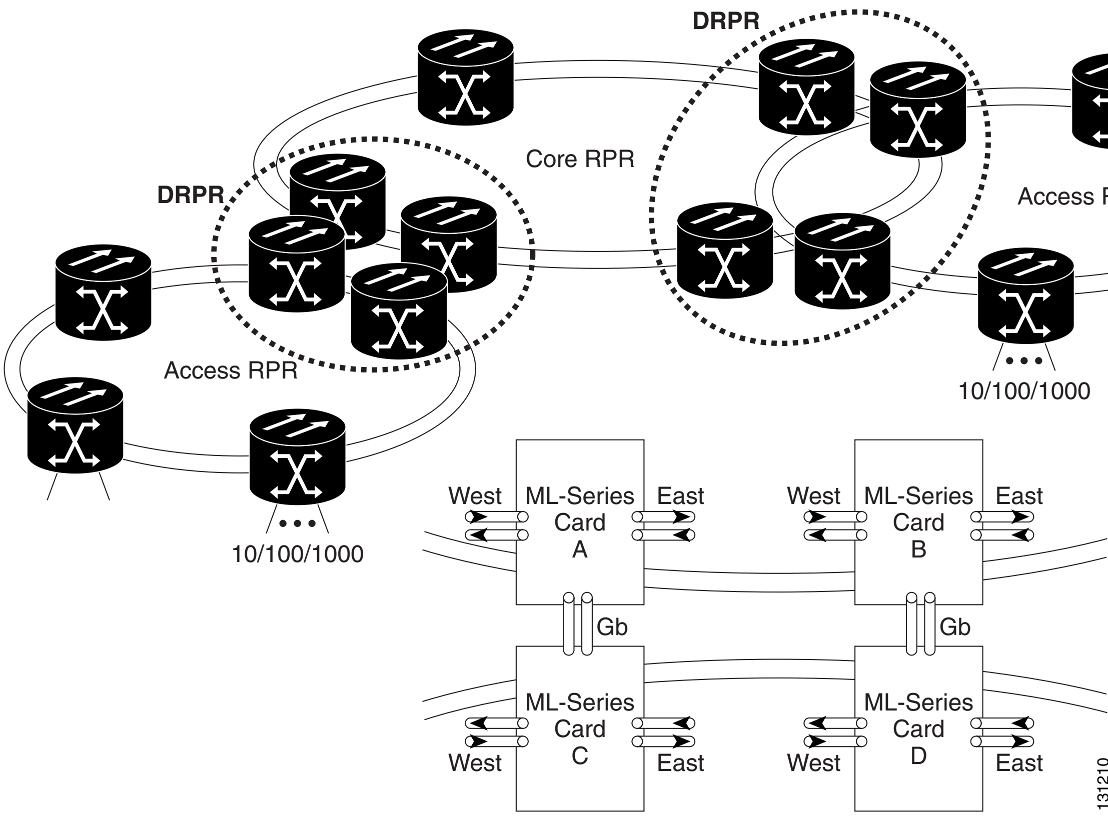
Figure 5-43 RPR Ring Wrapping



Dual RPR Interconnect

The bridge-group protocol DRPRI is an RPR mechanism that interconnects rings for protection during an ONS 15454 node failure. Interconnecting ONS 15454 nodes do not have to be adjacent to the RPR. The protocol provides two parallel connections of the rings linked by a special instance of RSTP. One connection is the active node and the other is the standby node. During a failure of the active node, link, or card, a proprietary algorithm detects the failure and causes a switchover to the standby node. Figure 5-44 shows two access rings interconnected to a core ring via DRPRI.

Figure 5-44 Dual RPR Interconnect (DRPRI)



DRPRI provides a less than 200-msec recovery time for Layer 2 bridged traffic when the ML-Series cards use the enhanced microcode image. The Layer 2 recovery time is up to 12 seconds for other microcode images. The recovery time for Layer 3 unicast and multicast traffic also depends on the convergence time of the routing protocol implemented regardless of the microcode image used.

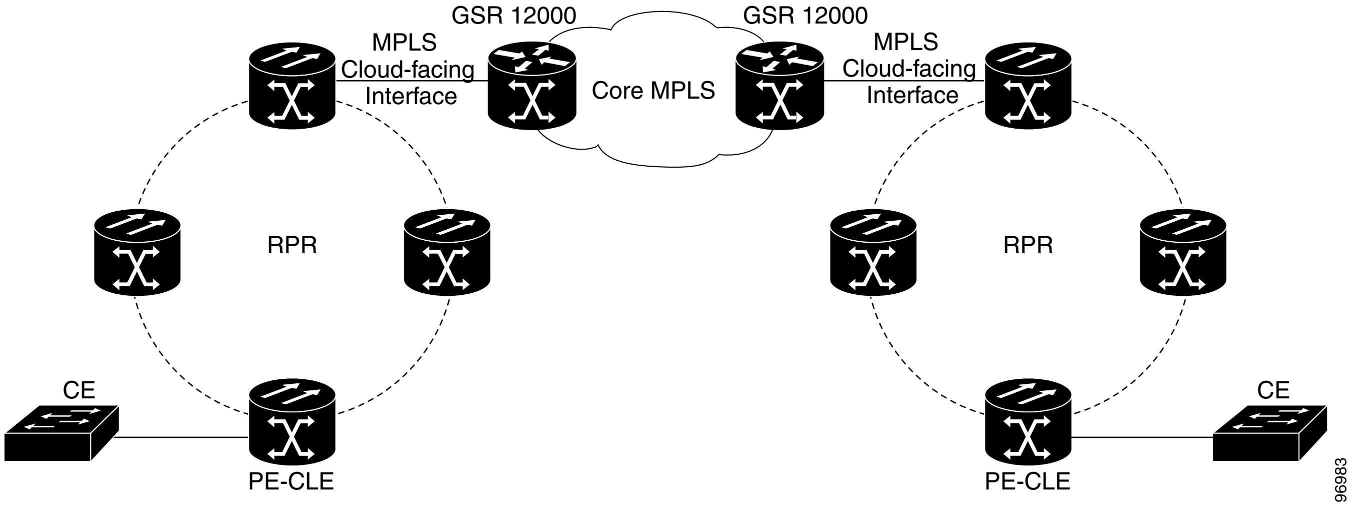
Understanding EoMPLS

EoMPLS provides a tunneling mechanism for Ethernet traffic through an MPLS-enabled Layer 3 core. It encapsulates Ethernet protocol data units (PDUs) inside MPLS packets and using label stacking forwards them across the MPLS network. EoMPLS is an Internet Engineering Task Force (IETF) standard-track protocol based on the Martini draft, specifically the draft-martini-l2circuit-encap-mpls-01 and draft-martini-l2circuit-transport-mpls-05 sections.

EoMPLS allows service providers to offer customers a virtual Ethernet line service or VLAN service using the service provider's existing MPLS backbone. It also simplifies service provider provisioning, since the provider edge customer-located edge (PE-CLE) equipment only needs to provide Layer 2 connectivity to the connected customer edge (CE) equipment.

Figure 5-45 shows an example of EoMPLS implemented on a service provider network. In the example, the ML-Series card acts as PE-CLE equipment connecting to the Cisco GSR 12000 Series through an RPR access ring. Point-to-point service is provided to CE equipment in different sites that connect through ML-Series cards to the ML-Series card RPR access ring.

Figure 5-45 EoMPLS Service Provider Network



Implementing EoMPLS on a service provider network requires ML-Series card interfaces to play three major roles. The ML-Series card interface roles must be configured on both sides of the EoMPLS point-to-point service crossing the MPLS core.

1. ML-Series card interfaces connect the provider's network directly to the customer edge equipment and are known as the PE-CLE interfaces. This PE-CLE interface on the ML-Series card is FastEthernet or GigabitEthernet and is configured to be an endpoint on the EoMPLS point-to-point session.
2. An ML-Series card interface bridges the PE-CLE interface and the RPR network of ML-Series cards. This RPR/SPR interface contains POS ports and is configured for MPLS IP.
3. An ML-Series card interface connects to a core MPLS interface. This interface is GigabitEthernet or FastEthernet and connects to the port of a Cisco GSR 12000 Series or similar device that is on the MPLS network. This MPLS cloud-facing interface bridges the SPR interface and the MPLS cloud.

Implementing EoMPLS across a service provider's network requires setting up directed Label Distribution Protocol (LDP) sessions (LSPs) between the ingress and egress PE-CLE routers to exchange information for a virtual circuit (VC). Each VC consists of two LSPs, one in each direction, since an LSP is a directed path to carry Layer 2 frames in one direction only.

EoMPLS uses a two-level label stack to transport Layer 2 frames, where the bottom/inner label is the VC label and the top/outer label is the tunnel label. The VC label is provided to the ingress PE-CLE by the egress PE-CLE of a particular LSP to direct traffic to a particular egress interface on the egress PE-CLE. A VC label is assigned by the egress PE-CLE during the VC setup and represents the binding between the egress interface and a unique and configurative VC ID. During a VC setup, the ingress and egress PE-CLE exchange VC label bindings for the specified VC ID.

An EoMPLS VC on the ML-Series card can transport an Ethernet port or an IEEE 802.1Q VLAN over MPLS. A VC type 5 tunnels an Ethernet port and a VC type 4 transports a VLAN over MPLS. In a VC type 5 session, the user can expect any traffic that is received on an ML-Series card PE-CLE port with an mpls l2transport route command to be tunneled to the remote egress interface on the far-end ML-Series card PE-CLE port. With a VC type 4, a user can expect the tunnel to act as physical extension to that VLAN. The EoMPLS session commands are entered on a VLAN subinterface on the PE-CLE, and only VLAN-tagged traffic received on that port will be tunneled to the remote PE-CLE.

EoMPLS Support

In Software Release 4.6 and higher, EoMPLS on the ML-Series card has the following characteristics:

- EoMPLS is only supported on FastEthernet and GigabitEthernet interfaces or subinterfaces.
- MPLS tag switching is only supported on SPR interfaces.
- Class of service (CoS) values are mapped to the experimental (EXP) bits in the MPLS label, either statically or by using the IEEE 802.1p bits (default).
- The ingress PE-CLE ML-Series card sets the time-to-live field to 2 and the tunnel label to a value of 255.
- Ingress PE-CLE ML-Series cards set the S bit of the VC label to 1 to indicate that the VC label is at the bottom of the stack.
- Since EoMPLS traffic is carried over the RPR, whatever load balancing is applicable for the traffic ingressing RPR is also applicable for the EoMPLS traffic.
- The Ethernet over MPLS feature is part of the Cisco Any Transport over MPLS (AToM) product set.
- The ML-Series card hosting the EoMPLS endpoint ports must be running the MPLS microcode image to support EoMPLS. Other ML-Series cards in the RPR are not restricted to the MPLS microcode image.

EoMPLS Restrictions

In Software Release 4.6 and higher, EoMPLS on the ML-Series card has the following restrictions:

- Packet-based load balancing is not supported. Instead, circuit-ID based load balancing is used.
- Zero hop or hairpin VCs are not supported. A single ML-Series card cannot be both the source and destination for a VC.
- MPLS control word for sequencing of data transmission is not supported. Packets must be received and transmitted without control word.
- Sequence checking or resequencing of EoMPLS traffic is not supported. Both depend on the control word to function.
- Maximum transmission unit (MTU) fragmentation is not supported.
- Explicit-null label for back-to-back LDP sessions is not supported.

Caution Since MTU fragmentation is not supported across the MPLS backbone, the network operator must make sure the MTU of all intermediate links between endpoints is sufficient to carry the largest Layer 2 PDU.

EoMPLS Quality of Service

The EXP is a 3-bit field and part of the MPLS header. It was created by the IETF on an experimental basis, but later became part of the standard MPLS header. The EXP bits in the MPLS header carry the packet priority. Each label switch router along the path honors the packet priority by queuing the packet into the proper queue and servicing the packet accordingly.

By default, the ML-Series card does not map the IEEE 802.1P bits in the VLAN tag header to the MPLS EXP bits. The MPLS EXP bits are set to a value of 0.

There is no straight copy between Layer 2 CoS and MPLS EXP, but the user can use the set mpls experimental action to set the MPLS EXP bit values based on a match to 802.1p bits. This mapping occurs at the entry point, the ingress of the network.

Quality of service (QoS) for EoMPLS traffic on ML-Series cards uses strict priority and/or weighted round robin scheduling in the egress interface of both imposition and disposition router. This requires selection of the service class queue that determines the type of scheduling. In the imposition router, the priority bits EXP or RPR CoS that are marked based on policing are used to select the service class queue and in the disposition router, the dot1p CoS bits (which are copied from EXP bits of the labels) are used to do the same. In addition to scheduling in the egress interface, the output policy action can also include remarking of EXP and RPR CoS bits.

EoMPLS on the ML-Series card uses the Cisco Modular Quality of Service Command-Line Interface (MQC), just like the standard QoS on the ML-Series card. But the full range of MQC commands are not available. See Table 18-1 in the *Cisco ONS 15454 Ethernet Card Software Feature and Configuration Guide*, Software Release 5.0 for the applicable MQC statements and actions for the ML-Series card interfaces.

EoMPLS Configuration Guidelines

These are the guidelines for configuring EoMPLS over the ML-Series card:

- Loopback addresses are used to specify the peer ML-Series card's IP address.
- LDP configuration is required. The default Tag Distribution Protocol (TDP) will not work.
- EoMPLS uses LDP targeted session between the ML-Series cards to create the EoMPLS VCs.
- The MPLS backbone must use an Interior Gateway Protocol (IGP) routing protocol, for example, Intermediate System-to-Intermediate System (IS-IS) Protocol or Open Shortest Path First (OSPF).
- Tag switching of IP packets must be enabled on the SPR interface for the PE-CLE ML-Series card.

Refer to the *Cisco ONS 15454 Ethernet Card Software Feature and Configuration Guide, Software Release 5.0* for configuration commands.

RMON

The ML-Series card features remote monitoring (RMON) that allows network operators to monitor the health of the network with a network management system (NMS). The ML-Series card Ethernet interfaces support RMON for statistics, utilization, and history. You can access RMON threshold provisioning through TL1 or CTC. For RMON threshold provisioning with CTC, refer to the *Cisco ONS 15454 Troubleshooting Guide*. For TL1 information, refer to the *Cisco ONS SONET TL1 Command Guide*.

The MIBs supported are as follows:

- RFC-2819 - RMON MIB
- RFC-2358 - Ether-Like-MIB
- RFC-2233 - IF MIB

SNMP

Both the ONS 15454 and the ML-Series cards have SNMP agents and support SNMP Version 1 (SNMPv1) and SNMP Version 2c (SNMPv2c) sets and traps. The ONS 15454 accepts, validates, and forwards get/getNext/set requests to the ML-Series through a proxy agent. The ML-Series requests contain the slot identification of the ML-Series cards to distinguish the request from a general ONS 15454 SNMP request. Responses from the ML-Series are relayed by the ONS 15454 to the requesting SNMP agents.

The ML-Series card SNMP support includes:

- Spanning Tree Protocol (STP) traps from Bridge-MIB (RFC 1493)
- Authentication traps from RFC 1157
- Link-up and link-down traps for Ethernet ports from IF-MIB (RFC 1573)
- Export of QoS statistics through the CISCO-PORT-QOS-MIB extension

Note The ML-Series card CISCO-PORT-QOS-MIB extension includes support for COS-based QoS indexing. It does not support configuration objects.

CHAPTER 6

Technical 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.

This chapter describes technical specifications of the ONS 15454 equipment. For additional information, refer to the *Cisco ONS 15454 Reference Manual*.

The following topics are covered in this chapter:

Note In this chapter, the terms ONS 15454, shelf, and node are used interchangeably.

ONS 15454 Specifications

The Cisco ONS 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 Network 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

ONS 15454 Configurations

Table 6-1 lists how the ONS 15454 can be configured.

Table 6-1 ONS 15454 Node Configurations

ONS 15454 MSPP	ONS 15454 MSTP	ONS 15454 Hybrid
Terminal	Hub	1+1 Protected Flexible Terminal
Point-to-Point	Terminal	Terminal
Linear	OADM	Scalable Terminal
Two-fiber path protection	ROADM	OADM
Two- fiber BLSR	Anti-ASE	Line Amplifier
Four-fiber BLSR	Line Amplifier	Amplified TDM
Dual Ring Interconnect (DRI)	OSC Regeneration	
Path protected mesh network (PPMN)		
Add-drop multiplexer (ADM)		
Regenerator		
Hubbed Rings		
Multi-hubbed Rings		

Physical Specifications

The ONS 15454 shelf assemblies with a fan tray and reversible mounting ears has the following dimensions:

Table 6-2 ONS 15454 Shelf Dimensions

Physical Dimension	15454-SA-ANSI Shelf	15454-SA-HD Shelf
Height	18.5 inches (40.7 cm)	18.5 inches (40.7 cm)
Width:		
• Minimum	19 inches (41.8 cm)	19 inches (41.8 cm)
• Maximum	23 inches (50.6 cm)	23 inches (50.6 cm)
Depth[1] BNC and SMB EIAs:		
• Without cabling and rear cover	12 inches (26.4 cm)	12 inches (26.4 cm)
• With cabling and rear cover	14 inches (35.6 cm)	14 inches (35.6 cm)
Depth[1] UBIC-H EIAs:		
• Without cabling and rear cover	NA	12 inches (26.4 cm)
• With cabling and rear cover	NA	15.0 inches (33 cm)

Table 6-2 ONS 15454 Shelf Dimensions (continued)

Physical Dimension	15454-SA-ANSI Shelf	15454-SA-HD Shelf
Depth[1] UBIC-V EIAs:		
• Without cabling and rear cover	NA	12 inches (26.4 cm)
• With cabling and rear cover	NA	16.75 inches (36.85 cm)
Weight:		
• Empty (without cards)	55 lb (24.947 kg)	55 lb (24.947 kg)
• Full (with cards)	98 lb (44.451 kg)	98 lb (44.451 kg)
Footprint	13 ft^2	13 ft^2
Minimum Aisle Clearance Requirement	24-inches	24-inches

1. The optional deep door adds approximately 2 inches (4.4 cm) to depth dimensions.

Environmental Specifications

Note The Cisco ONS 15454 is intended for use with telecommunications equipment only.

Warning **Only trained and qualified personnel should be allowed to install, replace, or service this equipment.**

Warning **This equipment must be installed and maintained by service personnel as defined by AS/NZS 3260. Incorrectly connecting this equipment to a general purpose outlet could be hazardous. The telecommunications lines must be disconnected 1) before unplugging the main power connector and/or 2) while the front door is open.**

Warning **The ONS 15454 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.**

Warning **The ONS 15454 is suitable for mounting on concrete or other non-combustible 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 Telcordia 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 Environments (CPEs).

Note 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.

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

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°F to +149°F (-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 environmentally hardened and will function at operating temperatures of -40°F to +149°F (-40°C to +65°C) and humidity of 5 to 95 percent (non-condensing) when configured with the following components:

- 15454-SA-HD Shelf
- 15454-SA-ANSI Shelf
- 15454-FTA2 Fan Tray
- 15454-FTA3-T Fan Tray
- 15454-TCC2
- 15454-TCC2P
- 15454-XC-T
- 15454-AIC-T
- 15454-AIC-I
- 15454-AEP
- 15454-DS3_EC1-48[1]
- 15454-DSXM-12

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

Note The I-Temp symbol is displayed on the faceplate of an I-Temp compliant card. A card without this symbol is C-Temp compliant.

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

- UL 1950

1. Not deployable as I-Temp because the exising XC-10G cross-connect card is not rated as I-Temp.

- 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: -40 to -56.7VDC
- Maximum Power Consumption: 1060W (System Release 3.1 or higher); 952W (System Release prior to 3.1)
- Recommended Amperage: 35A with SA-HD; 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/TCC2P)
- Volatile memory (synchronous dynamic RAM): 256 MB (with TCC2/TCC2P)
- When dual TCC2/TCC2P cards are installed in the ONS 15454, each TCC2/TCC2P card hosts a separate database; therefore, the protect card database is available if the database on the working TCC2/TCC2P fails. You can also store a backup version of the database on the workstation running CTC. This operation should be part of a regular ONS 15454 maintenance program at approximately weekly intervals, and should also be completed when preparing an ONS 15454 for a pending natural disaster, such as a flood or fire.

Note The following parameters are not backed up and restored: node name, IP address, mask and gateway, and Internet Inter-ORB Protocol (IIOP) port. If you change the node name and then restore a backed up database with a different node name, the circuits map to the new node name. Cisco recommends keeping a record of the old and new node names.

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)
- Modes: External, Line, Mixed
- References: BITS 1, BITS 2, Line, Internal
- SSM Message Set: Generation 1 or Generation 2

BITS Interface

- Two DS-1 or 64KHz+8KHz (TCC2P with R5.0 and higher only) BITS inputs
- Two derived DS-1 or 6MHz (TCC2P with R5.0 and higher only) outputs
- BITS 1 and BITS 2 pins provided on backplane
- BITS Coding: AMI or B8ZS
- BITS Framing: SF (D4) or ESF

Operations Interface

- Local Craft Access: An EIA/TIA-232 ASCII interface (9600 baud) or 10BaseT LAN interface on the TCC2/TCC2P faceplate.
- External Network/LAN Access: A 10BaseT LAN interface via the backplane. Set the LAN 10/100 Ethernet port for half-duplex.
- Modem Access: An EIA/TIA-232 DB-9 type connector on the TCC2/TCC2P faceplate. See Table 6-3, Computer Requirements, for modem settings.
- TL1 Access: An EIA/TIA-232 ASCII interface (9600 baud) on the TCC2/TCC2P faceplate or 10BaseT LAN interface on both the TCC2/TCC2P faceplate and backplane.
- Cisco Transport Controller (CTC) Access: A 10BaseT LAN interface on the TCC2/TCC2P faceplate and backplane.

Computer Requirements

Table 6-3 lists the requirements for PCs and UNIX workstations. In addition to the Java Runtime Environment (JRE), the Java plug-in and modified java.policy file are also included on the ONS 15454 software CD and the ONS 15454 documentation CD.

Table 6-3 Computer Requirements

Area	Requirements	Notes
Processor	Pentium III (or higher) 700 MHz, UltraSPARC, or equivalent	700 MHz is the recommended processor speed. You can use computers with a lower processor speed; however, you may experience longer response times and slower performance.
RAM	384 MB RAM recommended, 512 MB RAM optimum	Cisco recommends using 512 MB RAM for networks with 25 nodes or more to avoid longer response times and slower performance.

Table 6-3 Computer Requirements (continued)

Area	Requirements	Notes
Hard Drive	20 GB recommended with 50 MB vacant space available	—
Operating System	• PC: Windows 98, Windows NT 4.0 with Service Pack 6, Windows 2000, or Windows XP • Workstation: Solaris versions 8 or 9	—
JRE	JRE 1.4.2 or 1.3.1_02	JRE 1.4.2 is installed by the CTC Installation Wizard included on the Cisco ONS 15454 software and documentation CDs. JRE 1.4.2 provides enhancements to CTC performance, especially for large networks with numerous circuits. Cisco recommends that you use JRE 1.4.2 for networks with Software R4.6 nodes. If CTC must be launched directly from nodes running software earlier than R4.6, Cisco recommends JRE 1.3.1_02.
Web Browser	• PC: Netscape 4.76, Netscape 7.x, Internet Explorer 6.x • UNIX Workstation: Netscape 4.76, Netscape 7.x	For the PC, use JRE 1.4.2 or 1.3.1_02 with any supported web browser. For UNIX, use JRE 1.4.2 with Netscape 7.x or JRE 1.3.1_02 with Netscape 4.76. Netscape 4.76 or 7.x is available at the following site: http://browser.netscape.com Internet Explorer 6.x is available at the following site: http://www.microsoft.com
java.policy File	A java.policy file modified for CTC	The java.policy file is modified by the CTC Installation Wizard included on the Cisco ONS 15454 software and documentation CDs.

Table 6-3 Computer Requirements (continued)

Area	Requirements	Notes
Cable	User-supplied CAT-5 straight-through cable with RJ-45 connectors on each end to connect the computer to the ONS 15454 directly or through a LAN port on the TCC2/TCC2P faceplate	—
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 Assemblies

The ONS 15454 shelf assembly is the physical steel enclosure that holds plug-in cards, EIAs, and connectors for power, grounding, and alarm contacts. Table 6-4 lists the shelf assemblies deployed to date, with the newest assembly available listed at the top of the table.

Table 6-4 Shelf Assembly Versions

Product Name	Part Number	Description
15454-SA-HD	800-23890-xx 800-24848-xx	Cisco ONS 15454 High Density Shelf Assembly, NEBS 3 ANSI, High Density Electrical Capacity, Industrial Temperature Rated
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)

Table 6-4 Shelf Assembly Versions (continued)

Product Name	Part Number	Description
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

Shelf Assembly Overview

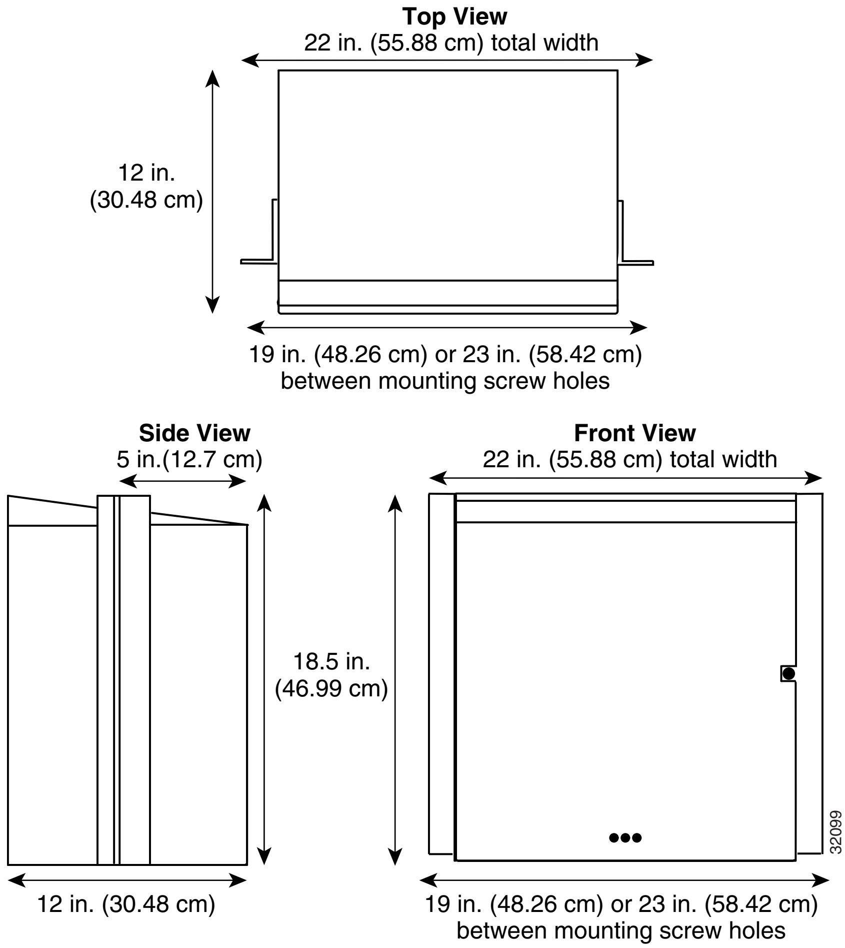
When installed in an equipment rack, the ONS 15454 assembly is typically connected to a fuse and alarm panel to provide centralized alarm connection points and distributed power for the ONS 15454. Fuse and alarm panels are third-party equipment and are not described in this documentation. The front door of the ONS 15454 allows access to the shelf assembly, fan-tray assembly, and cable-management area. The backplane provide access to alarm contacts, external interface contacts, power terminals, and BNC, SMB, and UBIC connectors.

You can mount the ONS 15454 in a 19- or 23-inch rack (482.6 or 584.2 mm). The shelf assembly ships preset for installation in a 23-inch (584.2 mm) rack, but you can reverse the mounting bracket to fit the smaller 19-inch (482.6 mm) rack. The shelf assembly weighs approximately 55 pounds (24.94 kg) with no cards installed. The shelf assembly includes a front door for added security, a fan tray module for cooling, and extensive cable-management space. An optional deep door kit (P/N 15454-SA-DRKIT) can be ordered to accommodate fiber jumpers requiring extended bending radius. 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.

ONS 15454 optical cards have SC and 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, and EC-1) require electrical interface assemblies (EIAs) to provide the cable connection points for the shelf assembly. In most cases, EIAs are ordered with the ONS 15454 and come preinstalled on the backplane. See the Electrical Interface Assemblies section in this chapter for more information about the EIAs.

The ONS 15454 is powered using two -48 VDC power feeds (Breaker A and Breaker B) with a minimum of 30 Amp circuit breakers. Maximum power consumption is 1,060 Watts. Negative, return, and ground power terminals are accessible on the backplane. Figure 6-1 shows the dimensions of the ONS 15454 shelf assembly.

Figure 6-1 Shelf Assembly Dimensions



System Release 3.1 introduced the 15454-SA-ANSI shelf assembly. This shelf 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.

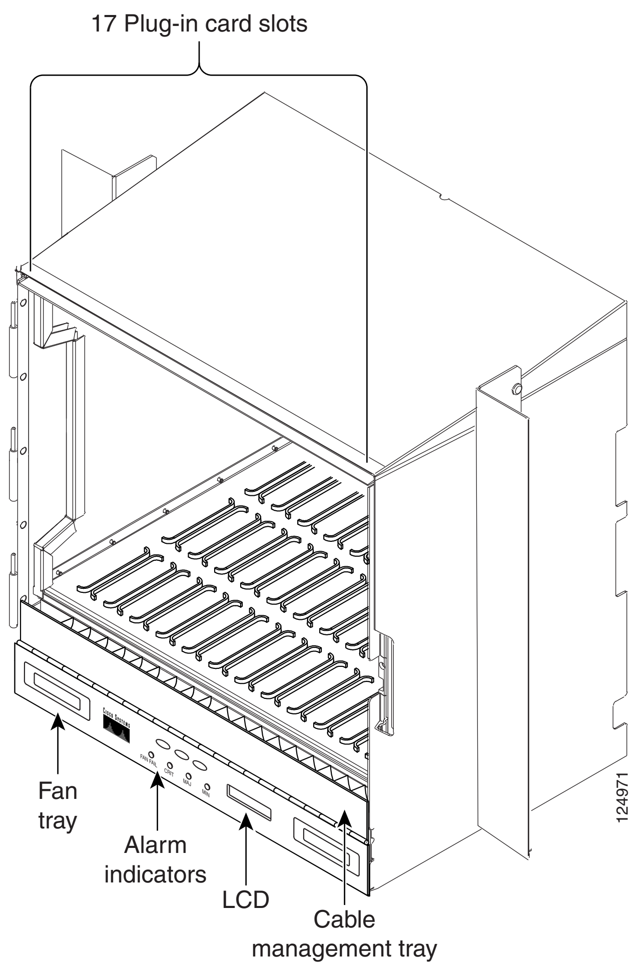
Release 4.6 introduced the new high density 15454-SA-HD shelf assembly and updated universal backplane interface connector (UBIC) EIAs. This new high-density shelf assembly and UBICs with an increased number of connectors enables a single shelf to support up to 224 DS1s, 192 DS3/EC-1s, and 1:N protection where N is less than or equal to five, leveraging higher-density electrical cards, as well as free-up valuable shelf slots to be used for other service interfaces. Except for these changes and new symbols identifying the high density card slots, this new shelf is identical to the 15454-SA-ANSI shelf assembly. The high density shelf is software independent and backwards compatible with early releases.

Slot Assignments

As shown in Figure 6-2, 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 TCC2/TCC2P 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 DS3XM-12 cards that are used in 1:N protection.

Figure 6-2 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 6-5 lists the slot and card symbol definitions.

Table 6-5 Slot and Card Symbol Definitions

Symbol Color/Shape	Definition
Orange/Circle	Multi-speed slots 1 to 6 and 12 to 17. Only install ONS 15454 cards with a circle symbol on the faceplate in these slots.
Blue/Triangle	High-speed slots 5, 6, 12, and 13. Only install ONS 15454 cards with circle or a triangle symbol on the faceplate in these slots.
Purple/Square	TCC2/TCC2P slots 7 and 11. Only install ONS 15454 cards with a square symbol on the faceplate in these slots.

Table 6-5 Slot and Card Symbol Definitions (continued)

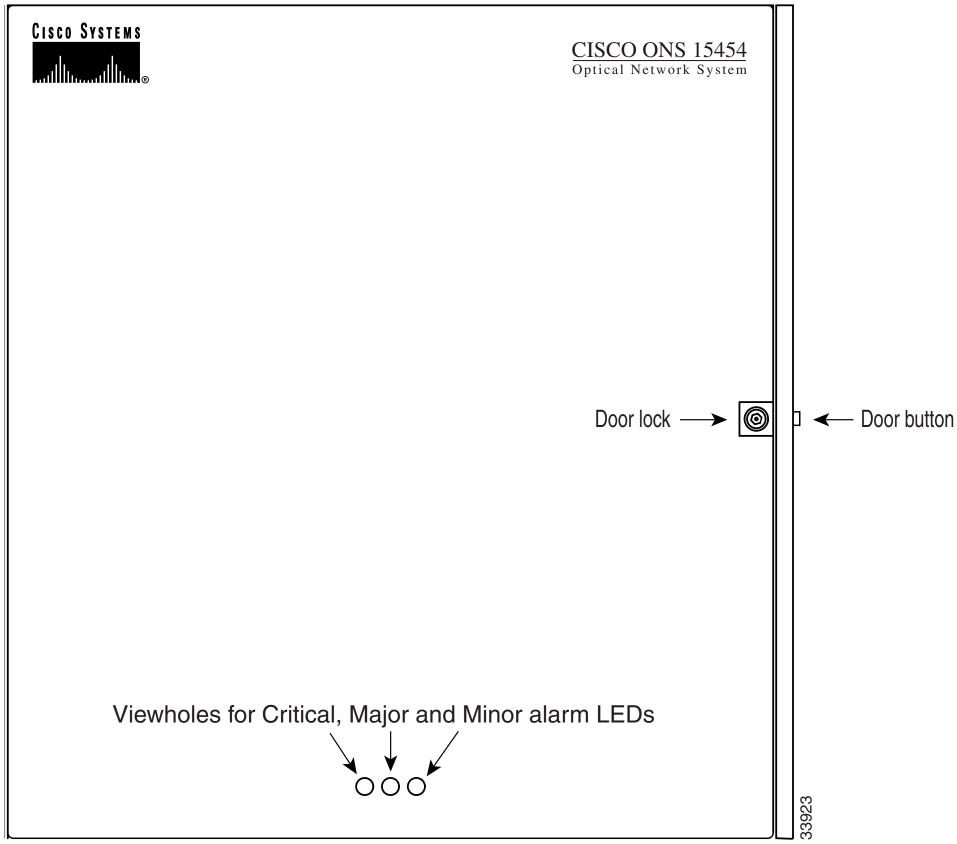
Symbol Color/Shape	Definition
Green/Cross	Cross-connect (XC/XCVT/XC10G) slots 8 and 10. Only install ONS 15454 cards with a cross symbol on the faceplate in these slots.
Red/P	Protection slots 5 and 15 for 1:N protection schemes. In these slots, install only ONS 15454 cards with a red P on the faceplate.
Red/Diamond	AIC slot 9. In this slot, install only ONS 15454 cards with a diamond symbol on the faceplate.
Gold/Star	Multi-speed slots 1 to 4 and 14 to 17. In these slots, install only ONS 15454 cards with a star symbol on the faceplate.
Blue/Hexagon	(Only used with the 15454-SA-HD shelf assembly) High density card slots 1 to 3 and 15 to 17. In these slots, install only high density ONS 15454 cards with a blue hexagon 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 Doors

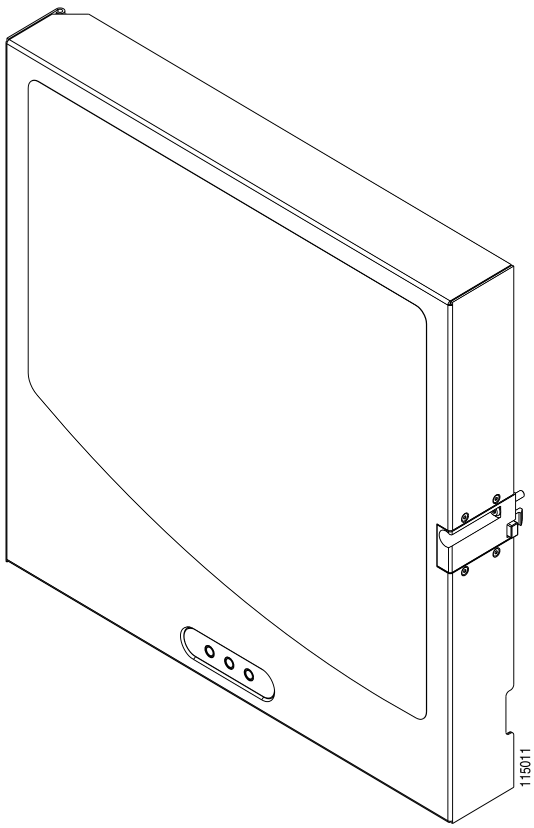
The ONS 15454 shelf assembly features a standard locked door to the front compartment. A pinned hex key that unlocks the front door ships with the ONS 15454. A button on the right side of the shelf assembly releases the door. The front door shown in Figure 6-3 provides access to the shelf assembly, cable-management tray, fan-tray assembly, and LCD screen.

Figure 6-3 Shelf Assembly Front Door



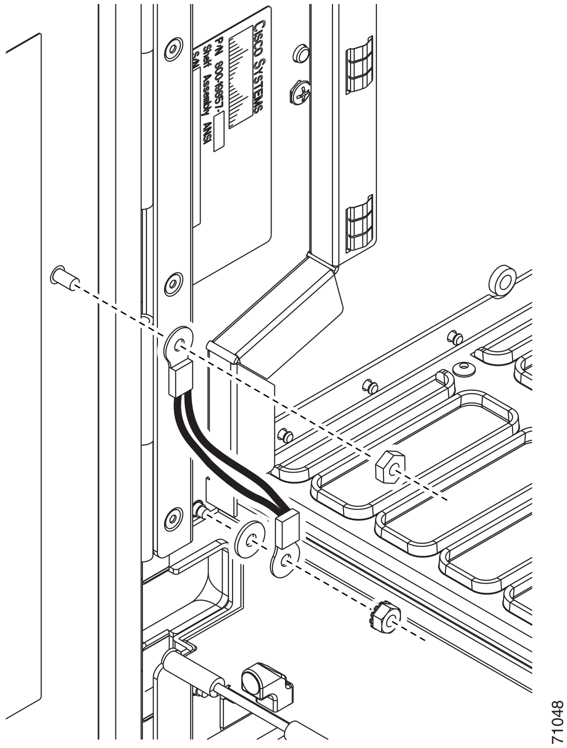
The ONS 15454 ships with a standard door, but an optional deep door kit (P/N 15454-SA-DRKIT) can be ordered to accommodate fiber jumpers requiring an extended bending radius (see Figure 6-4).

Figure 6-4 Cisco ONS 15454 Deep Door



A button on the right side of the shelf assembly releases the 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

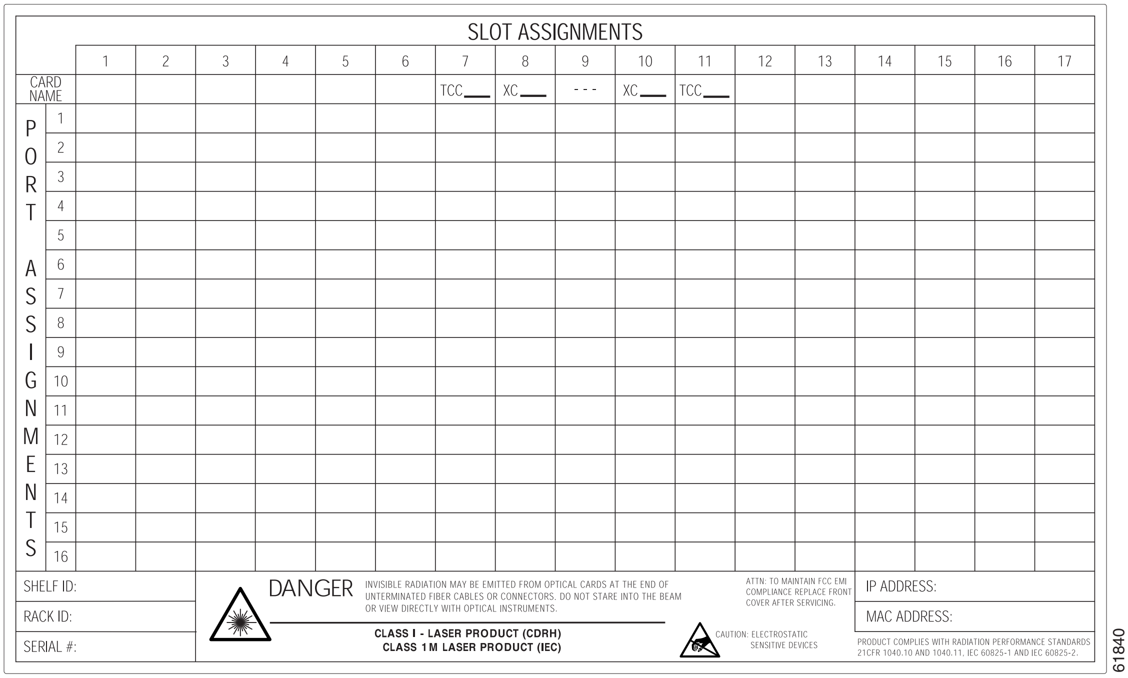
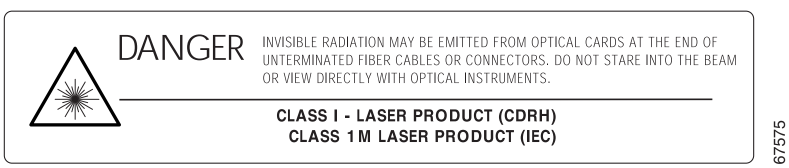


Figure 6-7 Laser Warning on the Front Door Label



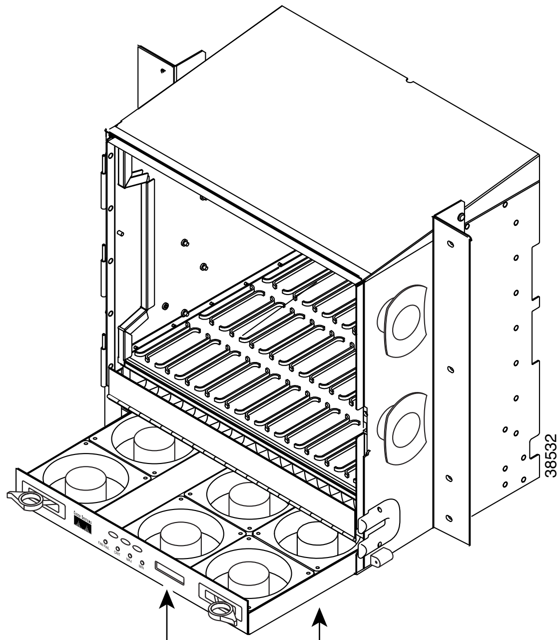
Fan Tray Assembly

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.

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

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 installed and removed by hand. Inspect the air filter every 30 days, and clean the filter every three to six months. Replace the air filter every two to three years and keep spare filters in stock. Avoid cleaning the air filter with harsh cleaning agents or solvents.

Caution Do not operate an ONS 15454 without the mandatory fan-tray air filter.

Fan speed is controlled by TCC2/TCC2P card temperature sensors. The sensors measure the input air temperature at the fan-tray assembly. Fan speed options are low, medium, and high. If the TCC2/TCC2P card fails, the fans automatically shift to high speed. The temperature measured by the TCC2/TCC2P sensors is displayed on the LCD screen. Table 6-6 lists power requirements for the fan-tray assembly.

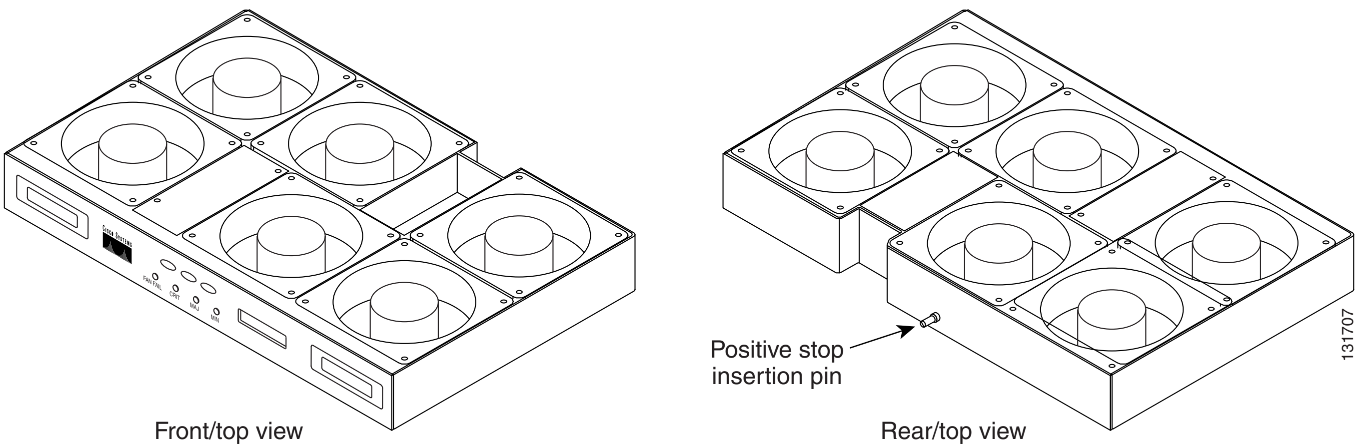
If one or more fans fail on the fan-tray assembly, replace the entire assembly. You cannot replace individual fans. The red Fan Fail LED on the front of the fan tray illuminates when one or more fans fail. For fan tray replacement instructions, refer to the *Cisco ONS 15454 Troubleshooting Guide*. The red Fan Fail LED clears after you install a working fan tray.

Table 6-6 Fan-tray Power Requirements

Fan Tray Assembly	Watts	Amps	BTU/Hr
FTA2	53	1.21	198
FTA3 -T	86.4	1.8	295

The FTA3-T shown in Figure 6-9 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 ANSI offering.

Figure 6-9 FTA3-T High Airflow Assembly



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 (-40o to +65o Celsius).

The compatibility between fan tray assemblies and shelf assemblies is outlined in Table 6-7.

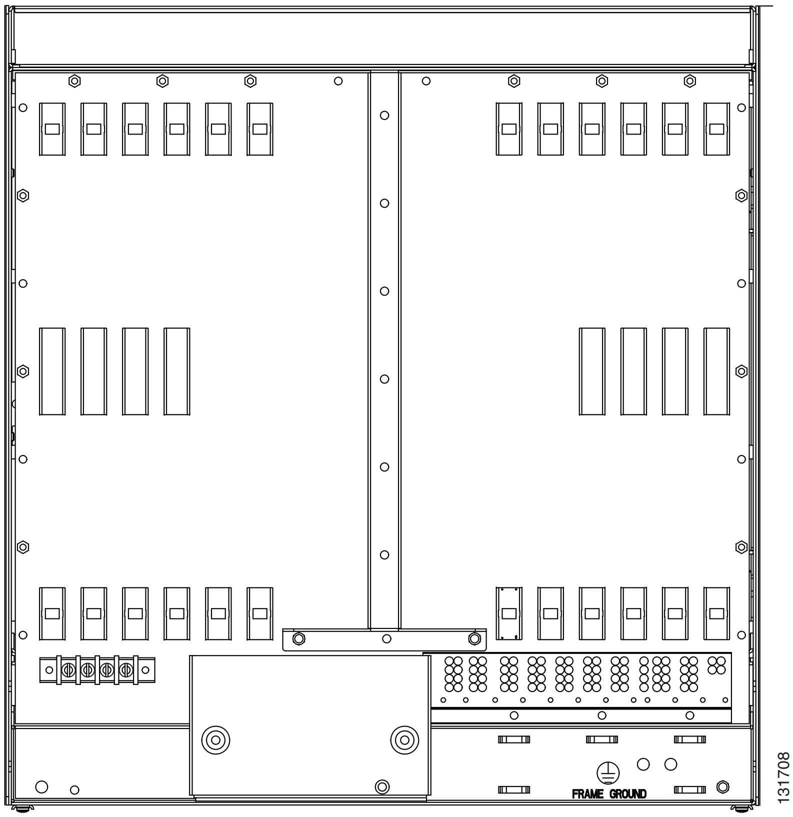
Table 6-7 Fan and Assembly Tray Compatibility Matrix

Fan Tray Assembly Product Name	Fan Tray Assembly Part Number	Shelf Assembly Product Name
15454-FTA3-T (Required for XC-10G equipped systems)	800-23907-xx 800-21448-xx 800-19858-xx (FTA-3)	15459-SA-HD 15454-SA-ANSI
15454-FTA2	800-07145-xx 800-07385-xx 800-19591-xx 800-19590-xx	15454-SA-ANSI 15454-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

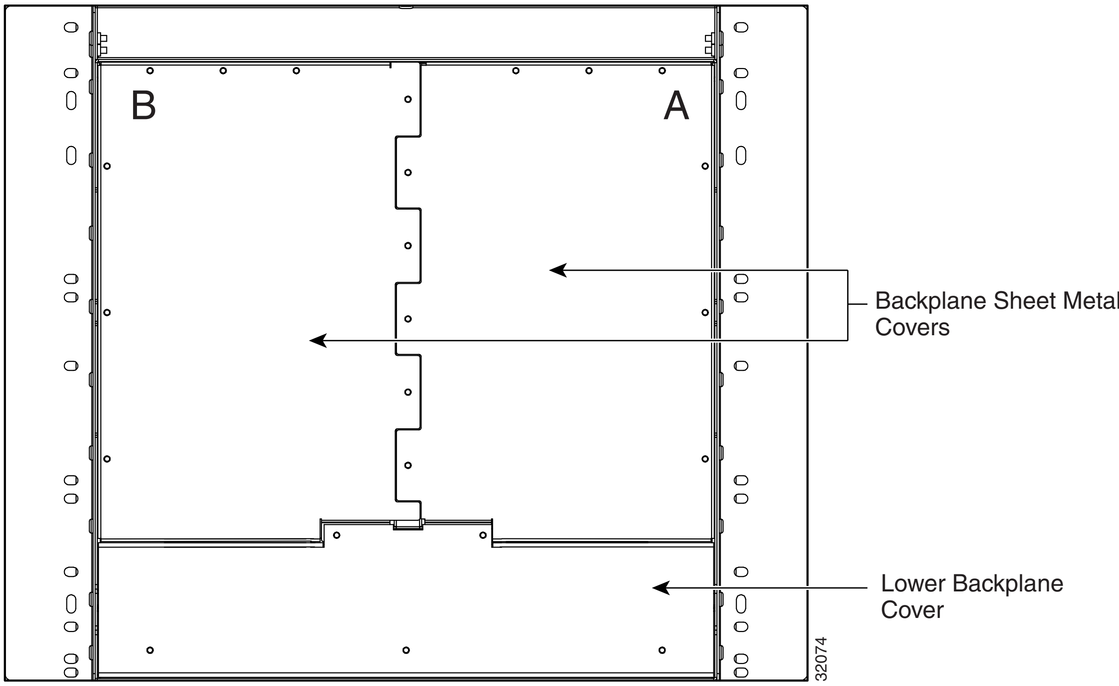
The backplane (Figure 6-10) provides access to alarm contacts, external interface contacts, power terminals, and Electrical Interface Assemblies (EIAs).

Figure 6-10 ONS 15454 Backplane



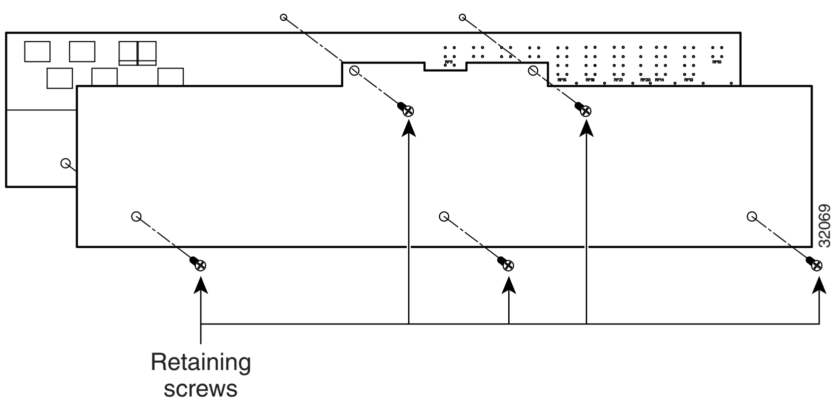
If a backplane does not have Electrical Interface Assembly (EIA) panels installed, it should have two sheet metal backplane covers (one on each side of the backplane) as illustrated in Figure 6-11. Each cover is held in place with nine 6-32 x 3/8 inch Phillips screws.

Figure 6-11 Sheet Metal Backplane Covers



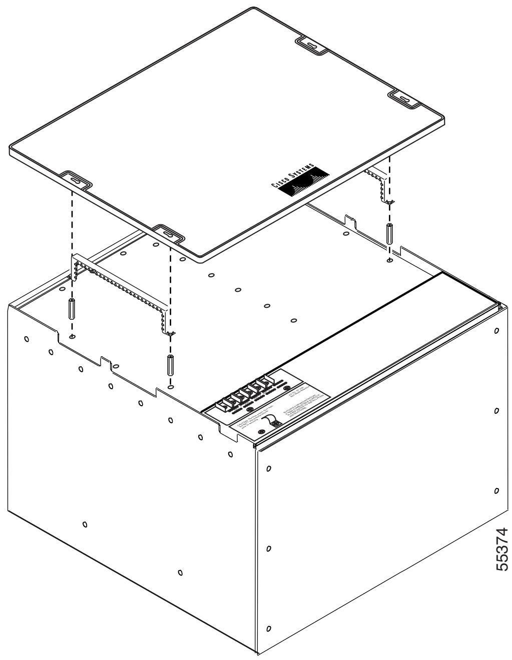
Prior to System R4.0, the lower section of the backplane was covered by a clear plastic protector. With System R4.0 and higher, this section of the backplane is covered by a metal protector to reduce electro-magnetic interference. Both protectors are held in place by five 6-32 x 1/2 inch screws. Remove 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 plastic Rear Cover Assembly (RCA) that provides additional protection for the cables and connectors on the backplane (see Figure 6-13).

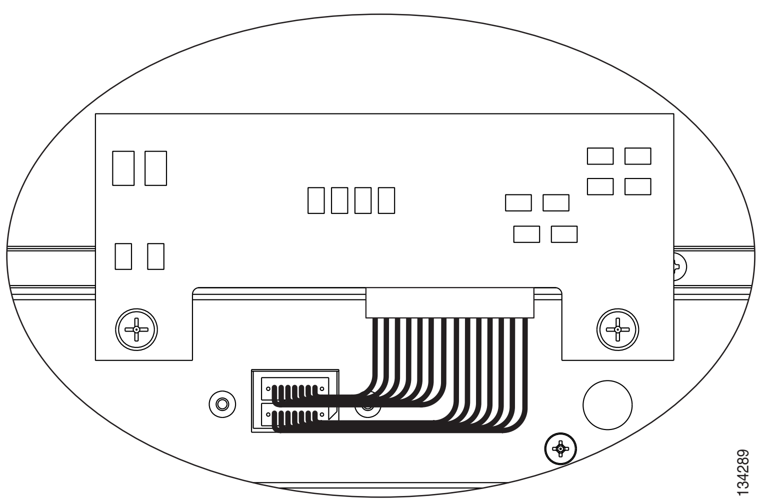
Figure 6-13 Plastic Rear Cover with Spacers



Alarm Interface Panel

The Alarm Interface Panel (AIP) is located next to 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).

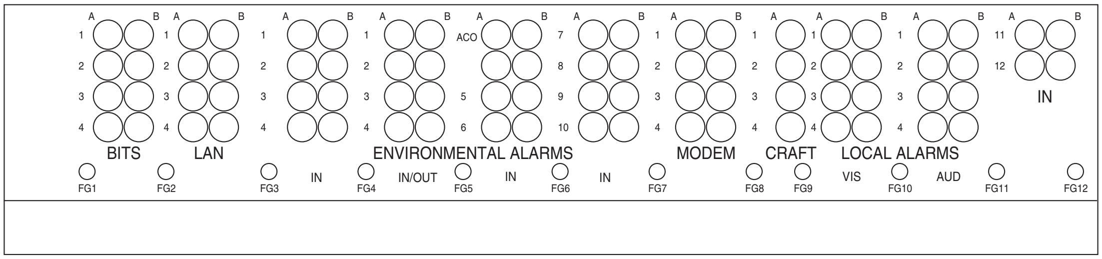
Note The MAC address identifies the nodes that support circuits. It allows CTC to determine circuit sources, destinations, and spans. The TCC2 or TCC2P cards in the ONS 15454 also use the MAC address to store the node's database.

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 Later)



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 B1	Alarm input pair number 1: Reports closure on connected wires.
	A2 B2	Alarm input pair number 2: Reports closure on connected wires.
	A3 B3	Alarm input pair number 3: Reports closure on connected wires.
	A4 B4	Alarm input pair number 4: Reports closure on connected wires.
	A5 B5	Alarm input pair number 5: Reports closure on connected wires.
	A6 B6	Alarm input pair number 6: Reports closure on connected wires.
	A7 B7	Alarm input pair number 7: Reports closure on connected wires.
	A8 B8	Alarm input pair number 8: Reports closure on connected wires.
	A9 B9	Alarm input pair number 9: Reports closure on connected wires.
	A10 B10	Alarm input pair number 10: Reports closure on connected wires.
	A11 B11	Alarm input pair number 11: Reports closure on connected wires.
	A12 B12	Alarm input pair number 12: Reports closure on connected wires.

Field	Pin	Function
ENVIR ALARMS IN/OUT N/O	A1/A13 B1/B13	Normally open output pair number 1
	A2/A14 B2/B14	Normally open output pair number 2
	A3/A15 B3/B15	Normally open output pair number 3
	A4/A16 B4/B16	Normally open output pair number 4
ACO	A1 B1	Normally open ACO pair
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 B1	Alarm output pair number 1: Remote audible alarm.
	A2 B2	Alarm output pair number 2: Critical audible alarm.
	A3 B3	Alarm output pair number 3: Major audible alarm.
	A4 B4	Alarm output pair number 4: Minor audible alarm.
LOCAL ALARMS VIS (Visual) N/O	A1 B1	Alarm output pair number 1: Remote visual alarm.
	A2 B2	Alarm output pair number 2: Critical visual alarm.
	A3 B3	Alarm output pair number 3: Major visual alarm.
	A4 B4	Alarm output pair number 4: Minor visual alarm.

If you are using an AIC-I card, contacts provisioned as OUT are 1-4. Contacts provisioned as IN are 13-16.

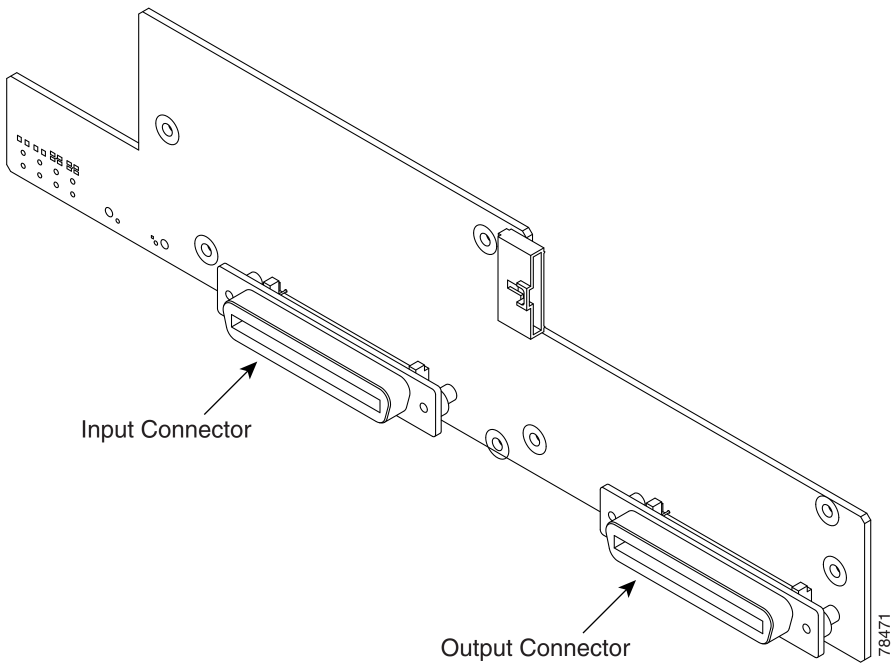
83020

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 (Alarm Cut Off) for audible alarms. You can also activate the ACO function by pressing the ACO button on the TCC2/TCC2P 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 6-16 is a printed circuit board assembly that is installed on the backplane. Here, 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.

See the *Cisco ONS 15454 Reference Manual* for AEP Specifications.

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, DS3XM-12, EC-1, or DS3/EC1-48 cards.

Seven different EIA backplane covers are available for the ONS 15454:

1. BNC
2. High-Density BNC

3. Mini BNC
4. SMB
5. AMP Champ
6. UBIC-V
7. UBIC-H

EIAs are attached to the shelf assembly backplane to provide electrical interface cable connections. EIAs are available with SMB, BNC, and SCSI connectors for DS-3 or STS-1 electrical circuits. EIAs are available with AMP Champ and SCSI connectors for DS-1 circuits. You must use SMB or UBIC EIAs for DS-1 twisted-pair cable installations. UBIC-V, UBIC-H or Mini-BNC (DS3/EC-1) EIAs are required when using the high-density (48-port DS-3/EC-1 and 56-port DS-1) electrical cards. UBIC-V and UBIC-H EIAs use 50-pin SCSI connectors for DS3, EC-1 and DS-1 circuits.

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 including the UBIC).

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 6-8 describes the EIA configurations available for the ONS 15454.

Table 6-8 Electrical Interface Assembly Configurations

EIA Type	Interface Cards Supported	A Side Connector Capacity	A Side Connectors Map To	A Side Product Number	B Side Connector Capacity	B Side Connectors Map To	B Side Product Number
Low-Density BNC	DS3-12 DS3XM-6 EC1-12	24 pairs of BNC connectors	Slot 2 and Slot 4	15454-EIA-BNC-A48	24 pairs of BNC connectors	Slot 14 and Slot 16	15454-EIA-BNC-B48
High-Density BNC	DS3-12 DS3XM-6 EC1-12	48 pairs of BNC connectors	Slot 1, Slot 2, Slot 4, and Slot 5	15454-EIA-BNC-A96	96 pairs of BNC connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, and Slot 17	15454-EIA-BNC-B96
MiniBNC	DS3-12 DS3/EC1-48 DS3XM-6 DS3XM-12 EC1-12	96 pairs of BNC connectors	Slot 1[1], Slot 2[1], Slot 3[1], Slot 4, Slot 5, and Slot 6	15454-EIA-BNC-A96	96 pairs of BNC connectors	Slot 12, Slot 13, Slot 14, Slot 15[1], Slot 16[1], and Slot 17[1]	15454-EIA-BNC-B96

Table 6-8 Electrical Interface Assembly Configurations (continued)

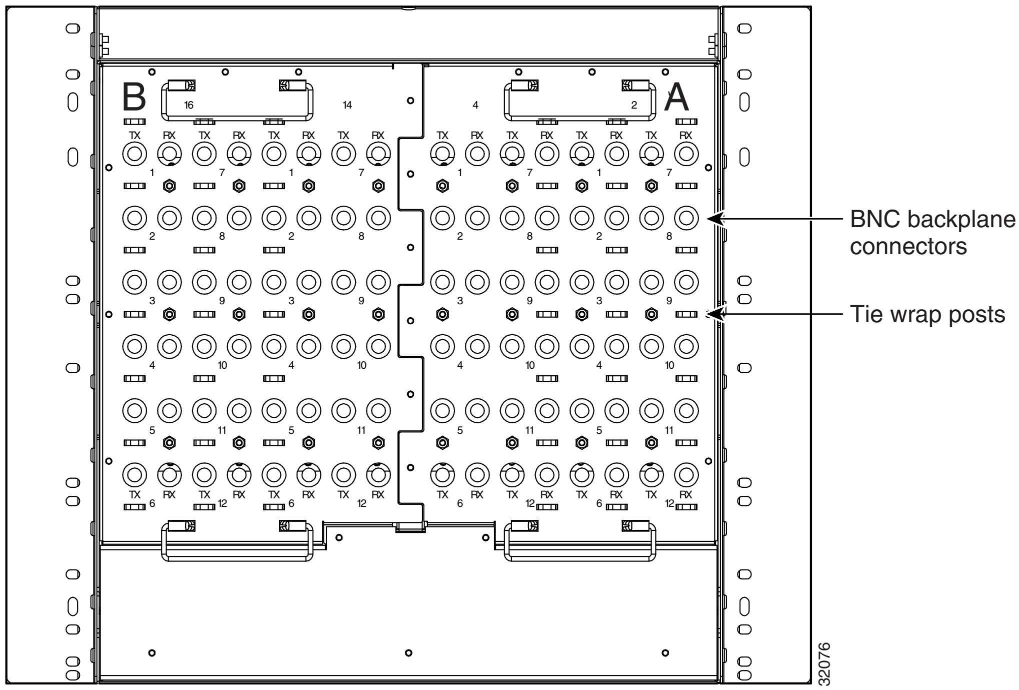
EIA Type	Interface Cards Supported	A Side Connector Capacity	A Side Connectors Map To	A Side Product Number	B Side Connector Capacity	B Side Connectors Map To	B Side Product Number
SMB	DS1-14 DS3-12 EC1-12 DS3XM-6 DS3XM-12	84 pairs of SMB connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, and Slot 6	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	DS1-14	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
UBIC	DS1-14 DS3-12 DS3/EC1-48 DS3XM-6 DS3XM-12 EC1-12	16 SCSI connectors	Slot 1[1], Slot 2[1], Slot 3[1], Slot 4, Slot 5, and Slot 6	15454-EIA-UBIC-V-A and 15454-EIA-UBIC-H-A	16 SCSI connectors: 112 DS1s, 96 DS3s, 96 EC-1s	Slot 12, Slot 13, Slot 14, Slot 15[1], Slot 16[1], and Slot 17[1]	15454-EIA-UBIC-V-B and 15454-EIA-UBIC-H-B

1. High-density card slots.

Low-Density BNC EIA

You can use BNC EIAs for DS-3 and STS-1 electrical circuits. The Low-Density BNC EIA supports 24 DS-3 or 24 STS-1 electrical circuits on each side of the ONS 15454 (24 transmit and 24 receive connectors). If you install Low-Density BNC EIAs on both sides of the shelf assembly, the ONS 15454 hosts up to 48 circuits. The BNC connectors on the 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. You can use Low-Density BNC EIAs with the DS3-12, DS3-12E, DS3XM-6, DS3XM-12, or EC1-12 cards. Figure 6-17 shows the ONS 15454 with pre-installed Low-Density 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.

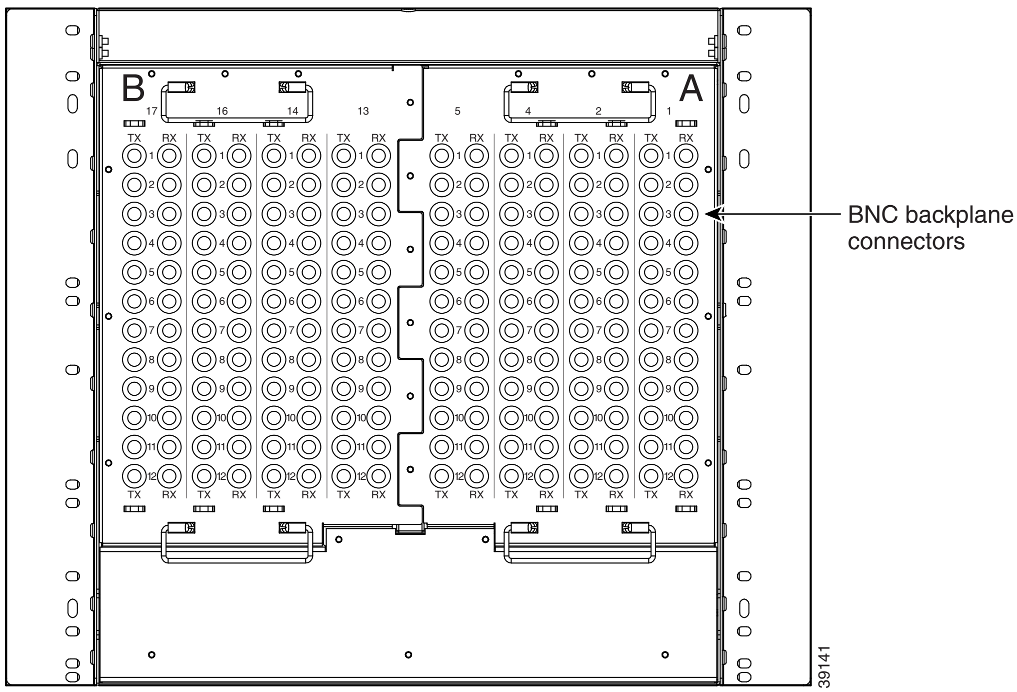
The EIA side marked "B" provides an additional 24 pairs of BNC connectors. The first 12 BNC connector pairs correspond to Ports 1 to 12 for a 12-port card and map to Slot 14 on the shelf assembly. The BNC connector pairs are marked "Tx" and "Rx" to indicate transmit and receive cables for each port. 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 or STS-1 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 with DS3-12, DS3-12E, DS3XM-6, DS3XM-12, or EC1-12 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



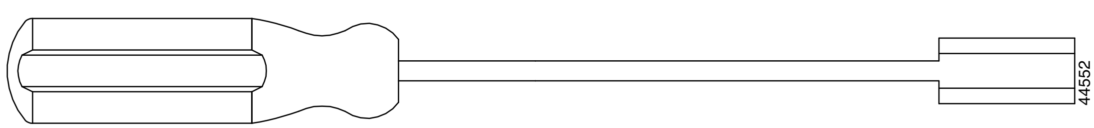
The EIA side marked "A" hosts 48 pairs of BNC connectors. Each column of connector pairs is numbered and corresponds to the slot of the same number. The first column (12 pairs) of BNC connectors corresponds to Slot 1 on the shelf assembly, the second column to Slot 2, the third column to Slot 4, and 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



The BNC insertion and removal tool can be obtained from the following vendors:

- Trompeter Electronics Inc. (www.trompeter.com)

31186 La Baya Drive

Westlake Village, CA 91362-4047

Phone: (800) 982-2629 Fax: (818) 706-1040

Part Number: RT-1L

MiniBNC EIA

The ONS 15454 MiniBNC EIA supports a maximum of 192 transmit and receive DS-3 or STS-1 electrical connections, 96 per side (A and B) through 192 miniBNC connectors on each side. If you install BNC EIAs on both sides of the unit, the ONS 15454 hosts up to 192 circuits. The MiniBNC EIAs are designed to support DS-3 and EC-1 signals. The MiniBNC EIA supports the following cards:

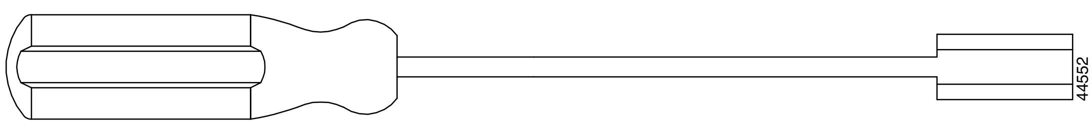
- DS3-12
- DS3-12E
- EC1-12
- DS3XM-6
- DS3XM-12
- DS3/EC1-48

Note EC-1 functionality will be available on the 48-port DS-3/EC-1 card in a future software release.

Mini 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 6-20 Mini BNC Insertion and Removal Tool



The Mini BNC insertion and removal tool can be obtained from the following vendors:

- Trompeter Electronics Inc. (www.trompeter.com)

  31186 La Baya Drive

  Westlake Village, CA 91362-4047

  Phone: (800) 982-2629 Fax: (818) 706-1040

  Part Number: RT-4L

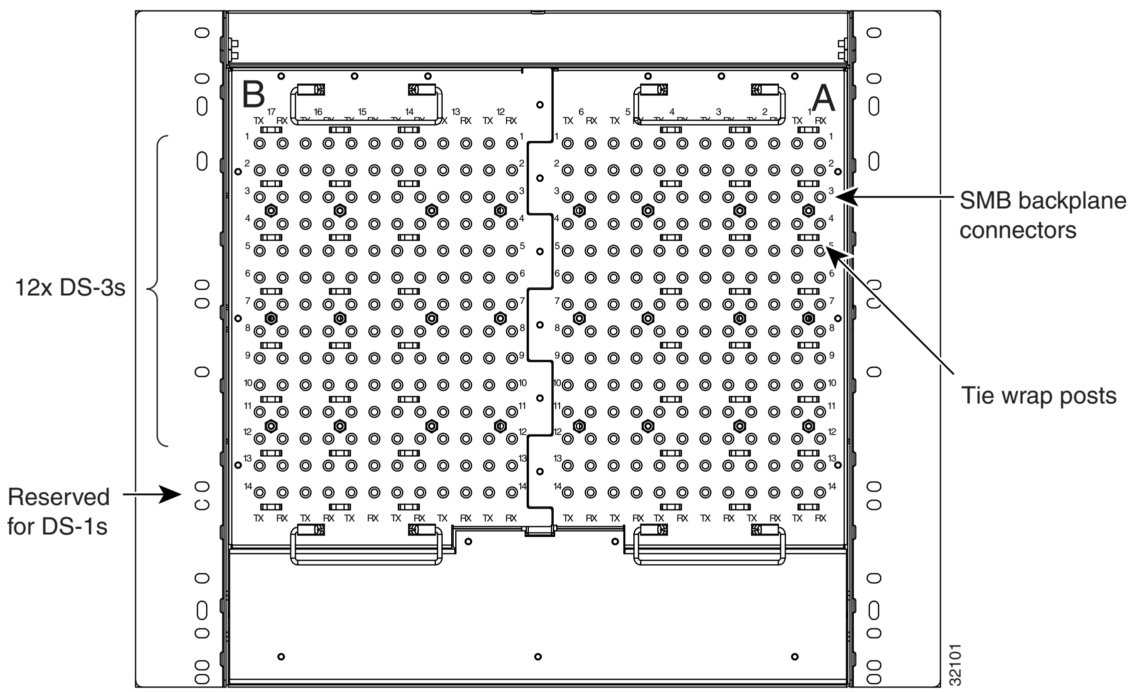
SMB EIA

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 DS1-14, DS3-12, DS3-12E, DS3XM-6, DS3XM-12, and EC1-12 cards. If you use DS1-14 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 DS1-14 card, 12 ports per slot when used with a DS3-12, DS3XM-12, or EC1-12 card, and 6 ports per slot when used with a DS3XM-6 card.

Figure 6-21 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 6-21 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).

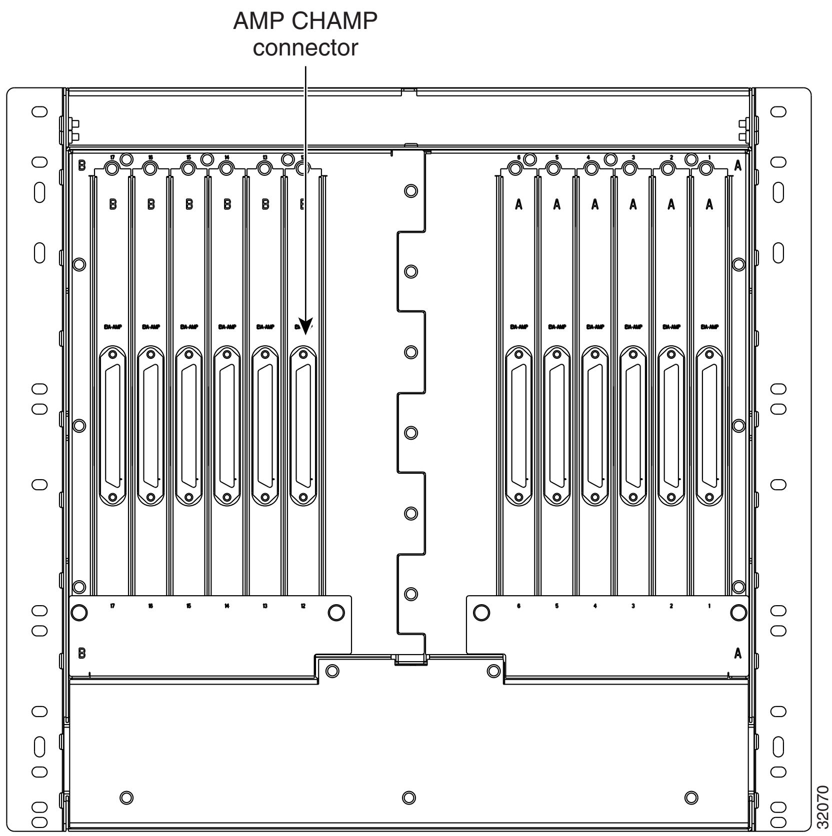
The SMB EIA side marked "A" hosts 84 SMB connectors in six columns of 14 connectors. The "A" side columns are numbered 1 to 6 and correspond to Slots 1 to 6 on the shelf assembly. The SMB EIA side marked "B" hosts an additional 84 SMB connectors in six columns of 14 connectors. The "B" side columns are 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 SMB 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 6 or 12 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 6-22 shows the ONS 15454 with pre-installed AMP Champ EIAs and the corresponding sheet metal cover and screw locations for the EIA.

Figure 6-22 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.

UBIC-V EIA

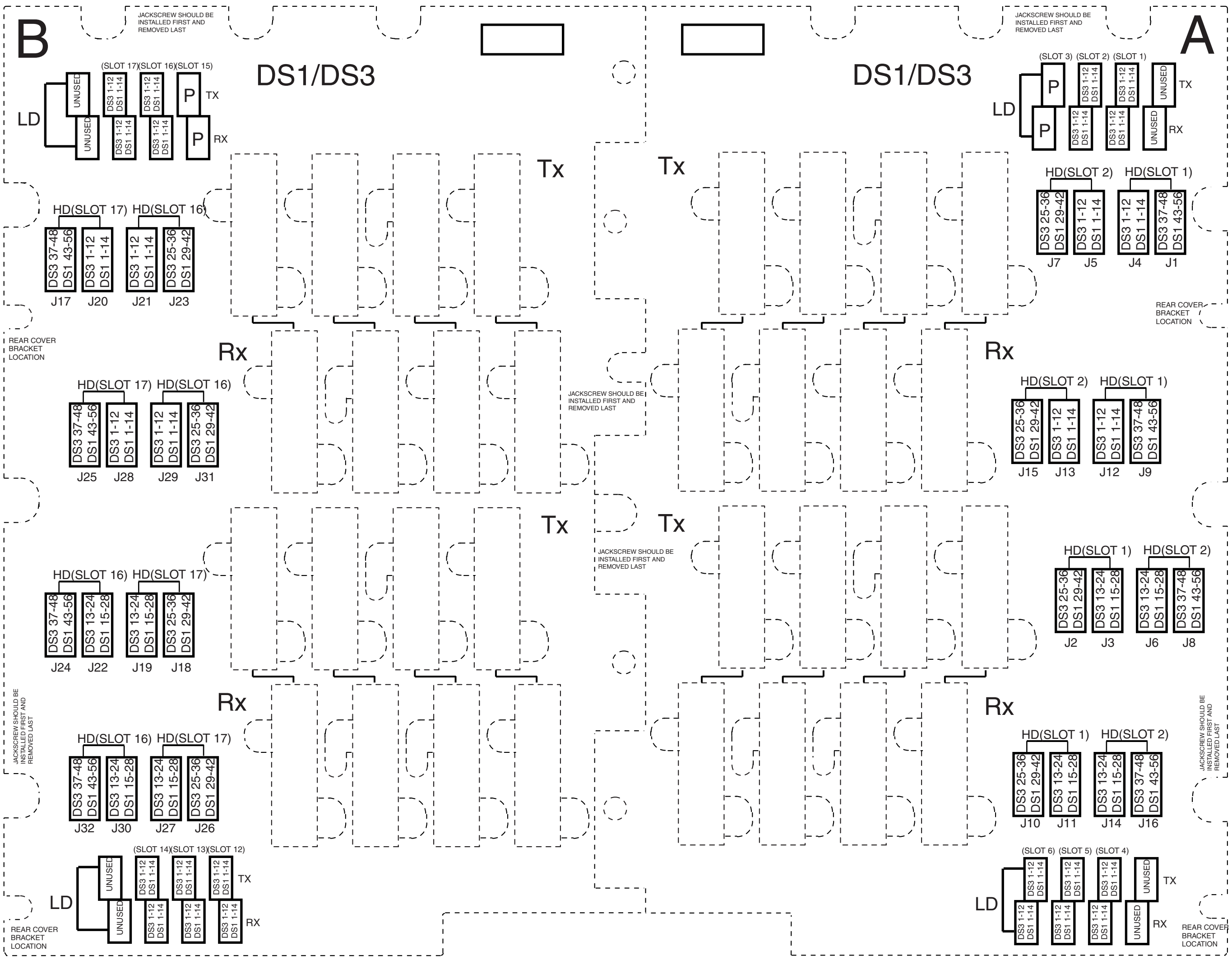
The universal backplane interface connector (UBIC-V) backplane covers are typically preinstalled when ordered with the ONS 15454 high density shelf (15454-SA-HD). UBIC-Vs are required when using the high-density (48-port DS-3/EC-1 and 56-port DS-1) electrical cards.

UBIC-V EIAs are attached to the shelf assembly backplane to provide up to 112 transmit and receive connections through 16 SCSI connectors per side (A and B). The UBIC-V EIAs are designed to support DS-1, DS-3, and EC-1 signals. The appropriate cable assembly is required depending on the type of signal.

You can install UBIC-Vs on one or both sides of the ONS 15454. As you face the rear of the ONS 15454 shelf assembly, the right side is the A side (15454-EIA-UBIC-V-A) and the left side is the B side (15454-EIA-UBIC-V-B). The diagrams adjacent to each row of SCSI connectors indicate the slots and ports that correspond with each SCSI connector in that row, depending on whether you are using a high-density (HD) or low-density (LD) configuration. UBIC-V EIAs will support the high-density DS3/EC1-48 and DS3XM-12 cards, as well as low-density electrical cards. Figure 6-23 shows the slot assignments for sides A and B.

Note The high-density DS1-56 electrical card will be available in a future release.

Figure 6-23 UBIC-V Slot Designations



The UBIC-V sheet metal covers use the same screw holes as the standard sheet metal covers, but they have 12 additional holes for pan-head screws and three holes for jack screws, so you can screw down the cover and the board using standoffs on the UBIC-V board.

When installed with the standard door and cabling on the backplane, the ONS 15454 shelf measures approximately 15.7 inches deep when partially populated with backplane cables, 16.1 inches deep when fully populated, and 16.75 inches deep with the rear cover installed.

When installed with the deep door and cabling on the backplane, the ONS 15454 shelf measures approximately 17.5 inches deep when partially populated with backplane cables, 17.9 inches deep when fully populated, and 18.55 inches deep with the rear cover installed.

The A and B sides each host 16 high-density, 50-pin SCSI connectors. The A-side maps to Slots 1 through 6 and the B-side maps to Slots 12 through 17.

In Software Releases 4.1.x and 4.6.x, UBIC-V EIAs support unprotected, 1:1, and 1:N (N < 5) protection groups. In Software R5.0 and higher, UBIC-V EIAs also support available high-density cards in unprotected and 1:N (N < 2) protection groups.

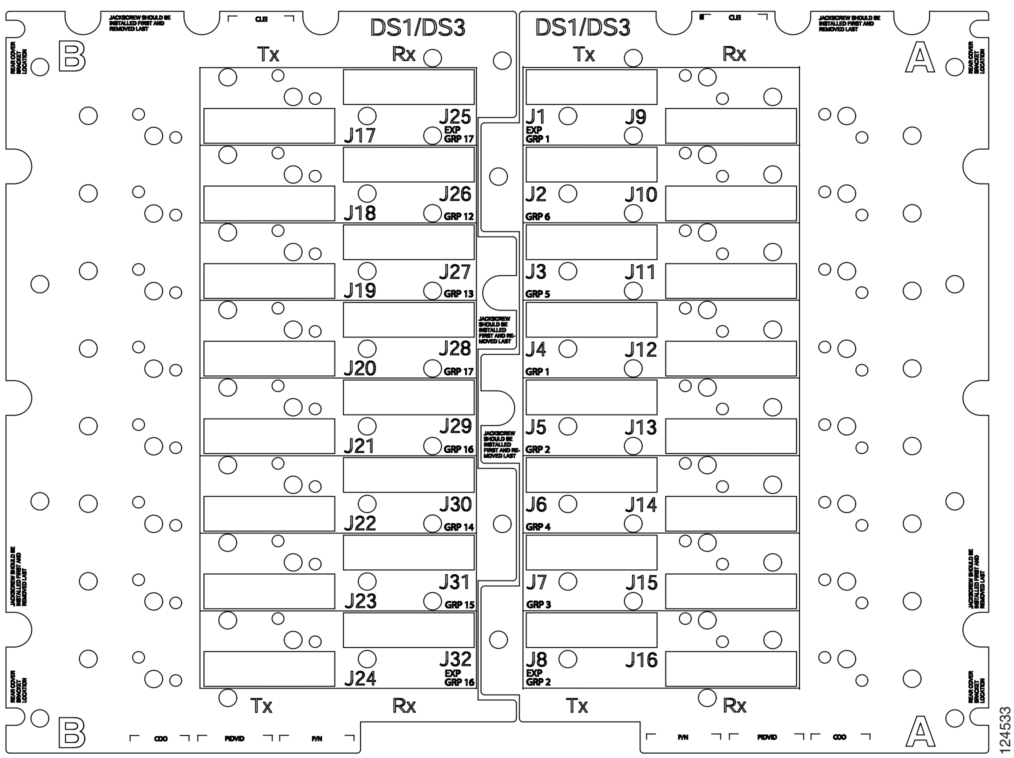
UBIC-H EIA

UBIC-H EIAs are attached to the shelf assembly backplane to provide up to 112 transmit and receive DS-1 connections through 16 SCSI connectors per side (A and B) or 96 transmit and receive DS-3 connections. The UBIC-H EIAs are designed to support DS-1, DS-3, and EC-1 signals. The appropriate cable assembly is required depending on the type of signal.

You can install UBIC-H EIAs on one or both sides of the ONS 15454. As you face the rear of the ONS 15454 shelf assembly, the right side is the A side (15454-EIA-UBICH-A) and the left side is the B side (15454-EIA-UBICH-B). The J-labels adjacent to each row of SCSI connectors indicate the slots and ports that correspond with each SCSI connector in that row, depending on whether you are using a high density (HD) or low density (LD) configuration. UBIC-H EIAs will support the high-density DS3/EC1-48 and DS3XM-12 cards, as well as low-density electrical cards. Figure 6-24 shows the A and B side connector labeling.

Note The high-density DS1-56 electrical card will be available in a future release.

Figure 6-24 UBIC-H EIA Connector Labeling



When installed with the standard door and cabling on the backplane, the ONS 15454 shelf measures approximately 14.5 inches deep when fully populated with backplane cables, and 15.0 inches deep with the rear cover installed.

When installed with the deep door and cabling on the backplane, the ONS 15454 shelf measures approximately 16.5 inches deep when fully populated with backplane cables, and 17.0 inches deep with the rear cover installed.

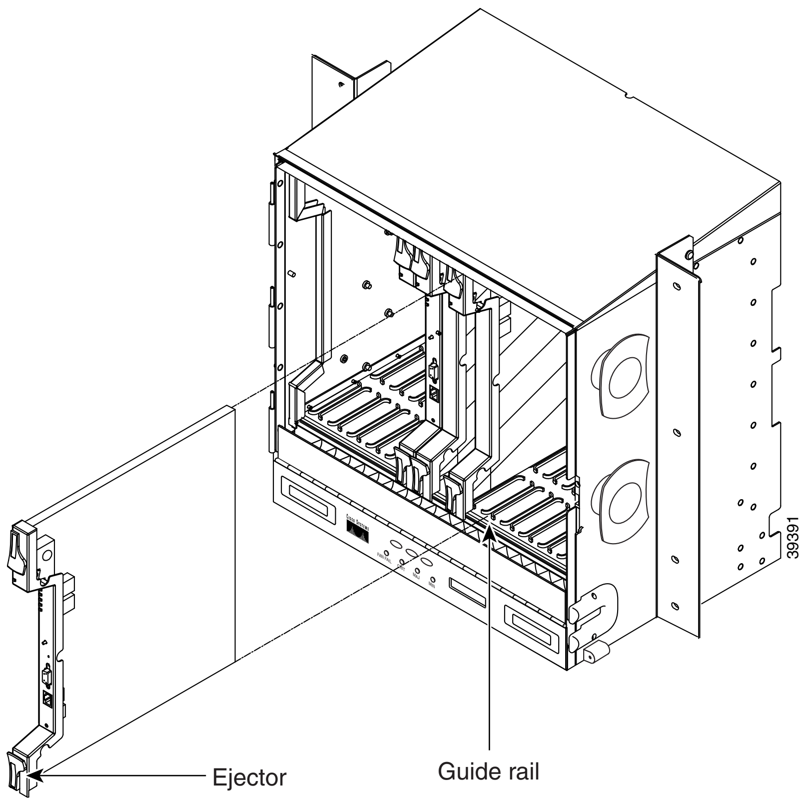
The A and B sides each host 16 high-density, 50-pin SCSI connectors. The A-side maps to Slots 1 through 6 and the B-side maps to Slots 12 through 17.

In Software Releases prior to Release 5.0, UBIC-H EIAs support unprotected, 1:1, and 1:N (where N < 5) protection groups. In Software R5.0 and greater, UBIC-Hs additionally support available high-density cards in unprotected and 1:N protection (where N < 2) protection groups.

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 6-25 shows card installation.

Figure 6-25 Installation of Plug-in Cards



Release 5.0 features background ASIC monitoring for all line cards and cross connect cards, standby assurance for DS-3 cards, and BLSR PCA Pseudo Random Bit Signal (PRBS) generation and detection. This inhibits switching to a failed line card, if such a card exists, by generating a diagnostic failure alarm. The feature also causes a switch-away on the cross connect cards via an equipment failure alarm. All diagnostic failures are logged in the alarm history. The feature accomplishes these goals by adding three new timers that ensure the correct state of the cards at key points in card communication. A verification guard timer is used when a Force is issued, to ensure that the far end has a chance to respond. A detection guard timer is used to ensure the presence of an SF/SD condition before switching away from a card. A recover guard timer ensures the absence of SF/SD prior to switching to a card.

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

The tables in this section describe 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 6-9 for Common Card Functions and Slot Assignment
- Refer to Table 6-10 for Electrical Card Functions and Slot Assignment
- Refer to Table 6-11 for Optical Card Functions and Slot Assignment
- Refer to Table 6-12 for Transponder and Muxponder Card Functions and Slot Assignments
- Refer to Table 6-15 for Ethernet Card Functions and Slot Assignment
- Refer to Table 6-17 for DWDM Card Functions and Slot Assignment
- Refer to Table 6-16 for Storage Area Network (SAN) Transport Card Function and Slot Assignment

See http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html for the latest list of End-Of-Life and End-Of-Sale notices.

Table 6-9 Common Card Functions and Slot Assignments

Card	Description	Slot Assignment
TCC+	The TCC+ is the main processing center for the ONS 15454 running Software Release 3.4 and earlier. It 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
TCC2P	The TCC2P card performs the same functions as the TCC2, but also has Ethernet security features and 64K composite clock building integrated timing supply (BITS) timing. These additional features require Software Release 5.0 and later. The TCC2P is backwards compatible with Software Release 4.0.	7 and 11
XCVT	The XCVT card performs the same functions as the XC, but can manage both STS and VT circuits up to 48c.	8 and 10
XC10G	The XC10G 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

Table 6-9 Common Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
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 card and one XC/XCVT/XC10G card. Two TCC and cross-connect cards must always be installed for redundant operation.

Table 6-10 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 Mb/s 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 Mb/s 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 Mb/s 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

Table 6-10 Electrical Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
DS3N-12E	The DS3N-12E card supports the same features as the DS3N-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
DS3/EC1-48	The ONS 15454 DS3/EC1-48 card provides 48 Telcordia-compliant, GR-499 DS-3 ports per card. Each port operates at 44.736 Mb/s over a single 75-ohm 728A or equivalent coaxial span. The DS3/EC1-48 card operates as a working or protect card in 1:N protection schemes, where N<=2. Note: EC-1 functionality will be supported in a future software release.	1–3 and 15–17 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
DS3XM-12	This card provides the same M13 multiplexing functions as the DS3XM-6 card, however the DS3XM-12 converts up to 12 framed DS-3 network connections to 12 x 28 VT1.5s. The DS3XM-12 card also provides a portless transmux interface to change DS-3s mapped in an OC-N signal into VT1.5s.	1–6 and 12–17 1:N protection: 3, 15
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

Table 6-11 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 non-concatenated 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 bidirectional 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 non-concatenated 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 bidirectional 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 non-concatenated 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 bidirectional 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]

Table 6-11 Optical Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
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 non-concatenated, 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 bidirectional protection switching. The OC48 IR 1310 card uses SC connectors.	5, 6, 12, and 13
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, non-concatenated 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 bidirectional 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 non-concatenated or concatenated payloads at STS-1, STS-3c, STS-6c, STS-12c, or STS-48c signal levels. The card supports 1+1 unidirectional or bidirectional 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 Cisco's ONS 15454) 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 non-concatenated payloads at STS-1, STS-3c, STS-6c, STS-12c, or STS-48c signal levels. Each card supports 1+1 unidirectional or bidirectional protection switching and uses SC connectors.	5, 6, 12, and 13

Table 6-11 Optical Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
OC192-SR/STM64-IO-1310 nm	The OC192 SR/STM64 IO 1310 card provides one intra-office (IO) short-range 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 non-concatenated or concatenated payloads. The OC192 SR/STM64 IO 1310 card supports 1+1 unidirectional or bidirectional protection switching and uses SC connectors.	5, 6, 12, and 13
OC192-IR/STM64-SH-1550 nm	The OC192 IR/STM64 SH 1550 card provides one intermediate-range 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 non-concatenated or concatenated payloads. The OC192 IR/STM64 SH 1550 card supports 1+1 unidirectional or bidirectional 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 non-concatenated or concatenated payloads. Each card supports 1+1 unidirectional or bidirectional protection switching and uses SC connectors.	5, 6, 12, and 13

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.

Table 6-12 Transponder and Muxponder Card Functions and Slot Assignments

Card	Description	Slot Assignment
TXP_MR_10G	The 10 Gb/s Transponder-100 GHz-Tunable xx.xx-xx.xx card (TXP_MR_10G) processes one 10 Gb/s signal (client side) into one 10-Gb/s, 100 GHz DWDM signal (trunk side). It provides one 10 Gb/s port per card that can be provisioned for an STM64/OC-192 short reach (1310nm) signal, compliant with ITU-T G.707, G.709, ITU-T G.691, Telcordia GR-253-CORE, or to 10 GE BASE-LR, compliant to IEEE 802.3. The TXP_MR_10G card is tunable over two neighboring wavelengths in the 1550nm, ITU 100 GHz range. It is available in sixteen different versions, covering thirty-two different wavelengths in the 1550nm range.	1–6 and 12–17
TXP_MR_10E	The 10 Gb/s Transponder-100 GHz-Tunable xx.xx-xx.xx (TXP_MR_10E) card is a multirate transponder for the ONS 15454 platform. It processes one 10 Gb/s signal (client side) into one 10 Gb/s, 100 GHz DWDM signal (trunk side) that is tunable on four wavelength channels (ITU-T 100 GHz grid). You can provision this card in a linear configuration, BLSR, path protection, or a regenerator. The card can be used in the middle of BLSR or 1+1 spans when the card is configured for transparent termination mode. The TXP_MR_10E port features a 1550nm laser for the trunk port and an ONS-XC-10G-S1 XFP module for the client port and contains two transmit and receive connector pairs (labeled) on the card faceplate. The TXP_MR_10E card is tunable over four wavelengths in the 1550nm ITU 100-GHz range. They are available in eight versions of the card, covering thirty-two different wavelengths in the 1550nm range.	11–6 and 12–17
TXP_MR_2.5G	The 2.5 Gb/s Multirate Transponder-100 GHz-Tunable xx.xx-xx.xx (TXP_MR_2.5G) card processes one 8 Mb/s to 2.488 Gb/s signal (client side) into one 8 Mb/s to 2.5 Gb/s, 100 GHz DWDM signal (trunk side). It provides one long-reach STM-16/OC-48 port per card, compliant with ITU-T G.707, ITU-T G.709, ITU-T G.957, and Telcordia GR-253-CORE. The TXP_MR_2.5G card is tunable over four wavelengths in the 1550nm ITU 100-GHz range. They are available in eight versions of the card, covering thirty-two different wavelengths in the 1550nm range. The TXP_MR_2.5G card support 2R and 3R modes of operation where the client signal is mapped into a ITU-T G.709 frame.	1–6 and 12–17
TXPP_MR_2.5G	The 2.5 Gb/s Multirate Transponder-Protected-100 GHz-Tunable xx.xx-xx.xx (TXPP_MR_2.5G) card processes one 8 Mb/s to 2.488 Gb/s signal (client side) into two 8 Mb/s to 2.5 Gb/s, 100 GHz DWDM signals (trunk side). It provides two long-reach STM-16/OC-48 ports per card, compliant with ITU-T G.707, ITU-T G.957, and Telcordia GR-253-CORE. The TXPP_MR_2.5G card is tunable over four wavelengths in the 1550nm ITU 100-GHz range. They are available in eight versions of the card, covering thirty-two different wavelengths in the 1550nm range. The TXPP_MR_2.5G card support 2R and 3R modes of operation where the client signal is mapped into a ITU-T G.709 frame.	1–6 and 12–17

Table 6-12 Transponder and Muxponder Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
MXP_2.5G_10G	The 2.5 Gb/s-10 Gb/s Muxponder-100 GHz-Tunable xx.xx-xx.xx (MXP_2.5G_10G) card multiplexes/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.709, ITU-T G.957, and Telcordia GR-253-CORE) and four intermediate- or short-range OC-48/STM-16 ports per card on the client side. The port operates at 9.95328 Gb/s over unamplified distances up to 80 km (50 miles) with different types of fiber such as C-SMF or dispersion compensated fiber limited by loss and/or dispersion. The port can also operate at 10.70923 Gb/s in ITU-T G.709 Digital Wrapper/FEC mode. Client ports on the MXP_2.5G_10G card are also interoperable with OC-1 (STS-1) fiber optic signals defined in Telcordia GR-253-CORE. An OC-1 signal is the equivalent of one DS3 channel transmitted across optical fiber. OC-1 is primarily used for trunk interfaces to phone switches in the United States. The MXP_2.5G_10G card is tunable over two neighboring wavelengths in the 1550nm, ITU 100 GHz range. It is available in sixteen different versions, covering thirty-two different wavelengths in the 1550nm range.	11–6 and 12–17
MXP_2.5G_10E	The 2.5 Gb/s-10 Gb/s Muxponder-100 GHz-Tunable xx.xx-xx.xx (MXP_2.5G_10E) card is a DWDM muxponder for the ONS 15454 platform that supports full optical transparency on the client side. The card multiplexes four 2.5 Gb/s client signals (4 x OC48/STM-16 SFP) into a single 10 Gb/s DWDM optical signal on the trunk side. The MXP_2.5G_10E provides wavelength transmission service for the four incoming 2.5 Gbps client interfaces. The MXP_2.5G_10E muxponder passes all SONET overhead bytes transparently. The MXP_2.5G_10E works with Optical Transparent Network (OTN) devices defined in ITU-T G.709. The card supports Optical Data Channel Unit 1 (ODU1) to Optical Channel Transport Unit (OTU2) multiplexing, an industry standard method for asynchronously mapping a SONET/SDH payload into a digitally wrapped envelope. The MXP_2.5G_10E card is tunable over four neighboring wavelengths in the 1550nm, ITU 100 GHz range. It is available in eight different versions, covering thirty-two different wavelengths in the 1550nm range. The MXP_2.5G_10E card is not compatible with the MXP_2.5G_10G card, which does not supports full optical transparency. The faceplate designation of the card is "4x2.5G 10E MXP."	1–6 and 12–17

Table 6-12 Transponder and Muxponder Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
MXP_MR_2.5G	The 2.5 Gb/s Multirate Muxponder-100 GHz-Tunable 15xx.xx-15yy.yy (MXP_MR_2.5G) card aggregates a mix and match of client Storage Area Network (SAN) service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s STM-16/OC-48 DWDM signal on the trunk side. It provides one long-reach STM-16/OC-48 port per card and is compliant with Telcordia GR-253-CORE. The client interface supports the following payload types: • GE • 1G FC • 2G FC • 1G FICON • 2G FICON Because the card is tunable to one of four adjacent grid channels on a 100 GHz spacing, this card is available in eight versions covering thirty-two different wavelengths in the 1550 nm range.	1–6 and 12–17
MXPP_MR_2.5G	The 2.5 Gb/s Multirate Muxponder-Protected-100 GHz-Tunable 15xx.xx-15yy.yy (MXPP_MR_2.5G) card aggregates various client SAN service client inputs (GE, FICON, and Fibre Channel) into one 2.5 Gb/s STM-16/OC-48 DWDM signal on the trunk side. It provides two long-reach STM-16/OC-48 ports per card and is compliant with ITU-T G.957 and Telcordia GR-253-CORE. The client interface supports the following payload types: • GE • 1G FC • 2G FC • 1G FICON • 2G FICON Because the card is tunable to one of four adjacent grid channels on a 100 GHz spacing, this card is available in eight versions covering thirty-two different wavelengths in the 1550 nm range.	1–6 and 12–17

The TXP_MR_2.5G and TXPP_MR_2.5G cards support 2R and 3R modes of operation where the client signal is mapped into a ITU-T G.709 frame. The mapping function is simply done by placing a digital wrapper around the client signal. Only OC-48/STM-16 client signals are fully ITU-T G.709 compliant and the output bit rate depends on the input client signal. Table 6-13 shows the possible combinations of client interfaces, input bit rates, 2R and 3R modes, and ITU-T G.709 monitoring.

Table 6-13 2R and 3R Mode and ITU-T G.709 Compliance by Client Interface

Client Interface	Input Bit Rate	3R vs. 2R	ITU-T G.709
OC-48/STM-16	2.488 Gb/s	3R	On or Off
DV-6000	2.38 Gb/s	2R	NA

Table 6-13 2R and 3R Mode and ITU-T G.709 Compliance by Client Interface (continued)

Client Interface	Input Bit Rate	3R vs. 2R	ITU-T G.709
2 Gigabit Fiber Channel (2G-FC)/FICON	2.125 Gb/s	3R[1]	On or Off
High definition television (HDTV)	1.48 Gb/s	2R	NA
Gigabit Ethernet (GE)	1.25 Gb/s	3R	On or Off
1 Gigabit Fiber Channel (1G-FC)/FICON	1.06 Gb/s	3R	On or Off
OC-12/STM-4	622 Mb/s	3R	On or Off
OC-3/STM-1	155 Mb/s	3R	On or Off
ESCON	200 Mb/s	2R	NA
SDI/D1 Video	270 Mb/s	2R	NA

1. No monitoring.

The output bit rate is calculated for the trunk bit rate by using the 255/238 ratio as specified in ITU-T G.709 for OTU1. Table 6-14 lists the calculated trunk bit rates for the client interfaces with ITU-T G.709 enabled.

Table 6-14 Trunk Bit Rates With ITU-T G.709 Enabled

Client Interface	ITU-T G.709 Disabled	ITU-T G.709 Enabled
OC-48/STM-16	2.488 Gb/s	2.66 Gb/s
2G-FC	2.125 Gb/s	2.27 Gb/s
GE	1.25 Gb/s	1.34 Gb/s
1G-FC	1.06 Gb/s	1.14 Gb/s
OC-12/STM-3	622 Mb/s	666.43 Mb/s
OC-3/STM-1	155 Mb/s	166.07 Mb/s

Table 6-15 Ethernet Card Functions and Slot Assignments

Card	Description	Slot Assignment
CE-100T-8	The CE-100T-8 card provides eight RJ-45 10/100 Mb/s Ethernet ports as well as an RJ-45 console port, all of which are accessible at the faceplate. The CE-100T-8 card provides mapping of 10/100 Mb/s Ethernet traffic into SONET STS-12 payloads, making use of low order (VT1.5) virtual concatenation, high order (STS-1) virtual concatenation, and generic framing procedure (GFP), point-to-point protocol/high-level data link control (PPP/HDLC) framing protocols. It also supports the link capacity adjustment scheme (LCAS), which allows hitless dynamic adjustment of SONET link bandwidth. The circuit types supported are: • HO-CCAT • LO-VCAT with no HW-LCAS • LO-VCAT with HW-LCAS • STS-1-2v SW-LCAS with ML only Each 10/100 Ethernet port can be mapped to a SONET channel in increments of VT1.5 or STS-1 granularity, allowing an efficient transport of Ethernet and IP over the SONET infrastructure.	1–6 and 12–17
E100T-12[1]	Use the E100T-12 with the XC or XCVT 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 auto configure 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.	1–6 and 12–17
E1000-2[1]	Use the E1000-2 with the XC or XCVT cards. Do not use the E1000-2 when the XC10G 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.	11–6 and 12–17
E100T-G	The E100T-G is the functional equivalent of the E100T-12, but will interoperate with the XC10G cross-connect. The E100T-G ports use RJ-45 interfaces.	1–6 and 12–17
E1000-2-G	The E1000-2-G is the functional equivalent of the E1000-2, but will interoperate with the XC10G cross-connect.	1–6 and 12–17

Table 6-15 Ethernet Card Functions and Slot Assignments

Card	Description	Slot Assignment
G1000-4[1]	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.	1–6 and 12–17
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 bidirectional per port, and 2.5 Gb/s or 5 Gb/s bidirectional per card. Each port auto negotiates for full duplex and 802.3z 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.	1–6 and 12–17

Table 6-15 Ethernet Card Functions and Slot Assignments

Card	Description	Slot Assignment
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 auto configure to operate at either half or full duplex and can determine whether to enable or disable flow control. The card features two virtual packet over SONET (POS) ports with a maximum combined bandwidth of STS-48. The ports function in a manner similar to OC-N card ports, and 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 POS ports supports virtual concatenation (VCAT) of SONET circuits and a software link capacity adjustment scheme (SW-LCAS). The ML-Series card supports a maximum of two VCAT groups with each group corresponding to one of the POS ports. Each VCAT group must be provisioned with two circuit members. An ML-Series card supports STS-1c-2v, STS-3c-2v and STS-12c-2v.	1–6 and 12–17 with the XC10G or 5, 6, 12, and 13 with the XC or XCVT
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 auto configures for full duplex and IEEE 802.3z 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 card features two virtual packet over SONET (POS) ports with a maximum combined bandwidth of STS-48. The ports function in a manner similar to OC-N card ports, and 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 POS ports supports VCAT of SONET circuits and a software link capacity adjustment scheme (SW-LCAS). The ML-Series card supports a maximum of two VCAT groups with each group corresponding to one of the POS ports. Each VCAT group must be provisioned with two circuit members. An ML-Series card supports STS-1c-2v, STS-3c-2v and STS-12c-2v. The ML1000-2 card interfaces to Small Form Factor Pluggable (SFP) slots supporting SX and LS GBICs.	1–6 and 12–17 with the XC10G or 5, 6, 12, and 13 with the XC or XCVT

1. See http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html for the latest End-Of-Life and End-Of-Sale notices.

Table 6-16 Storage Area Network (SAN) Transport Card Function and Slot Assignment

Card	Description	Slot Assignment
FC_MR-4	The FC_MR-4 card is compatible with Software R4.6 and greater. The FC_MR-4 card uses pluggable Gigabit Interface Converters (GBICs) to transport non-SONET/SDH-framed, block-coded protocols over SONET/SDH. The FC_MR-4 enables four client Fibre Channel (FC) ports to be transported over SONET/SDH, encapsulating the frames using the ITU-T Generic Framing Protocol (GFP) format and mapping them into either T1X1 G.707-based Virtual Concatenated (VCAT) payloads or standard contiguously concatenated SONET/SDH payloads. The FC_MR-4 card has the following features: • Four FICON ports operating at 1 Gb/s or 2 Gb/s – All four ports can be operational at any time due to subrate support – Advanced Distance Extension capability (buffer-to-buffer credit spoofing) • Pluggable GBIC optics: – Dual rate (1G/2G): MM (550 m) and SM (10 km) – Single rate (1G): SX (550 m) and LX (10 km) • SONET/SDH support – Four 1.0625 Gbps FC channels can be mapped into SONET/SDH containers as small as STS1/VC3 (subrate), with a minimum of STS-24c/VC4-8c for full rate, and as large as STS48c/VC4-24c. – Four 2.125 Gbps FC channels can be mapped into SONET/SDH containers as small as STS1/VC3 (subrate), with a minimum of STS48c/VC4-24c for full rate, and as large as STS48c/VC4-24c. • Frame encapsulation: ITU-T G.7041 Generic Framing Procedure-Transparent (GFP-T) • High-order SONET/SDH virtual concatenation support (STS1-xv/VC-3 and STS3c-xv/VC-4) The card can be provisioned as part of any valid ONS 15454 SONET/SDH network topology, such as a path protection, bidirectional line switched ring (BLSR), or linear network topologies. The FC_MR-4 card can operate in two different modes: • Line Rate mode - This mode is backward compatible with the Software Release 4.6 Line Rate mode. • Enhanced mode - This mode supports subrate, distance extension, and other enhancements. The FC_MR-4 card reboots when a card mode changes (a traffic hit results). The FPGA running on the card upgrades to the required image. However, the FPGA image in the card's flash is not modified.	5, 6, 12, and 13 when used with XCVT cards or 1–6 and 12–17 when used with XC10G cards

Table 6-17 DWDM Card Functions and Slot Assignments

Card	Description	Slot Assignment
OSCM	The OSCM has one set of optical ports and one Ethernet port located on the faceplate. An optical service channel (OSC) is a bidirectional channel connecting all the nodes in a ring. The channel transports OSC overhead that is used to manage ONS 15454 DWDM networks. The OSC uses the 1510 nm wavelength and does not affect client traffic. The primary purpose of this channel is to carry clock synchronization and orderwire channel communications for the DWDM network. It also provides transparent links between each node in the network. The OSC is an OC-3 formatted signal. The OSCM is used in amplified nodes that include the OPT-BST booster amplifier. The OPT-BST includes the required OSC wavelength combiner and separator component. The OSCM cannot be used in nodes where you use OC-N cards, electrical cards, or cross-connect cards. The OSCM supports the following features: • OC-3/STM-1 formatted OSC • Supervisory data channel (SDC) forwarded to the TCC2/TCC2P cards for processing • Distribution of the synchronous clock to all nodes in the ring • 100BaseT far-end (FE) user data channel (UDC) • Monitoring functions such as orderwire support and optical safety	8 and 10
OSC-CSM	The OSC-CSM has three sets of optical ports and one Ethernet port located on the faceplate. The OSC-CSM is identical to the OSCM, but also contains a combiner and separator module in addition to the OSC module. The OSC-CSM is used in unamplified nodes. This means that the booster amplifier with the OSC wavelength combiner and separator is not required for OSC-CSM operation. The OSC-CSM supports the following features: • Optical combiner and separator module for multiplexing and demultiplexing the optical service channel to or from the wavelength division multiplexing (WDM) signal • OC-3/STM-1 formatted OSC • SDC forwarded to the TCC2/TCC2P cards for processing • Distribution of the synchronous clock to all nodes in the ring • 100BaseT FE UDC • Monitoring functions such as orderwire support • Optical safety: Signal loss detection and alarming, fast transmitted power shut down by means of an optical 1x1 switch • Optical safety remote interlock (OSRI), a feature capable of shutting down the optical output power • Automatic laser shutdown (ALS), a safety mechanism used in the event of a fiber cut	1–6 and 12–17

Table 6-17 DWDM Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
OPT-PRE	The OPT-PRE amplifier has five optical ports (three sets) located on the faceplate. The OPT-PRE is designed to support 64 channels at 50-GHz channel spacing, but Software R4.6 and R5.0 only supports 32 channels at 100 GHz. The OPT-PRE is a C-band DWDM, two-stage erbium-doped fiber amplifier (EDFA) with mid-amplifier loss (MAL) for allocation to a dispersion compensation unit (DCU). To control the gain tilt, the OPT-PRE is equipped with a built-in VOA. The VOA can also be used to pad the DCU to a reference value. The OPT-PRE features: • Fixed gain mode with programmable tilt • True variable gain • Fast transient suppression • Nondistorting low-frequency transfer function • Settable maximum output power • Fixed output power mode (mode used during provisioning) • MAL for fiber-based DCU • Amplified spontaneous emissions (ASE) compensation in fixed gain mode • Full monitoring and alarm handling with settable thresholds • Optical safety features that include signal loss detection and alarming, fast power down control and reduced maximum output power in safe power mode • Four signal photodiodes to monitor the input and output optical power of the two amplifier stages through CTC • An optical output port for external monitoring	1–6 and 12–17

Table 6-17 DWDM Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
OPT-BST	The OPT-BST amplifier has four sets of optical ports located on the faceplate. The OPT-BST is designed to support 64 channels at 50-GHz channel spacing, but Software R4.6 supports 32 channels at 100 GHz. The OPT-BST is a C-band DWDM EDFA with OSC add-and-drop capability. When an ONS 15454 MSTP has an OPT-BST installed, it is only necessary to have the OSCM to process the OSC. To control the gain tilt, the OPT-BST is equipped with a built-in VOA. The OPT-BST features include: • Fixed gain mode (with programmable tilt) • True variable gain • Fast transient suppression • Nondistorting low-frequency transfer function • Settable maximum output power • Fixed output power mode (mode used during provisioning) • ASE compensation in fixed gain mode • Full monitoring and alarm handling with settable thresholds • Optical safety features, including signal loss detection and alarming, fast power down control, and reduced maximum output power in safe power mode • OSRI, which is a software feature capable (through CTC) of shutting down the optical output power or reducing the power to a safe level (automatic power reduction) • ALS, which is a safety mechanism used in the event of a fiber cut **Note** Note: The optical splitters each have a ratio of 1:99. The result is that the power at the MON TX and MON RX ports is about 20 dB lower than the power at the COM TX and COM RX ports.	1–6 and 12–17
32MUX-O	The 32MUX-O has five sets of ports located on the faceplate. The 32-channel multiplexer card (32 MUX-O) multiplexes 32 100 GHz-spaced channels identified in the channel plan. The 32MUX-O is typically used in hub nodes and provides the multiplexing of 32 channels, spaced at 100 GHz, into one fiber before their amplification and transmission along the line. The 32MUX-O features include: • Arrayed waveguide grating (AWG) device that enables full multiplexing functions for the channels. • Each single-channel port is equipped with VOAs for automatic optical power regulation prior to multiplexing. In the case of electrical power failure, the VOA is set to its maximum attenuation for safety purposes. A manual VOA setting is also available. • Each single-channel port is monitored using a photodiode to enable automatic power regulation. • An additional optical monitoring port with 1/99 splitting ratio is available.	Two slots between Slots 1–5 and 12–16

Table 6-17 DWDM Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
32DMX-O	The 32DMX-O has five sets of ports located on the faceplate. The 32-Channel Demultiplexer (32 DMX-O) card demultiplexes 32 100 GHz-spaced channels identified in the channel plan. The 32DMX-O features include: • AWG that enables channel demultiplexing functions. • Each single-channel port is equipped with VOAs for automatic optical power regulation after demultiplexing. In the case of electrical power failure, the VOA is set to its maximum attenuation for safety purposes. A manual VOA setting is also available. • Each single-channel port is monitored using a photodiode to enable automatic power regulation. **Note** Note: In contrast, the single-slot 32DMX card does not have VOAs on each drop port for optical power regulation. The 32DMX optical demultiplexer module is used in conjunction with the 32-Channel Wavelength Selective Switch (32WSS) card in ONS 15454 Multiservice Transport Platform (MSTP) nodes.	Two slots between Slots 1–5 and 12–16
32DMX	The 32DMX has five sets of ports located on the faceplate. The 32-Channel Demultiplexer card (32DMX) is a single-slot optical demultiplexer. The card receives an aggregate optical signal on its COM RX port and demultiplexes it into to 32 100-GHz-spaced channels. The 32DMX card works in conjunction with the 32WSS card to create a software-controlled network element with ROADM functionality. ROADM functionality requires two 32DMX single-slot cards and two 32WSS double-slot cards (six slots in the ONS 15454 chassis). Equipped with ROADM functionality, ONS 15454 MSTP nodes can be configured at the optical channel level using CTC, Cisco MetroPlanner, and Cisco Transport Manager (CTM). Both the 32DMX card and 32WSS card utilize planar lightwave circuit (PLC) technology to perform wavelength-level processing. The 32DMX includes these high-level features: • COM RX port: COM RX is the input port for the aggregate optical signal being demultiplexed. This port is supported by both a VOA for optical power regulation and a photodiode for optical power monitoring. • DROP ports (1-32): On its output, the 32DMX provides 32 drop ports that are typically used for dropping channels within the ROADM node. Each drop port has a photodiode for optical power monitoring. Unlike the two-slot 32DMX-O demultiplexer, the drop ports on the 32DMX do not have a VOA per channel for optical power regulation.	1–6 and 12–17

Table 6-17 DWDM Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
4MD-xx.x	The 4MD-xx.x card has five sets of ports located on the faceplate. The 4-Channel Multiplexer/Demultiplexer (4MD-xx.x) card multiplexes and demultiplexes four 100 GHz-spaced channels identified in the channel plan. The 4MD-xx.x card is designed to be used with band OADMs (both AD-1B-xx.x and AD-4B-xx.x). There are eight versions of this card that correspond with the eight sub-bands specified in Table 4-17. The 4MD-xx.x has the following features implemented inside a plug-in optical module: • Passive cascade of interferential filters perform the channel multiplex/demultiplex function. • Software controlled VOAs at every port of the multiplex section to regulate the optical power of each multiplexed channel. • Software monitored photodiodes at the input and output multiplexer and demultiplexer ports for power control and safety purposes. • Software-monitored "virtual photodiodes" at the common DWDM output and input ports. A "virtual photodiode" is a firmware calculation of the optical power at that port. This calculation is based on the single channel photodiode reading and insertion losses of the appropriated paths.	1–6 and 12–17
AD-1C-xx.x	The AD-1C-xx.x card has three sets of ports located on the faceplate. The 1-Channel OADM (AD-1C-xx.x) card passively adds or drops one of the 32 channels utilized within the 100 GHz-spacing of the DWDM card system. There are thirty-two versions of this card, each designed only for use with one wavelength. Each wavelength version of the card has a different part number. The AD-1C-xx.x has the following internal features: • Two cascaded passive optical interferential filters perform the channel add and drop functions. • One software-controlled VOA regulates the optical power of the inserted channel. • Software-controlled VOA regulates the insertion loss of the express optical path. • Internal control of the VOA settings and functions, photodiode detection, and alarm thresholds. • Software-monitored virtual photodiodes (firmware calculations of port optical power) at the common DWDM output and input ports.	1–6 and 12–17

Table 6-17 DWDM Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
AD-2C-xx.x	The AD-2C-xx.x card has four sets of ports located on the faceplate. The 2-Channel OADM (AD-2C-xx.x) card passively adds or drops two adjacent 100 GHz channels within the same band. There are sixteen versions of this card, each designed for use with one pair of wavelengths. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. Each version of the card has a different part number. The AD-2C-xx.x cards are provisioned for the channel pairs in Table 4-18. In this table, channel IDs are given rather than wavelengths. The AD-2C-xx.x has the following features: • Passive cascade of interferential filters perform the channel add and drop functions. • Two software-controlled VOAs in the add section, one for each add port, regulate the optical power of inserted channels. • Software-controlled VOAs regulate insertion loss on express channels. • Internal control of the VOA settings and functions, photodiode detection, and alarm thresholds. • Software-monitored virtual photodiodes (firmware calculation of port optical power) at the common DWDM output and input ports.	1–6 and 12–17
AD-4C-xx.x	The AD-4C-xx.x card has six sets of ports located on the faceplate. The 4-Channel OADM (AD-4C-xx.x) card passively adds or drops all four 100 GHz-spaced channels within the same band. There are eight versions of this card, each designed for use with one band of wavelengths. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. There are eight versions of this card with eight part numbers. The AD-4C-xx.x cards are provisioned for the channel pairs in Table 4-19. The AD-4C-xx.x has the following features: • Passive cascade of interferential filters perform the channel add and drop functions. • Four software-controlled VOAs in the add section, one for each add port, regulate the optical power of inserted channels. • Two software-controlled VOAs regulate insertion loss on express and drop path, respectively. • Internal control of the VOA settings and functions, photodiode detection, and alarm thresholds. • Software-monitored virtual photodiodes (firmware calculation of port optical power) at the common DWDM output and input ports.	1–6 and 12–17

Table 6-17 DWDM Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
AD-1B-xx.x	The AD-1B-xx.x card has three sets of ports located on the faceplate. The 1-Band OADM (AD-1B-xx.x) card passively adds or drops a single band of four adjacent 100 GHz-spaced channels. There are eight versions of this card with eight different part numbers, each version designed for use with one band of wavelengths. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. This card can be used when there is asymmetric adding and dropping on each side (east or west) of the node; a band can be added or dropped on one side but not on the other. The AD-1B-xx.x has the following features: • Passive cascaded interferential filters perform the channel add and drop functions. • Two software-controlled VOAs regulate the optical power flowing in the express and drop OADM paths (drop section). • Output power of the dropped band is set by changing the attenuation of the VOA drop. • The VOA express is used to regulate the insertion loss of the express path. • Internal controlled VOA settings and functions, photodiode detection, and alarm thresholds. • Software-monitored virtual photodiode (firmware calculation of port optical power) at the common DWDM output.	1–6 and 12–17
AD-4B-xx.x	The AD-4B-xx.x card has six sets of ports located on the faceplate. The 4-Band OADM (AD-4B-xx.x) card passively adds or drops four bands of four adjacent 100 GHz-spaced channels. There are two versions of this card with different part numbers, each version designed for use with one set of bands. The card bidirectionally adds and drops in two different sections on the same card to manage signal flow in both directions. This card can be used when there is asymmetric adding and dropping on each side (east or west) of the node; a band can be added or dropped on one side but not on the other. The AD-4B-xx.x cards are provisioned for the channel pairs in Table 4-20. The AD-4B-xx.x has the following features: • Five software-controlled VOAs regulate the optical power flowing in the OADM paths. • Output power of each dropped band is set by changing the attenuation of each VOA drop. • The VOA express is used to regulate the insertion loss of the express path. • Internal controlled VOA settings and functions, photodiode detection, and alarm thresholds. • Software-monitored virtual photodiode (firmware calculation of port optical power) at the common DWDM output port.	1–6 and 12–17

Table 6-17 DWDM Card Functions and Slot Assignments (continued)

Card	Description	Slot Assignment
32WSS	The 32WSS card has seven sets of ports located on the faceplate. The card takes up two slots and can operates in Slots 1-2, 3-4, 5-6, or in Slots 12-13, 14-15, or 16-17. The 32-Channel Wavelength Selective Switch (32WSS) card performs channel add/drop processing within the ONS 15454 DWDM node. The 32WSS works in conjunction with the 32DMX to implement ROADM functionality. Equipped with ROADM functionality, the ONS 15454 DWDM can be configured to add or drop individual optical channels using CTC, Cisco MetroPlanner, and CTM. A ROADM network element utilizes two 32WSS cards (two slots each) and two 32DMX cards (one slot each), for a total of six slots in the chassis. The 32WSS has six types of ports: • ADD RX ports (1-32): These ports are used for adding channels. Each add channel is associated with an individual switch element that selects whether an individual channel is added. Each add port has optical power regulation provided by a VOA. • EXP RX port: The EXP RX port receives an optical signal from another 32WSS module in the same network element. • EXP TX port: The EXP TX port sends an optical signal to the other 32WSS module within the network element. • COM TX port: The COM TX port sends an aggregate optical signal to a booster card (for example, OPT_BST) for transmission outside of the network element. • COM RX port: The COM RX port receives the optical signal from a pre-amplifier and sends it to the optical splitter. • DROP TX port: The DROP TX port sends the split off optical signal that contains drop channels to the 32DMX card where the channels are further processed and dropped.	1–2, 3–4, 5–6, and 12–13, 14–15, or 16–17

LED Indicators

TCC+, TCC2, and TCC2P Cards

The TCC+, TCC2, and TCC2P (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, XCVT, and XC10G Cards

The XC, XCVT, and XC10G (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, Optical, and DWDM Cards

The electrical, optical, and DWDM 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.

Port-level indicators include the following:

- Bicolor LEDs show the status per port. The LEDs shows green if the port is available to carry traffic, is provisioned as in-service, and is part of a protection group, in the active mode. You can also 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.
- The OSCM has three OC-3 optical ports located on the faceplate. One long-reach OSC transmits and receives the OSC to and from another DWDM node. Both data communications network (DCN) data and far-end (FE) payload are carried on this link. Two intermediate-reach OC-3 ports are used for DCN extension.
- The OSC-CSM has a UC port and three sets of ports located on the faceplate.
- The OPT-PRE amplifier has five optical ports located on the faceplate. MON is the output monitor port. COM Rx is the input signal port. COM Tx is the output signal port. DCC Rx is the MAL input signal port. DCC Tx is the MAL output signal port.

- The OPT-BST amplifier has eight optical ports located on the faceplate. MON Rx is the output monitor port (receive section). MON Tx is the output monitor port. COM Rx is the input signal port. LINE Tx is the output signal port. LINE Rx is the input signal port (receive section). COM Tx is the output signal port (receive section). OSC Rx is the OSC add input port. OSC Tx is the OSC drop output port.
- The 32MUX-O and 32DMX-O cards have five sets of ports located on the faceplate. COM Tx is the line output. MON is the optical monitoring port. The xx.x-yy.y Rx ports represent the four groups of 8 channels ranging from xx.x wavelength to yy.y wavelength according to the channel plan.
- The 32DMX card has five ports located on the faceplate. The port labeled COM RX is the line input (it typically receives DROP TX from the 32WSS module). The TX ports are 32 drop ports. The connectors provide four groups of eight channels ranging from xx.x wavelength to yy.y wavelength according to the channel plan.
- The 4MD-xx.x card has five sets of ports located on the faceplate. COM Rx is the line input. COM Tx is the line output. The 15xx.x Tx ports represent demultiplexed channel Outputs 1 to 4. The 15xx.x Rx ports represent multiplexed channel Inputs 1 to 4.
- The AD-1C-xx.x has six LC-PC-II optical ports: two for add/drop channel client input and output, two for express channel input and output, and two for communication.
- The AD-2C-xx.x card has eight LC-PC-II optical ports: four for add/drop channel client input and output, two for express channel input and output, and two for communication.
- The AD-4C-xx.x card has 12 LC-PC-II optical ports: eight for add/drop channel client input and output, two for express channel input and output, and two for communication.
- The AD-1B-xx.x has six LC-PC-II optical ports: two for add/drop channel client input and output, two for express channel input and output, and two for communication.
- The AD-4B-xx.x has 12 LC-PC-II optical ports: eight for add/drop band client input and output, two for express channel input and output, and two for communication.
- The 32WSS card has five sets of ports located on the faceplate. COM RX is the line input, COM TX is the line output, EXP RX is the port where a channel can be added or passed through, EXP TX is the port that passes through the channels that are not dropped, and DROP TX is the port for the dropped channels. The xx.x-yy.y TX ports represent the four groups of eight channels ranging from xx.x wavelength to yy.y wavelength according to the channel plan.
- Each FC_MR-4 port has a corresponding ACT/LNK LED. The ACT/LNK LED is solid green if the port is available to carry traffic, is provisioned as in-service, and in the active mode. The ACT/LNK LED is blinking green if the port is carrying traffic.

Ethernet Cards

The Ethernet cards have the following card-level LED 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 include the following:

- 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 6-18 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]	Backplane EIA
DS3/EC1-48	48	GR-499-CORE	44.736 Mb/s	SMB or BNC[1]	Backplane EIA
DS3XM-6	6	GR-499-CORE M13	44.736 Mb/s	SMB or BNC[1]	Backplane EIA
DS3XM-12	12	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	Faceplate
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

Table 6-18 Card Port and Connector Information (continued)

Plug-in Card	Number of Ports	Compliant Standard	Line Rate	Connector Type	Connector Location
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: SFP Trunk: LC	Faceplate
MXP_2.5G_10E[2]	4-Client 1-Trunk	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	Client: SFP Trunk: LC	Faceplate
TXP-MR-10G[2]	1-Client 1-Trunk	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC	Faceplate
TXP-MR-10E[2]	1-Client 1-Trunk	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC	Faceplate
TXP_MR_2.5G	1-Client 1-Trunk	GR-253-CORE ITU-T G.707 ITU-T G.957	2.488 Gb/s	Client: SFP Trunk: LC	Faceplate
TXPP_MR_2.5G	1-Client 2-Trunk	GR-253-CORE ITU-T G.707 ITU-T G.957	2.488 Gb/s	Client: SFP Trunk: LC	Faceplate
FC_MR-4	4	GR-253-CORE ITU-T G.957	1.0625- or 2.125-Gb/s	GBIC-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
OSCM	2	GR-253-CORE ITU-T G.957	155.52 Mb/s	LC	Faceplate
OSC-CSM	4	GR-253-CORE ITU-T G.957	UDC: FE Optical: 155.52 Mb/s	UDC: RJ45 Optical: LC	Faceplate
OPT-PRE	5	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate

Table 6-18 Card Port and Connector Information (continued)

Plug-in Card	Number of Ports	Compliant Standard	Line Rate	Connector Type	Connector Location
OPT-BST	4	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
32MUX-O	5	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
32DMX-O	5	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
32DMX	5	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
4MD-xx.x	5	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
AD-1C-xx.x	3	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
AD-2C-xx.x	4	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
AD-4C-xx.x	6	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
AD-1B-xx.x	3	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate
AD-4B-xx.x	6	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	Faceplate

Table 6-18 Card Port and Connector Information (continued)

Plug-in Card	Number of Ports	Compliant Standard	Line Rate	Connector Type	Connector Location
32WSS	7	GR-253-CORE ITU-T G.707 ITU-T G.957	9.95328 Gb/s	LC-UPC/2	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 Compatibility

The following tables list the software release and common card compatibility for each plug-in card. Table cells with dashes (—) mean cards are not compatible with the listed software release or cross-connect card.

See http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html for the latest list of End-Of-Life and End-Of-Sale notices.

Table 6-19 Common Card Software and Hardware Compatibility

Card	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x	XC	XCVT	XC10G[1]
TCC+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	—	Yes	Yes	Yes
TCC2	—	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TCC2P	—	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes
XC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	—	Yes	Yes	—
XCVT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	—	Yes	Yes	—
XC10G[1]	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	—	Yes
AIC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AIC-I	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AEP	—	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

1. The XC10G card requires a TCC+/TCC2/TCC2P card, Software R3.1 or later, and the 15454-SA-ANSI or 15454-SA-HD shelf assemblies to operate.

Table 6-20 Electrical Card Software and Cross-Connect Card Compatibility

Card	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x	XC	XCVT	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	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6-20 Electrical Card Software and Cross-Connect Card Compatibility

Card	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x	XC	XCVT	XC10G
DS3N-12E	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS3/EC1-48	—	—	—	—	—	—	—	Yes	Yes	Yes	Yes
DS3XM-6	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DS3XM-12	—	—	—	—	—	—	—	Yes	Yes	Yes	Yes

Table 6-21 Optical Card Software and Cross-Connect Card Compatibility

Card	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x	XC	XCVT	XC10G
OC3-IR-4/STM1-SH-1310	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC-3-IR-8/STM1-SH-1310	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-	Yes in slots 1-4 and 14-17
OC12-IR/STM4-SH-1310	Yes	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	Yes
OC12-LR/STM4-LH-1550	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC12-IR-4/STM4-SH-1310	—	—	—	Yes	Yes	Yes	Yes	Yes	Yes	—	—	Yes in slots 1-4 and 14-17
OC48-IR-1310	Yes	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	Yes
OC48-IR/STM16-SH-AS-1310	—	Yes[1]	Yes	Yes	Yes	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	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	Yes
OC48-ELR-200 GHz	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OC192-SR/STM64-IO-1310	—	—	—	—	—	Yes	Yes	Yes	Yes	—	—	Yes[1]
OC192-IR/STM64-SH-1550	—	—	—	—	—	Yes	Yes	Yes	Yes	—	—	Yes[1]

Table 6-21 Optical Card Software and Cross-Connect Card Compatibility (continued)

Card	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x	XC	XCVT	XC10G
OC192-LR/STM 64-LH-1550	—	Yes[1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	—	Yes[1]
OC192-LR/STM 64-LH-ITU	—	—	—	—	—	Yes	Yes	Yes	Yes	—	—	Yes[1]

1. The XC10G card requires a TCC+/TCC2/TCC2P card, Software R3.1 or later, and the 15454-SA-ANSI or 15454-SA-HD shelf assemblies to operate.

Table 6-22 Ethernet Card Software and Cross-Connect Card Compatibility

Card	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x	XC	XC-VT	XC10G
CE-100T-8	—	—	—	—	—	—	—	—	Yes	—	—	Yes
E100T-12	Yes	Yes	Yes	yes	Yes	Yes	Yes	Yes	Yes	—	Yes	—
E1000-2	Yes	Yes	Yes	yes	Yes	Yes	Yes	Yes	Yes	—	Yes	—
E100T-G	Yes	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	Yes[1]
G1000-4	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes[1]
G1K-4	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ML100T-12	—	—	—	—	—	Yes	Yes	Yes	Yes	Yes, in slots 5, 6, 12, and 13	Yes, in slots 5, 6, 12, and 13	Yes
ML1000-2	—	—	—	—	—	Yes	Yes	Yes	Yes	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 card, select either the E100T-G, E1000-2-G, G1000-4, or G1K4 card. Do not use the E100T-12 card or E1000-2 card with the XC10G.

Table 6-23 SAN Card Software and Common Card Compatibility

Card	R4.6.x	R5.0.x	XC	XC-VT	XC10G
FC_MR-4	Yes	Yes	Yes, in slots 5, 6, 12, and 13	Yes, in slots 5, 6, 12, and 13	Yes

Table 6-24 Transponder/Muxponder Card Software and Common Card Compatibility

Card	R4.5.x	R4.6.x	R4.7.x	R5.0.x	TCC2	TCC2P	AIC/AIC-I	XC10G[1]
TXP_MR-10G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TXP_MR_10E	-	-	Yes	Yes	Yes	Yes	Yes	Yes
TXP_MR_2.5G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TXPP_MR_2.5G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6-24 Transponder/Muxponder Card Software and Common Card Compatibility

Card	R4.5.x	R4.6.x	R4.7.x	R5.0.x	TCC2	TCC2P	AIC/AIC-I	XC10G[1]
MXP_2.5_10G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MXP_2.5_10E	-	-	Yes	Yes	Yes	Yes	Yes	Yes
MXP_MR_2.5G	-	-	Yes	Yes	Yes	Yes	Yes	Yes
MXPP_MR_2.5G	-	-	Yes	Yes	Yes	Yes	Yes	Yes

1. XC10G cannot be used with Release 4.5, but is supported in Release 4.6 and higher for hybrid MSTP/MSPP configurations.

Table 6-25 DWDM Card Software and Common Card Compatibility

Card	R4.5.x	R4.6.x	R4.7.x	R5.0.x	TCC2	TCC2P	AIC/AIC-I	XC10G[1]
OSCM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OSC-CSM	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OPT-PRE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OPT-BST	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
32MUX-O	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
32DMX-O	Yes	Yes	Yes	yes	Yes	Yes	Yes	Yes
32DMX	—	—	Yes	Yes	Yes	Yes	Yes	Yes
4MD-xx.x	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AD-1C-xx.x	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AD-2C-xx.x	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AD-4C-xx.x	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AD-1B-xx.x	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AD-4B-xx.x	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
32WSS	—	—	Yes	Yes	Yes	Yes	Yes	Yes

1. XC10G cannot be used with Release 4.5, but is supported in Release 4.6 and higher for hybrid MSTP/MSPP configurations.

GBIC and SFP Connectors

The ONS 15454 Ethernet cards use industry standard small form-factor pluggable connectors (SFPs) and Gigabit Interface Converter (GBIC) modular receptacles. The ML-Series Gigabit Ethernet cards use standard Cisco SFPs. The Gigabit E-Series card and the G-Series card use standard Cisco GBICs. With Software Release 4.1 and higher, G-Series cards can also be equipped with dense wavelength division multiplexing (DWDM) and coarse wavelength division multiplexing (CWDM) GBICs to function as Gigabit Ethernet transponders.

For all Ethernet cards, the type of GBIC or SFP plugged into the card is displayed in CTC and TL1. Cisco offers SFPs and GBICs as separate orderable products.

GBIC and SFP Card Compatibility

Caution Only use GBICs and SFPs certified for use in Cisco Optical Networking Systems. The qualified Cisco GBIC and SFP pluggable module's top assembly numbers (TANs) are provided in Table 6-50.

The technical specifications for Cisco's GBICs and SFPs are listed in Table 6-26.

Table 6-26 GBIC and SFP Specifications

Specifications	1000BaseSX	1000BaseLX	1000BaseZX	1000BaseSX SFP	1000BaseLX SFP
General:					
Connector	SC	SC	SC	SFP	SFP
Wavelength	850 nm	1300 nm	1550 nm	850 nm	1300 nm
Minimum Cable Distance[1]	2 m	2 m	2 m	2 m	2 m
Maximum Cable Distance	1,804 ft (550 m)	32,810 ft. (10 km)	262,480 ft. (80 km)	1,804 ft (550 m)	32,810 ft. (10 km)
Port Cabling					
Wavelength	850 nm	1300 nm	1550 nm	850 nm	1300 nm
Fiber Type	MMF	SMF	SMF	MMF	SMF
Core Size (microns)	62.5	62.5	Not Conditional	62.5	62.5
Modal Bandwidth	160 MHz/km	500 MHz/km	NA	160 MHz/km	500 MHz/km
Maximum Distance	220 m	550 m	80 km	220 m	550 m
Fiber Loss Budgets:					
Transmit Minimum	-9.5 dBm	-11 dBm	0 dBm	-9.5 dBm	-11 dBm
Transmit Maximum	-4 dBm	-3 dBm	4.77 dBm	-4 dBm	-3 dBm
Receive Minimum	-17 dBm	-19 dBm	-24 dBm	-17 dBm	-19 dBm
Receive Maximum	0 dBm	-3 dBm	-1 dBm	0 dBm	-3 dBm
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)	• Commercial: -5° to 70°C • Extended: -5°C to +85°C • I-Temp: -40°C to +85°C	• Commercial: -5° to +70°C • Extended: -5°C to +85°C • I-Temp: -40°C to +85°C
Dimensions:					
Height	0.39 in.	0.39 in.	0.39 in.	0.03 in.	0.03 in.

Table 6-26 GBIC and SFP Specifications (continued)

Specifications	1000BaseSX	1000BaseLX	1000BaseZX	1000BaseSX SFP	1000BaseLX SFP
Width	1.18 in.	1.18 in.	1.18 in.	0.53 in.	0.53 in.
Depth	2.56 in.	2.56 in.	2.56 in.	2.22 in.	2.22 in.
IEEE Compliant	Yes	Yes	Yes	Yes	Yes

1. When using an LX SFP or LX GBIC with multimode fiber, you must install a mode-conditioning patch cord between the SFP/GBIC and the multimode fiber cable on both the transmit and receive ends of the link. The mode-conditioning patch cord is required for link distances less than 100 m (328 feet) or greater than 300 m (984 feet). The mode-conditioning patch cord prevents overdriving the receiver for short lengths of multimode fiber and reduces differential mode delay for long lengths of multimode fiber.

DWDM and CWDM GBICs

DWDM (15454-GBIC-xx.x, 15454E-GBIC-xx.x) and CWDM (15454-GBIC-xxxx, 15454E-GBIC-xxxx) GBICs operate in the ONS 15454 G-Series card when the card is configured in Gigabit Ethernet Transponding mode or in Ethernet over SONET mode. DWDM and CWDM GBICs are both wavelength division multiplexing (WDM) technologies and operate over single-mode fibers with SC connectors. Cisco CWDM GBIC technology uses a 20 nm wavelength grid and Cisco ONS 15454 DWDM GBIC technology uses a 1 nm wavelength grid. CTC displays the specific wavelengths of the installed CWDM or DWDM GBICs. DWDM wavelengths are spaced closer together and require more precise lasers than CWDM. The DWDM spectrum allows for optical signal amplification.

The DWDM and CWDM GBICs receive across the full 1300 nm and 1500 nm bands, which includes all CWDM, DWDM, LX/LH, ZX wavelengths, but transmit on one specified wavelength. This capability can be exploited in some of the G-Series transponding modes by receiving wavelengths that do not match the specific transmission wavelength.

G1000-4 cards support CWDM and DWDM GBICs. G1K-4 cards with the Common Language Equipment Identification (CLEI) code of WM5IRWPCAA (manufactured after August 2003) support CWDM and DWDM GBICs. G1K-4 cards manufactured prior to August 2003 do not support CWDM or DWDM GBICs.

The ONS 15454-supported CWDM GBICs reach support eight wavelengths as shown in Table 6-27.

Table 6-27 Supported Wavelengths for CWDM GBICs

CWDM GBIC Wavelengths	1470 nm	1490 nm	1510 nm	1530 nm	1550 nm	1570 nm	1590 nm	1610 nm
Corresponding GBIC Colors	Grey	Violet	Blue	Green	Yellow	Orange	Red	Brown
Band	47	49	51	53	55	57	59	61

The ONS 15454 supports 32 different DWDM GBICs in the red and blue bands and can be paired with optical amplifiers, such as the Erbium-Doped Fiber Amplifier (EDFA). Operating temperature range for DWDM GBICs is from -5 to +40 degrees Celsius.

Table 6-28 100 GHz DWDM GBIC Channel Plan

Blue Band	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

Table 6-28 100 GHz DWDM GBIC Channel Plan

Red Band	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

Network Element Defaults and Performance Monitoring Thresholds

The following tables lists the network element (NE) default settings for the ONS 15454 and threshold ranges for monitored parameters. These tables include card and node default settings from the factory. Cards not listed in these tables are not supported by NE defaults. The factory [default] settings are in brackets. For a description of defaults and performance monitoring (PM) parameters, see the *Cisco ONS 15454 Reference Manual*.

You can disable any monitored threshold by setting its value to zero. To change card settings individually (that is, without changing the NE defaults), refer to the Change Card Settings chapter of the *Cisco ONS 15454 Procedure Guide*. To change node settings, refer to the Change Node Settings chapter of the *Cisco ONS 15454 Procedure Guide*.

- Refer Table 6-29 for CTC defaults
- Refer Table 6-30 for Node defaults
- Refer Table 6-31 for DS1-14 defaults
- Refer Table 6-32 for DS3-12/DS3-12E defaults
- Refer Table 6-33 for DS3/EC1-48 defaults
- Refer Table 6-34 for DS3XM-6 defaults
- Refer Table 6-35 for DS3XM-12 defaults
- Refer Table 6-36 for EC1-12 defaults
- Refer Table 6-37 for OC3-4/OC3-8 defaults
- Refer Table 6-38 for OC12/OC12-4 defaults
- Refer Table 6-39 for OC48 defaults
- Refer Table 6-40 for OC-192 defaults
- Refer Table 6-41 for OSC-CSM defaults
- Refer Table 6-42 for OSCM defaults
- Refer Table 6-43 for MXP_2.5G_10G defaults
- Refer Table 6-44 for MXP_2.5G_10E defaults
- Refer Table 6-45 for MXP_MR_2.5G/MXPP_MR_2.5G defaults
- Refer Table 6-46 for TXP_MR_10G defaults
- Refer Table 6-47 for TXP_MR_10E defaults
- Refer Table 6-48 for TXP_MR_2.5G/TXPP_MR_2.5G defaults
- Refer Table 6-49 for FC_MR-4 defaults
- Refer Table 6-50 for CE-100T-8 defaults
- Refer Table 6-51 for G1000-4/G1K4 defaults

- Refer Table 6-52 for ML100T-12 defaults
- Refer Table 6-53 for ML1000-2 defaults

See http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html for the latest list of End-Of-Life and End-Of-Sale notices.

Table 6-29 CTC Defaults

Field	Parameter	Settable Range [Default]
CTC	Circuits Auto Route	TRUE - FALSE [TRUE]
	Circuits Create Like TL1	TRUE - FALSE [FALSE]
	Circuits State	IS; OOS,DSBLD; OOS,MT; IS,AINS [IS,AINS]
	Network Map	Germany, Japan, Netherlands, South Korea, United Kingdom, United States [United States]

Table 6-30 Node Defaults

Field	Parameter	Settable Range [Default]
Circuits	Send PDIP	TRUE - FALSE [TRUE]
	UPSR Reversion Time (minutes)	0.5 - 12.0 [5.0]
	UPSR Revertive	TRUE - FALSE [FALSE]
	UPSR STS-Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-6]
	UPSR STS-Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]
	UPSR Switch on PDIP	TRUE - FALSE [FALSE]
	UPSR VT-Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-5]
	UPSR VT-Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]
General	Defaults Description	HTML Text [Factory Defaults]
	IIOP Listener Port	0 - 65535 [57790]
	Insert AIS On SDP	TRUE - FALSE [FALSE]
	NTP SNTP Server	Variable [0.0.0.0]
	SDP BER	1E-5 - 1E-9 [1E-6]
	Time Zone	GMT-EST, CST, PST [GMT-PST]
	USE Daylight Savings Time (DST)	TRUE - FALSE [TRUE]
Network	Alarm Missing Backplane LAN	TRUE - FALSE [FALSE]
	CTC IP Display Suppression	TRUE - FALSE [FALSE]
	Gateway Settings	None, ENE, GNE [None]
	LCD IP Setting	Allow Configuration, Display Only, Suppress Display [Allow Configuration]

Table 6-30 Node Defaults (continued)

Field	Parameter	Settable Range [Default]
Power Monitor	Extremely High Input Voltage (EHIBATVG)	-40.5 to -56.5 V in 0.5 V steps [-56.5]
	Extremely Low Input Voltage (ELWBATVG)	-40.5 to -56.5 V in 0.5 V steps [-40.5]
	High Input Voltage (HIBATVG)	-40.5 to -56.5 V in 0.5 V steps [-54.0]
	Low Input Voltage (LWBATVG)	-40.5 to -56.5 V in 0.5 V steps [-44.0]
Protection	1+1 bidirectional Switching	TRUE - FALSE [FALSE]
	1+1 Detection Guard Timer (seconds)	0 - 5 [1]
	1+1 Recovery Guard Timer (seconds)	0 - 10 [1]
	1+1 Reversion Time (minutes)	0.5 - 12.0 [5.0]
	1+1 Revertive	TRUE - FALSE [FALSE]
	1+1 Verify Guard Timer	0.5 - 1 [0.5]
	BLSR Ring Reversion Time (minutes)	0.5 - 12.0 [5.0]
	BLSR Ring Revertive	TRUE - FALSE [TRUE]
	BLSR Span Reversion Time (minutes)	0.5 - 12.0 [5.0]
	BLSR Span Revertive	TRUE - FALSE [TRUE]
	Ycable Reversion Time (minutes)	0.5 - 12.0 [5.0]
	Ycable Revertive	TRUE - FALSE [FALSE]
	Splitter Reversion Time (minutes)	0.5 - 12.0 [5.0]
	Splitter Revertive	TRUE - FALSE [FALSE]

Table 6-30 Node Defaults (continued)

Field	Parameter	Settable Range [Default]
Security	Access LAN Access	No LAN Access, Backplane Only, Front & Backplane [Front & Backplane]
	Access Restore Time Out	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]
	Legal Disclaimer 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.]
	Other Disable Inactive User	TRUE - FALSE [FALSE]
	Other Inactive Duration	40 - 90 Days [45]
	Other PM Clearing Privilege	SUPERUSER, PROVISIONING, MAINTENANCE, RETRIEVE [PROVISIONING]
	Other Single Session Per User	TRUE - FALSE [FALSE]
	Password Aging Enforce Password Aging	TRUE - FALSE [FALSE]
	Password Aging Maintenance Expiration Period	20 to 90 days [45]
	Password Aging Maintenance Warning Period	2 to 90 days [5]
	Password Aging Provisioning Expiration Period	20 to 90 days [45]
	Password Aging Provisioning Warning Period	2 to 90 days [5]
	Password Aging Retrieve Expiration Period	20 to 90 days [45]
	Password Aging Retrieve Warning Period	2 to 90 days [5]
	Password Aging Superuser Expiration Period	20 to 90 days [45]
	Password Aging Superuser Warning Period	2 to 90 days [5]
	Password Change Cannot Change New Password	TRUE - FALSE [FALSE]
	Password Change Cannot Change New Password For N Days	20 to 90 days [45]
	Password Change Prevent Reusing Last N Passwords	0 - 10 [1]
	Password Change Require Password Change On First Login To New Account	TRUE - FALSE [FALSE]
	Shell Access SSH	TRUE - FALSE [FALSE]
	Shell Access Telnet Port	23 - 9999 [23]
	User Lockout Failed Logins Before Lockout	0 - 10 [5]
	User Lockout Lockout Duration (min:sec)	00:00 - 10:00 [00:30]
	User Lockout Manual Unlock By Superuser	TRUE - FALSE [FALSE]

Table 6-30 Node Defaults (continued)

Field	Parameter	Settable Range [Default]
Timing	BITS-1 Alarm Indication Signal (AIS) Threshold	PRS - RES [SMC]
	BITS 1 Admin SSM In	PRS - RES [STU]
	BITS-1 Coding	B8ZS - AMI [B8ZS]
	BITS 1 Coding Out	B8ZS - AMI [B8ZS]
	BITS 1 Facility Type	DS1 - 64Khz+8Khz [DS1]
	BITS 1 Facility Type Out	DS1 - 64Khz+8Khz [DS1]
	BITS-1 Framing	ESF - SF(D4) [ESF]
	BITS 1 Framing Out	ESF - SF(D4) [ESF]
	BITS-1 Line Build Out (LBO) in feet	0 -655 [0-133]
	BITS-1 State	IS - OOS [IS]
	BITS-1 State Out	IS - OOS [IS]
	BITS-2 Alarm Indication Signal (AIS) Threshold	PRS - RES [SMC]
	BITS 2 Admin SSM In	PRS - RES [STU]
	BITS 2 Coding	B8ZS - AMI [B8ZS]
	BITS 2 Coding Out	B8ZS - AMI [B8ZS]
	BITS 2 Facility Type	DS1 - 64Khz+8Khz [DS1]
	BITS 2 Facility Type Out	DS1 - 64Khz+8Khz [DS1]
	BITS 2 Framing	ESF - SF(D4) [ESF]
	BITS 2 Framing Out	ESF - SF(D4) [ESF]
	BITS 2 Line Build Out (LBO) in feet	0 -655 [0-133]
	BITS 2 State	IS - OOS [IS]
	BITS 2 State Out	IS - OOS [IS]
	General Mode	Line, External, Mixed [External]
	General Quality of RES	PRS<RES - RES=DUS [RES=DUS]
	General Reversion Time (minutes)	0.5 - 12.0 [5.0]
	General Revertive	TRUE - FALSE [FALSE]
	General SSM Message Set	Generation 1 - Generation 2 [Generation 1]

Table 6-31 DS1-14 Defaults

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]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	
Line - Near End	Coding Violations (CV) [BPV count]	0-1388700 [13340]	0-133315200 [133400]
	Errored Seconds (ES)	0-900 [65]	0-86400 [648]
	Loss of Signal Seconds (LOSS)	0-900 [10]	0-86400 [10]
	Severely Errored Seconds (SES)	0-900 [10]	0-86400 [100]
Line - Far End	Errored Seconds (ES)	0-900 [65]	0-86400 [648]
Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [13296]	0-27561600 [132960]
	Errored Seconds (ES)	0-900 [65]	0-86400 [648]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [17]
	Severely Errored Seconds (SES)	0-900 [10]	0-86400 [100]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Path - Far End	Controlled Slip Seconds (CSS)	0-900 [25]	0-86400 [25]
	Coding Violations (CV) [BIP count]	0-287100 [13296]	0-27561600 [132960]
	Errored Seconds (ES)	0-900 [65]	0-86400 [648]
	Errored Seconds-A (ESA) sent by the NE	0-900 [25]	0-86400 [25]
	Errored Seconds-B (ESB) sent by CPE	0-900 [25]	0-86400 [25]
	Severely Errored Framed Seconds (SEFS)	0-900 [25]	0-86400 [25]
	Severely Errored Seconds (SES)	0-900 [10]	0-86400 [100]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-31 DS1-14 Defaults (continued)

Field	Parameter	Threshold Range [Default] 15 Minutes	1 Day
VT - Near End	Coding Violations (CV) [BIP8 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [10]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
VT - Far End	Coding Violations (CV) [BIP8 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS - Far End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-32 DS3-12/DS3-12E Defaults

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]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	

Table 6-32 DS3-12/DS3-12E Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Line - Near End	Coding Violations (CV) [BPV count]	0-38700 [387]	0-3715200 [3865]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Loss of Signal Seconds (LOSS)	0-900 [10]	0-86400 [10]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
Pbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Cbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Cbit Path - Far End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-32 DS3-12/DS3-12E Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
STS - Far End	Coding Violations (CV) [G1 count]	0-72 [15]	0-6912 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-2160000 [10]	0-207360000 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-33 DS3/EC1-48 Defaults

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]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [IS,AINS]	
Line - Near End	Coding Violations (CV) [BPV count]	0-38700 [387]	0-3715200 [3865]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Loss of Signal Seconds (LOSS)	0-900 [10]	0-86400 [10]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
Pbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Cbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-33 DS3/EC1-48 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Cbit Path - Far End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS - Far End	Coding Violations (CV) [G1 count]	0-72 [15]	0-6912 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-2160000 [10]	0-207360000 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-34 DS3XM-6 Defaults

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	TRUE - FALSE [FALSE]	
	Line Length (feet)	0 - 450 [0-225]	
	Line Type	M13, CBIT [M13]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	
Line - Near End	Coding Violations (CV) [BPV count]	0-38700 [387]	0-3715200 [3865]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Loss of Signal Seconds (LOSS)	0-900 [10]	0-86400 [10]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]

Table 6-34 DS3XM-6 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
Pbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Cbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Cbit Path - Far End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
DS1 Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Errored Seconds (ES)	0-900 [65]	0-86400 [648]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [17]
	Severely Errored Seconds (SES)	0-900 [10]	0-86400 [100]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS - Far End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-34 DS3XM-6 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
VT - Near End	Coding Violations (CV) [BIP8 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
VT - Far End	Coding Violations (CV) [BIP8 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-35 DS3XM-12 Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration	Far End Inhibit Loopback	TRUE - FALSE [FALSE]	
	Line Length (feet)	0 - 450 [0-225]	
	Line Type	M13, CBIT [M13]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	
DS1 Configurations	Facility Datalink Mode	T1.403 [T1.403]	
	Line Type	ESF, D4, UNFRAMED, AUTO FRAMED [AUTO FRAMED]	
Line - Near End	Coding Violations (CV) [BPV count]	0-38700 [387]	0-3715200 [3865]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Loss of Signal Seconds (LOSS)	0-900 [10]	0-86400 [10]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
Pbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-35 DS3XM-12 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Cbit Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Cbit Path - Far End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-287100 [382]	0-27561600 [3820]
	Errored Seconds (ES)	0-900 [25]	0-86400 [250]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [8]
	Severely Errored Seconds (SES)	0-900 [4]	0-86400 [40]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
Ds1 Network - Far End	Errored Seconds (ES) FE	0-900 [65]	0-86400 [648]
	Errored Seconds (ES) NE	0-900 [65]	0-86400 [648]
	Severely Errored Seconds (SES) FE	0-900 [10]	0-86400 [100]
	Severely Errored Seconds (SES) NE	0-900 [10]	0-86400 [100]
	Unavailable Seconds (UAS) FE	0-900 [10]	0-86400 [10]
	Unavailable Seconds (UAS) NE	0-900 [10]	0-86400 [10]
DS1 Path - Near End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Coding Violations (CV) [BIP count]	0-2160000 [13296]	0-13219200 [132960]
	Errored Seconds (ES)	0-900 [65]	0-86400 [648]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [17]
	Severely Errored Seconds (SES)	0-900 [10]	0-86400 [100]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
DS1 Path - Far End	AIS Seconds (AISS)	0-900 [10]	0-86400 [10]
	Controlled Slip Seconds (CSS)	0-900 [25]	1-86400 [25]
	Coding Violations (CV) [BIP count]	0-2160000 [13296]	0-13219200 [132960]
	Errored Seconds (ES)	0-900 [65]	0-86400 [648]
	Errored Seconds-A (ESA) sent by the NE	0-900 [25]	1-86400 [25]
	Errored Seconds-B (ESB) sent by the CPE	0-900 [25]	1-86400 [25]
	Severely Errored Seconds Alarm Signal (SAS)	0-900 [2]	0-86400 [17]
	Severely Errored Framed Seconds (SEFS)	0-900 [25]	1-86400 [25]
	Severely Errored Seconds (SES)	0-900 [10]	0-86400 [100]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-36 EC1-12 Defaults

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]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	
Configuration - STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE - FALSE [FALSE]	
Line - Near End	STS-1 Coding Violations (CV) [B2 count]	0-137700 [1312]	0-8850600 [13120]
	STS-1 Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	STS-1 Failure Count (FC)	0-72 [10]	0-6912 [40]
	STS-1 Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	STS-1 Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Line - Far End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-8850600 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Section - Near End	Coding Violations (CV) [B1 count]	0-138600 [10000]	0-13219200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-36 EC1-12 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
STS-1 - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Difference (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-37 OC3-4/ OC3-8 Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration - Line	AINS Soak Time (hrs:min)	00:00 - 48:00 [08:00]	
	Admin SSM In	PRD - RES [STU]	
	AIS Mode (OC-3 8 port card only)	Enable - Disabled [Disabled]	
	AlS Recovery Interval (OC-3-8 card only)	60-300 [100] seconds	
	AlS Recovery Pulse Duration (OC-3-8 card only)	2.0-100.0 [2.0] seconds	
	Enable Synch Messaging (SyncMsgIn)	TRUE - FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0-3 [0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	Send <FF> Do Not Use	TRUE - FALSE [FALSE]	
	Send Do Not Use (DUS)	TRUE - FALSE [FALSE]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	

Table 6-37 OC3-4/ OC3-8 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration - STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE - FALSE [FALSE]	
Line - Near End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Protection Switching Count (PSC)	0-600 [1]	0-57600 [5]
	Protection Switching Duration (PSD) seconds	0-900 [300]	0-86400 [600]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Line - Far End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Section - Near End	Coding Violations (CV) [B1 count]	0-138600 [10000]	0-13219200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
STS-1 - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Difference (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-37 OC3-4/ OC3-8 Defaults (continued)

Field	Parameter	Threshold Range [Default] 15 Minutes	Threshold Range [Default] 1 Day
STS-3c - Near End	Coding Violations (CV) [B3 count]	0-2160000 [25]	0-207360000 [250]
	Errored Seconds (ES)	0-900 [20]	0-86400 [200]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Diff. (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-600 [60]	0-57600 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-600 [60]	0-57600 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-38 OC12/ OC12-4 Defaults

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]	
	Admin SSM In	PRD - RES [STU]	
	Enable Synch Messaging (SyncMsgIn)	TRUE - FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0-12 [0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	Send <FF> Do Not Use	TRUE - FALSE [FALSE]	
	Send Do Not Use (DUS)	TRUE - FALSE [FALSE]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	
Configuration - STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE - FALSE [FALSE]	

Table 6-38 OC12/ OC12-4 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Line - Near End	Coding Violations (CV) [B2 count]	0-137700 [5315]	0-13219200 [53150]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Protection Switching Count (PSC)	0-600 [1]	0-57600 [5]
	Protection Switching Count (PSC) - Working	0-600 [1]	0-57600 [5]
	Protection Switching Duration (PSD) seconds	0-600 [300]	0-57600 [600]
	Protection Switching Duration (PSD) seconds - Working	0-600 [300]	0-57600 [600]
	Severely Errored Seconds (SES)	0-900 [1]	1-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	1-86400 [10]
Line - Far End	Coding Violations (CV) [B2 count]	0-137700 [5315]	1-13219200 [53150]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Section - Near End	Coding Violations (CV) [B1 count]	0-138600 [10000]	0-13219200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
STS-1 - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Difference (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-38 OC12/ OC12-4 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
STS-3c-9c - Near End	Coding Violations (CV) [B3 count]	0-2160000 [25]	0-207360000 [250]
	Errored Seconds (ES)	0-900 [20]	0-86400 [200]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Diff. (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS-12c - Near End	Coding Violations (CV) [B3 count]	0-2160000 [75]	0-207360000 [750]
	Errored Seconds (ES)	0-900 [60]	0-86400 [600]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Diff. (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-39 OC48 Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration - Line	AINS Soak Time (hrs:min)	00:00 - 48:00 [08:00]	
	Admin SSM In	PRD - RES [STU]	
	AIS Mode	Enable - Disabled [Disabled]	
	AlS Recovery Interval (seconds)	60-300 [100]	
	AlS Recovery Pulse Duration (seconds)	2.0-100.0 [2.0]	
	Enable Synch Messaging (SyncMsgIn)	TRUE - FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0-48 [0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Send <FF> Do Not Use	TRUE - FALSE [FALSE]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	Send Do Not Use (DUS)	TRUE - FALSE [FALSE]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	
Configuration - STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE - FALSE [FALSE]	
Line - Near End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Protection Switching Count (PSC)	0-600 [1]	0-57600 [5]
	Protection Switching Count (PSC) - Ring	0-600 [1]	0-57600 [5]
	Protection Switching Count (PSC) - Span	0-600 [1]	0-57600 [5]
	Protection Switching Count (PSC) - Working	0-600 [1]	0-57600 [5]
	Protection Switching Duration (PSD) seconds	0-600 [300]	0-86400 [600]
	Protection Switching Duration (PSD) seconds - Ring	0-900 [300]	0-86400 [600]
	Protection Switching Duration (PSD) seconds - Span	0-900 [300]	0-86400 [600]
	Protection Switching Duration (PSD) seconds - Working	0-900 [300]	0-86400 [600]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Line - Far End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]

Table 6-39 OC48 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
STS-1 - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Difference (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS-3c-9c - Near End	Coding Violations (CV) [B3 count]	0-2160000 [25]	0-207360000 [250]
	Errored Seconds (ES)	0-900 [20]	0-86400 [200]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Diff. (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-39 OC48 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
STS-12c-48c - Near End	Coding Violations (CV) [B3 count]	0-2160000 [75]	0-207360000 [750]
	Errored Seconds (ES)	0-900 [60]	0-86400 [600]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Diff. (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-40 OC-192 Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
Configuration - Line	AINS Soak Time (hrs:min)	00:00 - 48:00 [08:00]	
	Admin SSM In	PRD - RES [STU]	
	AIS Mode	Enable - Disabled [Disabled]	
	AIS Recovery Interval (seconds)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [2.0]	
	Enable Synch Messaging (SyncMsgIn)	TRUE - FALSE [TRUE]	
	Pointer Justification (PJ) STS Monitor #	0-192 [0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	Send <FF> Do Not Use	TRUE - FALSE [FALSE]	
	Send Do Not Use (DUS)	TRUE - FALSE [FALSE]	
	State	IS; OOS,DSBLD; OOS,MT; IS,AINS [OOS,DSBLD]	
Configuration - STS	Intermediate Path Performance Monitoring (IPPM) Enabled	TRUE - FALSE [FALSE]	

Table 6-40 OC-192 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Line - Near End	Coding Violations (CV) [B2 count]	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Protection Switching Count (PSC)	0-600 [1]	0-57600 [5]
	Protection Switching Count (PSC) - Ring	0-600 [1]	0-57600 [5]
	Protection Switching Count (PSC) - Span	0-600 [1]	0-57600 [5]
	Protection Switching Count (PSC) - Working	0-600 [1]	0-57600 [5]
	Protection Switching Duration (PSD) seconds	0-900 [300]	0-86400 [600]
	Protection Switching Duration (PSD) seconds - Ring	0-900 [300]	0-86400 [600]
	Protection Switching Duration (PSD) seconds - Span	0-900 [300]	0-86400 [600]
	Protection Switching Duration (PSD) seconds - Working	0-900 [300]	0-86400 [600]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Line - Far End	Coding Violations (CV) [B2 count]	0-8850600 [85040]	0-849657600 [85040]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Section - Near End	Coding Violations (CV) [B1 count]	0-7967700 [10000]	0-764899200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-40 OC-192 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
STS-1 - Near End	Coding Violations (CV) [B3 count]	0-2160000 [15]	0-207360000 [125]
	Errored Seconds (ES)	0-900 [12]	0-86400 [100]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Difference (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]
STS-3c-9c - Near End	Coding Violations (CV) [B3 count]	0-2160000 [25]	0-207360000 [250]
	Errored Seconds (ES)	0-900 [20]	0-86400 [200]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Diff. (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-40 OC-192 Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
STS-12c-192c - Near End	Coding Violations (CV) [B3 count]	0-2160000 [75]	0-207360000 [750]
	Errored Seconds (ES)	0-900 [60]	0-86400 [600]
	Failure Count (FC)	0-72 [10]	0-6912 [10]
	Negative Pointer Justification Count - Path Detected (NPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Negative Pointer Justification Count - Path Generated (NPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Pointer Justification Count Diff. (PJCDIFF)	0-1200 [0]	0-115200 [0]
	Pointer Justification Count Sum (PJCS-PDET)	0-3600000 [0]	0-345600000 [0]
	Pointer Justification Count Sum (PJCS-PGEN)	0-3600000 [0]	0-345600000 [0]
	Positive Pointer Justification Count - Path Detected (PPJC-Pdet)	0-3600000 [60]	0-345600000 [5760]
	Positive Pointer Justification Count - Path Generated (PPJC-Pgen)	0-3600000 [60]	0-345600000 [5760]
	Severely Errored Seconds (SES)	0-900 [3]	0-86400 [7]
	Unavailable Seconds (UAS)	0-900 [10]	0-86400 [10]

Table 6-41 OSC-CSM Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
PM Thresholds-Line - Near End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Protection Switching Count (PSC)	0-600 [1]	0-57600 [5]
	Protection Switching Duration (PSD) seconds	0-900 [300]	0-86400 [600]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Line - Far End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]

Table 6-41 OSC-CSM Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
PM Thresholds-Section - Near End	Coding Violations (CV) [B1 count]	0-138600 [10000]	0-13219200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-42 OSCM Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
PM Thresholds-Line - Near End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Protection Switching Count (PSC)	0-600 [1]	0-57600 [5]
	Protection Switching Duration (PSD) seconds	0-900 [300]	0-86400 [600]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Line - Far End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Section - Near End	Coding Violations (CV) [B1 count]	0-138600 [10000]	0-13219200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-43 MXP_2.5G_10G Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration - Client	Payload Data Type	SONET, SDH [SONET]	
	Termination Mode	TRANSPARENT, SECTION, LINE [TRANSPARENT]	

Table 6-43 MXP_2.5G_10G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
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)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [2.0]	
	Enable Synch Messaging (SyncMsgIn)	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]	
	Termination Mode	TRANSPARENT, SECTION, LINE [TRANSPARENT]	
	Pluggable Port Module (PPM) Port Assignment	UNASSIGNED, OC48 [UNASSIGNED]	
	Pluggable Port Module (PPM) Slot Assignment	UNASSIGNED, PPM (1 port) [UNASSIGNED]	
Configuration - Trunk	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)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [4.0]	
Optical Transport Network (OTN)	OTN Lines Forward Error Correction (FEC)	DISABLE, STANDARD, ENHANCED [STANDARD]	
	OTN Lines G709 OTN	TRUE - FALSE [TRUE]	
	OTN Lines Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
OTN G709 Thresholds-Section Monitoring (SM) - Near End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]
OTN G709 Thresholds-Section Monitoring (SM) - Far End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]

Table 6-43 MXP_2.5G_10G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
OTN G709 Thresholds-Path Monitoring (PM) - Near End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN G709 Thresholds-Path Monitoring (PM) - Far End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN FEC Thresholds - Standard	Bit Errors Corrected	0-9033621811200 [903330]	0-867227693875200 [8671968]
	Uncorrectable Words	0-4724697600 [5]	0-453570969600 [480]
Optical Thresholds-Client - Warning	High Laser Bias (percent)	0 - 100.0 [81.0]	31.5 - 100.0 [85.5]
	High Rx Power (dBm)	-40.0 - 30.0 [2.0]	-20.9 - 30.0 [2.5]
	High Tx Power (dBm)	-19.9 - 30.0 [2.0]	-10.5 - 30.0 [2.5]
	Low Rx Power (dBm)	-40.0 - 1.8 [-20.0]	-40.0 - 1.9 [-20.5]
	Low Tx Power (dBm)	-40.0 - 1.8 [-7.0]	-40.0 - 10.5 [-7.5]
Optical Thresholds-Client - Alarm	High Laser Bias (percent)	33.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-19.9 - 30.0 [3.0]	
	High Tx Power (dBm)	-11.0 - 30.0 [3.0]	
	Low Rx Power (dBm)	-40.0 - 2.0 [-21.0]	
	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 Rx Power (dBm)	-25.2 - 30.0 [-7.5]	-26.6 - 30.0 [-7.3]
	High Tx Power (dBm)	-22.5 - 30.0 [3.5]	-23.8 - 30.0 [3.7]
	Low Rx Power (dBm)	-40.0 - -3.3 [-24.5]	-40.0 - -3.2 [-24.7]
	Low Tx Power (dBm)	-40.0 - 3.1 [2.5]	-40.0 - 23.8 [2.3]
Optical Thresholds-Trunk - Alarm	High Laser Bias (percent)	30.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-28.0 - 30.0 [-7.0]	
	High Tx Power (dBm)	-25.0 - 30.0 [4.0]	
	Low Rx Power (dBm)	-40.0 - -3.0 [-25.0]	
	Low Tx Power (dBm)	-40.0 - 3.5 [2.0]	

Table 6-43 MXP_2.5G_10G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
PM Thresholds-Client-Line - Near End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Client-Line - Far End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Client-Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
PM Thresholds-Trunk-Line - Near End	Coding Violations (CV) [B2 count]	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Trunk-Section - Near End	Coding Violations (CV) [B1 count]	0-7967700 [10000]	0-764899200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-44 MXP_2.5G_10E Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
Configuration - Client	AINS Soak Time (hrs:min)	00:00 - 48:00 [08:00]	
	AIS Squelch Mode	AIS, Squelch [Squelch]	
	AIS Mode	Disabled, Automatic Restart, Manual Restart, Manual Restart for Test [Disabled]	
	AIS Recovery Interval (seconds)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [2.0]	
	Enable Synch Messaging (SyncMsgIn)	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]	
	Termination Mode	TRANSPARENT, SECTION, LINE [TRANSPARENT]	
	Pluggable Port Module (PPM) Port Assignment	UNASSIGNED, OC48 [UNASSIGNED]	
	Pluggable Port Module (PPM) Slot Assignment	UNASSIGNED, PPM (1 port) [UNASSIGNED]	
Configuration - Trunk	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)	60-300 [300]	
	AIS Recovery Pulse Duration (seconds)	60-200.0 [100]	
Optical Transport Network (OTN)	OTN Lines Asynchronous/Synchronous Mapping	ODU Multiplex [ODU Multiplex]	
	OTN Lines Forward Error Correction (FEC)	DISABLE, STANDARD, ENHANCED [STANDARD]	
	OTN Lines G709 OTN	TRUE - FALSE [TRUE]	
	OTN Lines Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
OTN G709 Thresholds-Section Monitoring (SM) - Near End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]
OTN G709 Thresholds-Section Monitoring (SM) - Far End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]

Table 6-44 MXP_2.5G_10E Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
OTN G709 Thresholds-Path Monitoring (PM) - Near End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN G709 Thresholds-Path Monitoring (PM) - Far End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN FEC Thresholds - Standard	Bit Errors Corrected	0-9033621811200 [903330]	0-867227693875200 [8671968]
	Uncorrectable Words	0-4724697600 [5]	0-453570969600 [480]
OTN FEC Thresholds - Enhanced	Bit Errors Corrected	0-9033621811200 [903330]	0-867227693875200 [8671968]
	Uncorrectable Words	0-4724697600 [5]	0-453570969600 [480]
Optical Thresholds-Client - Warning	High Laser Bias (percent)	0 - 100.0 [81.0]	31.5 - 100.0 [85.5]
	High Rx Power (dBm)	-40.0 - 30.0 [2.0]	-20.9 - 30.0 [2.5]
	High Tx Power (dBm)	-19.9 - 30.0 [2.0]	-10.5 - 30.0 [2.5]
	Low Rx Power (dBm)	-40.0 - 1.8 [-20.0]	-40.0 - 1.9 [-20.5]
	Low Tx Power (dBm)	-40.0 - 1.8 [-7.0]	-40.0 - 10.5 [-7.5]
Optical Thresholds-Client - Alarm	High Laser Bias (percent)	33.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-19.9 - 30.0 [3.0]	
	High Tx Power (dBm)	-11.0 - 30.0 [3.0]	
	Low Rx Power (dBm)	-40.0 - 2.0 [-21.0]	
	Low Tx Power (dBm)	-40.0 - 2.0 [-8.0]	
Optical Thresholds-Trunk - Warning	High Laser Bias (percent)	33.0 - 100.0 [95.0]	31.5 - 100.0 [96.0]
	High Rx Power (dBm)	-25.2 - 30.0 [-7.5]	-26.6 - 30.0 [-7.3]
	High Tx Power (dBm)	-22.5 - 30.0 [7.0]	-23.8 - 30.0 [7.0]
	Low Rx Power (dBm)	-40.0 - -3.3 [-24.5]	-40.0 - -3.2 [-24.7]
	Low Tx Power (dBm)	-40.0 - 3.1 [2.0]	-40.0 - 23.8 [2.0]
Optical Thresholds-Trunk - Alarm	High Laser Bias (percent)	30.0 - 100.0 [98.0]	
	High Rx Power (dBm)	-28.0 - 30.0 [-7.0]	
	High Tx Power (dBm)	-25.0 - 30.0 [8.0]	
	Low Rx Power (dBm)	-40.0 - -3.0 [-25.0]	
	Low Tx Power (dBm)	-40.0 - 3.5 [1.0]	

Table 6-44 MXP_2.5G_10E Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
PM Thresholds-Client-Line - Near End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Client-Line - Far End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Client-Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
PM Thresholds-Trunk-Section - Near End	Coding Violations (CV) [B1 count]	0-7967700 [10000]	0-764899200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-45 MXP_MR_2.5G/MXPP_MR_2.5G Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration - Client	AIS Mode	Disabled, Automatic Restart, Manual Restart, Manual Restart for Test [Disabled]	
	AIS Recovery Interval (seconds)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [4.0]	
	Pluggable Port Module (PPM) Port Assignment	UNASSIGNED, One_GE, FC1G ISL, FC2G ISL, FICON1G ISL, FICON2G ISL [UNASSIGNED]	
	Pluggable Port Module (PPM) Slot Assignment	UNASSIGNED, PPM (1 port) [UNASSIGNED)]	

Table 6-45 MXP_MR_2.5G/MXPP_MR_2.5G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
Configuration - Fibre Channel (FC)	Distance Extension Auto Detect	TRUE - FALSE [TRUE]	
	Distance Extension Auto Adjust GFP Buffer Threshold	TRUE - FALSE [FALSE]	
	Distance Extension Enabled	TRUE - FALSE [FALSE]	
	Distance Extension Number of Credits	2-256 [32]	
	Distance Extension Number of GFP Buffers	16-1200 [16]	
	Enhanced FC Maximum Frame Size	2148-2172 [2148]	
Configuration - Trunk	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)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [4.0]	
	Enable Synch Messaging (SyncMsgIn for MXP_MR_2.5G card only)	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 for MXP_MR_2.5G card only)	TRUE - FALSE [FALSE]	
Optical Thresholds-Client - Warning	High Laser Bias (percent)	0 - 100.0 [81.0]	31.5 - 100.0 [85.5]
	High Rx Power (dBm)	-40.0 - 30.0 [2.0]	-20.9 - 30.0 [2.5]
	High Tx Power (dBm)	-19.9 - 30.0 [2.0]	-10.5 - 30.0 [2.5]
	Low Rx Power (dBm)	-40.0 - 1.8 [-20.0]	-40.0 - 1.9 [-20.5]
	Low Tx Power (dBm)	-40.0 - 1.8 [-7.0]	-40.0 - 10.5 [-7.5]
Optical Thresholds-Client - Alarm	High Laser Bias (percent)	33.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-19.9 - 30.0 [3.0]	
	High Tx Power (dBm)	-11.0 - 30.0 [3.0]	
	Low Rx Power (dBm)	-40.0 - 2.0 [-21.0]	
	Low Tx Power (dBm)	-40.0 - 2.0 [-8.0]	
Optical Thresholds-Trunk - Warning	High Laser Bias (percent)	33.0 - 100.0 [95.0]	31.5 - 100.0 [96.0]
	High Rx Power (dBm)	-25.2 - 30.0 [-7.5]	-26.6 - 30.0 [-7.3]
	High Tx Power (dBm)	-22.5 - 30.0 [30.0]	-23.8 - 30.0 [30.0]
	Low Rx Power (dBm)	-40.0 - -3.3 [-24.5]	-40.0 - -3.2 [-24.7]
	Low Tx Power (dBm)	-40.0 - 3.1 [-40.0]	-40.0 - 23.8 [-40]

Table 6-45 MXP_MR_2.5G/MXPP_MR_2.5G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Optical Thresholds-Trunk - Alarm	High Laser Bias (percent)	30.0 - 100.0 [98.0]	
	High Rx Power (dBm)	-28.0 - 30.0 [-7.0]	
	High Tx Power (dBm)	-25.0 - 30.0 [30.0]	
	Low Rx Power (dBm)	-40.0 - -3.0 [-25.0]	
	Low Tx Power (dBm)	-40.0 - 3.5 [-40.0]	
PM Thresholds-Trunk-Line - Near End	Coding Violations (CV) [B2 count]	0-8850600 [21260]	0-849657600 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Trunk-Line - Far End	Coding Violations (CV) [B2 count]	0-8850600 [21260]	0-849657600 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Trunk-Section - Near End	Coding Violations (CV) [B1 count]	0-7967700 [10000]	0-764899200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-46 TXP_MR_10G Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration - Client	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)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [2.0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	Termination Mode	TRANSPARENT, LINE [TRANSPARENT]	
	Multi-rate (MR) Port Assignment	UNASSIGNED, SONET (including 10G Thernet WAN Phy), 10G Ethernet LAN Phy [UNASSIGNED]	

Table 6-46 TXP_MR_10G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
Configuration - Trunk	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)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [4.0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
Optical Transport Network (OTN)	OTN Lines Forward Error Correction (FEC)	DISABLE, ENABLE [ENABLE]	
	OTN Lines G709 OTN	TRUE - FALSE [TRUE]	
	OTN Lines Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
OTN G709 Thresholds-Section Monitoring (SM) - Near End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]
OTN G709 Thresholds-Section Monitoring (SM) - Far End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]
OTN G709 Thresholds-Path Monitoring (PM) - Near End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN G709 Thresholds-Path Monitoring (PM) - Far End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN FEC Thresholds - Standard	Bit Errors Corrected	0-9033621811200 [903330]	0-867227693875200 [8671968]
	Uncorrectable Words	0-4724697600 [5]	0-453570969600 [480]

Table 6-46 TXP_MR_10G Defaults (continued)

Field	Parameter	Threshold Range [Default] 15 Minutes	Threshold Range [Default] 1 Day
Optical Thresholds-Client - Warning	High Laser Bias (percent)	0 - 100.0 [81.0]	31.5 - 100.0 [85.5]
	High Rx Power (dBm)	-40.0 - 30.0 [1.0]	-20.9 - 30.0 [1.5]
	High Tx Power (dBm)	-19.9 - 30.0 [1.0]	-10.5 - 30.0 [1.5]
	Low Rx Power (dBm)	-40.0 - 1.8 [-16.0]	-40.0 - 1.9 [-16.5]
	Low Tx Power (dBm)	-40.0 - 1.8 [-8.0]	-40.0 - 10.5 [-8.5]
Optical Thresholds-Client - Alarm	High Laser Bias (percent)	33.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-19.9 - 30.0 [2.0]	
	High Tx Power (dBm)	-11.0 - 30.0 [2.0]	
	Low Rx Power (dBm)	-40.0 - 2.0 [-17.0]	
	Low Tx Power (dBm)	-40.0 - 2.0 [-9.0]	
Optical Thresholds-Trunk - Warning	High Laser Bias (percent)	33.0 - 100.0 [81.0]	31.5 - 100.0 [85.5]
	High Rx Power (dBm)	-25.2 - 30.0 [-7.5]	-26.6 - 30.0 [-7.3]
	High Tx Power (dBm)	-22.5 - 30.0 [3.5]	-23.8 - 30.0 [3.7]
	Low Rx Power (dBm)	-40.0 - -3.3 [-24.5]	-40.0 - -3.2 [-24.7]
	Low Tx Power (dBm)	-40.0 - 3.1 [2.5]	-40.0 - 23.8 [2.3]
Optical Thresholds-Trunk - Alarm	High Laser Bias (percent)	30.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-28.0 - 30.0 [-7.0]	
	High Tx Power (dBm)	-25.0 - 30.0 [4.0]	
	Low Rx Power (dBm)	-40.0 - -3.0 [-25.0]	
	Low Tx Power (dBm)	-40.0 - 3.5 [2.0]	
PM Thresholds-Client-Line - Near End	Coding Violations (CV) [B2 count]	0-2212200 [85040]	0-212371200 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Client-Line - Far End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Client-Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-46 TXP_MR_10G Defaults (continued)

Field	Parameter	Threshold Range [Default] 15 Minutes	1 Day
PM Thresholds-Trunk-Line - Near End	Coding Violations (CV) [B2 count]	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Trunk-Line - Far End	Coding Violations (CV) [B2 count]	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Trunk-Section - Near End	Coding Violations (CV) [B1 count]	0-7967700 [10000]	0-764899200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-47 TXP_MR_10E Defaults

Field	Parameter	Threshold Range [Default] 15 Minutes	1 Day
Configuration - Client	AINS Soak Time (hrs:min)	00:00 - 48:00 [08:00]	
	AIS Squelch Mode	AIS, Squelch [Squelch]	
	AIS Mode	Disabled, Automatic Restart, Manual Restart, Manual Restart for Test [Disabled]	
	AIS Recovery Interval (seconds)	60-300 [100]	
	AIS Recovery Pulse Duration (seconds)	2.0-100.0 [2.0]	
	Enable Synch Messaging (SyncMsgIn)	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]	
	Termination Mode	TRANSPARENT, SECTION, LINE [TRANSPARENT]	
	Pluggable Port Module (PPM) Port Assignment	UNASSIGNED, SONET (including 10G Thernet WAN Phy), 10G Ethernet LAN Phy, 10G Fibre Channel [UNASSIGNED]	
	Pluggable Port Module (PPM) Slot Assignment	UNASSIGNED, PPM (1 port) [UNASSIGNED]	

Table 6-47 TXP_MR_10E Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
Configuration - Trunk	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)	60-300 [300]	
	AIS Recovery Pulse Duration (seconds)	60-200.0 [100]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
Optical Transport Network (OTN)	OTN Lines Asynchronous/Synchronous Mapping	Asynch Mapping, Synch Mapping [Synch Mapping]	
	OTN Lines Forward Error Correction (FEC)	DISABLE, STANDARD, ENHANCED [STANDARD]	
	OTN Lines G709 OTN	TRUE - FALSE [TRUE]	
	OTN Lines Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
OTN G709 Thresholds-Section Monitoring (SM) - Near End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]
OTN G709 Thresholds-Section Monitoring (SM) - Far End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]
OTN G709 Thresholds-Path Monitoring (PM) - Near End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN G709 Thresholds-Path Monitoring (PM) - Far End	Background Block Errors (BBE)	0-8850600 [85040]	0-849657600 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN FEC Thresholds - Standard	Bit Errors Corrected	0-9033621811200 [903330]	0-867227693875200 [8671968]
	Uncorrectable Words	0-4724697600 [5]	0-453570969600 [480]

Table 6-47 TXP_MR_10E Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
OTN FEC Thresholds - Enhanced	Bit Errors Corrected	0-9033621811200 [903330]	0-867227693875200 [8671968]
	Uncorrectable Words	0-4724697600 [5]	0-453570969600 [480]
Optical Thresholds-Client - Warning	High Laser Bias (percent)	0 - 100.0 [81.0]	31.5 - 100.0 [85.5]
	High Rx Power (dBm)	-40.0 - 30.0 [1.0]	-20.9 - 30.0 [1.5]
	High Tx Power (dBm)	-19.9 - 30.0 [1.0]	-10.5 - 30.0 [1.5]
	Low Rx Power (dBm)	-40.0 - 1.8 [-16.0]	-40.0 - 1.9 [-16.5]
	Low Tx Power (dBm)	-40.0 - 1.8 [-8.0]	-40.0 - 10.5 [-8.5]
Optical Thresholds-Client - Alarm	High Laser Bias (percent)	33.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-19.9 - 30.0 [2.0]	
	High Tx Power (dBm)	-11.0 - 30.0 [2.0]	
	Low Rx Power (dBm)	-40.0 - 2.0 [-17.0]	
	Low Tx Power (dBm)	-40.0 - 2.0 [-9.0]	
Optical Thresholds-Trunk - Warning	High Laser Bias (percent)	33.0 - 100.0 [95.0]	31.5 - 100.0 [96.0]
	High Rx Power (dBm)	-25.2 - 30.0 [-7.5]	-26.6 - 30.0 [-7.3]
	High Tx Power (dBm)	-22.5 - 30.0 [7.0]	-23.8 - 30.0 [7.0]
	Low Rx Power (dBm)	-40.0 - -3.3 [-24.5]	-40.0 - -3.2 [-24.7]
	Low Tx Power (dBm)	-40.0 - 3.1 [2.0]	-40.0 - 23.8 [2.0]
Optical Thresholds-Trunk - Alarm	High Laser Bias (percent)	30.0 - 100.0 [98.0]	
	High Rx Power (dBm)	-28.0 - 30.0 [-7.0]	
	High Tx Power (dBm)	-25.0 - 30.0 [8.0]	
	Low Rx Power (dBm)	-40.0 - -3.0 [-25.0]	
	Low Tx Power (dBm)	-40.0 - 3.5 [1.0]	
PM Thresholds-Client-Line - Near End	Coding Violations (CV) [B2 count]	0-2212200 [85040]	0-212371200 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Client-Line - Far End	Coding Violations (CV) [B2 count]	0-2212200 [85040]	0-212371200 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]

Table 6-47 TXP_MR_10E Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
PM Thresholds-Client-Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
PM Thresholds-Trunk-Line - Near End	Coding Violations (CV) [B2 count]	0-2212200 [85040]	0-212371200 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Trunkt-Line - Far End	Coding Violations (CV) [B2 count]	0-2212200 [85040]	0-212371200 [850400]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-Trunk-Section - Near End	Coding Violations (CV) [B1 count]	0-7967700 [10000]	0-764899200 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]

Table 6-48 TXP_MR_2.5G / TXPP_MR_2.5G Defaults

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
Configuration - Client	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)	60-300 [100]	
	AIS Recovery Pulse Width (seconds)	2.0-100.0 [4.0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
	Termination Mode	TRANSPARENT, SECTION, LINE [TRANSPARENT]	
	Pluggable Port Module (PPM) Port Assignment	UNASSIGNED, OC3_PORT, OC12_PORT, ONE_GE_PORT, ESCON_PORT, DV6000_PORT, SDI_D1_VIDEO_PORT, HDTV_PORT [UNASSIGNED]	
	Pluggable Port Module (PPM) Slot Assignment	UNASSIGNED, PPM (1 port) [UNASSIGNED]	
Configuration - Trunk	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)	60-300 [100]	
	AIS Recovery Pulse Width (seconds)	2.0-100.0 [4.0]	
	Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
	Signal Fail (SF) BER	1E-3 - 1E-5 [1E-4]	
Optical Transport Network (OTN)	OTN Lines Forward Error Correction (FEC)	DISABLE, ENABLE[ENABLE]	
	OTN Lines G709 OTN	TRUE - FALSE [TRUE]	
	OTN Lines Signal Degrade (SD) BER	1E-5 - 1E-9 [1E-7]	
OTN G709 Thresholds-Section Monitoring (SM) - Near End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]
OTN G709 Thresholds-Section Monitoring (SM) - Far End	Background Block Errors (BBE)	0-8850600 [10000]	0-849657600 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
	Unavailable Seconds (UAS)	0-900 [500]	0-86400 [5000]

Table 6-48 TXP_MR_2.5G / TXPP_MR_2.5G Defaults (continued)

Field	Parameter	Threshold Range [Default] 15 Minutes	1 Day
OTN G709 Thresholds-Path Monitoring (PM) - Near End	Background Block Errors (BBE)	0-8850600 [21260]	0-849657600 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
OTN G709 Thresholds-Path Monitoring (PM) - Far End	Background Block Errors (BBE)	0-8850600 [21260]	0-849657600 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
Optical Thresholds-Client - Warning	High Laser Bias (percent)	0 - 100.0 [81.0]	31.5 - 100.0 [85.5]
	High Rx Power (dBm)	-40.0 - 30.0 [2.0]	-20.9 - 30.0 [2.5]
	High Tx Power (dBm)	-19.9 - 30.0 [2.0]	-10.5 - 30.0 [2.5]
	Low Rx Power (dBm)	-40.0 - 1.8 [-20.0]	-40.0 - 1.9 [-20.5]
	Low Tx Power (dBm)	-40.0 - 1.8 [-7.0]	-40.0 - 10.5 [-7.5]
Optical Thresholds-Client - Alarm	High Laser Bias (percent)	33.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-19.9 - 30.0 [3.0]	
	High tx Power (dBm)	-19.9 - 30.0 [3.0]	
	Low Rx Power (dBm)	-40.0 - 2.0 [-21.0]	
	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 Rx Power (dBm)	-25.2 - 30.0 [-7.5]	-26.6 - 30.0 [-7.3]
	Low Rx Power (dBm)	-40.0 - -3.3 [-24.5]	-40.0 - -3.2 [-24.7]
Optical Thresholds-Trunk - Alarm	High Laser Bias (percent)	30.0 - 100.0 [90.0]	
	High Rx Power (dBm)	-28.0 - 30.0 [-7.0]	
	Low Rx Power (dBm)	-40.0 - -3.0 [-25.0]	
PM Thresholds-OC-3 Line - Near End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]

Table 6-48 TXP_MR_2.5G / TXPP_MR_2.5G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	1 Day
PM Thresholds-OC-3 Line - Far End	Coding Violations (CV) [B2 count]	0-137700 [1312]	0-13219200 [13120]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-OC-3 Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
PM Thresholds-OC-12 Line - Near End	Coding Violations (CV) [B2 count]	0-137700 [5315]	0-13219200 [53150]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-OC-12 Line - Far End	Coding Violations (CV) [B2 count]	0-137700 [5315]	0-13219200 [53150]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-OC-12 Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
PM Thresholds-OC-48 Line - Near End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]
PM Thresholds-OC-48 Line - Far End	Coding Violations (CV) [B2 count]	0-2212200 [21260]	0-212371200 [212600]
	Errored Seconds (ES)	0-900 [87]	0-86400 [864]
	Failure Count (FC)	0-72 [10]	0-6912 [40]
	Severely Errored Seconds (SES)	0-900 [1]	0-86400 [4]
	Unavailable Seconds (UAS)	0-900 [3]	0-86400 [10]

Table 6-48 TXP_MR_2.5G / TXPP_MR_2.5G Defaults (continued)

Field	Parameter	Threshold Range [Default]	
		15 Minutes	**1 Day**
PM Thresholds-OC-48 Section - Near End	Coding Violations (CV) [B1 count]	0-2151900 [10000]	0-206582400 [100000]
	Errored Seconds (ES)	0-900 [500]	0-86400 [5000]
	Severely Errored Framed Seconds (SEFS)	0-900 [500]	0-86400 [5000]
	Severely Errored Seconds (SES)	0-900 [500]	0-86400 [5000]
FEC Thresholds-OC-3	Bit Errors Corrected	0-9033621811200 [15012]	0-867227693875200 [1441152]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]
FEC Thresholds-OC-12	Bit Errors Corrected	0-9033621811200 [56457]	0-867227693875200 [5419872]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]
FEC Thresholds-OC-48	Bit Errors Corrected	0-9033621811200 [225837]	0-867227693875200 [21680352]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]
FEC Thresholds-1 Gigabit Ethernet	Bit Errors Corrected	0-9033621811200 [112500]	0-867227693875200 [10800000]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]
FEC Thresholds-1 Gigabit Fibre Channel/Ficon	Bit Errors Corrected	0-9033621811200 [90000]	0-867227693875200 [8640000]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]
FEC Thresholds-1 Gigabit FICON	Bit Errors Corrected	0-9033621811200 [90000]	0-867227693875200 [8640000]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]
FEC Thresholds-Trunk-2 Gigabit Fibre Channel	Bit Errors Corrected	0-9033621811200 [180900]	0-867227693875200 [17366400]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]
FEC Thresholds-Trunk-2 Gigabit FICON	Bit Errors Corrected	0-9033621811200 [180900]	0-867227693875200 [17366400]
	Uncorrectable Words	0-4724697600 [1]	0-453570969600 [96]

Table 6-49 FC_MR-4 Defaults

Field	Parameter	Threshold Range [Default]
Configuration	Card Mode	
	Port Link Recovery	TRUE-FALSE [FALSE]
	Port Media Type	Fibre Channel-1Gbps ISL, Fibre Channel-2Gbps ISL, FICON-1Gbps ISL, FICON-2Gbps ISL, Undefined [Fibre Channel-1Gbps ISL]
	Port State	IS; OOS,DSLBD; OOS,MT [OOS,DSLBD]
	Port Distance Extension Auto Detect	TRUE-FALSE [TRUE]
	Port Distance Extension Auto Adjust GFP Buffer Threshold	TRUE-FALSE [FALSE]
	Port Distance Extension Enable	TRUE-FALSE [FALSE]
	Port Distance Extension Number of Credits	2-256 [256]
	Port Distance Extension Number of GFP Buffers	16-1200 [16]
	Port Enhanced Fibre Channel/FICON Ingress Idle Filtering	TRUE-FALSE [TRUE]
	Port Enhanced Fibre Channel/FICON Maximum Frame Size	2148-2174 [2148]

Table 6-50 CE-100T-8 Defaults

Field	Parameter	Threshold Range [Default]
Configuration	AINS Soak Time (hrs:min)	00:00 - 48:00 [08:00]
	State	IS; OOS,DSLBD; OOS,MT [OOS,DSLBD]
	Ethernet Port Configuration for 802.1Q-VLAN CoS (count)	0-7 [7]
	Ethernet Port Configuration for IP ToS (count)	0-255 [255]

Table 6-51 G1000-4/G1K4 Defaults

Field	Parameter	Threshold Range [Default]
Configuration	AINS Soak Time (hrs:min)	00:00 - 48:00 [08:00]
	State	IS; OOS,DSLBD; OOS,MT [OOS,DSLBD]

Table 6-52 ML100T-12 Defaults

Field	Parameter	Threshold Range [Default]
Configuration	Card Mode	HDLC, GFP-F [HDLC]

Table 6-53 ML1000-2 Defaults

Field	Parameter	Threshold Range [Default]
Configuration	Card Mode	HDLC, GFP-F [HDLC]

Remote Monitoring Specification Alarm Thresholds

The ONS 15454 supports remote monitoring (RMON) Management Information Base (MIB) objects specified in RFC 2819 [1], RFC 2358, and RFC 2233. RMON MIBs are intended to interface with a network management system (NMS) to monitor the health of the ONS 15454 network.

One of the ONS 15454 RMON MIBs is the Alarm group, which consists of the alarmTable. An NMS uses the alarmTable to find the alarm-causing thresholds for network performance. The thresholds apply to the current 15-minute interval and the current 24-hour interval. RMON monitors several variables, such as Ethernet collisions, and triggers an event when the variable crosses a threshold during that time interval. For example, if a threshold is set at 1000 collisions and 1001 collisions occur during the 15-minute interval, an event triggers. CTC allows you to provision these thresholds for Ethernet statistics.

Release 5.0 adds enhancements to the SNMP agent on the ONS 15454 MSPP to supplement existing RMON support. This enhancement includes support for the High Capacity RMON (HC-RMON) MIB. HC-RMON-MIB is an extension of RMON. RMON counters are 32-bit while HC-RMON counters are 32-bit and 64-bit as defined in the MIB. Release 5.0 supports the following HC-RMON tables:

- mediaIndependentTable
- etherStatsHighCapacityTable
- etherHistoryHighCapacityTable

Table 6-54 defines the RMON MIB variables you can provision in CTC. For example, to set the collision threshold, choose etherStatsCollisions from the Variable menu.

Table 6-54 Ethernet Threshold Variables (MIBs)

Variable	Definition
iflnOctets	Total number of octets received on the interface, including framing octets
iflnUcastPkts	Total number of unicast packets delivered to an appropriate protocol
ifInMulticastPkts	Number of multicast frames received error free (not supported by E-Series)
ifInBroadcastPkts	Number of packets, delivered by this sublayer to a higher (sub)layer, which were addressed to a broadcast address at this sublayer (not supported by E-Series)

Table 6-54 Ethernet Threshold Variables (MIBs) (continued)

Variable	Definition
ifInDiscards	Number of inbound packets which were chosen to be discarded even though no errors had been detected to prevent their being deliverable to a higher-layer protocol (not supported by E-Series)
iflnErrors	Number of inbound packets discarded because they contain errors
ifOutOctets	Total number of transmitted octets, including framing packets
ifOutUcastPkts	Total number of unicast packets requested to transmit to a single address
ifOutMulticastPkts	Number of multicast frames transmitted error free (not supported by E-Series)
ifOutBroadcastPkts	Total number of packets that higher-level protocols requested be transmitted, and which were addressed to a broadcast address at this sublayer, including those that were discarded or not sent (not supported by E-Series)
ifOutDiscards	Number of outbound packets which were chosen to be discarded even though no errors had been detected to prevent their being transmitted (not supported by E-Series)
dot3statsAlignmentErrors	Number of frames with an alignment error, that is, the length is not an integral number of octets and the frame cannot pass the Frame Check Sequence (FCS) test
dot3StatsFCSErrors	Number of frames with framecheck errors, that is, there is an integral number of octets, but an incorrect FCS
dot3StatsSingleCollisionFrames	Number of successfully transmitted frames that had exactly one collision
dot3StatsMutlipleCollisionFrame	Number of successfully transmitted frames that had multiple collisions
dot3StatsDeferredTransmissions	Number of times the first transmission was delayed because the medium was busy
dot3StatsExcessiveCollision	Number of frames where transmissions failed because of excessive collisions
dot3StatsFrameTooLong	Number of received frames that were larger than the maximum size permitted
dot3StatsCarrierSenseErrors	Number of transmission errors on a particular interface that are not otherwise counted (not supported by E-Series)
dot3StatsSQETestErrors	Number of times that the SQE TEST ERROR message is generated by the PLS sublayer for a particular interface (not supported by E-Series)
etherStatsJabbers	Total number of Octets of data (including bad packets) received on the network
etherStatsUndersizePkts	Number of packets received with a length less than 64 octets
etherStatsFragments	Total number of packets that are not an integral number of octets or have a bad FCS, and that are less than 64 octets long

Table 6-54 Ethernet Threshold Variables (MIBs) (continued)

Variable	Definition
etherStatsOversizePkts	Total number of packets received that were longer than 1518 octets (excluding framing bits, but including FCS octets) and were otherwise well formed
etherStatsOctets	Total number of octets of data (including those in bad packets) received on the network (excluding framing bits but including FCS octets)
etherStatsPkts64Octets	Total number of packets received (including error packets) that were 64 octets in length
etherStatsPkts65to127Octets	Total number of packets received (including error packets) that were 65-172 octets in length
etherStatsPkts128to255Octets	Total number of packets received (including error packets) that were 128-255 octets in length
etherStatsPkts256to511Octets	Total number of packets received (including error packets) that were 256-511 octets in length
etherStatsPkts512to1023Octets	Total number of packets received (including error packets) that were 512-1023 octets in length
etherStatsPkts1024to1518Octets	Total number of packets received (including error packets) that were 1024-1518 octets in length
etherStatsJabbers	Total number of packets longer than 1518 octets that were not an integral number of octets or had a bad FCS
etherStatsCollisions	Best estimate of the total number of collisions on this segment
etherStatsCollisionFrames	Best estimate of the total number of frame collisions on this segment
etherStatsCRCAlignErrors	Total number of packets with a length between 64 and 1518 octets, inclusive, that had a bad FCS or were not an integral number of octets in length
receivePauseFrames	Number of received 802.x pause frames (not supported by E-Series)
transmitPauseFrames	Number of transmitted 802.x pause frames (not supported by E-Series)
receivePktsDroppedInternalCongestion	Number of received frames dropped because of frame buffer overflow and other reasons (not supported by E-Series)
transmitPktsDroppedInternalCongestion	Number of frames dropped in the transmit direction because of frame buffer overflow and other reasons (not supported by E-Series)
txTotalPkts	Total number of transmit packets (not supported by E-Series)
rxTotalPkts	Total number of receive packets (not supported by E-Series)

System 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.

This chapter describes the basic planning and engineering information required to configure an ONS 15454 for deployment.

The following topics are covered in this chapter:

> **Note** The terms ONS 15454, shelf, and node shall mean a single ONS 15454 assembly shelf in this chapter.

Shelf Configurations

The ONS 15454 is a flexible platform that can be deployed in three types of configurations; multiservice provisioning platform (MSPP), multiservice transport platform (MSTP) or Hybrid. Each of these configurations requires a minimum set of components to operate the system. The following tables outline the minimum required components necessary to operate an ONS 15454 node.

MSPP Configurations

Cisco ONS 15454 MSPP configurations provide efficient multiservice aggregation (multiplexing) to SONET transport. Table 7-1 outlines the minimum components needed to build a functional MSPP node.

Table 7-1 Minimum MSPP Node Configuration

Component	Terminal Node	Linear ADM Node	Two-Fiber Ring Node	Four-Fiber Ring Node
Shelf Assembly	1	1	1	1
Fan Tray Assembly	1	1	1	1
Air Filter	1	1	1	1
Timing, Communications, Control (TCC+/TCC2/TCC2P) Card	2	2	2	2
Cross-connect Card	2	2	2	2
Optical Card	2	4	2	4
System Software License	1	1	1	1

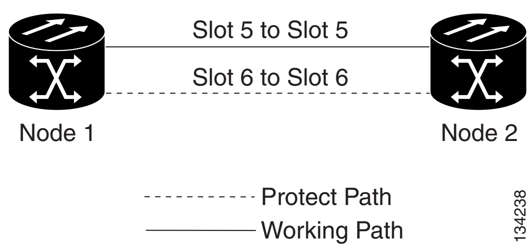
An ONS 15454 MSPP node can be activated with only the above equipment. You will then need to select appropriate service interfaces, which can include optical cards, electrical cards (with appropriate electrical interface adapter [EIA] panels), Ethernet cards, and storage access networking (SAN) cards to meet the particular deployment application.

Point-to-Point Nodes

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 to provide 1+1 protected transport directly to end users when the fiber topology warrants point-to-point connection rather than ring connection.

Figure 7-1 shows two ONS 15454 nodes in a point-to-point configuration. Working traffic flows from Slot 5/Node 1 to Slot 5/Node 2. You create the protect path by placing Slot 6/Node 1 in 1+1 protection with Slot 6/Node 2.

Figure 7-1 Point-to-Point 1+1 Protection Configuration

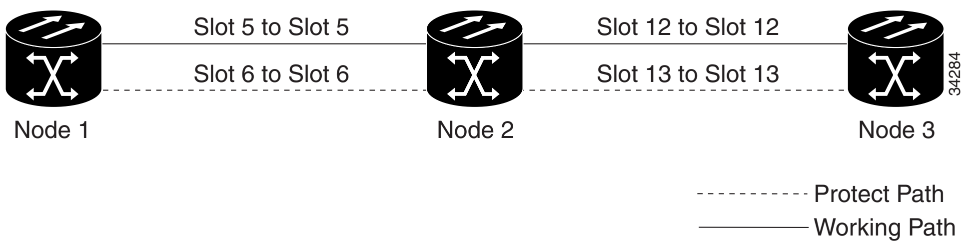


Linear ADM Nodes

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 7-2 shows three ONS 15454 nodes in a linear ADM configuration. Working traffic flows from Slot 5/Node 1 to Slot 5/Node 2, and from Slot 12/Node 2 to Slot 12/Node 3. You create the protect path by placing Slot 6 in 1+1 protection with Slot 5 at Nodes 1 and 2, and Slot 12 in 1+1 protection with Slot 13 at Nodes 2 and 3.

Figure 7-2 Linear ADM Configuration



Path Protection Nodes

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 is the default ring configuration for the ONS 15454. CTC automates the path protection 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 as the default.

A path protection circuit requires two DCC-provisioned optical spans per node. Path protection circuits can be created across these spans until their bandwidth is consumed.

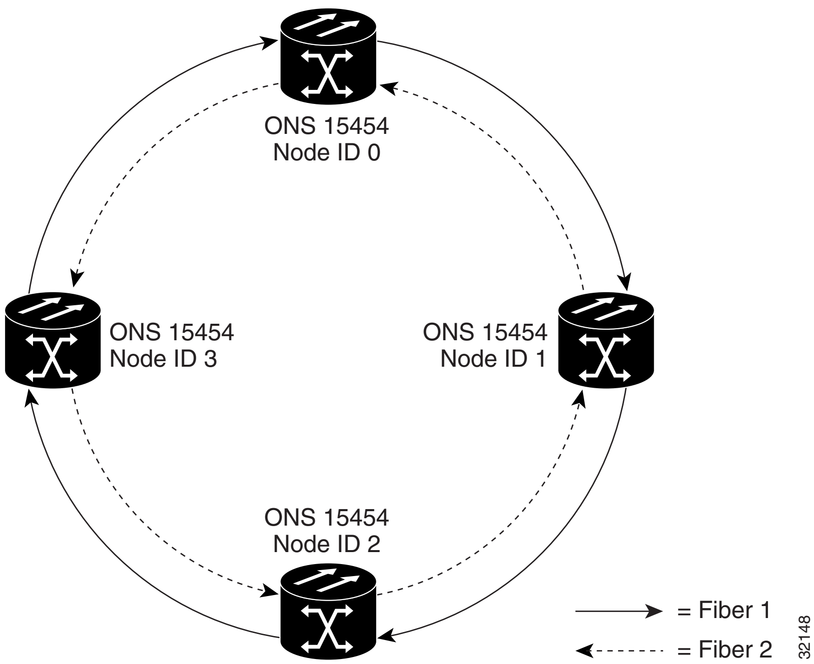
Note If a path protection circuit is created manually by TL1, data communications channels (DCCs) are not needed. Therefore, path protection circuits are limited by the cross-connection bandwidth, or the span bandwidth, but not by the number of DCCs.

The span bandwidth consumed by a path protection circuit is two times the circuit bandwidth, because the circuit is duplicated. The cross-connection bandwidth consumed by a path protection circuit is three times the circuit bandwidth at the source and destination nodes only. The cross-connection bandwidth consumed by an intermediate node has a factor of one. The same STSs assigned to a circuit are used throughout the ring.

The path protection 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 84 SDCCs divided by two if you are using redundant TCC2/TCC2P 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 STS-192c.

Figure 7-3 shows a basic OC-48 path protection configuration. If Node ID 0 sends a signal to Node ID 2, the working signal travels on the working traffic path through Node ID 1. The same signal is also sent on the protect traffic path through Node ID 3.

Figure 7-3 Basic OC-48 Path Protection Configuration

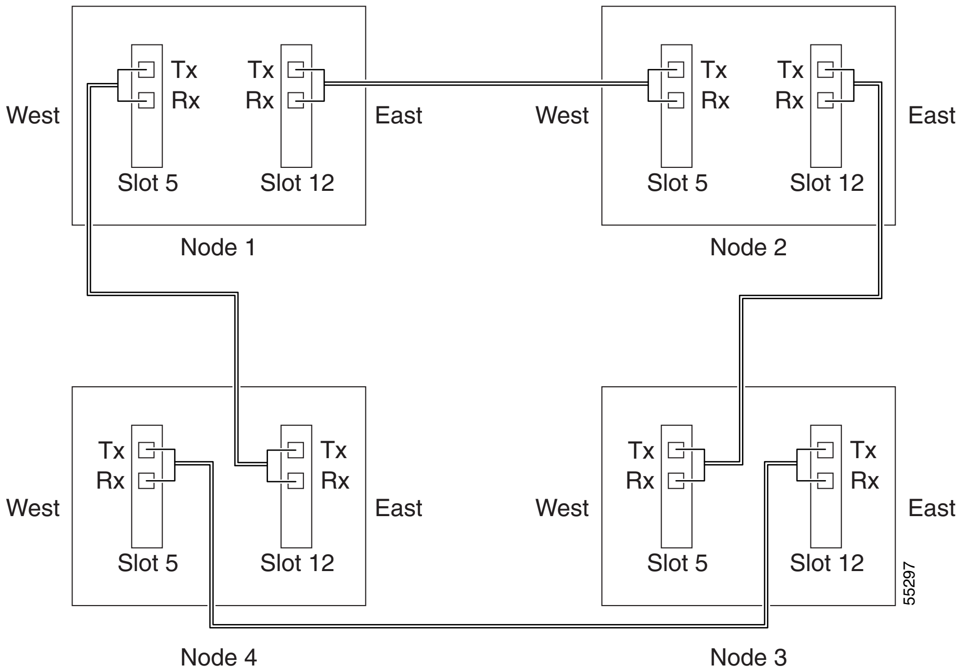


Path Protection Fiber Connections

Plan your fiber connections and use the same plan for all path protection nodes. For example, make the east port the farthest slot to the right and the west port the farthest slot to the left. Plug fiber connected to an east port at one node into the west port on an adjacent node. Figure 7-4 shows fiber connections for a path protection with trunk cards in Slot 5 (west) and Slot 12 (east) at each of the nodes in the ring. Refer to the *Cisco ONS 15454 Procedure Guide* for fiber connection procedures.

Note Always plug the transmit (Tx) connector of an OC-N card at one node into the receive (Rx) connector of an OC-N card at the adjacent node. Cards display an SF LED when Tx and Rx connections are mismatched.

Figure 7-4 Connecting Fiber to a Four-Node Path Protection

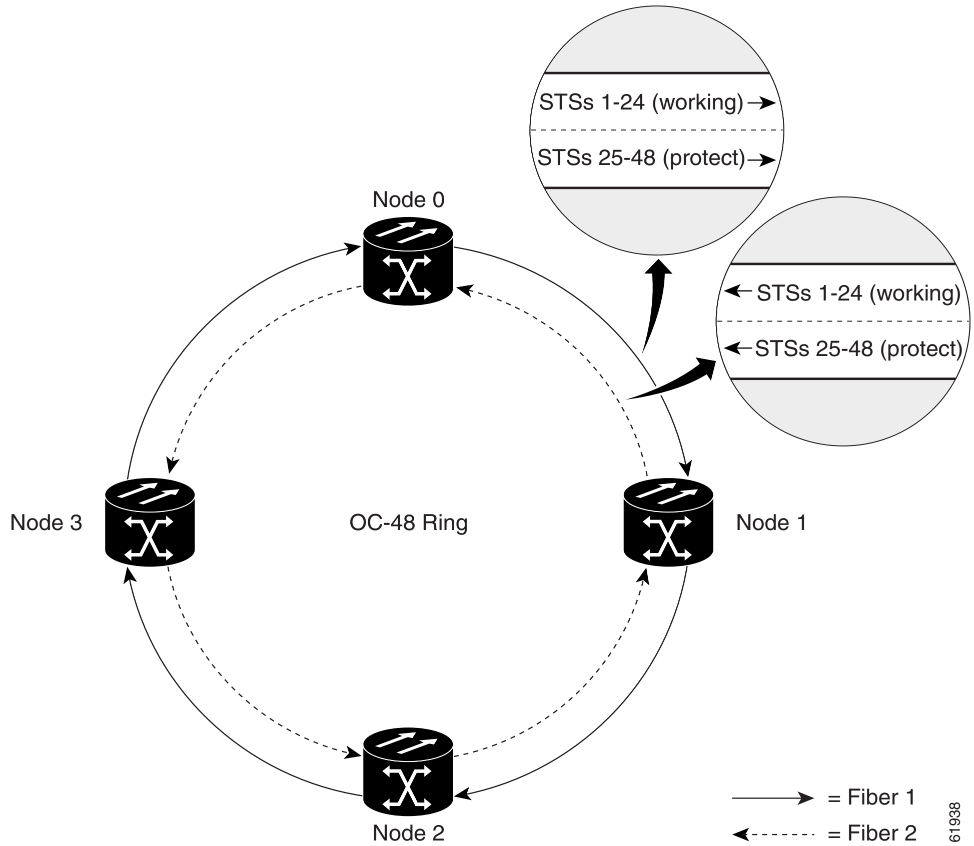


For more information about path protection configurations, refer to Chapter 2 in this document.

Two-Fiber BLSR Nodes

In two-fiber BLSR nodes, each fiber is divided into working and protect bandwidths. For example, in an OC-48 BLSR (Figure 7-5), STSs 1 to 24 carry the working traffic, and STSs 25 to 48 are reserved for protection. Working traffic (STSs 1 to 24) travels in one direction on one fiber and in the opposite direction on the second fiber. STS bandwidth can be reused as traffic is added or dropped at various nodes. An ONS 15454 network can support up to 16 nodes in a BLSR.

Figure 7-5 Four-Node, Two-Fiber BLSR



The Cisco Transport Controller (CTC) circuit routing routines calculate the shortest path for circuits based on many factors, including user requirements, traffic patterns, and distance. For example, in Figure 7-5 circuits going from Node 0 to Node 1 typically travel on Fiber 1, unless that fiber is full, in which case circuits are routed on Fiber 2 through Node 3 and Node 2. Traffic from Node 0 to Node 2 (or Node 1 to Node 3) can be routed on either fiber, depending on circuit provisioning requirements and traffic loads.

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.

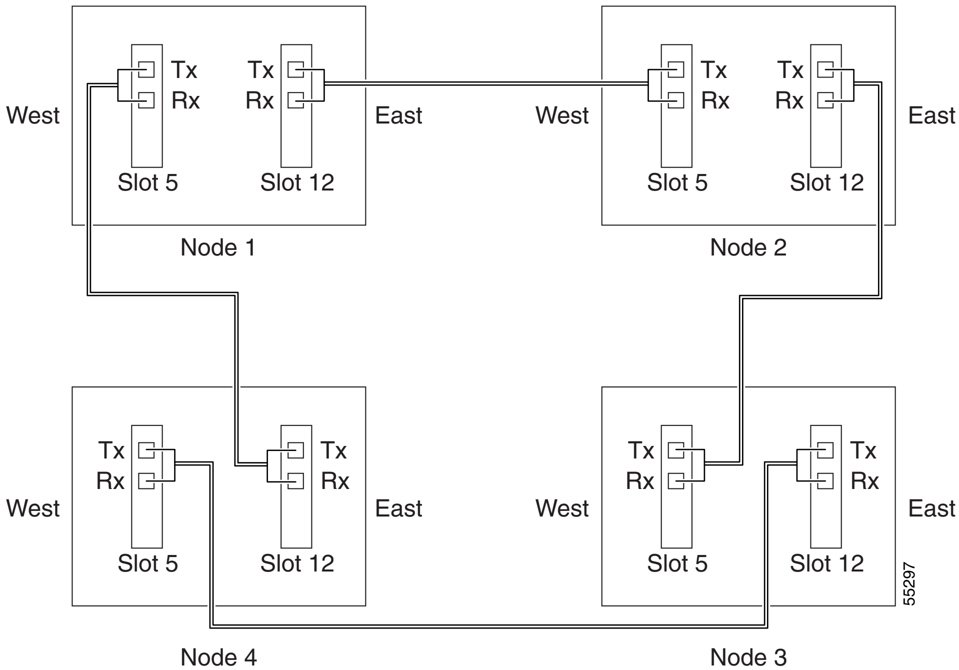
If a break occurs on one fiber, working traffic targeted for a node beyond the break switches to the protect bandwidth on the second fiber. The traffic travels in a reverse direction on the protect bandwidth until it reaches its destination node. At that point, traffic is switched back to the working bandwidth.

Fiber Connections for Two-Fiber BLSR Nodes

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 slot to the left. Plug fiber connected to an east port at one node into the west port on an adjacent node. Figure 7-6 shows fiber connections for a two-fiber BLSR with trunk cards in Slot 5 (west) and Slot 12 (east). Refer to the Cisco ONS 15454 Procedure Guide for fiber connection procedures.

Note Always plug the transmit (Tx) connector of an OC-N card at one node into the receive (Rx) connector of an OC-N card at the adjacent node. Cards display an SF LED when Tx and Rx connections are mismatched.

Figure 7-6 Connecting Fiber to a Four-Node, Two-Fiber BLSR

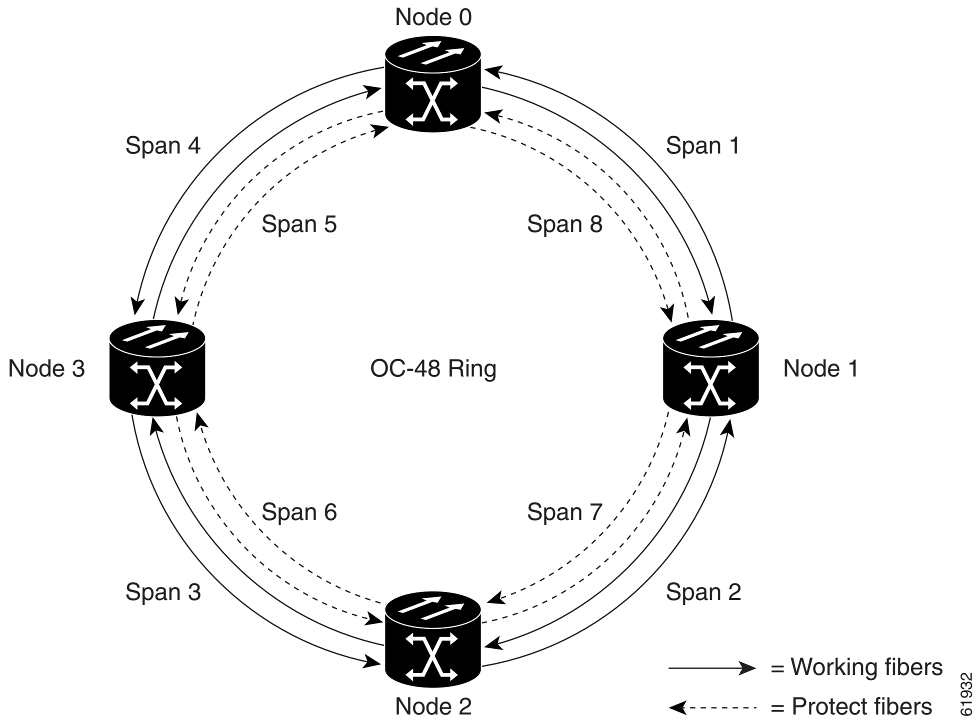


For more information on two-fiber BLSRs, refere to Chapter 2 in this document.

Four-Fiber BLSR Nodes

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 7-7. 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.

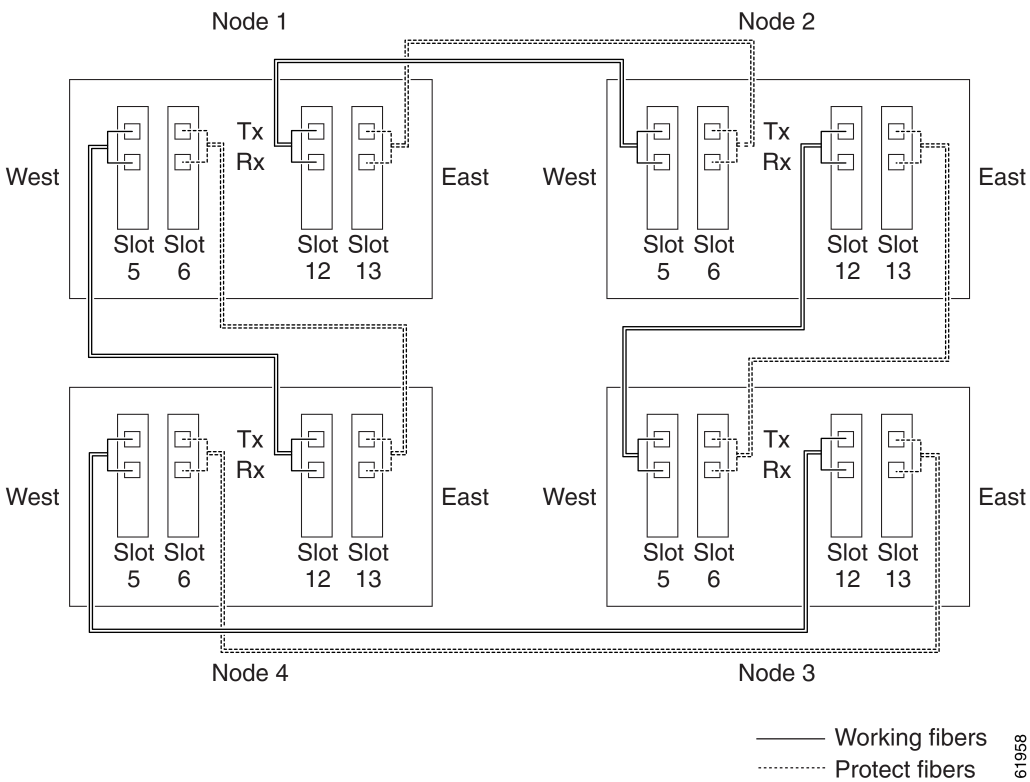
Figure 7-7 Four Node, Four-Fiber BLSR



Fiber Connections to a Four-Fiber BLSR Node

For four-fiber BLSRs, use the same east-west connection pattern for the working and protect fibers as you would for two-fiber BLSRs. Do not mix working and protect card connections. The BLSR does not function if working and protect cards are interconnected. Figure 7-8 shows fiber connections for a four-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 7-8 Connecting Fiber to a Four-Node, Four-Fiber BLSR



For more information on four-fiber BLSRs, refer to Chapter 2 in this document.

Subtended Rings

The ONS 15454 supports up to ten SONET SDCCs with TCC+ cards and 84 SONET SDCCs with TCC2/TCC2P cards. See Table 7-2 and Table 7-3 for the maximum number of rings supported per ONS 15454 node.

Table 7-2 ONS 15454 Rings with Redundant TCC+ Cards

Ring Type	Maximum Rings per Node
2-Fiber BLSR	2
4-Fiber BLSR	1
Path protection	5

Table 7-3 ONS 15454 Rings with Redundant TCC2/TCC2P Cards

Ring Type	Maximum Rings per Node
2-Fiber BLSR	5
4-Fiber BLSR	1
Path protection	42

Table 7-4 shows the combination of subtending ring configurations each ONS 15454 can support.

Table 7-4 Supported Subtending Ring Configurations

< Release 3.4	Release 4.0 - 4.1	> Release 4.6
5 path protection configurtations, or	16 path protection configurations, or	34 path protection configurations, or
4 path protection configurations and 1 Two-Fiber BLSR, or	15 path protection configurations and 1 Two-Fiber BLSR, or	29 path protection configurations and 5 Two-Fiber BLSRs, or
3 path protection configurations and 2 Two-Fiber BLSRs, or	14 path protection configurations and 2 Two-Fiber BLSRs, or	28 path protection configurations, 4 Two-Fiber BLSRs, and 1 Four-Fiber BLSR, or
3 path protection configuraitons and 1 Four-Fiber BLSR	14 path protection configurations and 1 Four-Fiber BLSR	38 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 7-9 shows multiple rings subtending from Node 1 inside the CO. Node 1 is part of an OC-192 BLSR. 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 (see Figure 7-10). The subtending shelf contains multiple OC-3 and DS-3 drops supporting various end users.

Figure 7-9 Multiple Subtending Rings

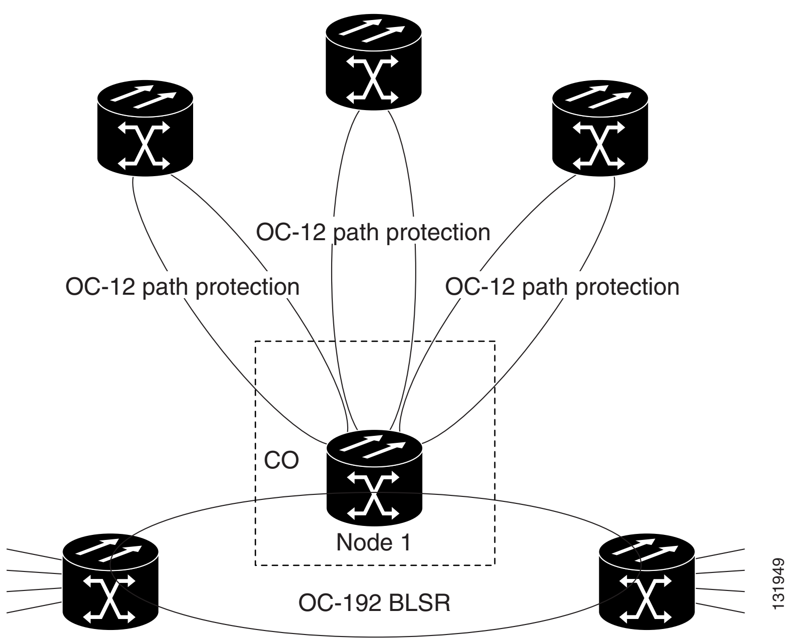
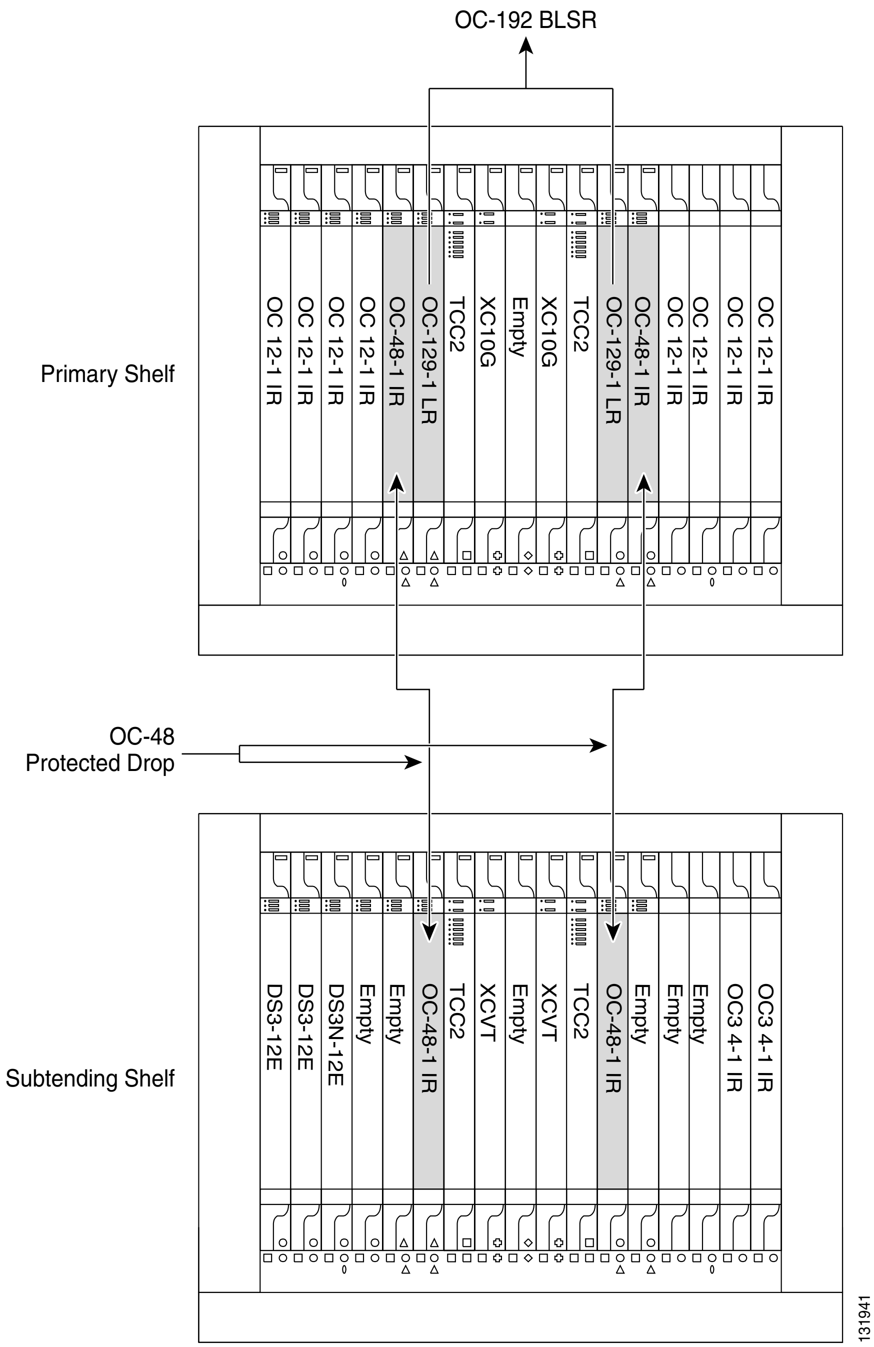


Figure 7-10 Node 1 Subtending Shelves



MSTP Configurations

MSTP nodes provide wavelength aggregation for DWDM transport. Table 7-5 and Table 7-6 outline the minimum components necessary, by ring and linear node types, to build a functional MSTP system.

Note The Cisco MetroPlanner R2.5 tool is a network design tool available to Cisco sales engineers for MSTP configurations. MetroPlanner prepares a shelf plan for each network node and calculates the power and attenuation levels for the DWDM cards installed in the node. For information about Cisco MetroPlanner, refer to the *Cisco MetroPlanner DWDM Operations Guide, Release 2.5*.

Table 7-5 Ring Network Component Requirements by Node Type

Component	Hub Node	Passive OADM Node	Active OADM Node	Line Amplifier Node
Shelf Assembly	1	1	1	1
Fan Tray Assembly	1	1	1	1
TCC2/TCC2P card	2	2	2	2
Optical Sevice Channel (OSC) card	2	2	2	2
Multiplexer card	2	—	—	—
Demultiplexer card	2	—	—	—
Optical Add/Drop Multiplexer (OADM) card	—	2	2	-
Optical Amplifier card	Distance Dependent	—	2	2
System software license	1	1	1	1
Fiber Patch Panel shelf	2	—	—	—
Fiber Storage shelf	1	1	1	1

Table 7-6 Linear Network Component Requirements by Node Type

Component	Hub Node	Passive OADM Node	Active OADM Node	Line Amplifier Node
Shelf Assembly	1	1	1	1
Fan Tray Assembly	1	1	1	1
TCC2/TCC2P Card	2	2	2	2
Optical Sevice Channel (OSC) Card	1	2	2	2
Multiplexer Card	1	—	—	—
Demultiplexer Card	1	—	—	—
Optical Add/Drop Multiplexer (OADM) Card	—	2	2	—
Optical Amplifier Card	Distance Dependent	—	2	2
System Software License	1	1	1	1
Fiber Patch Panel Shelf	1	—	—	—
Fiber Storage Shelf	1	1	1	1

Each of the ONS 15454 MSTP node can be activated with only the above equipment. Depending upon your particular application, the system will require additional components, including optical services cards and additional optical filters. For additional informat regarding MSTP node types, refer to Chapter 4 in this document or the Cisco ONS 15454 DWDM Installation and Operations Guide.

Hybrid Configuration

The Hybrid configuration is a combination of the MSPP and MSTP functionality contained within a single network element. Each of these system configurations will be unique and will require a minimum of the following equipment outlined in Table 7-7.

Table 7-7 Minimum Hybrid Node Requirements

Component	Hybrid Node
Shelf Assembly	1
Fan Tray Assembly	1
TCC2/TCC2P Card	2
Cross-connect Card	2
System Software License	1

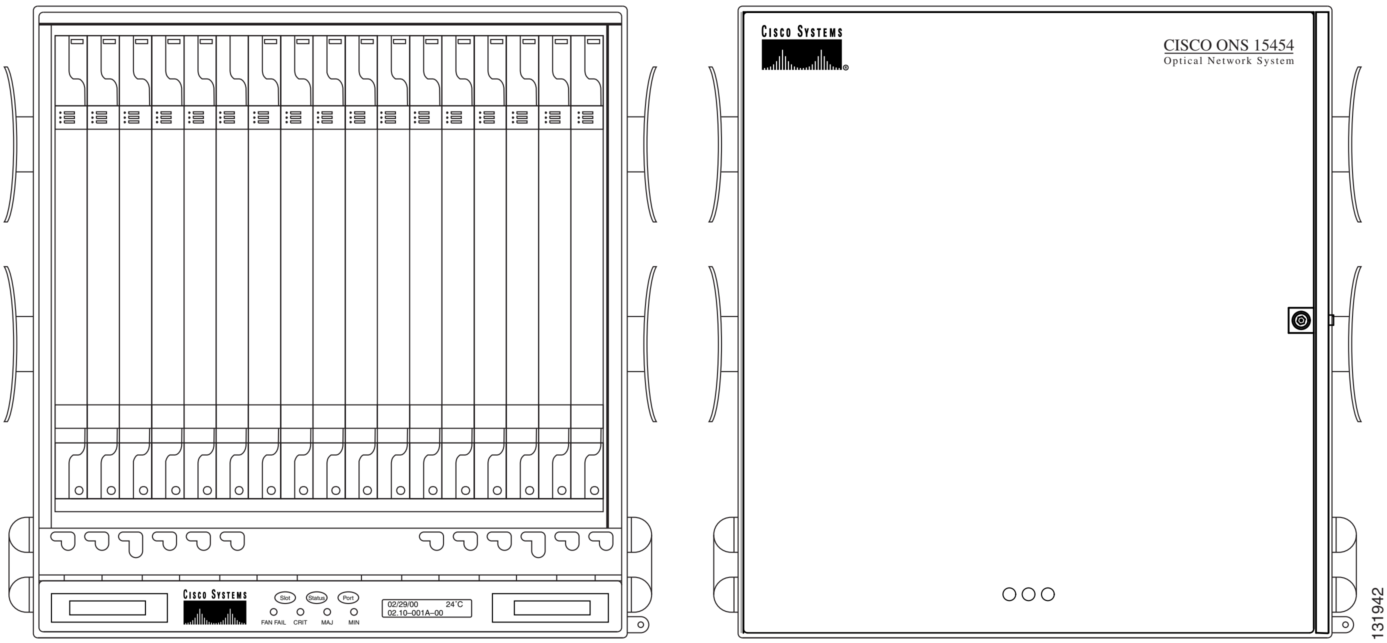
Hybrid nodes may also include optical filters, amplifiers, optical service channel cards, multiservice interfaces, Transponders, Muxponders, or a combination of these components.

Shelf Assembly Configuration Rules

Each shelf assembly requires you to follow a minimal set of configuration rules for proper operation and performance. The main rules focus on selecting an assembly shelf and fan tray assembly, understanding ONS 15454 card slot assignments, and choosing the common control and cross-connect cards compatible with your software release.

The ONS 15454 shelf assembly, shown in Figure 7-11, is a very compact footprint with an integrated upper air ramp and fan tray slot enabling up to 4 shelves to be installed within a typical 7-foot high ANSI equipment rack, including room for a 1.75-inch high fuse and alarm panel. The shelf assembly supports rear mounted connections for redundant -48 VDC power inputs, LAN interfaces, timing inputs and outputs, and housekeeping alarms. The ONS 15454 shelf assembly provides flexibility through pluggable front access interface card slots for common control and service interface cards and flexible electrical signal termination capabilities through the rear mounted, pluggable electrical interface adapter (EIA) panels. The shelf assembly comes equipped with mounting hardware for installation in 19-inch or 23-inch ANSI compliant racks.

Figure 7-11 ONS 15454 Shelf Assembly



The physical and environmental specifications for both the ONS 15454-SA-ANSI and ONS 15454-SA-HD shelf is listed in Table 7-8.

Table 7-8 ONS 15454 Assembly Shelf Specifications

Physical Dimension	15454-SA-ANSI Shelf	15454-SA-HD Shelf
Height	18.5 inches (40.7 cm)	18.5 inches (40.7 cm)
Width:		
• Minimum	19 inches (41.8 cm)	19 inches (41.8 cm)
• Maximum	23 inches (50.6 cm)	23 inches (50.6 cm)
Depth BNC and SMB EIAs:		
• Without cabling and rear cover	12 inches (26.4 cm)	12 inches (26.4 cm)
• With cabling and rear cover	14 inches (35.6 cm)	14 inches (35.6 cm)
Depth UBIC-H EIAs:		
• Without cabling and rear cover	—	12 inches (26.4 cm)
• With cabling and rear cover	—	15.0 inches (33 cm)
Depth UBIC-V EIAs:		
• Without cabling and rear cover	—	12 inches (26.4 cm)
• With cabling and rear cover	—	16.75 inches (36.85 cm)
Weight:		
• Empty (without cards)	55 lbs (24.947 kg)	55 lbs (24.947 kg)
• Full (with cards)	98 lbs (44.451 kg)	98 lbs (44.451 kg)
Footprint	13 ft^2	13 ft^2

Table 7-8 ONS 15454 Assembly Shelf Specifications (continued)

Physical Dimension	15454-SA-ANSI Shelf	15454-SA-HD Shelf
Minimum Aisle Clearance Requirement	24-inches	24-inches
Input Power	-48VDC	-48VDC
Maximum Power Consumption	1060W	1060W
Maximum Amperage	24A	24A
Minimum Fuse Recommendation (includes safety margin)	30A	35A
Compliance	NEBS Level 3	NEBS Level 3

For more information on the ONS 15454 assembly shelf, refer to "Shelf Assemblies" section on page 6-8 in this document.

Shelf Assemblies

The latest version shelf assembly, model 15454-SA-HD, is the default shelf shipping for new installations since Software Release 4.6. This shelf assembly is backwards compatible to Release 4.0 installations. For installations prior to Release 4.6, select the shelf assembly from Table 7-9 that is compatible with the version of software you plan to use. The 15454-SA-HD, 15454-SA-ANSI, and 15454-SA-NEBS3E shelves meet NEBS Level 3 specifications for Type 2 and Type 4 equipment, which is intended for installation in restricted access areas.

Table 7-9 Shelf Assembly Software Release Compatibility

Shelf	Part Number	<R2.2.2	R3.0.1	R3.1	R3.2	R3.3	R3.4	R4.0	R4.1	R4.5	R4.6	R5.0
15454-SA-HD	800-24443	—	—	—	—	—	—	Yes	Yes	Yes	Yes	Yes
15454-SA-ANSI	800-19857	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—
15454-SA-NEBS3E	800-07149	Yes	Yes	—	—	—	—	—	—	—	—	—

System Release 3.1 introduced the 15454-SA-ANSI shelf assembly. This shelf 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. This shelf is compatible with Software Release 4.6, but cannot support the high-density electrical cards.

Although the high density shelf became available with Release 4.6, it is not software dependant. The new 15454-SA-HD shelf incorporates additional DS-1, DS-3, and EC-1 interfaces that enable the ONS 15454 to support up to 224 DS-1s, 192 DS-3s and EC-1s, and 1:N protection. Except for these changes and new symbols identifying the high density card slots assignments, this new shelf is identical to the 15454-SA-ANSI shelf assembly. In order to support the additional electrical traffic, the 15454-SA-HD shelf must be equipped with new high density DS-1 and DS-3 plug-in cards and either the MiniBNC, UBIC-H, or UBIC-V electrical interface assemblies (EIAs). The 15454-SA-HD shelf is the standard shelf shipped for new installations starting with Release 4.6.

Fan-Tray Assemblies

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 and higher 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 touch pad.

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.

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 7-10 to select the fan-tray assembly that is compatible with the version of shelf assembly you plan to use.

Table 7-10 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-HD	800-24443
		15454-SA-ANSI	800-19857
15454-FTA2	800-07145	15454-SA-ANSI	800-19857
	800-07385	15454-SA-NEBS3E	800-07149
	800-19591	15454-SA-NEBS3E	800-07149
	800-19590	15454-SA-NEBS3E	800-07149

Power requirements for the FTA3-T and FTA2 fan-tray assemblies are listed in Table 7-11.

Table 7-11 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.

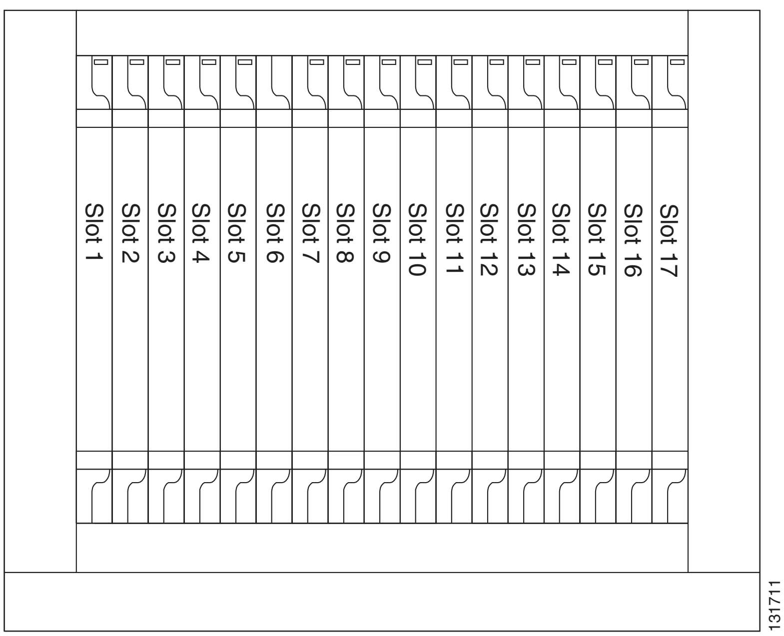
Air Filter

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.

Card Slot Assignments

The shelf assembly has 17 card slots as shown in Figure 7-12.

Figure 7-12 Shelf Assembly Card Slots



The card slots are numbered sequentially from 1 to 17 with slot #1 starting at the far left. Each slot is also labeled with an ICON symbol that can be matched with a symbol on the card's faceplate. These symbols provide easy identification of card to slot compatibility. Five card slots, 7 - 11, are dedicated to system operations, also known as common cards, and twelve card slots, 1 - 6 and 12 - 17, are for multi-service interface cards. A further breakout is outlined below:

Slots 1 through 6 - Referred to the A-Side of the shelf assembly and are compatible with a wide variety of interface cards. Bandwidth supported per shelf slot is dependent upon the type of cross-connect card installed. In Figure 7-12, slots 1 through 4, are low-speed card slots and support up to STS-48 (2.49Gb/s) bandwidth. Slots 5 and 6, are considered high-speed slots and support up to STS-192 (10Gb/s) bandwidth. Multi-service interface cards can be operated in protected and unprotected pairs or groups.

Slots 7 and 11 - Support the system processors referred to as the Timing, Communications and Control (TCC) cards. The shelf assembly should be equipped with two TCC cards to enable full system redundancy. Cisco does not support operation of the ONS 15454 with only one TCC card.

Slots 8 and 10 - Support either the system Cross-connect cards or the Optical Service Channel (OSC) cards. For TDM switching, equip the shelf assembly with two cross-connect cards of matching variety, to allow for 1+1 redundant operation. OSC cards are deployed in MSTP configurations for each DWDM span terminating on the shelf.

Slot 9 - Supports the optional Alarm Interface Controller (AIC) card. This card provides environmental alarm inputs and output controls, orderwire, and user data channel (UDC) capabilities. It is not required for system operation.

Slots 12 through 17 - Referred to the B-Side of the shelf assembly and are compatible with a wide variety of interface cards. Bandwidth supported per shelf slot is dependent upon the type of cross-connect card installed. In Figure 7-12, slots 1 through 4, are low-speed card slots and supports up to STS-48 (2.49Gb/s) bandwidth. Slots 12 and 13, are high-speed slots and support up to STS-192 (10Gb/s) bandwidth. Multi-service interface cards can be operated in protected and unprotected pairs or groups.

Shelf Slot Filler Cards - For all unpopulated card slots, numbered 1 to 17, a blank filter slot card must be installed to maintain proper airflow and compliance Telcordia GR-1089-CORE EMI and ESD requirements.

Table 7-12 lists the card slot compatibility for the ONS 15454 shelf assembly.

Table 7-12 Shelf Assembly Card Slot Compatibility

Slot Assignment	ONS 15454 Cards
1 - 3 and 15 - 17 only	DS3/EC1-48
1 - 4 and 14 - 17 only	OC3 IR/STM1 SH 1310-8 and OC12 IR/STM4 SH 1310-4
1 - 5 and 12 - 16 only	32MUX-O (2 slot card), 32DMX-O (2 slot card)

Table 7-12 Shelf Assembly Card Slot Compatibility

Slot Assignment	ONS 15454 Cards
1 - 6 and 12 - 17 only	DS1-14, DS3-12, DS3-12E, DS3XM-6, DS3XM-12, and EC1-12 OC3 IR SH 1310, OC3 IR 4/STM1 SH 1310, OC3 IR/STM1 SH 1310-8, OC12 IR 1310, OC12 IR/STM4 SH 1310, OC12 LR 1310, OC12 LR/STM4 LH 1310, OC12 LR/STM4 LH 1550, OC12 IR/STM4 SH 1310-4, OC48 IR/STM16 SH AS 1310, and OC48 LR/STM16 LH AS 1550 CE-100T-8, E100T-12, E1000-2, E100T-G, E1000-2-G, G1000-4, G1K4, ML100T-12 (with XC-10G), and ML1000-2 (with XC-10G) FC_MR-4 (with XC-10G) OSC-CSM, OPT-PRE, OPT-BST, 32DMX, 4MD-xx.x, AD-1C-xx.x, AD-2C-xx.x, AD-4C-xx.x, AD-1B xx.x, AD4B-xx.x, and 32WSS (2 slot card)
3 and 15 only	DS1N-14, DS3N-12, DS3N-12E and DS3/EC1-48 cards when provisioned for 1:N protection
5 - 6 and 12 - 13 only	OC48 IR 1310, OC48 LR 1550, OC48 ELR/STM16 EH 100 GHz, OC48 ELR 200 GHz, OC192 SR/STM64 IO 1310, OC192 IR/STM64 SH 1550, OC192 LR/STM64 LH 1550, and OC192 LR/STM64 LH ITU 15xx.xx 100 GHz ML100T-12 (with XC or XC-VT), and ML1000-2 (with XC or XC-VT) FC_MR-4 (with XC-VT)
7 and 11 only	TCC+, TCC2, and TCC2P
8 and 10 only	XC, XC-VT, and XC-10G OSCM
9 only	AIC and AIC-I

Note Each card is marked with a symbol that corresponds to a slot (or slots) on the ONS 15454 shelf assembly. The cards must be installed into slots displaying the same symbols to operate. If a card is installed in the wrong slot, it will not boot up.

Common-Control Cards

Table 7-13 lists the compatibility of each of the ONS 15454 common-control cards to software releases. In the table below, "Yes" means the card is compatible with the listed software release. Table cells with dashes mean the card is not compatible with the listed software release.

Table 7-13 Common-Control Card Software Compatibility

Card	<R2.2.2	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x
TCC+	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—	—
TCC2	—	—	—	—	—	—	Yes	Yes	Yes	Yes
TCC2P	—	—	—	—	—	—	Yes	Yes	Yes	Yes

Table 7-13 Common-Control Card Software Compatibility (continued)

Card	<R2.2.2	R3.0.1	R3.1.x	R3.2.x	R3.3.x	R3.4.x	R4.0.x	R4.1.x	R4.6.x	R5.0.x
XC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
XCVT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
XC10G	—	—	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AIC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AIC-I	—	—	—	—	—	Yes	Yes	Yes	Yes	Yes
AEP	—	—	—	—	—	Yes	Yes	Yes	Yes	Yes

See http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html for updates on End-Of-Life and End-Of-Sale notices.

Table 7-14 lists the compatible cross-connect cards for each ONS 15454 common-control card. In the table below, "Yes" means the card is compatible with the listed cross-connect card. Table cells with dashes mean the card is not compatible with the listed cross-connect card.

Table 7-14 Common-Control Card Cross-Connect Compatibility

Card	XC	XCVT	XC10G
TCC+	Yes	Yes	Yes
TCC2	Yes	Yes	Yes
TCC2P	Yes	Yes	Yes
XC	Yes	—	—
XCVT	—	Yes	—
XC10G	—	—	Yes
AIC	Yes	Yes	Yes
AIC-I	Yes	Yes	Yes
AEP	Yes	Yes	Yes

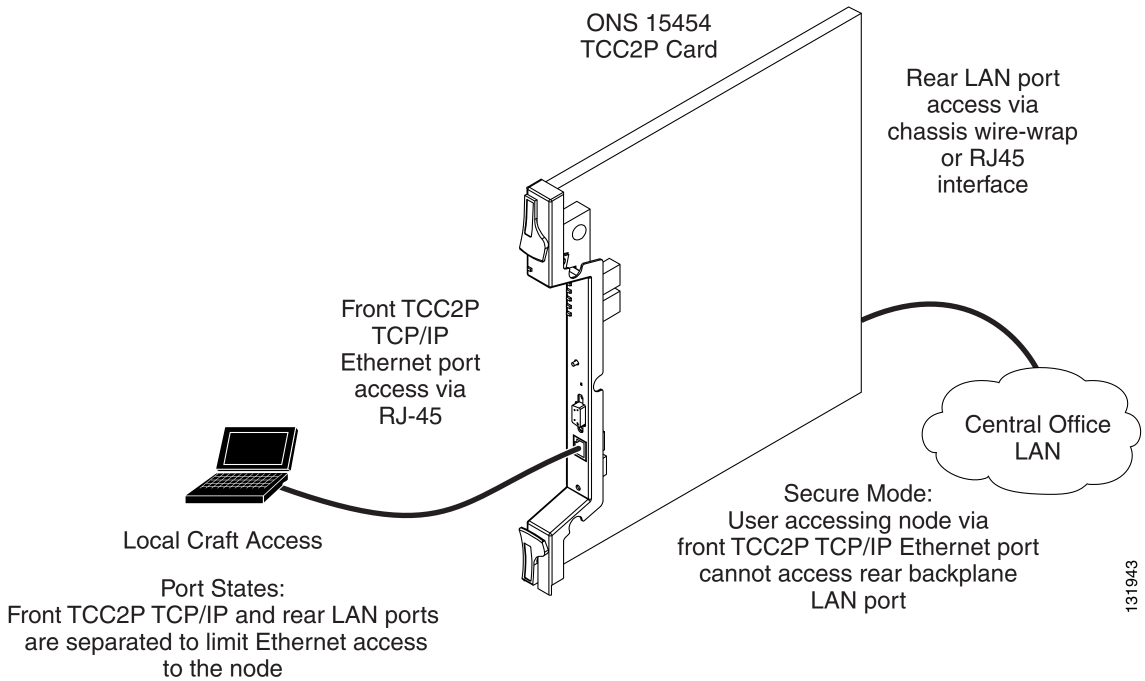
Timing Control Cards (TCCs)

For systems running Software R4.0 or higher, use the TCC2 or TCC2P card. For all other software releases, use the TCC+ card.

If you want to run the ONS 15454 node in Secure Mode, which allows you to provision two IP addresses for the ONS 15454, use the only TCC2P cards and Software Release 5.0 or higher. In Secure Mode, one IP address (192.1.0.2) is the default IP address provisioned for the ONS 15454 backplane LAN port. The other IP address (10.10.0.1) is the default IP address provisioned for the TCC2P TCP/IP Ethernet port. When Secure Mode is on, the ONS 15454 node automatically configures itself to perform as Gateway Network Element (GNE) and disables the communications link between the TCC2P and LAN Ethernet ports. If Secure Mode is off, the TCC2P and LAN Ethernet ports are bridged together and share a single IP address (192.1.0.2).

Figure 7-13 shows a TCC2P card operating in Secure Mode.

Figure 7-13 TCC2P Secure Mode Operation



Note Before you can connect an ONS 15454 node to other ONS 15454 nodes or to a LAN, you must change the default IP addresses that are shipped with each ONS 15454. The IP addresses provisioned for the TCC2P Ethernet port must follow general IP addressing guidelines. In Secure Mode, the TCC2P TCP/IP address must reside on a different subnet from the backplane LAN port and ONS 15454 default router IP address. For more information about Secure Mode and IP networking, refer to Chapter 8.

To enable OC-192 and OC-48 any-slot card operation, use the XC-10G card, the TCC+, TCC2, or TCC2P card, Software R3.1 and higher, and the 15454-SA-ANSI or new 15454-SA-HD 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 the TCC2 or TCC2P card with the XC-10G card, and the 15454-SA-ANSI or new 15454-SA-HD shelf assembly. Do not pair an XC or XC-VT with an XC-10G card.

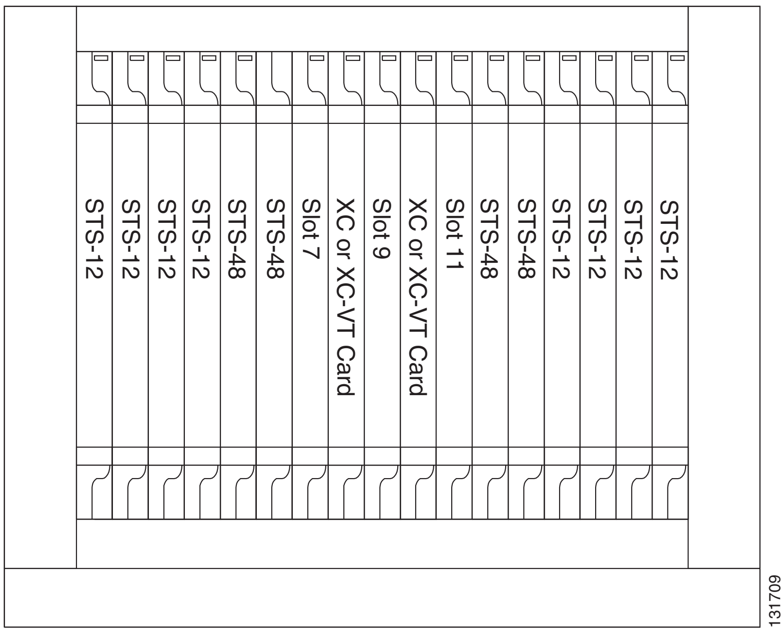
Cisco does not support operation of the ONS 15454 with only one TCC+, TCC2, or TCC2P card. For full functionality and to safeguard your system, always operate in a redundant configuration using two TCC+, TCC2, or TCC2P cards. You can have a network of ONS 15454 nodes with mixed TCC+, TCC2, and TCC2P cards, but you cannot mix different types of TCC cards in the same node.

Note The TCC+, TCC2, and TCC2P cards can be installed in slots 7 and 11 only.

Cross-connect Cards (XCs)

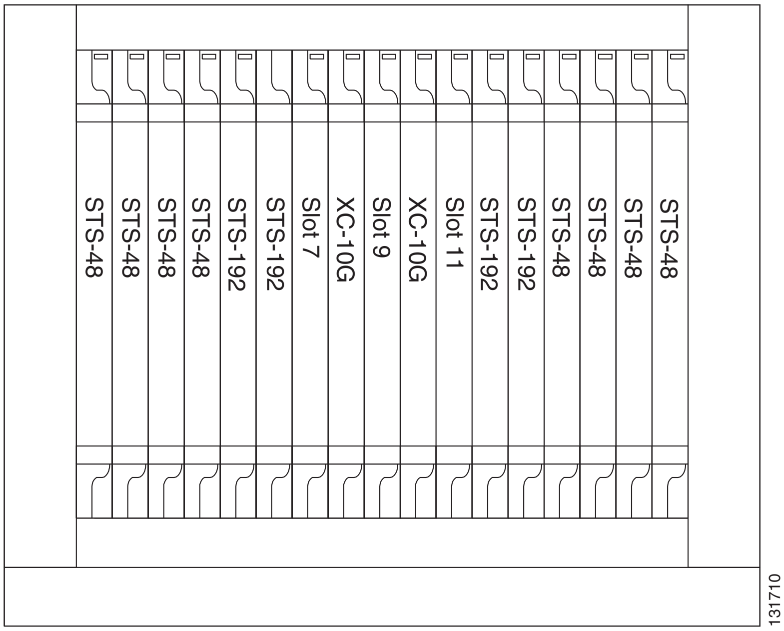
The selection of the proper cross-connect card is critical, as the cross-connect card is the "bandwidth enabling" device for the shelf assembly. As depicted in Figure 7-14, an ONS 15454 equipped with the XC or XCVT cross-connect card in Slots 8 and 10 can support up to 2.49 Gb/s (STS-48) bandwidth in card Slots 5, 6, 12, and 13, and up to 622 Mb/s (STS-12) bandwidth in card Slots 1 to 4 and 14 to 17.

Figure 7-14 Per Slot Bandwidth Available with the XC and XCVT Cross-Connect Cards



Equipped with the XC10G cross-connect card, Slots 5, 6, 12, and 13 can support up to 10 Gb/s (STS-192) bandwidth and up to 2.49 Gb/s (STS-48) bandwidth in Slots 1 to 4 and 14 to 17, as shown in Figure 7-15.

Figure 7-15 Per Slot Bandwidth Available with the XC10G Cross-Connect Card



Card and Hardware Compatibility

When configuring an ONS 15454 node, use Table 7-15 to determine the compatibility between common-control cards, interface cards, slot assignments, shelf assemblies, and software.

Table 7-15 ONS 15454 Card Compatibility

Card	Slot Assignment	TCC Card	Cross-connect Card	Shelf Assembly	Fan-Tray Assembly	Software Release
TCC+	7 and 11	—	All	All	All	R2.1 - R4.1
TCC2	7 and 11	—	All	All	All	>= R4.0
TCC2P	7 and 11	—	All	All	All	>= R4.0
XC	8 and 10	All	—	All	All	>= R2.0
XCVT	8 and 10	All	—	All	All	>= R2.2
XC10G	8 and 10	All	—	SA-HD, SA-ANSI	FTA3-T	>= R3.1
AIC	9	All	All	All	All	>= R2.2
AIC-I	9	TCC+, TCC2, TCC2P	All	All	All	>= R3.4
AEP	Backplane	TCC+, TCC2, TCC2P	All	All	All	>= R3.4
DS1-14	1-6 and 12-17	All	All	All	All	>= R2.2

Table 7-15 ONS 15454 Card Compatibility (continued)

Card	Slot Assignment	TCC Card	Cross-connect Card	Shelf Assembly	Fan-Tray Assembly	Software Release
DS1N-14	1:1 protection: 1-6 and 12-17 1:N protection: 3, 5	All	All	All	All	>= R2.2
DS3-12	1-6 and 12-17	All	All	All	All	>= R2.2
DS3N-12	1:N protection: 3, 5	All	All	All	All	>= R2.2
DS3-12E	1-6 and 12-17	All	All	All	All	>= R3.0
DS3N-12E	1:1 protection: 1-6 and 12-17 1:N protection: 3, 5	All	All	All	All	>= R3.0
DS3/EC1-48	1-3 and 15-17	TCC2, TCC2P	XC-10G	SA-HD	FTA3-T	>= R5.0
DS3XM-6	1-6 and 12-17	All	All	All	All	>= R2.2
DS3XM-12	1-6 and 12-17	TCC2, TCC2P	All	SA-HD, SA-ANSI	FTA3-T	>= R5.0
EC1-12	1-6 and 12-17	All	All	All	All	>= R2.2
OC3-4IR1310	1-6 and 12-17	All	All	All	All	>= R2.2
OC38I-1310	1-4 and 14-17	All	All	SA-HD, SA-ANSI	FTA3-T	>= R4.0
OC12IR1310	1-6 and 12-17	All	All	All	All	>= R2.0
OC12LR1310	1-6 and 12-17	All	All	All	All	>= R2.0
OC12LR1550	1-6 and 12-17	All	All	All	All	>= R2.0
OC12I4-1310	1-4 and 14-17	All	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R3.3
OC48IR1310	5, 6, 12, 13	All	All	All	All	>= R2.2
OC48LR1550	5, 6, 12, 13	All	All	All	All	>= R2.1
OC48IR1310A (any slot)	1-6 and 12-17	TCC+, TCC2, TCC2P	XC-10G	SA-ANSI, SA-HD	FTA3-T	>= R3.1
	5, 6, 12, 13	TCC+, TCC2, TCC2P	XC, XC-VT	All	All	>= R3.2
OC48ELR-100GHz	5, 6, 12, 13	All	All	All	All	>= R3.3
OC48ELR-200GHz	5, 6, 12, 13	All	All	All	All	>= R2.2

Table 7-15 ONS 15454 Card Compatibility (continued)

Card	Slot Assignment	TCC Card	Cross-connect Card	Shelf Assembly	Fan-Tray Assembly	Software Release
OC192SR1310	5, 6, 12, 13	TCC+, TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
OC192IR1550	5, 6, 12, 13	TCC+, TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
OC192LR1550	5, 6, 12, 13	TCC+, TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R3.1
OC192LR2	5, 6, 12, 13	TCC+, TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
OC192LR-100GHz	5, 6, 12, 13	TCC+, TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
MXP_2.5G_10G	1-6 and 12-17	TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
MXP_2.5G_10E	1-6 and 12-17	TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.7
MXP_MR_2.5G MXPP_MR_2.5G	1-6 and 12-17	TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.7
TXP_MR_10G	1-6 and 12-17	TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
TXP_MR_10E	1-6 and 12-17	TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.7
TXP_MR_2.5G TXPP_MR_2.5G	1-6 and 12-17	TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
CE-100T-8	1-6 and 12-17	TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R5.0.2
E100T-12	1-6 and 12-17	All	XC, XC-VT	All	All	>= R2.0
E100T-G	1-6 and 12-17	All	XC, XC-VT, XC 10G	All	All	>= R2.0
E1000-2	1-6 and 12-17	All	All	All	All	>= R2.2
E1000-2-G	1-6 and 12-17	All	All	All	All	>= R2.2
G1000-4	1-6 and 12-17	TCC+, TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R3.2

Table 7-15 ONS 15454 Card Compatibility (continued)

Card	Slot Assignment	TCC Card	Cross-connect Card	Shelf Assembly	Fan-Tray Assembly	Software Release
G1K-4	1-6 and 12-17	TCC+, TCC2, TCC2P	XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R3.2
	5, 6, 12, 13	TCC2, TCC2P	XC, XC-VT	All	All	>=R4.0
ML100T-12	5, 6, 12, 13 1-6 and 12-17	TCC2, TCC2P	XC-VT[1] XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
ML1000-2	5, 6, 12, 13 1-6 and 12-17	TCC2, TCC2P	XC-VT[1] XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.0
FC_MR-4	5, 6, 12, 13 1-6 and 12-17	TCC2, TCC2P	XC-VT, XC-10G	SA-HD, SA-ANSI	FTA3-T	>= R4.6
OSCM	8 and 10	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
OSC-CSM	1-6 and 12-17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
OPT-PRE	1-6 and 12-17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
OPT-BST	1-6 and 12-17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
32MUX-O	1&2, 3&4, 5&6, 12&13, 14&15, 16&17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
32DMX-O	1&2, 3&4, 5&6, 12&13, 14&15, 16&17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
32DMX	1-6 and 12-17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.7
4MD-xx.x	1-6 and 12-17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
AD-1C-xx.x	1-6 and 12-17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
AD-2C-xx.x	1-6 and 12-17	TCC2, TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
AD-4C-xx.x	1-6 and 12-17	TCC2 TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
AD-1B-xx.x	1-6 and 12-17	TCC2 TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5

Table 7-15 ONS 15454 Card Compatibility (continued)

Card	Slot Assignment	TCC Card	Cross-connect Card	Shelf Assembly	Fan-Tray Assembly	Software Release
AD-4B-xx.x	1-6 and 12-17	TCC2 TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.5
32WSS	1-6 and 12-17	TCC2 TCC2P	—	SA-HD, SA-ANSI	FTA3-T	>= R4.7

1. Compatible in Slots 5, 6, 12, and 13 with the XC-VT card.

Filler Card

The filler card (15454-BLANK or 15454-FILLER) is designed to occupy empty plug-in card slots in the assembly shelf (Slots 1 - 6, 9, and 12 - 17). The filler card cannot operate in the XC slots (Slots 8 and 10) or TCC2/TCC2P slots (7 and 11). In a future software release 15454-FILLER will be detectable through the management interfaces of the ONS 15454.

You must install a filler card in each empty assembly shelf card slot to maintaining proper air flow and EMI requirements.

Electrical Interface Adapters (EIAs)

Optional Electrical Interface Adapter (EIA) backplane covers are typically preinstalled when ordered with the ONS 15454. EIAs must be ordered when using DS1-14, DS3-12, DS3-12E, DS3/EC1-48, DS3XM-6, DS3XM-12, and EC1-12 cards. For a description of EIAs, refer to Chapter 6.

EIAs are attached to the shelf assembly backplane to provide electrical interface cable connections. EIAs are available with SMB and BNC connectors for DS3-12, DS3-12E, DS3XM-6, DS3XM-12, or EC1-12 cards. EIAs are available with AMP Champ connectors for DS1-14 cards. You must use SMB EIAs for DS-1 twisted-pair cable installation. UBIC-H and UBIC-V EIAs have SCSI connectors, which are used for use with the DS3/EC1-48 card and any of the low-density DS-1, DS-3, DS3XM, or EC-1 cards.

Note The MiniBNC EIAs only support cables using the Trompetor connectors for termination.

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.

As you face the rear of the ONS 15454 shelf assembly, the right side is the A side and the left side is the B side. Side A interoperates with card slots 1 to 6 and side B interoperates with card slots 12 to 17. 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. You can install EIAs on one or both sides of the assembly shelf 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).

Choose an EIA from Table 7-16 or Table 7-17 that is compatible with your assembly shelf and interface cards.

> **Note** UBIC-H and UBIC-V EIAs can only be installed on shelf assembly 15454-SA-HD. The 15454-SA-HD shelf assembly is differentiated from other shelf assemblies by the blue hexagon symbol, which indicates the available high-density slots, found under Slots 1 through 3 and 15 through 17.

> **Note** You do not need to power down the shelf before removing or installing an EIA that is not terminating any electrical (DS-1, DS-3, and EC-1) traffic. An in-service upgrade of one EIA (A side or B side) is possible if all electrical traffic is being terminated on the other side.

Table 7-16 EIAs Compatible with the 15454-SA-ANSI Shelf Only

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	DS3-12, DS3-12E, DS3XM-6, EC1-12	24 pairs of BNC connectors	Slot 2, Slot 4	15454-EIA-BNC-A24	24 pairs of BNC connectors	Slot 14, Slot 16	15454-EIA-BNC-B24
High-Density BNC	DS3-12, DS3-12E, DS3XM-6, EC1-12	48 pairs of BNC connectors	Slot 1, Slot 2, Slot 4, Slot 5	15454-EIA-BNC-A48	48 pairs of BNC connectors	Slot 13, Slot 14, Slot 16, Slot 17	15454-EIA-BNC-B48
SMB	DS1-14, DS3-12, DS3-12E, EC1-12, DS3XM-6	84 pairs of SMB connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, Slot 6	15454-EIA-SMB-A84	84 pairs of SMB connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, Slot 17	15454-EIA-SMB-B84
AMP Champ	DS1-14	6 AMP Champ connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, Slot 6	15454-EIA-AMP-A84	6 AMP Champ connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, Slot 17	15454-EIA-AMP-B84

Table 7-17 EIAs Compatible with the 15454-SA-HD Shelf

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
UBIC-H	DS1-14, DS3-12, DS3-12E, DS3/EC1-48, DS3XM-6, DS3XM-12, EC1-12	8 pairs of SCSI connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, Slot 6	15454-EIA-UBICH-A	8 pairs of SCSI connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, Slot 17	15454-EIA-UBICH-B
UBIC-V	DS1-14, DS3-12, DS3-12E, DS3/EC1-48, DS3XM-6, DS3XM-12, EC1-12	8 pairs of SCSI connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, Slot 6	15454-EIA-UBICV-A	8 pairs of SCSI connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, Slot 17	15454-EIA-UBICV-B
Low-Density BNC	DS3-12, DS3-12E, DS3XM-6, DS3XM-12, EC1-12	24 pairs of BNC connectors	Slot 2, Slot 4	15454-EIA-1BNC-A24	24 pairs of BNC connectors	Slot 14, Slot 16	15454-EIA-1BNC-B24
High-Density BNC	DS3-12, DS3-12E, DS3XM-6, DS3XM-12, EC1-12	48 pairs of BNC connectors	Slot 1, Slot 2, Slot 4, Slot 5	15454-EIA-1BNC-A48	48 pairs of BNC connectors	Slot 13, Slot 14, Slot 16, Slot 17	15454-EIA-1BNC-B48
MiniBNC	DS3-12, DS3-12E, DS3/EC1-48, DS3XM-6, DS3XM-12, EC1-12	96 pairs of BNC connectors	Slot 1, Slot 2, Slot 4, Slot 5	15454-EIA-HDBNC-A96	96 pairs of BNC connectors	Slot 13, Slot 14, Slot 16, Slot 17	15454-EIA-HDBNC-B96
SMB	DS1-14, DS3-12, DS3-12E, EC1-12, DS3XM-6, DS3XM-12	84 pairs of SMB connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, Slot 6	15454-EIA-1SMB-A84	84 pairs of SMB connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, Slot 17	15454-EIA-1SMB-B84
AMP Champ	DS1-14	6 AMP Champ connectors	Slot 1, Slot 2, Slot 3, Slot 4, Slot 5, Slot 6	15454-EIA-1AMP-A84	6 AMP Champ connectors	Slot 12, Slot 13, Slot 14, Slot 15, Slot 16, Slot 17	15454-EIA-1AMP-B84

Table 7-18 shows the number of connectors per side for each EIA type according to low-density and high-density interfaces. In the table, high-density (HD) cards include the DS3/EC1-48 card. Low-density (LD) cards include the following:

- DS1-14, DS1N-14
- DS3-12, DS3N-12
- DS3-12E, DS3N-12E
- DS3XM-6
- DS3XM-12
- EC1-12

Table 7-18 EIA Connector Capacity

Interfaces per Side	Standard BNC	High Density BNC	MIni BNC	SMB	AMP Champ	UBIC-H and UBIC-V
Total Physical Connectors	48	96	192	168	6	16
Maximum LD DS-1 Interfaces (Tx and Rx)	—	—	—	84[1]	84	84
Maximum LD DS-3 Interfaces (Tx and Rx)	24	48	72	72	—	72
Maximum HD DS-1 Interfaces (Tx and Rx)	—	—	—	—	—	112
Maximum HD DS-3 Interfaces (Tx and Rx)	—	—	96	—	—	96

1. Use SMB to wire-wrap Baun for DS-1 terminations (15454-WW-14).

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 shelf assembly comes preset for installation in a 23-inch (584.2 mm) rack, but you can reverse the mounting bracket to fit the smaller 19-inch (482.6 mm) rack. The shelf assembly projects five inches (127 mm) from the front of the rack. It mounts in both ANSI-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.

Two people should install the shelf assembly; however, one person can install it using the temporary set screws included. The shelf assembly should be empty for easier lifting. The front door can also be removed to lighten the weight of the shelf assembly.

Typical Bay Installation

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.

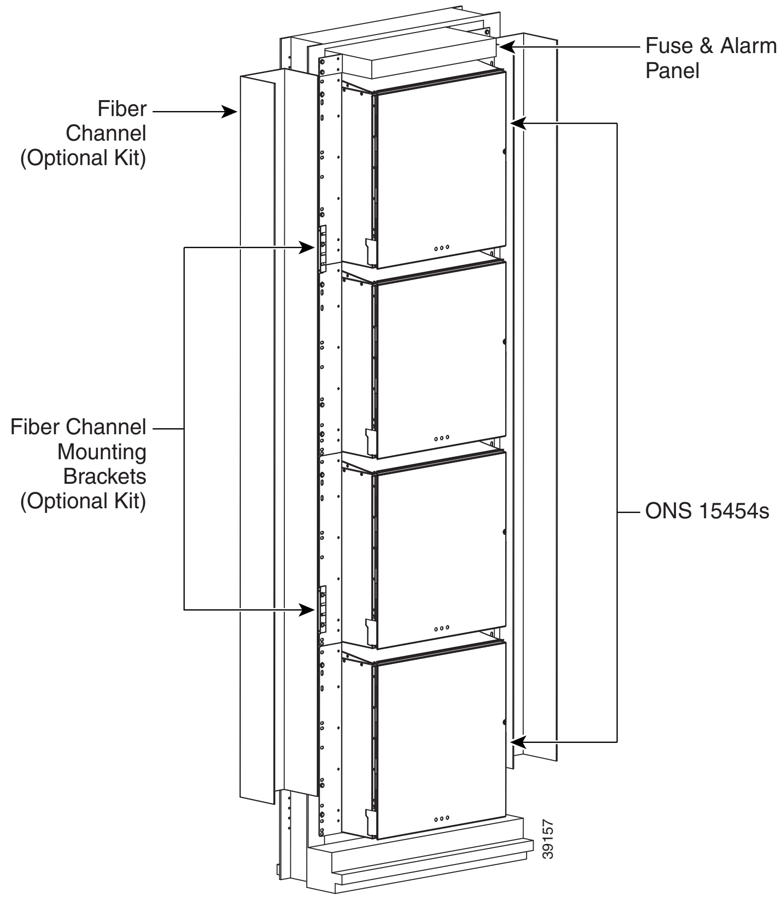
These typical equipment rack arrangements meet NEBS central office requirements for bay heat dissipation. If you do not use these arrangements, normal heat flow could be interrupted and adversely affect shelf operation. Fan-tray assemblies must be used to guarantee proper air circulation.

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.

Caution Do not operate an ONS 15454 without the mandatory fan-tray air filter.

Figure 7-16 shows a typical bay arrangement using four 15454-SA-HD shelf assemblies. Note that most standard (Telcordia GR-63-CORE, 19-inch [482.6 mm] or 23-inch [584.2 mm]) seven-foot (2,133 mm) racks can hold four ONS 15454s and a fuse and alarm panel.

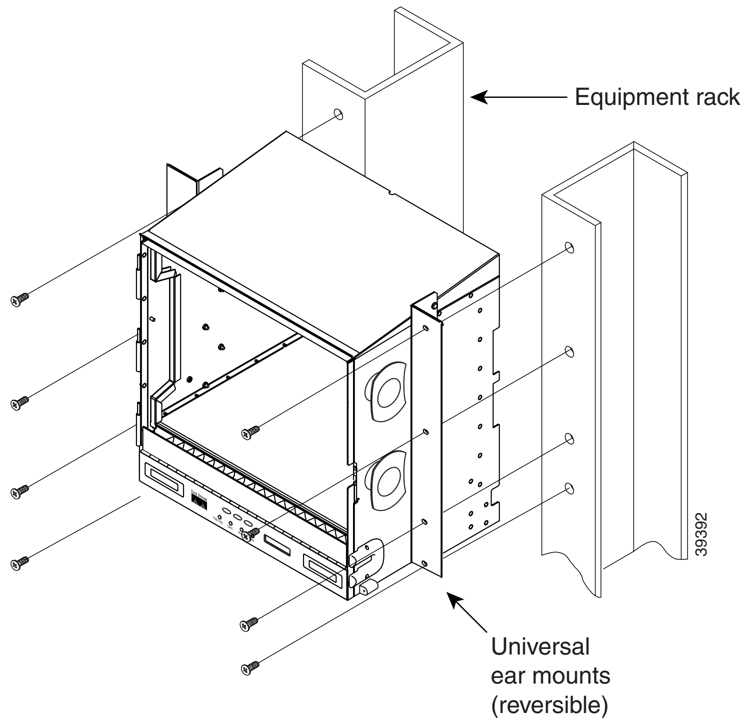
Figure 7-16 Typical 4-Shelf Equipment Rack Arrangement



Mounting a Single Shelf

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 that the mounting is secure, use two to four #12-24 mounting screws for each side of the shelf assembly. Figure 7-17 shows the rack mounting position for the ONS 15454.

Figure 7-17 Mounting an ONS 15454 in a Rack



Mounting Multiple Shelves

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.

OSP Cabinet Installations

The ONS 15454 is industrial temperature rated and can be installed in outside plant (OSP) cabinets when configured with the following components:

- 15454-SA-HD Shelf
- 15454-SA-ANSI Shelf
- 15454-FTA2 Fan Tray
- 15454-FTA3-T Fan Tray

- 15454-TCC+T
- 15454-TCC2
- 15454-TCC2P-K9
- 15454-XC-T
- 15454-XC-VT-T
- 15454-AIC-T
- 15454-AIC-I
- 15454-AEP
- 15454-DS1-14-T
- 15454-DS1N-14-T
- 15454-DS3-12-T
- 15454-DS3-12E-T
- 15454-DS3N-12E-T
- 15454-DS3EC1-48
- 15454-DS3XM-6-T
- 15454-DS3XM-12
- 15454-EC1-12-T
- 15454-OC34I13-T
- 15454-OC121I13-T
- 15454-OC121L13-T
- 15454-OC121L15-T

Note For 15454-DS3EC1-48, I-Temp operation is not supported because XC-10G cross-connect card is not I-Temp rated.

Power and Grounding

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 7-19 lists the power requirements for the ONS 15454.

Table 7-19 ONS 15454 Power Supply Requirements

Item	15454-SA-HD	15454-SA-ANSI	15454-SA-NEBS3E
Acceptable Input DC Voltage Range	–40.5 to –57VDC	–40.5 to –57VDC	–40.5 to –57VDC
Recommended Input DC Voltage (two power feeds: A and B)	–48VDC	–48VDC	–48VDC
Maximum Wattage	1060W	1060W	952W

Table 7-19 ONS 15454 Power Supply Requirements (continued)

Item	15454-SA-HD	15454-SA-ANSI	15454-SA-NEBS3E
Maximum Amperage	24A	24A	20A
Recommended circuit breakers (breaker A and breaker B)	35A	30A	25A

Cisco recommends a 100-A fuse panel (30-A fuse per shelf minimum) if you install the 15454-SA-ANSI or 15454-SA-HD shelf. If you install the 15454-SA-NEBS3 shelf, Cisco recommends you use a standard 80-A fuse panel (20-A fuse per shelf minimum).

Power Supplies

The power supply required for proper operation of a Cisco ONS 15454 is dependent on your specific needs and ONS 15454 shelf configuration. To learn more about Cisco power supplies, see http://cisco.com/en/US/products/ps6063/index.html.

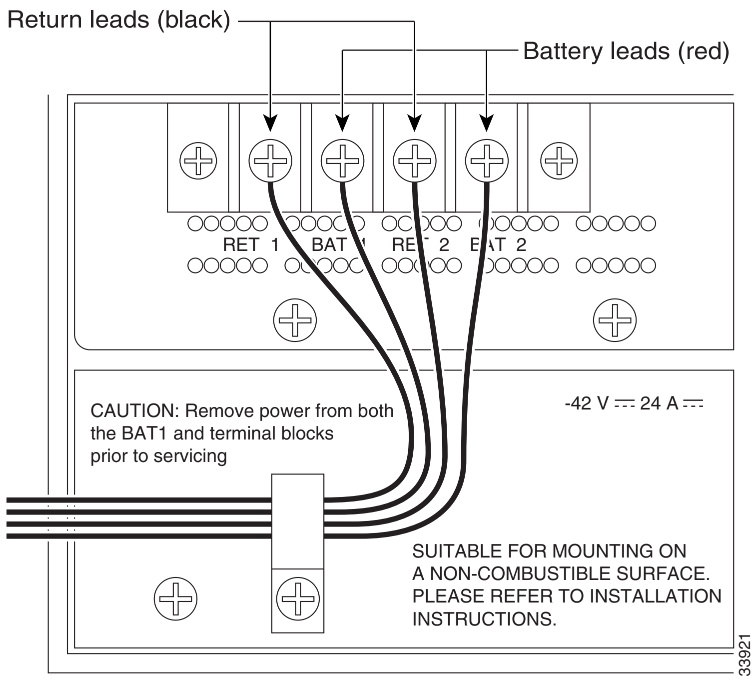
Cisco does not endorse any specific vendor and recommends considering solutions from as many vendors as appropriate. Vendors listed below are a sampling of companies providing power solutions suitable for the Cisco ONS 15454. Information regarding these vendor's products can be found on their respective Web sites.

- APC www.apc.com
- Hendry www.hendry.com
- Eltek www.eltek.no
- Sorensen www.sorenson.com

Power Feeds

The ONS 15454 has redundant -48VDC power feeds on the shelf assembly backplane. Power terminals (shown in Figure 7-18) are #8-32 screws, labeled RET1, BAT1, RET2, and BAT2, and are located on the lower section of the assembly shelf backplane. The power terminals will accept a conductor lug with a width up to 0.378 inches.

Figure 7-18 Power Feed Connections



To install redundant power feeds, use four #10 AWG (copper conductor, 194°F [90°C]) power cables, one ground cable (#10 AWG, copper conductor, 194°F [90°C]) from the 15454 shelf to the equipment rack, and one ground cable (#6 AWG) from the equipment rack to central office. Use a conductor with low impedance to ensure circuit overcurrent protection. However, the conductor must have the capability to safely conduct any faulty current that might be imposed. Cisco recommends the following wiring conventions illustrated in Figure 7-18:

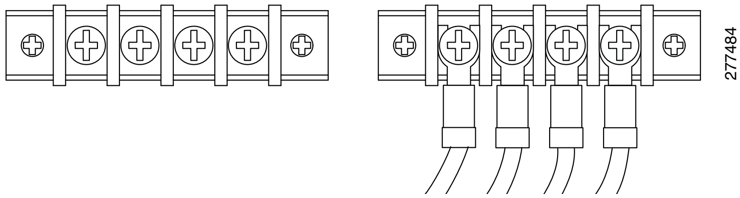
- Red wire for battery connections (-48 VDC)
- Black wire for battery return connections (0 VDC)
- The battery return connection is treated as DC-I, as defined in GR-1089-CORE, issue 3.

When terminating battery and battery return connections as shown in Figure 7-18, follow a torque specification of 10 in-lb.

Note If you are installing power on a Release 3.0 ONS 15454 shelf assembly (15454-SA-NEBS3E, 15454-SA-NEBS3, and 15454-SA-R1, P/N: 800-07149), the #12 to #14 AWG (2.053 to 1.628 mm²) power cable and #14 AWG (1.628 mm²) ground cable are required.

The black plastic dielectric dividers shown in Figure 7-19 isolate the A and B power feeds. This design better protects against voltage spikes and accidental shorting.

Figure 7-19 Dielectric Power Block



The redundant -48VDC is distributed through the backplane to each of the 17 card slots. Every ONS 15454 card contains ORing 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.

Power Monitoring

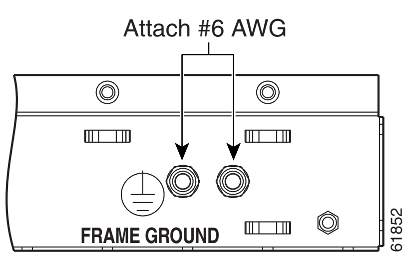
The Alarm Interface Controller-International (AIC-I) card provides a power monitoring circuit that monitors the supply voltage of -48 VDC for presence, under voltage, or over voltage.

The TCC2/TCC2P 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/TCC2P. The TCC2/TCC2P is capable of detecting a blown fuse based on shared knowledge between the active and standby TCC2/TCC2Ps. An alarm will be generated if one of the supply voltage inputs has a voltage out of the specified range of -40.5 to -57VDC.

Ground Connections

The frame ground posts are two #10-32 studs measuring 5/8 inch center-to-center to accommodate a dual-hole lug. The nuts provided for a field connection includes integral lock washers. The lug must be rated to accept the #10 AWG cable. Figure 7-20 shows the location of the ground posts.

Figure 7-20 Ground Posts on the ONS 15454 Backplane

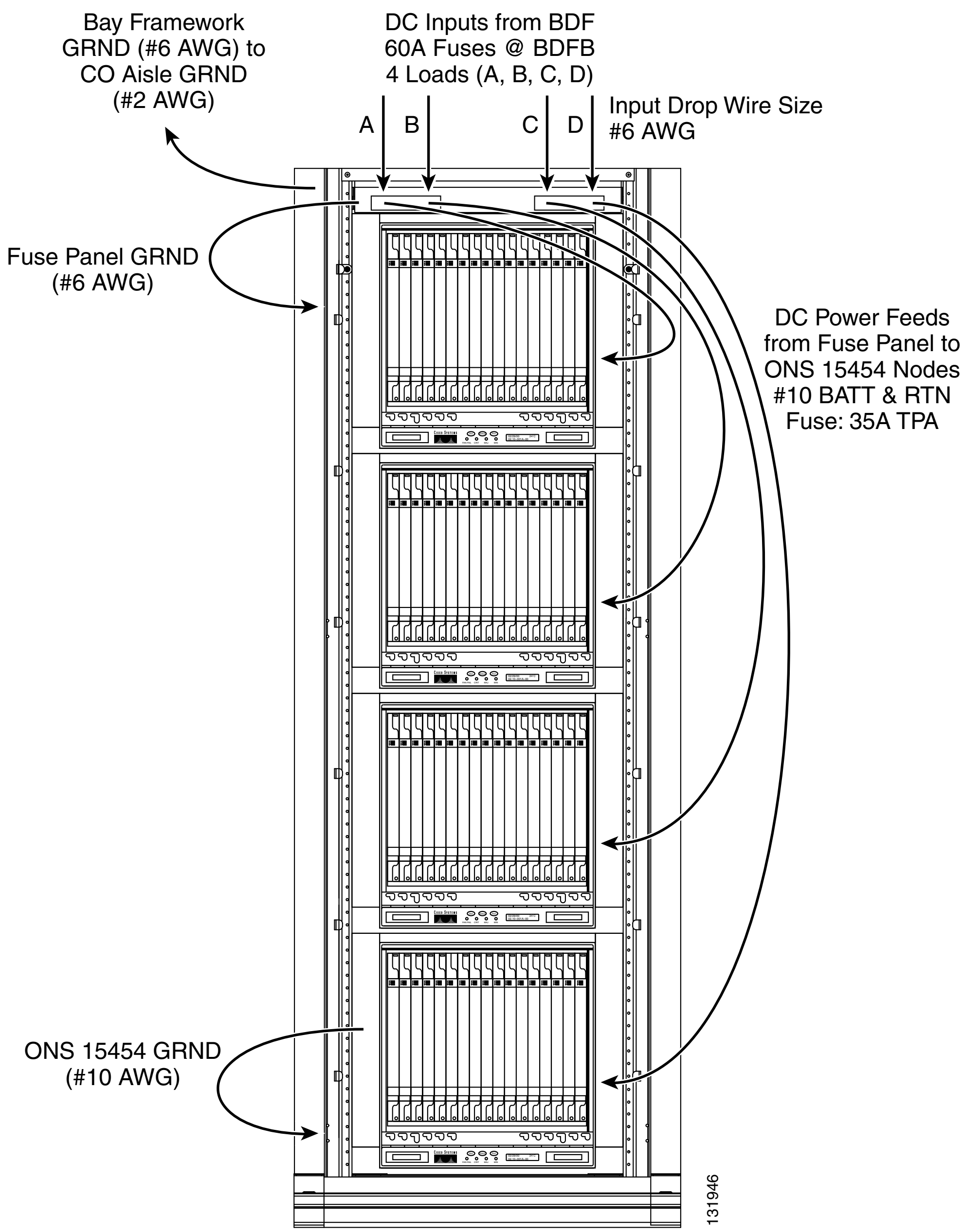


Ground only one cable to ground the shelf assembly. Terminate the other end of the ground cable to ground according to local site practice. Connect a ground terminal for the frame ground (FGND) terminal according to local site practice.

> **Note** When terminating a frame ground, use the kep nuts provided with the ONS 15454 and tighten it to a torque specification of 31 in-lb. The kep nut provides a frame ground connection that minimizes the possibility of loosening caused by rotation during installation and maintenance activity. The type of prevention the kep nut provides for the frame ground connection is inherently provided by the terminal block for battery and battery return connections.

Figure 7-21 shows the typical power and grounding wiring for a four-shelf Central Office bay.

Figure 7-21 Typcial Central Office Bay Power and Grounding



Alarm and Control Connections

For environmental alarms and power monitoring, use the Alarm Interface Controller (AIC) card with ONS 15454 systems running software prior to R3.4, or use the Alarm Interface Controller-International (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 7-20 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 listed in the Alarm Pins section of this document.

Table 7-20 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.

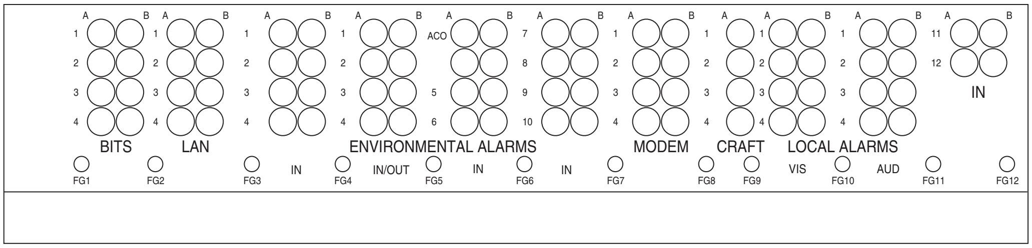
Alarm Pins

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 or AIC-I 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.

The 15454-AIC-I card requires an 15454-SA-ANSI or 15454-SA-HD shelf assembly running Software Release 3.4.0 or higher. The backplane of the 15454-SA-ANSI and 15454-SA-HD shelves contain a wire-wrap field with pin assignment according to the layout in Figure 7-22.

Figure 7-22 ONS 15454 Backplane Pinouts (System Release 3.4 and higher)



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 / B1	Alarm input pair number 1: Reports closure on connected wires.
	A2 / B2	Alarm input pair number 2: Reports closure on connected wires.
	A3 / B3	Alarm input pair number 3: Reports closure on connected wires.
	A4 / B4	Alarm input pair number 4: Reports closure on connected wires.
	A5 / B5	Alarm input pair number 5: Reports closure on connected wires.
	A6 / B6	Alarm input pair number 6: Reports closure on connected wires.
	A7 / B7	Alarm input pair number 7: Reports closure on connected wires.
	A8 / B8	Alarm input pair number 8: Reports closure on connected wires.
	A9 / B9	Alarm input pair number 9: Reports closure on connected wires.
	A10 / B10	Alarm input pair number 10: Reports closure on connected wires.
	A11 / B11	Alarm input pair number 11: Reports closure on connected wires.
	A12 / B12	Alarm input pair number 12: Reports closure on connected wires.

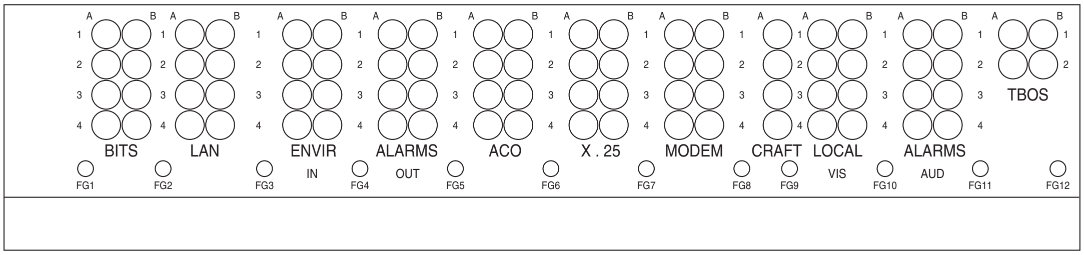
Field	Pin	Function
ENVIR ALARMS IN/OUT N/O	A1/A13 / B1/B13	Normally open output pair number 1
	A2/A14 / B2/B14	Normally open output pair number 2
	A3/A15 / B3/B15	Normally open output pair number 3
	A4/A16 / B4/B16	Normally open output pair number 4
ACO	A1 / B1	Normally open ACO pair
CRAFT	A1	Receive (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 / B1	Alarm output pair number 1: Remote audible alarm.
	A2 / B2	Alarm output pair number 2: Critical audible alarm.
	A3 / B3	Alarm output pair number 3: Major audible alarm.
	A4 / B4	Alarm output pair number 4: Minor audible alarm.
LOCAL ALARMS VIS (Visual) N/O	A1 / B1	Alarm output pair number 1: Remote visual alarm.
	A2 / B2	Alarm output pair number 2: Critical visual alarm.
	A3 / B3	Alarm output pair number 3: Major visual alarm.
	A4 / B4	Alarm output pair number 4: Minor visual alarm.

If you are using an AIC-I card, contacts provisioned as OUT are 1-4. Contacts provisioned as IN are 13-16.

83020

Figure 7-23 shows alarm pin assignments using the 15454-AIC in a 15454-SA-NEBS3E shelf for Release 3.3 and earlier.

Figure 7-23 ONS 15454 Backplane Pinouts (prior to System Release 3.4)



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	

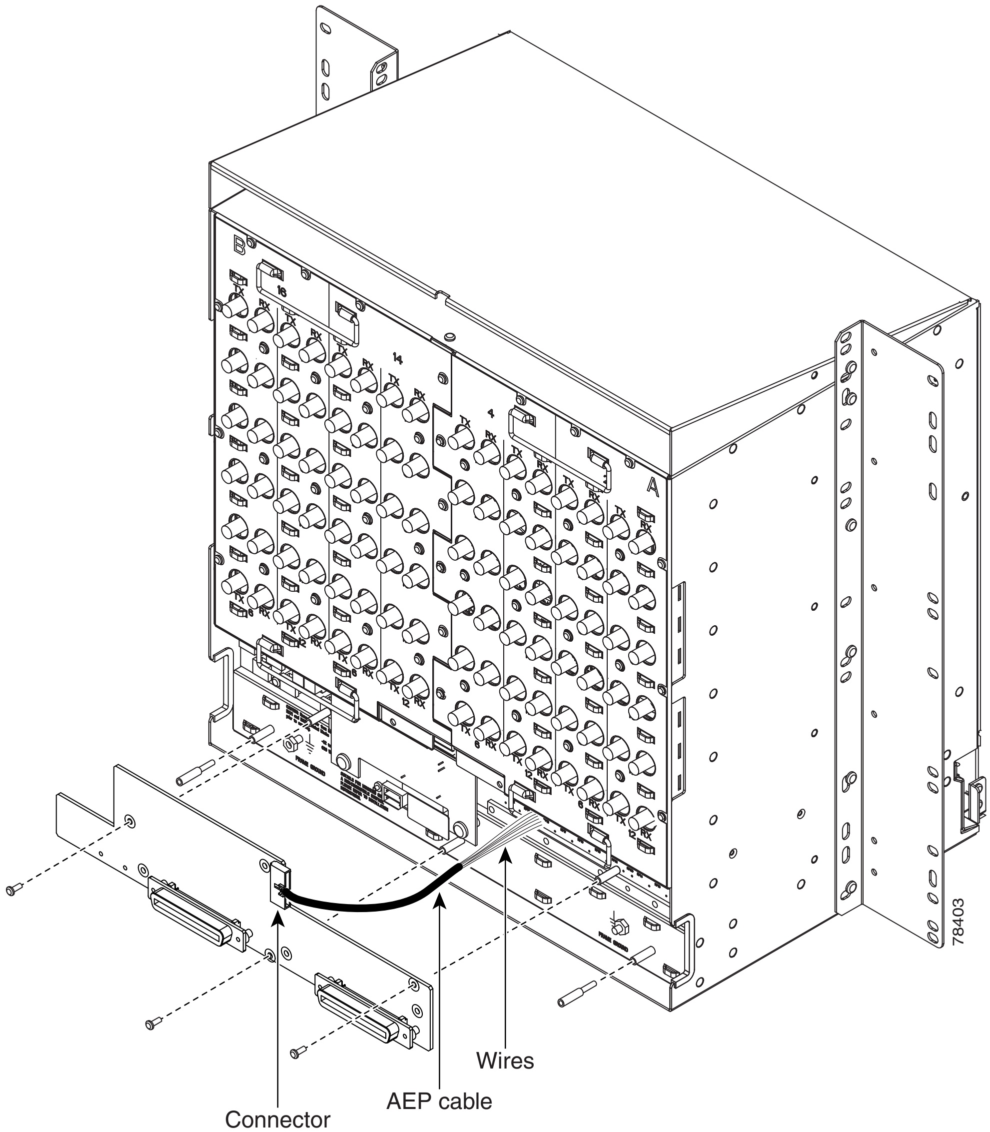
38533

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/TCC2P 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 upto 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. Typically, the AEP is preinstalled when ordered with the ONS 15454; however, the AEP can be ordered separately. The AIC-I card must be installed before you can provision the alarm contacts enabled by the AEP. Figure 7-24 shows how an AEP is attached to the backplane of an assembly shelf.

Figure 7-24 Attaching an AEP to the Backplane



Note If you install an AEP, the AIC-I alarm contacts cannot be used. Only the AEP alarm contacts can be used.

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, and a maximum current of 100 mA.

Figure 7-25 shows where the AEP cable wires connect to the wire-wrap pins on the backplane of the assembly shelf. Table 7-21 shows the wire-wrap pin assignments and corresponding signals on the AIC-I and AEP.

Figure 7-25 AEP Wire-Wrap Connections to Backplane Pins

Table 7-21 Backplane Wire-Wrap Pin Assignments for the AEP

AEP Cable Wire	Wire-Wrap Pin	Signal on AIC-I	Signal on AEP
Black	A1	GND	AEP_GND
White	A2	AE_+5V	AEP_+5V
Slate	A3	VBAT-	VBAT-
Violet	A4	VB+	VB+
Blue	A5	AE_CLK_P	AE_CLK_P
Green	A6	AE_CLK_N	AE_CLK_N
Yellow	A7	AE_DIN_P	AE_DOUT_P
Orange	A8	AE_DIN_N	AE_DOUT_P
Red	A9	AE_DOUT_P	AE_DIN_P
Brown	A10	AE_DOUT_N	AE_DIN_N

Connecting to external alarm sources via the Amp Champ cable must be done according to Table 7-22.

Table 7-22 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-

Table 7-22 Alarm Input Pin Association

AMP Champ Pin Number	Signal Name	AMP Champ Pin Number	Signal Name
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 7-23 to connect to the external elements being switched by external alarms.

Table 7-23 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

Table 7-23 Pin Association for Alarm Output Pins (continued)

AMP Champ Pin Number	Signal Name	AMP Champ Pin Number	Signal Name
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

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.

Cisco recommends using 100 ohm shielded BITS clock cable pair #22 or #24 AWG (0.51 mm^2 or 0.64 mm^2), twisted-pair T1-type when connecting an ONS 15454 to a BITS input cable. Wrap the clock wires on the appropriate wire-wrap pins according to local site practice. Ground the shield of the BITS input cable at the BITS end. For BITS output, wrap the ground shield of the BITS cable to the frame ground pin (FG1) located beneath the column of BITS Pins. Table 7-24 lists the pin assignments for the BITS timing pin fields.

Table 7-24 BITS External Timing Pin Assignments

External Device	Contact	Tip and Ring	Function
First External Device	A4 (BITS 1 In)	Primary ring (-)	Input from external device
	B4 (BITS 1 In)	Primary tip (+)	Input from external device
	A3 (BITS 1 Out)	Primary ring (-)	Output to external device
	B3 (BITS 1 Out)	Primary tip (+)	Output to external device
Second External Device	A2 (BITS 2 In)	Secondary ring (-)	Input from external device
	B2 (BITS 2 In)	Secondary tip (+)	Input from external device
	A1 (BITS 2 Out)	Secondary ring (-)	Output to external device
	B1 (BITS 2 Out)	Secondary tip (+)	Output to external device

Operations Systems (OSS) LAN Connections

Use the LAN pins on the ONS 15454 backplane to connect the ONS 15454 to an OSS LAN or to a LAN modem for remote access to the node. You can also use the TCP/IP Ethernet port on the TCC+, TCC2, or TCC2P faceplate to connect a PC to the network. Table 7-25 shows the LAN pin assignments.

Table 7-25 ONS 15454 LAN Pin Assignments

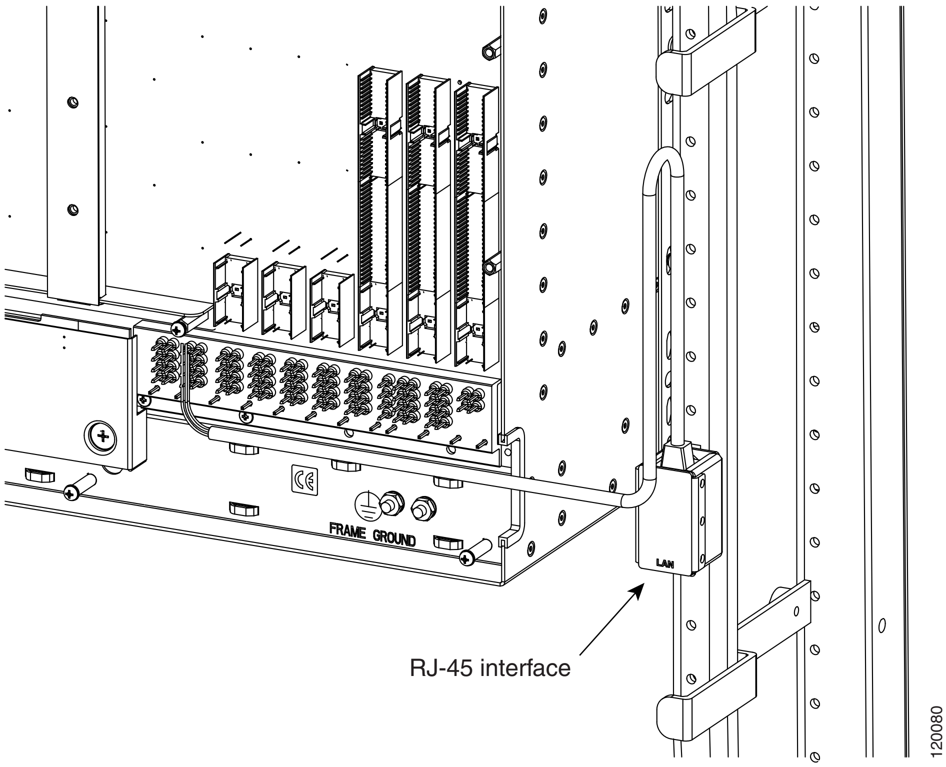
Pin Field	Backplane Pins	RJ-45 Pins
LAN 1 Connecting to data circuit-terminating equipment (DCE[1]) such as a hub or switch	B2	1
	A2	2
	B1	3
	A1	6
LAN 1 Connecting to data terminal equipment (DTE) such as a PC, workstation or router	B1	1
	A1	2
	B2	3
	A2	6

1. The Cisco ONS 15454 is a DCE.

An optional RJ45 jack-to-wire-wrap cable is also available that allows the backplane LAN pins to be terminated using an RJ-45 interface attached to the equipment rack (see Figure 7-26). The RJ45 jack-to-wire-wrap cable and bracket is part of the accessory kit, 53-2329-01, which ships with the following product IDs:

- 15454-SA-HD=
- 15454-HD-SHIPKIT=
- 15454-SA-HD-DDR=

Figure 7-26 Optional RJ45 Jack-to-Wire-Wrap Cable and Connector Installation



Note Before you can connect an ONS 15454 node to other ONS 15454 nodes or to a LAN, you must change the node default IP address (192.1.0.2) that is shipped with each ONS 15454.

Note If TCC2P cards are installed with Software Release 5.0 or higher, secure mode is available. Secure mode allows you to provision two IP addresses for the ONS 15454. One IP address is provisioned for the ONS 15454 backplane LAN port. The other IP address is provisioned for the TCC2P TCP/IP Ethernet port. When secure mode is off, the default IP address 192.1.0.2 applies to the backplane LAN port and the TCC2P TCP/IP Ethernet port. When secure mode is on, the default IP Address 192.1.0.2 is assigned to the backplane LAN port and a default IP address of 10.10.0.1 is assigned to the TCC2P LAN port.

For more information about IP address requirements, refer to Chapter 8 in this document.

TL1 Craft Interface

You can use the craft pins on the assembly shelf backplane or the EIA/TIA-232 port on the TCC2/TCC2P card faceplate to create a VT100 emulation window to serve as a TL1 craft interface to the ONS 15454. Use a straight-through cable to connect to the EIA/TIA-232 port. Table 7-26 shows the pin assignments for the CRAFT pin field.

Note You cannot use the craft backplane pins and the EIA/TIA-232 port on the TCC2/TCC2P card simultaneously.

Table 7-26 TL1 Craft Interface Pin Assignments

Pin Field	Contact	Function
Craft	A1	Receive
	A2	Transmit
	A3	Ground
	A4	DTR

Cabling

Cables are not included with the ONS 15454 and must be ordered separately. Coaxial cables for the BNC EIAs, optical interface cables, and CAT-5 Ethernet cables that have been approved for use with the ONS 15454 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

Cisco provides cable assemblies for the following EIAs:

- 15454-EIA-AMP-84
- 15454-EIA-SMB-84
- 15454-EIA-UBIC-H
- 15454-EIA-UBIC-V

Cable assemblies that can be ordered through Cisco are listed in Table 7-27, Table 7-28, and Table 7-29:

Table 7-27 Cisco ONS 15454 Low-Density Cable Assemblies

EIA Type	Cable Assembly Part Number	Description	Cable Length (ft)
15454-EIA-BNC-*96[1]	15454-CA-HDBNC-30	Mini BNC to standard BNC (unterminated), 75 Ohm.	30
	15454-CA-HDBNC-75		75

Table 7-27 Cisco ONS 15454 Low-Density Cable Assemblies (continued)

EIA Type	Cable Assembly Part Number	Description	Cable Length (ft)
15454-EIA-AMP-*84	15454-AMP-WW-30	AMP Champ unterminated wire-wrap cable	30
	15454-AMP-WW-50		50
	15454-AMP-WW-100		100
	15454-AMP-WW-250		250
15454-EIA-SMB-*84	15454-SMB-BNC-10	SMB to BNC cable assembly	10
	15454-SMB-BNC-30		30
	15454-SMB-BNC-50		50

1. * denotes side of shelf (A or B)

Table 7-28 UBIC-H Cable Assemblies

EIA Type	Cable Assembly Part Number	Description	Cable Length (ft)
15454-EIA-UBIC-H / 15454-EIA-UBICH-*	15454-CADS1-H-25	UBIC-H-DS1, one end is terminated with 50-pin SCSI connector and the other end is open-ended twisted pair.	25
	15454-CADS1-H-50		50
	15454-CADS1-H-75		75
	15454-CADS1-H-100		100
	15454-CADS1-H-150		150
	15454-CADS1-H-200		200
	15454-CADS1-H-250		250
	15454-CADS1-H-350		350
	15454-CADS1-H-450		450
	15454-CADS1-H-550		550
	15454-CADS1-H-655		655
	15454-CADS3-H-25		25
	15454-CADS3-H-50		50
	15454-CADS3-H-75		75
	15454-CADS3-H-100		100
	15454-CADS3-H-125		125
	15454-CADS3-H-150		150
	15454-CADS3-H-175		175
	15454-CADS3-H-200		200
	15454-CADS3-H-225		225
	15454-CADS3-H-250		250
	15454-CADS3-H-300		300
	15454-CADS3-H-350		350
	15454-CADS3-H-450		450

Table 7-29 UBIC-V Cable Assemblies

EIA Type	Cable Assembly Part Number	Description	Cable Length (ft)
15454-EIA-UBIC-V / 15454-EIA-UBICV-*	15454-CADS1-50	UBIC-V-DS1, one end is terminated with 50-pin SCSI connector and the other end is open-ended twisted pair.	50
	15454-CADS1-75		75
	15454-CADS1-100		100
	15454-CADS1-150		150
	15454-CADS1-200		200
	15454-CADS1-250		250
	15454-CADS1-350		350
	15454-CADS1-450		450
	15454-CADS1-550		550
	15454-CADS1-655		655
	15454-CADS3-25	UBIC-V-DS3, one end is terminated with 50-pin SCSI connector and the other end can be terminated with 75 ohms BNC connector	25
	15454-CADS3-50		50
	15454-CADS3-75		75
	15454-CADS3-100		100
	15454-CADS3-125		125
	15454-CADS3-150		150
	15454-CADS3-175		175
	15454-CADS3-200		200
	15454-CADS3-225		225
	15454-CADS3-250		250
	15454-CADS3-300		300
	15454-CADS3-350		350
	15454-CADS3-450		450

Table 7-30 lists the maximum length of cable you can have between the EIA and patch panel or cross-connect frame.

Table 7-30 Maximum Cable Distances

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 (King or ITT connectors are also compatible)	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)
UBIC-H-DS1	100 Ohm	Twisted Pair	655 ft (199.6 m)

Table 7-30 Maximum Cable Distances (continued)

EIA Interface	Impedance	Cable	Cable Length on Each Side of DSX
UBIC-H-DS3	75 Ohm	RG734 to RG735A	450 ft (137.2 m)
UBIC-V-DS1	100 Ohm	Twisted Pair	655 ft (199.6 m)
UBIC-V-DS3	75 Ohm	RG734 to RG735A	450 ft (137.2 m)

When using the RG-179 coaxial cable on an EIA, the maximum distance available is less than the maximum distance available with standard RG-59 (734A) cable. The shorter maximum distance available with the RG179 is due to a higher attenuation rate for the thinner cable. The following attenuation rates are calculated using a DS-3 signal:

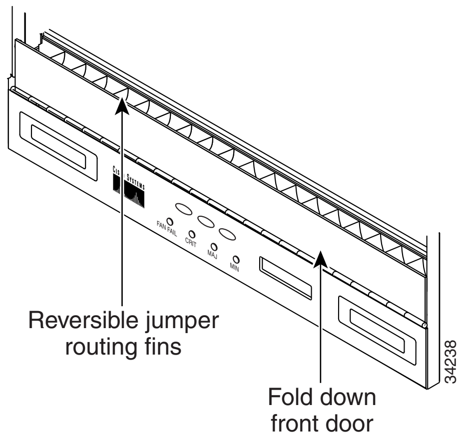
- For RG-179, the attenuation rate is 59 dB/kft at 22 MHz.
- For RG-59 (734A) the attenuation rate is 11.6 dB/kft at 22 MHz.

Cable Routing and Management Overview

The ONS 15454 cable routing and management facilities include the following:

- A cable-routing channel that runs the width of the shelf assembly (Figure 7-27).
- A fold-down door that provides access to the cable-management tray (Figure 7-27).
- Reversible jumper routing fins that enable you to route cables out either side by positioning the fins as desired. (Figure 7-27)
- Plastic fiber boots, which protects fiber jumpers from excessive bending (Figure 7-28).
- Plastic horseshoe-shaped directional cable guides at each side opening of the cable-routing channel that ensure the proper bend radius is maintained in the fibers (Figure 7-29). You can remove the fiber guide, if necessary, to create a larger opening for routing large cables, such as CAT-5 Ethernet cables (Figure 7-31). To remove the fiber guide, take out the three screws that anchor it to the side of the shelf assembly.
- Plastic post non-directional fiber guides at each side opening of the cable-routing channel that provide universal routing of cables and ensure proper bend radius is maintained for fiber optic cables (Figure 7-30). These guides can be removed in the same manner as the horseshoe-shaped guides.
- Cable tie-wrap facilities on EIAs that secure cables to the cover panel.
- 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.
- Optional fiber management tray (recommended for MSTP nodes).
- Optional tie-down bar (recommended for use with the UBIC-H and UBIC-V EIAs).

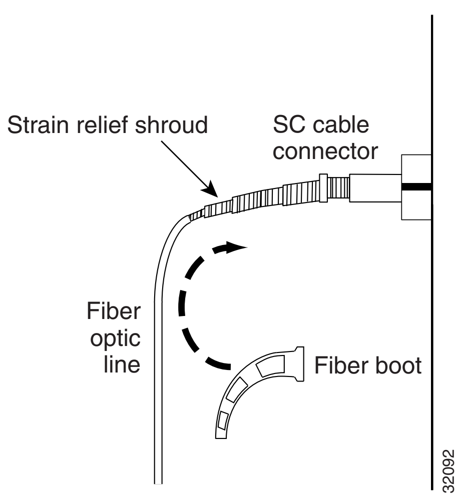
Figure 7-27 Cable Management Tray and Fold Down Front Door



Managing Fiber Optic Cables

Fiber boots (15454-Fiber-Boot=) are included with ONS 15454 OC-N cards that do not have angled optical port to protect the fiber from excessive bending. The fiber boot is placed over the jumper's strain relief shroud connected to the SC connector as shown in Figure 7-28.

Figure 7-28 Fiber Boot Attachment



> **Note** The fiber boot does not support the OC-48 IR/STM-16 SH AS 1310, OC-48 LR/STM-16 LH AS 1550, and OC-192 LR/STM64 LH 1550 cards. The boots are not necessary for these cards because of the angled SC connectors on the cards.

If you are installing an OC3IR/STM1SH 1310-8 card, you must use a fiber clip instead of a fiber boot on the Port 8 Rx fiber connector.

Fiber clips are factory-attached to the faceplate of OC-N cards.

GBICs do not have fiber clips; therefore, if you are routing fiber from an E1000-2-G, E1000-2, G1000-2-G, G10002, or FC_MR-4 card, route the fiber cables into the cable-management tray.

Route the fiber cables out either side of the cable-management tray through the cutouts on each side of the shelf assembly. The jumper routing fins and posts are designed to route fiber jumpers out of both sides of the shelf. Slots 1 to 6 exit to the left, and Slots 12 to 17 exit to the right. Figure 7-29 shows fibers routed from cards in the left slots, down through the fins, then exiting out the fiber channel to the left.

Figure 7-29 Fiber Optic Cable Guides

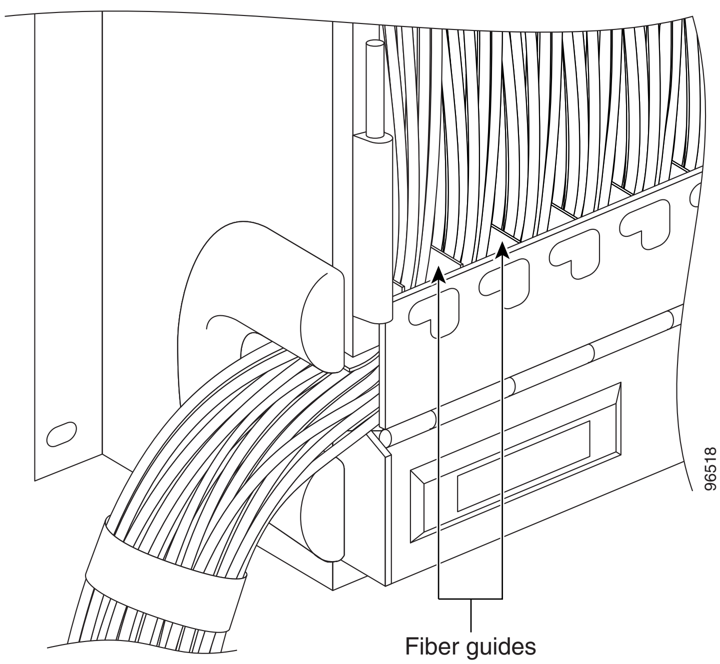
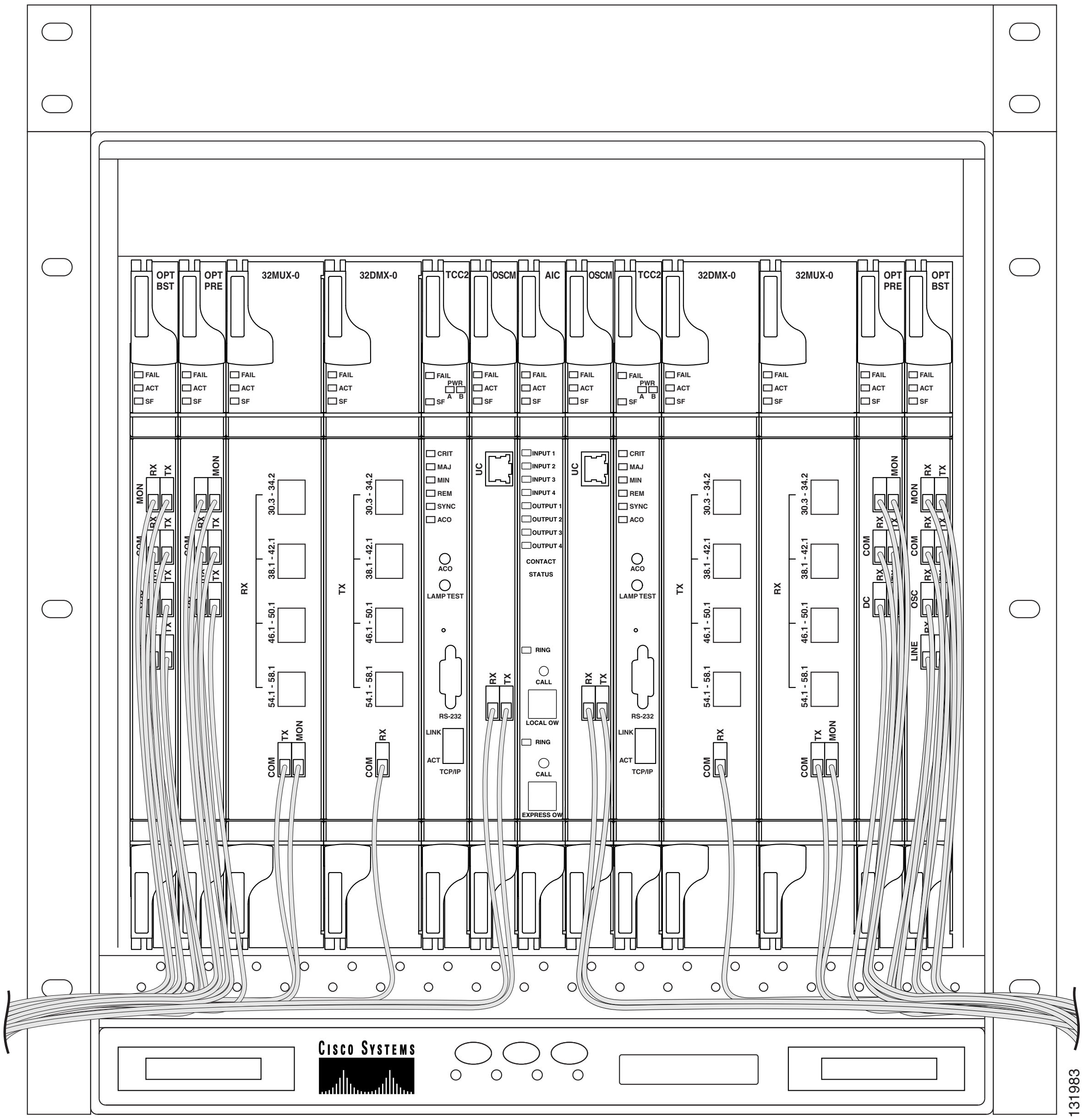


Figure 7-30 shows fiber jumpers routed out of both sides of the shelf from any card slot using the universal jumper routing posts.

Figure 7-30 Universal Jumper Routing with Posts



The maximum capacity of the fiber routing channel depends on the jacket diameter of the fiber jumpers. Table 7-31 gives the maximum capacity of the fiber channel for each side of the shelf, for the different fiber sizes.

Table 7-31 Fiber Optic Cable Capacity

	Maximum Number of Fibers Exiting Each Side		
Fiber Diameter	**No Ethernet Cables**	**One Ethernet Cables**	**Two Enthernet Cables**
1.6 mm (0.6 inch)	224	127	110

Table 7-31 Fiber Optic Cable Capacity (continued)

Fiber Diameter	Maximum Number of Fibers Exiting Each Side		
	No Ethernet Cables	**One Ethernet Cables**	**Two Enthernet Cables**
2 mm (0.7 inch)	144	80	70
3 mm (0.11 inch)	64	36	32

Plan your fiber size according to the number of cards/ports installed in each side of the shelf. For example, if your port combination requires 36 fibers, 3 mm (0.11 inch) fiber is adequate. If your port combination requires 68 fibers, you must use 2 mm(0.7 inch) or smaller fibers.

Managing Ethernet Cables

The CE-100T-8, E100T-12, E100T-12G, and ML100-12 Ethernet cards have RJ-45 connectors on the faceplate for client interfaces and do not require an EIA. Use the universal jumper posts or remove the cable routing guides, if necessary, to create a larger opening for Cat 5 Ethernet cables.

Note When installing Ethernet cards with RJ 45 interfaces, it is recommended that only 2 cards per side be installed in each assembly shelf (4 cards per shelf). This will allow for proper cable management of Cat 5 cables.

Note Removing the u-shaped cable routing guides (Figure 7-31) allows the front door of the ONS 15454 to be closed after fully cabling all 12 ports on each of the four 10/100 Ethernet cards with CAT-5 cables.

Figure 7-31 Cat 5 Cable Management with Cable Routing Guides Removed

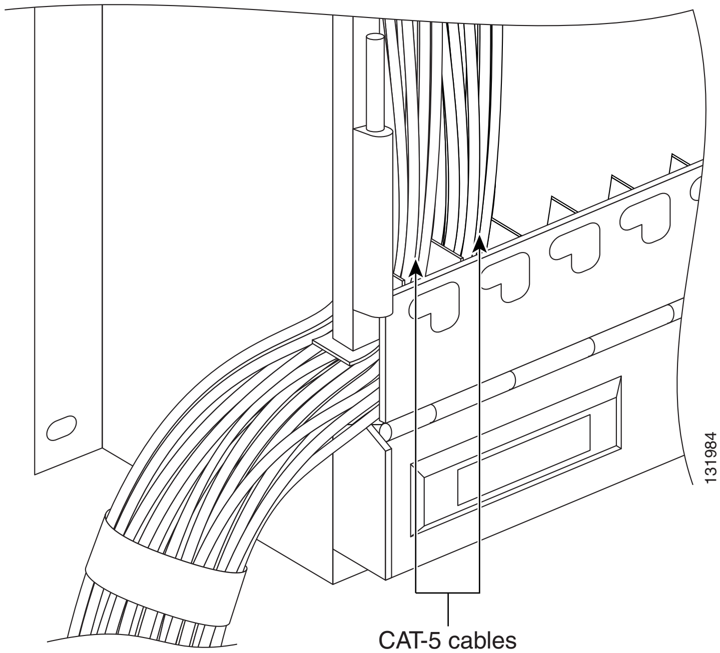
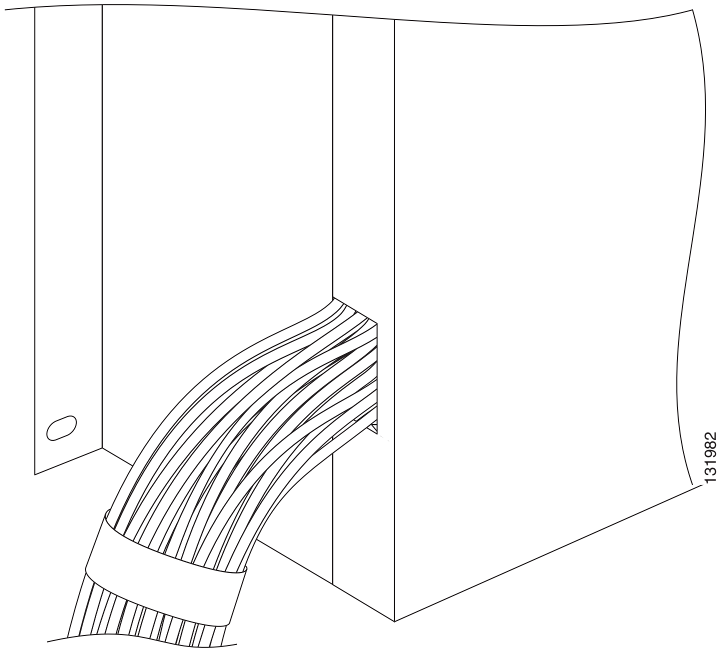


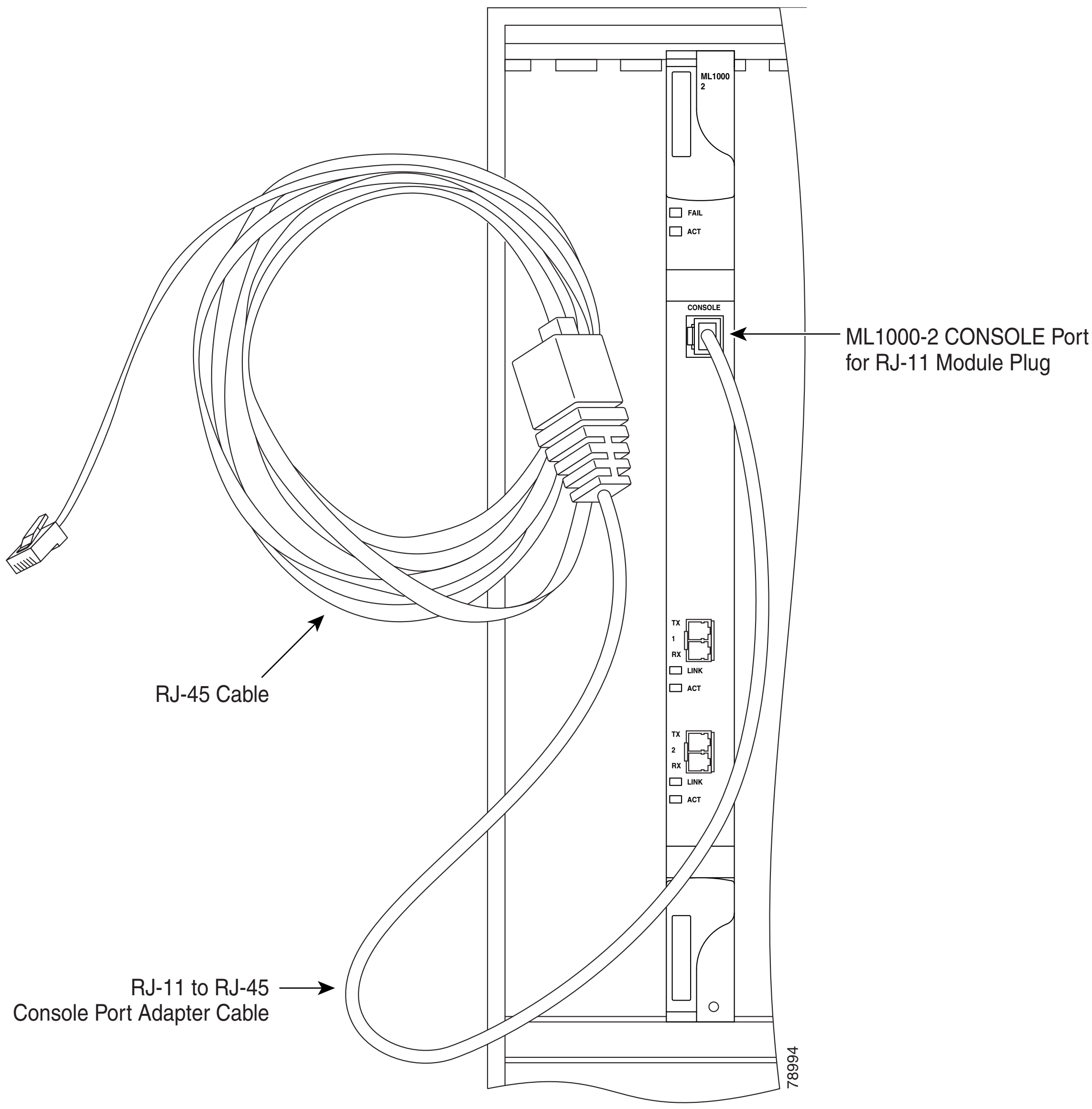
Figure 7-32 shows the door to the ONS 15454 closed after fully cabling all twelve RJ-45 ports on four 10/100 Ethernet cards.

Figure 7-32 Door Closed with Four 12-Port 10/100 Ethernet Cards Fully Cabled



Use an RJ-11 to RJ-45 console cable adapter, and a DB-9 adapter to connect a PC to the console port on ML100-12 and ML-1000-2 cards. Figure 7-33 shows an RJ-11 cable connected to the console port on the ML1000-2 faceplate via an RJ-11 to RJ-45 cable adapter. The console port on the ML100-12 is at the bottom of the card faceplate.

Figure 7-33 Connecting to the ML-Series Console Port



Managing Coaxial Cables

When using coaxial cables, the cables must terminate on an EIA installed on the shelf assembly backplane. All cables connected to ONS 15454 low-density (LD) DS3-12, DS3-12E, DS3XM-6, DS3XM-12, or EC1-12 cards and high-density (HD) DS3/EC1-48 cards must terminate with coaxial cables using the desired connector type to connect to the specified EIA.

The electromagnetic compatibility (EMC) performance of the node depends on good-quality coaxial cables, such as Shuner Type G 03233 D, or the equivalent.

The 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.

The BNC and High-Density BNC EIAs support BNC connectors. The MiniBNC EIA supports mini BNC connections.

The connector pairs on the BNC EIAs are marked "Tx" and "Rx" to indicate transmit and receive cables for each port. The MiniBNC EIA also supports the following J-Labeling that corresponds BNC connectors to the ports on low- and high-density electrical interface cards.

Table 7-32 and Table 7-33 show the J-labeling and corresponding card ports for a shelf assembly configured with low-density electrical cards.

Table 7-32 J-Labeling Port Assignments for a Shelf Assembly Configured with Low-Density (LD) Electrical Cards (A Side)

			J4	**J3**	**J2**	**J1**	**J5**	**J6**	**J7**	**J8**
			T1	T13	T25	T37	T1	T13	T25	T37
			T2	T14	T26	T38	T2	T14	T26	T38
			T3	T15	T27	T39	T3	T15	T27	T39
			T4	T16	T28	T40	T4	T16	T28	T40
			T5	T17	T29	T41	T5	T17	T29	T41
			T6	T18	T30	T42	T6	T18	T30	T42
			T7	T19	T31	T43	T7	T19	T31	T43
			T8	T20	T32	T44	T8	T20	T32	T44
			T9	T21	T33	T45	T9	T21	T33	T45
			T10	T22	T34	T46	T10	T22	T34	T46
			T11	T23	T35	T47	T11	T23	T35	T47
		TX	T12	T24	T36	T48	T12	T24	T36	T48
			J12	**J11**	**J10**	**J9**	**J13**	**J14**	**J15**	**J16**
			R1	R13	R25	R37	R1	R13	R25	R37
			R2	R14	R26	R38	R2	R14	R26	R38
			R3	R15	R27	R39	R3	R15	R27	R39
			R4	R16	R28	R40	R4	R16	R28	R40
			R5	R17	R29	R41	R5	R17	R29	R41
			R6	R18	R30	R42	R6	R18	R30	R42
			R7	R19	R31	R43	R7	R19	R31	R43
			R8	R20	R32	R44	R8	R20	R32	R44
			R9	R21	R33	R45	R9	R21	R33	R45
			R10	R22	R34	R46	R10	R22	R34	R46
			R11	R23	R35	R47	R11	R23	R35	R47
		RX	R12	R24	R36	R48	R12	R24	R36	R48
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
1	LD DS-3/EC1		1–12	—	—	—	—	—	—	—
2	LD DS-3/EC1		—	—	—	—	1–12	—	—	—
3	LD DS-3/EC1		—	—	—	—	—	—	1–12	—
4	LD DS-3/EC1		—	—	—	—	—	1–12	—	—
5	LD DS-3/EC1		—	1–12	—	—	—	—	—	—
6	LD DS-3/EC1		—	—	1–12		—	—	—	—

Table 7-33 J-Labeling Port Assignments for a Shelf Assembly Configure with Low-Density (LD) Electrical Cards (B Side)

			J20	**J19**	**J18**	**J17**	**J21**	**J22**	**J23**	**J24**
			T1	T13	T25	T37	T1	T13	T25	T37
			T2	T14	T26	T38	T2	T14	T26	T38
			T3	T15	T27	T39	T3	T15	T27	T39
			T4	T16	T28	T40	T4	T16	T28	T40
			T5	T17	T29	T41	T5	T17	T29	T41
			T6	T18	T30	T42	T6	T18	T30	T42
			T7	T19	T31	T43	T7	T19	T31	T43
			T8	T20	T32	T44	T8	T20	T32	T44
			T9	T21	T33	T45	T9	T21	T33	T45
			T10	T22	T34	T46	T10	T22	T34	T46
			T11	T23	T35	T47	T11	T23	T35	T47
		TX	T12	T24	T36	T48	T12	T24	T36	T48
			J28	**J27**	**J26**	**J25**	**J29**	**J30**	**J31**	**J32**
			R1	R13	R25	R37	R1	R13	R25	R37
			R2	R14	R26	R38	R2	R14	R26	R38
			R3	R15	R27	R39	R3	R15	R27	R39
			R4	R16	R28	R40	R4	R16	R28	R40
			R5	R17	R29	R41	R5	R17	R29	R41
			R6	R18	R30	R42	R6	R18	R30	R42
			R7	R19	R31	R43	R7	R19	R31	R43
			R8	R20	R32	R44	R8	R20	R32	R44
			R9	R21	R33	R45	R9	R21	R33	R45
			R10	R22	R34	R46	R10	R22	R34	R46
			R11	R23	R35	R47	R11	R23	R35	R47
		RX	R12	R24	R36	R48	R12	R24	R36	R48
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
17	LD DS-3/EC1		1–12	—	—	—	—	—	—	—
16	LD DS-3/EC1		—	—	—	—	1–12	—	—	—
15	LD DS-3/EC1		—	—	—	—	—	—	1–12	—
14	LD DS-3/EC1		—	—	—	—	—	1–12	—	—
13	LD DS-3/EC1		—	1–12	—	—	—	—	—	—
12	LD DS-3/EC1		—	—	1–12		—	—	—	—

Table 7-34 and Table 7-35 show the J-labeling and corresponding card ports for a shelf assembly configured with high-density 48-port DS-3/EC-1electrical cards.

Table 7-34 J-Labeling Port Assignments for a Shelf Assembly Configure with High-Density (HD) Electrical Cards (A Side)

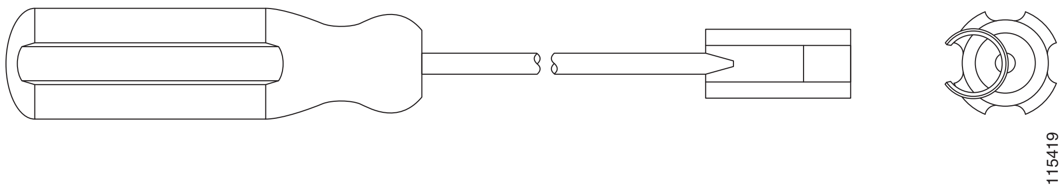
			J4	**J3**	**J2**	**J1**	**J5**	**J6**	**J7**	**J8**
			T1	T13	T25	T37	T1	T13	T25	T37
			T2	T14	T26	T38	T2	T14	T26	T38
			T3	T15	T27	T39	T3	T15	T27	T39
			T4	T16	T28	T40	T4	T16	T28	T40
			T5	T17	T29	T41	T5	T17	T29	T41
			T6	T18	T30	T42	T6	T18	T30	T42
			T7	T19	T31	T43	T7	T19	T31	T43
			T8	T20	T32	T44	T8	T20	T32	T44
			T9	T21	T33	T45	T9	T21	T33	T45
			T10	T22	T34	T46	T10	T22	T34	T46
			T11	T23	T35	T47	T11	T23	T35	T47
		TX	T12	T24	T36	T48	T12	T24	T36	T48
			J12	**J11**	**J10**	**J9**	**J13**	**J14**	**J15**	**J16**
			R1	R13	R25	R37	R1	R13	R25	R37
			R2	R14	R26	R38	R2	R14	R26	R38
			R3	R15	R27	R39	R3	R15	R27	R39
			R4	R16	R28	R40	R4	R16	R28	R40
			R5	R17	R29	R41	R5	R17	R29	R41
			R6	R18	R30	R42	R6	R18	R30	R42
			R7	R19	R31	R43	R7	R19	R31	R43
			R8	R20	R32	R44	R8	R20	R32	R44
			R9	R21	R33	R45	R9	R21	R33	R45
			R10	R22	R34	R46	R10	R22	R34	R46
			R11	R23	R35	R47	R11	R23	R35	R47
		RX	R12	R24	R36	R48	R12	R24	R36	R48
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
1	HD DS-3/EC1		1–12	13–24	25–36	37–48	—	—	—	—
2	HD DS-3/EC1		—	—	—	—	1–12	13–24	25–36	37–48

Table 7-35 J-Labeling Port Assignments for a Shelf Assembly Configure with High-Density (HD) Electrical Cards (B Side)

			J20	**J19**	**J18**	**J17**	**J21**	**J22**	**J23**	**J24**
			T1	T13	T25	T37	T1	T13	T25	T37
			T2	T14	T26	T38	T2	T14	T26	T38
			T3	T15	T27	T39	T3	T15	T27	T39
			T4	T16	T28	T40	T4	T16	T28	T40
			T5	T17	T29	T41	T5	T17	T29	T41
			T6	T18	T30	T42	T6	T18	T30	T42
			T7	T19	T31	T43	T7	T19	T31	T43
			T8	T20	T32	T44	T8	T20	T32	T44
			T9	T21	T33	T45	T9	T21	T33	T45
			T10	T22	T34	T46	T10	T22	T34	T46
			T11	T23	T35	T47	T11	T23	T35	T47
		TX	T12	T24	T36	T48	T12	T24	T36	T48
			J28	**J27**	**J26**	**J25**	**J29**	**J30**	**J31**	**J32**
			R1	R13	R25	R37	R1	R13	R25	R37
			R2	R14	R26	R38	R2	R14	R26	R38
			R3	R15	R27	R39	R3	R15	R27	R39
			R4	R16	R28	R40	R4	R16	R28	R40
			R5	R17	R29	R41	R5	R17	R29	R41
			R6	R18	R30	R42	R6	R18	R30	R42
			R7	R19	R31	R43	R7	R19	R31	R43
			R8	R20	R32	R44	R8	R20	R32	R44
			R9	R21	R33	R45	R9	R21	R33	R45
			R10	R22	R34	R46	R10	R22	R34	R46
			R11	R23	R35	R47	R11	R23	R35	R47
		RX	R12	R24	R36	R48	R12	R24	R36	R48
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
17	HD DS-3/EC1		1–12	13–24	25–36	37–48	—	—	—	—
16	HD DS-3/EC1		—	—	—	—	1–12	13–24	25–36	37–48

Due to the large number of MiniBNC connectors on the MiniBNC EIA, you might require a special tool for inserting and removing MiniBNC EIAs (Figure 7-34. This tool also helps with ONS 15454 patch panel connections.

Figure 7-34 MiniBNC 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

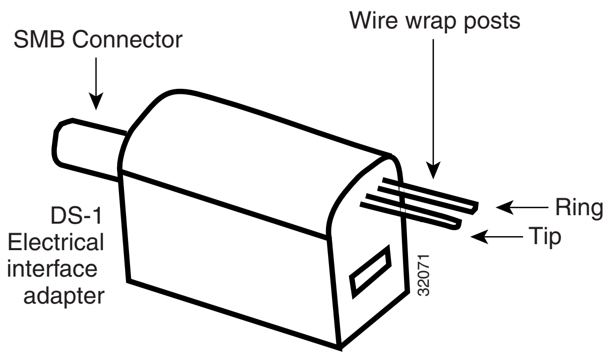
Managing Twisted-Pair Cables

Twisted-pair wire-wrap cables require SMB EIAs and DS-1 electrical interface adapters (baluns). Connect twisted-pair cables to SMB EIAs on the shelf assembly backplane using cable connectors and DS-1 baluns. Installing twisted-pair, wire-wrap cables to terminate DS-1 signals requires separate pairs of grounded twisted-pair wires for receive (in) and transmit (out). Prepare four cables, two for receive and two for transmit, for each DS-1 facility to be installed.

Note When using twisted-pair wire-wrap cables, you must install a balun on every transmit and receive connector for each DS-1 termination.

As shown in Figure 7-35, each DS-1 balun has a female SMB connector on one end and a pair of 0.045 inch (1.14 mm) square wire-wrap posts for tip and ring connections on the other end. The wire-wrap posts are 0.200 inches (5.08 mm) apart.

Figure 7-35 DS-1 Balun



Managing AMP Champ Cables

Amp Champ cables are used to terminate DS-1 signals on an ONS 15454. When using Amp Champ cables, you must equip the ONS 15454 with an AMP Champ EIA on each side of the shelf assembly 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.

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 (584.2 mm) rack, two additional inches (50.8 mm) of cable management area is available on each side of the shelf assembly.

To install AMP Champ connector cables to terminate DS-1 signals, 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 fourteen DS-1 ports, only 56 pins (28 pairs) of the 64-pin connector are used. Prepare one 56-wire cable for each working DS1-14 card installed.

Table 7-36 shows the pin assignments for the AMP Champ connectors on the ONS 15454.

Table 7-36 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

Table 7-36 AMP Champ Connector Pin Assignments (continued)

Signal/Wire	Pin	Pin	Signal/Wire	Signal/Wire	Pin	Pin	Signal/Wire
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 7-37 shows the pin assignments for the AMP Champ connectors on the ONS 15454 AMP Champ EIA for a shielded DS-1 cable.

Table 7-37 AMP Champ Connector Pin Assignments (Shielded DS-1 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	Rx Tip 1 white/blue	17	49	Rx Ring 1 blue/white
Tx Tip 2 white/orange	2	34	Tx Ring 2 orange/white	Rx Tip 2 white/orange	18	50	Rx Ring 2 orange/white
Tx Tip 3 white/green	3	35	Tx Ring 3 green/white	Rx Tip 3 white/green	19	51	Rx Ring 3 green/white
Tx Tip 4 white/brown	4	36	Tx Ring 4 brown/white	Rx Tip 4 white/brown	20	52	Rx Ring 4 brown/white
Tx Tip 5 white/slate	5	37	Tx Ring 5 slate/white	Rx Tip 5 white/slate	21	53	Rx Ring 5 slate/white
Tx Tip 6 red/blue	6	38	Tx Ring 6 blue/red	Rx Tip 6 red/blue	22	54	Rx Ring 6 blue/red
Tx Tip 7 red/orange	7	39	Tx Ring 7 orange/red	Rx Tip 7 red/orange	23	55	Rx Ring 7 orange/red
Tx Tip 8 red/green	8	40	Tx Ring 8 green/red	Rx Tip 8 red/green	24	56	Rx Ring 8 green/red
Tx Tip 9 red/brown	9	41	Tx Ring 9 brown/red	Rx Tip 9 red/brown	25	57	Rx Ring 9 brown/red
Tx Tip 10 red/slate	10	42	Tx Ring 10 slate/red	Rx Tip 10 red/slate	26	58	Rx Ring 10 slate/red
Tx Tip 11 black/blue	11	43	Tx Ring 11 blue/black	Rx Tip 11 black/blue	27	59	Rx Ring 11 blue/black
Tx Tip 12 black/orange	12	44	Tx Ring 12 orange/black	Rx Tip 12 black/orange	28	60	Rx Ring 12 orange/black
Tx Tip 13 black/green	13	45	Tx Ring 13 green/black	Rx Tip 13 black/green	29	61	Rx Ring 13 green/black

Table 7-37 AMP Champ Connector Pin Assignments (Shielded DS-1 Cable) (continued)

64-Pin Blue Bundle				64-Pin Orange Bundle			
Signal/Wire	**Pin**	**Pin**	**Signal/Wire**	**Signal/Wire**	**Pin**	**Pin**	**Signal/Wire**
Tx Tip 14 black/brown	14	46	Tx Ring 14 brown/black	Rx Tip 14 black/brown	30	62	Rx Ring 14 brown/black
Tx Tip 15 black/slate	15	47	Tx Tip 15 slate/black	Rx Tip 15 black/slate	31	63	Rx Tip 15 slate/black
Tx Tip 16 yellow/blue	16	48	Tx Tip 16 blue/yellow	Rx Tip 16 yellow/blue	32	64	Rx Tip 16 blue/yellow

Managing UBIC Cables

The UBIC-H and UBIC-V DS-1 and DS3/EC-1 cable assemblies are designed to support both low-density (LD) and high-density (HD) DS-1, DS-3, or EC-1 signals. One end of these cables is terminated with a 50-pin SCSI connector and the other end is unterminated. Each SCSI connector on the DS-1 cable assembly supports 14 separate Tx and Rx DS-1 twisted-pair, 24 AWG cables. Each SCSI connector on the DS-3/EC-1 cable assembly supports 12 separate Tx and Rx DS-3 RG734 to RG735A coaxial cables. If available, tie wrap or lace the cables to the optional ONS 15454 tie-down bar according to GR-1275-CORE or local site practice.

Note Cisco recommends that you plan for future slot utilization and fully cable all SCSI connectors you will use later.

Figure 7-36 shows the pin locations on the DS-1 and DS-3/EC-1 SCSI connectors.

Figure 7-36 SCSI Cable Connector Pins

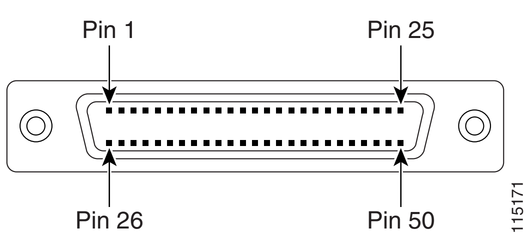


Table 7-38 shows the SCSI connector pin assignments for the DS-1 and DS-3/EC-1 cables.

Table 7-38 SCSI Pin Assignments

Pin	Cable Port	Pin	Cable Port
1	1	26	7
2	FGnd	27	FGnd
3	FGnd	28	FGnd
4	FGnd	29	FGnd
5	2	30	7
6	FGnd	31	FGnd

Table 7-38 SCSI Pin Assignments

Pin	Cable Port	Pin	Cable Port
7	FGnd	32	FGnd
8	FGnd	33	FGnd
9	3	34	9
10	FGnd	35	FGnd
11	FGnd	36	FGnd
12	FGnd	37	FGnd
13	4	38	10
14	FGnd	39	FGnd
15	FGnd	40	FGnd
16	FGnd	41	FGnd
17	5	42	11
18	FGnd	43	FGnd
19	FGnd	44	FGnd
20	FGnd	45	FGnd
21	6	46	12
22	FGnd	47	FGnd
23	FGnd	48	FGnd
24	FGnd	49	FGnd
25	13	50	14

Table 7-39 shows the UBIC-H and UBIC-V EIA DS-1 cable wiring.

Table 7-39 UBIC-H and UBIC-V EIA DS-1 Wiring

Signal	Wire Coloring	Signal	Wire Coloring
Tip Port 1	White/Blue	Ring Port 1	Blue/Whit
Tip Port 2	White/Orange	Ring Port 2	Orange/Whit
Tip Port 3	White/Green	Ring Port 3	Green/White
Tip Port 4	White/Brown	Ring Port 4	Brown/White
Tip Port 5	White/Slate	Ring Port 5	Slate/White
Tip Port 6	Red/Blue	Ring Port 6	Blue/Red
Tip Port 7	Red/Orange	Ring Port 7	Orange/Red
Tip Port 8	Red/Green	Ring Port 8	Green/Red
Tip Port 9	Red/Brown	Ring Port 9	Brown/Red
Tip Port 10	Red/Slate	Ring Port 10	Slate/Red
Tip Port 11	Black/Blue	Ring Port 11	Blue/Black
Tip Port 12	Black/Orange	Ring Port 12	Orange/Black

Table 7-39 UBIC-H and UBIC-V EIA DS-1 Wiring

Signal	Wire Coloring	Signal	Wire Coloring
Tip Port 13	Black/Green	Ring Port 13	Green/Black
Tip Port 14	Black/Brown	Ring Port 14	Brown/Black

DS-1 Cables

The DS-1 cables are connectorized at the ONS 15454 shelf end and must be wire-wrapped at the DSX end. Each Tx/Rx pair of SCSI connectors will support 140 DS-1s. A total of ten low-density (LD) DS-1 cards in slots 1, 2, 4, 5, 6, 12, 13, 14, 16, and 17 fully cabled can support 140 DS-1 drops. Four high-density (HD) cards in slots 1, 2, 16, and 17 fully cabled will have 224 DS-1 drop capacity when the HD DS-1 card becomes available.

Note The connectorized cable end is grounded to the ONS 15454 frame ground through the backplane. Cisco recommends that the shield at the both ends of the cable be grounded. Ground at the DSX end per office requirements.

DS-3/EC-1 Cables

The DS-3/EC-1 cable assemblies are used for the DS3-12, DS3-12E, DS3/EC1-48, DS3XM-6, DS3XM-12, and EC1-12 cards. The DS-3/EC-1 cables are connectorized at the UBIC Vend and unterminated at the far end. Twelve individual BNC connectors are supplied with each cable assembly in a separate package.

Each Tx/Rx pair of SCSI connectors will support 12 DS-3s or EC-1s. A total of ten LD DS-3 or EC-1 cards in slots 1, 2, 4, 5, 6, 12, 13, 14, 16, and 17 fully cabled can support 120 DS-3 or EC-1 drops. Four HD DS-3/EC-1 cards in slots 1, 2, 16, and 17 fully cabled will have 192 DS-3/EC-1 drop capacity.

Each Tx/Rx pair of SCSI connectors will also support 6 channelized DS-3s drops for the DSXM-6 and 12 channelized drops for the DS3XM-12 cards. Fully cabled the UBIC-H and UBIC-V can support 36 DS3XM-6 drops or 72 DS3XM-12 drops.

The UBIC-H and UBIC-V EIAs support the following J-Labeling that corresponds SCSI connectors to the ports on low- and high-density electrical interface cards.

Table 7-40 and Table 7-41 show the J-labeling and corresponding card ports for a shelf assembly configured for low-density electrical cards.

Table 7-40 J-Labeling Port Assignments for a Shelf Assembly Configured with Low-Density Electrical Cards (A Side)

		Tx	J4	J3	J2	J1	J5	J6	J7	J8
		Rx	J12	J11	J10	J9	J13	J14	J15	J16
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
1	DS-1		1–14	—	—	—	—	—	—	—
	DS-3/EC1		1–12	—	—	—	—	—	—	—
2	DS-1		—	—	—	—	1–14	—	—	—
	DS-3/EC1		—	—	—	—	1–12	—	—	—
3	DS-1		—	—	—	—	—	—	1–14	—
	DS-3/EC1		—	—	—	—	—	—	1–12	—
4	DS-1		—	—	—	—	—	1–14	—	—
	DS-3/EC1		—	—	—	—	—	1–12	—	—
5	DS-1		—	1–14	—	—	—	—	—	—
	DS-3/EC1		—	1–12	—	—	—	—	—	—
6	DS-1		—	—	1–14	—	—	—	—	—
	DS-3/EC1		—	—	1–12	—	—	—	—	—

Table 7-41 J-Labeling Port Assignments for a Shelf Assembly Configured with Low-Density Electrical Cards (B Side)

		Tx	J4	J3	J2	J1	J5	J6	J7	J8
		Rx	J12	J11	J10	J9	J13	J14	J15	J16
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
17	DS-1		1–14	—	—	—	—	—	—	—
	DS-3/EC1		1–12	—	—	—	—	—	—	—
16	DS-1		—	—	—	—	1–14	—	—	—
	DS-3/EC1		—	—	—	—	1–12	—	—	—
15	DS-1		—	—	—	—	—	—	1–14	—
	DS-3/EC1		—	—	—	—	—	—	1–12	—
14	DS-1		—	—	—	—	—	1–14	—	—
	DS-3/EC1		—	—	—	—	—	1–12	—	—
13	DS-1		—	1–14	—	—	—	—	—	—
	DS-3/EC1		—	1–12	—	—	—	—	—	—
12	DS-1		—	—	1–14	—	—	—	—	—
	DS-3/EC1		—	—	1–12	—	—	—	—	—

Table 7-42 and Table 7-43 show the J-labeling and corresponding card ports for a shelf assembly configured with high-density 48-port DS-3/EC-1 or 56-port DS-1 electrical cards.

Table 7-42 J-Labeling Port Assignments for a Shelf Configured with High-Density Electrical Cards (A Side)

		TX	J4	J3	J2	J1	J5	J6	J7	J8
		RX	J12	J11	J10	J9	J13	J14	J15	J16
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
1	DS-1		1–14	15–28	29–42	43–56	—	—	—	—
	DS-3/EC1		1–12	13–24	25–36	37–48	—	—	—	—
2	DS-1		—	—	—	—	1–14	15–28	29–42	43–56
	DS-3/EC1		—	—	—	—	1–12	13–24	25–36	37–48

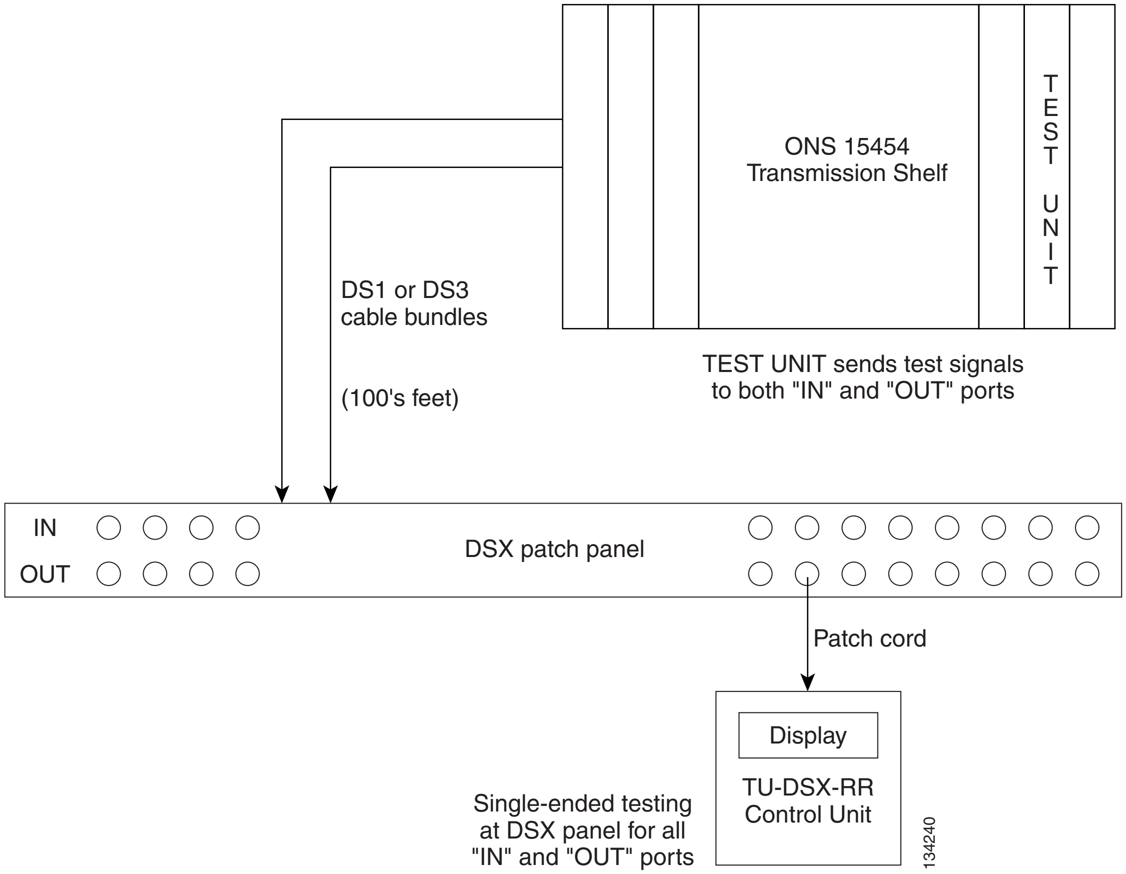
Table 7-43 J-Labeling Port Assignments for a Shelf Configured with High-Density Electrical Cards (B Side)

		TX	J20	J19	J18	J17	J21	J22	J23	J24
		RX	J28	J27	J26	J25	J29	J30	J31	J32
Slot	**Port Type**		**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**	**Ports**
17	DS-1		1–14	15–28	29–42	43–56	—	—	—	—
	DS-3/EC1		1–12	13–24	25–36	37–48	—	—	—	—
16	DS-1		—	—	—	—	1–14	15–28	29–42	43–56
	DS-3/EC1		—	—	—	—	1–12	13–24	25–36	37–48

DSX Wiring Verification Kits

The ONS 15454 DSX Wiring Verification Kit consists of an In-service test card (IS-DSX), hand-held control unit (TU-DSX-RR), a circuit card that plugs into the ONS 15454 shelf assembly (TU-DSX TEST UNIT), plus several patch cords and an AC/DC adaptor. The TU-DSX TEST UNIT works in Slots 3 and 15 of the Shelf assembly and gets power from either the shelf's office battery or from an optional low power AC/DC adaptor. The kit verifies installed cabling between the cross-connect DS-1 or DS-3 patch panel and a newly installed ONS 15454 shelf (see Figure 7-39). Tested conditions are for shorts, opens, wrong connections, and tip/ring reversals. Once testing is started, the DSX wiring can be verified at the DSX. There is no need for coordinated operations at both the DSX and the ONS 15454 shelf. For more information about the DSX wiring verification kit, refer to the Cisco Testing DSX Wiring with the Cisco ONS 15454 DSX Wiring Verification Kit document (74-3494-01-A0 Issue 3).

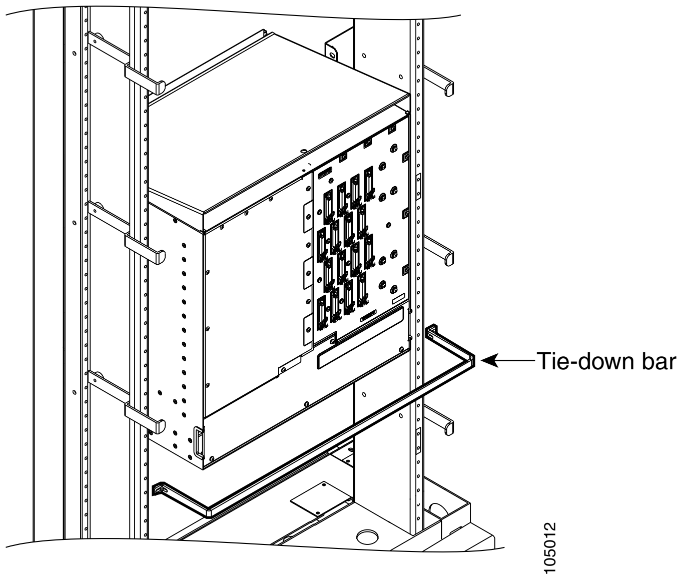
Figure 7-37 ONS 15454 DSX Wiring Verification Kit Block Diagram



Electrical Cable Management Using the Optional Tie-Down Bar

Optional ONS 15454 tie-down bars, 19 inches and 23 inches, can be used to provide a diverse path for redundant power feeds and EIA cables. You can install a 5-inch (127 mm) tie-down bar on the equipment rack at the rear of the assembly shelf. You can use tie-wraps or other site-specific material to bundle the cabling and attach it to the bar so that you can more easily route the cable away from the rack. Figure 7-38 shows the tie-down bar, the ONS 15454 shelf assembly, and the equipment rack.

Figure 7-38 EIA Cable Management Using the Optional Tie-Down Bar



Standoffs and Rear Plastic Cover

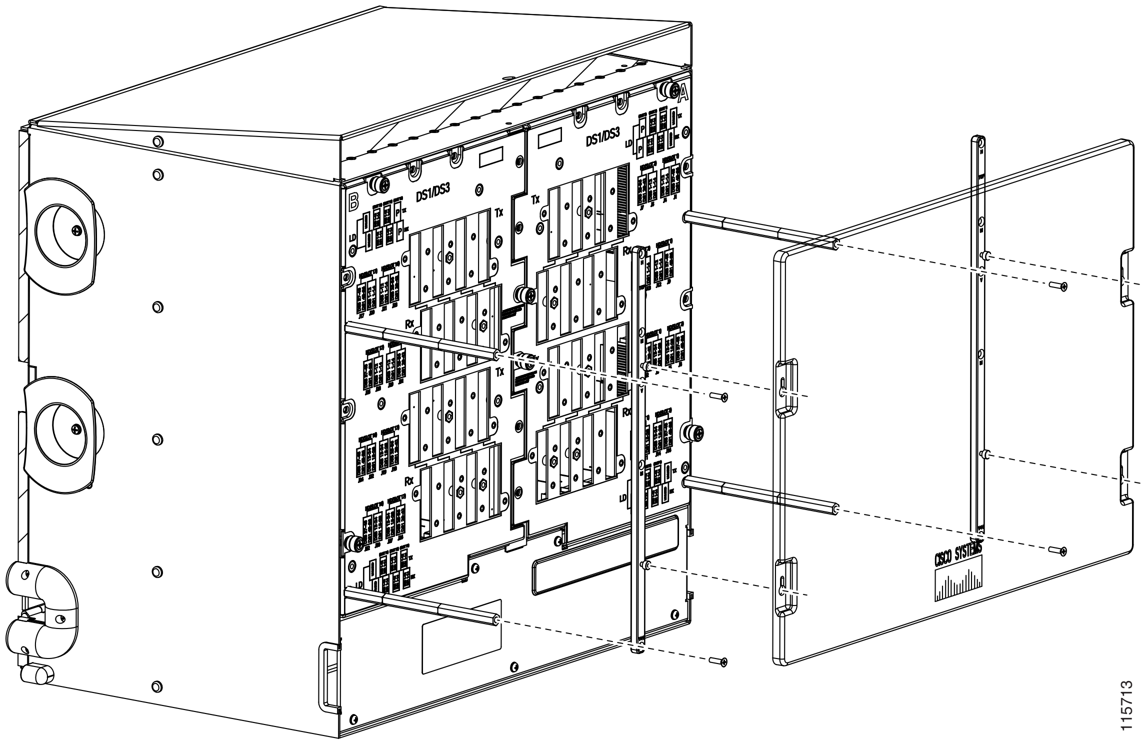
The ONS 15454 has an optional clear plastic rear cover that provides additional protection for the cables and connectors on the EIAs.

Optional spacers are included in the rear cover ship kit to provide the necessary space between the cables and rear covers for the UBIC-H and UBIC-V. You will need the following equipment to install the standoffs (necessary for installing the rear cover with over UBIC-V EIA cables) and the rear cover:

- #2 Phillips screwdriver
- Medium flathead screwdriver
- 1/4-inch nut driver
- 2 mounting screws, 6-32 x 0.375-inch Phillips head (P/N 48-0598-01)
- Four 1-inch standoffs (50-1193-01)
- Four 2-inch standoffs (50-1453-01)
- Two brackets

You attach the rear cover by hanging it from the mounting screws on the back of the mounting brackets and pulling it down until it fits firmly into place (see Figure 7-39).

Figure 7-39 Installing the Rear Cover with Standoffs



Synchronization

The Cisco ONS 15454 is designed to operate in a network that complies with synchronization and timing recommendations stated in GR-253-CORE, GR-436-CORE, and GR-1244-CORE.

SONET timing parameters must be set for each ONS 15454. Each ONS 15454 independently accepts its timing reference from one of three sources:

1. The BITS (building integrated timing supply) pins on the ONS 15454 backplane.
2. An OC-N card installed in the ONS 15454. The card is connected to a node that receives timing through a BITS source.
3. The internal ST3 clock on the TCC2/TCC2P 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. Dense wavelength division multiplexing (DWDM) cards normally derive timing from the line using the Optical Service Channel Module (OSCM) or Optical Service Channel and Combiner/Splitter Module (OSC-CSM) card that are inside an OC-3 channel.

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 TCC2/TCC2P card. This clock is a Stratum 3 (ST3). If an ONS 15454 becomes isolated, timing will be maintained at the ST3 level.

Release 5.0 supports a new 64KHz+8KHz composite clock reference, per ITU-T G.703 Table II.1. The 64KHz+8KHz clock features AMI with 8 KHz bipolar violation, and only works with dual TCC2P cards running software Release 5.0 and higher.

You can select the 64KHz+8KHz clock from the Facility Type selection box in the BITS Facilities subtab of the node view, Provisioning > Timing tabs. When using the 64KHz+8KHz clock as a source, only DS1 and 6MHz framing are allowed for BITS out, and the user selected Admin SMM message type is enforced, with the Sync Messaging check box disabled and grayed out. With the 64KHz+8KHz clock selected as the source, the user selectable Admin SSM defaults to STU. The following configurations are supported for the 64+8kHz clock:

- BITS INBITS OUT
- DS1None
- DS1DS1
- 64 KHzNone
- 64 KHzDS1
- 64 KHz
- 6132 KHz (6MHz)

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.

Timing Guidelines

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 TCC2/TCC2P card which is stratum 3 compliant. A redundant architecture protects against failure or removal of one TCC2/TCC2P card. For timing reliability, the TCC2/TCC2P 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 provision two timing references, the secondary reference provides protection. A slow-reference tracking loop allows the TCC2/TCC2P 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:

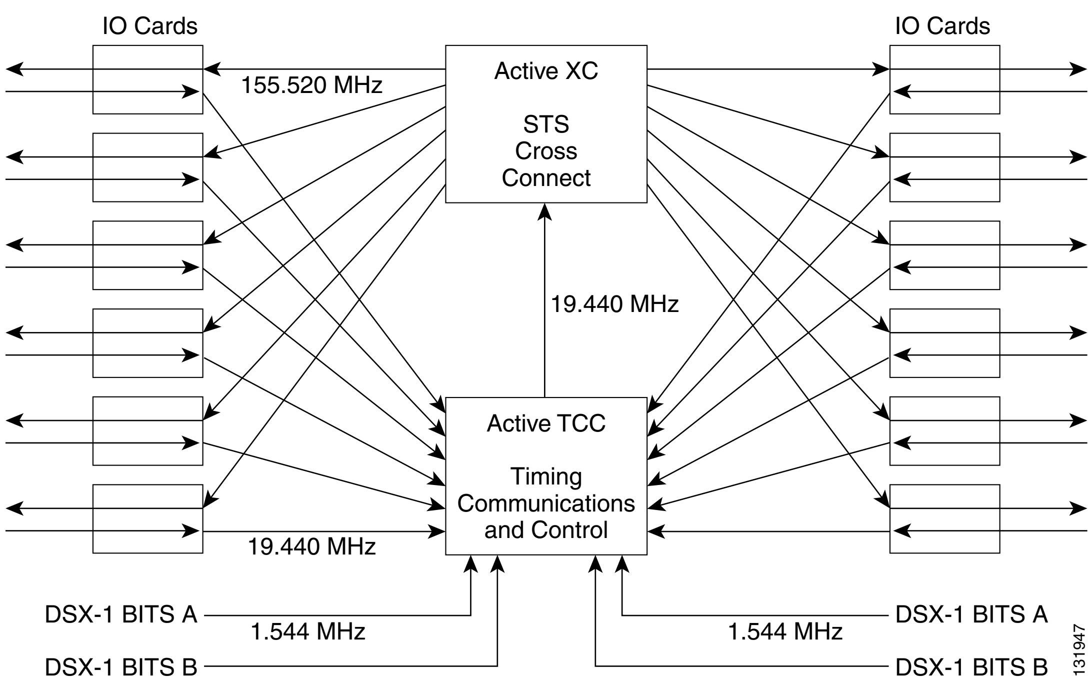
- External (BITS) timing
- Line (Optical) timing
- Mixed (both External and Internal) sources
- Holdover (automatically provided when all references fail)
- Free-running (a special case of holdover)

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 TCC2/TCC2P cards. Figure 7-40 illustrates how timing signals flow through the ONS 15454. The TCC2/TCC2P card selects a timing reference from one of several sources as discussed above and distributes this reference to the synchronous interface cards.

Figure 7-40 ONS 15454 Timing Flow



The TCC2/TCC2P 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 TCC2/TCC2P will track the external reference with the internal clock.

The BITS signal is a DS-1 level, 1.544 MHz signal, formatted either as D4 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 (D4) 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 TCC2/TCC2P 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 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 7-44 provides a summary of the BITS input physical connections and signal formats for the ONS 15454.

Table 7-44 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 DS-1 with either SF (D4) or ESF (required for SSM support) framing format. Release 5.0 and higher with redundant TCC2P cards supports a 64Khz+8KHz composite clock with AMI framing.

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 TCC2/TCC2P cards, where it is qualified for use as a timing reference.

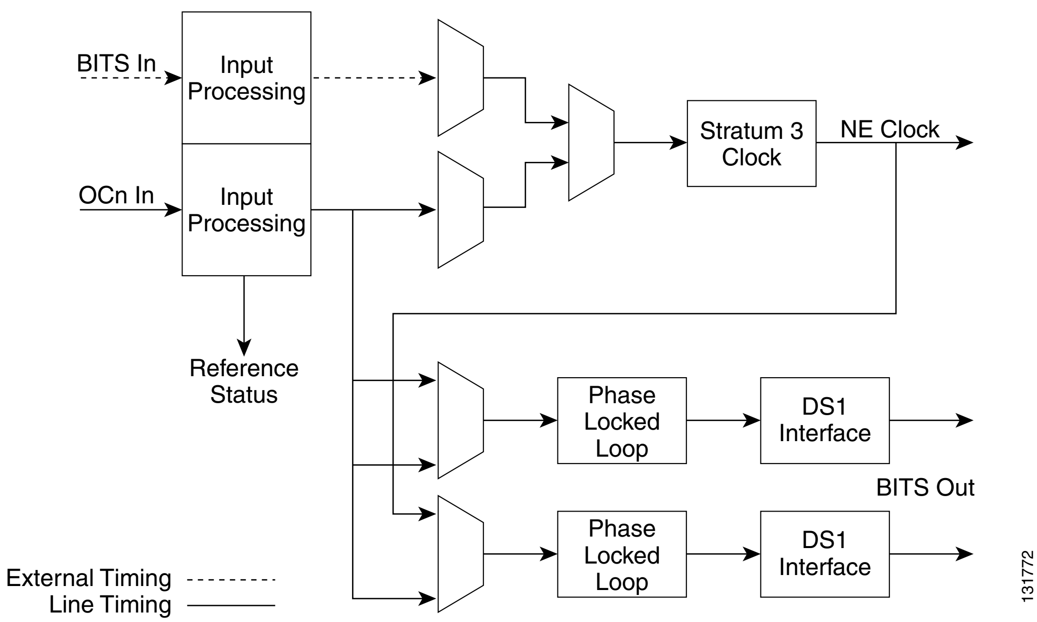
Synchronization Status Messaging (SSM) can be optionally enabled or disabled on an optical port. A controller on the optical card monitors the received SSM and reports any changes to the TCC2/TCC2P synchronization process. If an optical port (receiver) is selected as the active timing reference, the 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 7-41 has been provided to show the ONS 15454 timing circuit.

Figure 7-41 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 filtered through the Stratum 3 clock and the resulting output is the NE clock.
- The source of the BITS outputs are 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 TCC2/TCC2P 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 7-45 provides the timing characteristics of stratum 3 and stratum 3E clocks, and compliance details for the ONS 15454.

Table 7-45 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 x 10-9 initially (the first minute), and an additional 40 x 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 7-46 provides a summary of the physical connections and signal formats for BITS Out.

Table 7-46 BITS Out Connections and Signal Formats

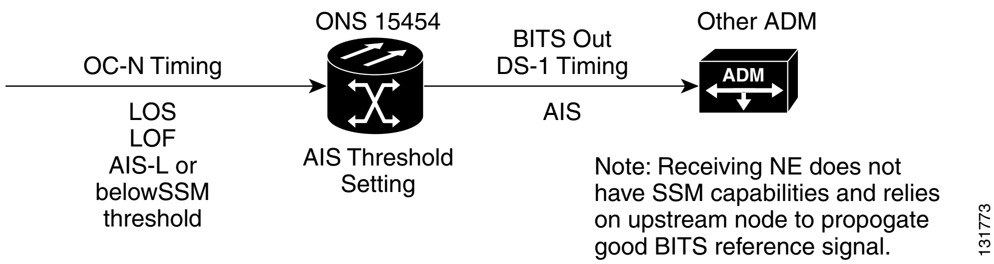
Number of BITS Outputs	BITS Output Physical Connection	BITS Output Signal Characteristics
2	4 BITS pins provide connections for redundant BITS clock outputs on the ONS 15454 backplane.	1.554 Mb/s DS-1 signal. DS-1 format per BITS Facility setting. Release 5.0 and higher with redundant TCC2P cards supports a 6MHz format per 64KHz+8KHz BITS Facility setting.

BITS Out framing of ESF or SF (D4) and coding of 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 (D4), 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 (D4) formatted DS-1. However, to insure reliability, when the BITS Out signal is used with equipment in SF (D4) 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 7-42 provides a list of conditions under which AIS will be sent on the BITS Out facility.

Figure 7-42 BITS Out AIS Conditions



Synchronization Status Messaging

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 7-47 describes the Generation 1 message set and Table 7-48 describes the Generation 2 message set.

Table 7-47 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

Caution

Table 7-48 SSM Generation 2 Message Set

Message	Quality Level	Description	S1 Bits
PRS	1	Primary reference source - Stratum 1	0001
STU	2	Synchronized - traceability unknown	0000
ST2	3	Stratum 2 Traceable	0111

Table 7-48 SSM Generation 2 Message Set (continued)

Message	Quality Level	Description	S1 Bits
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

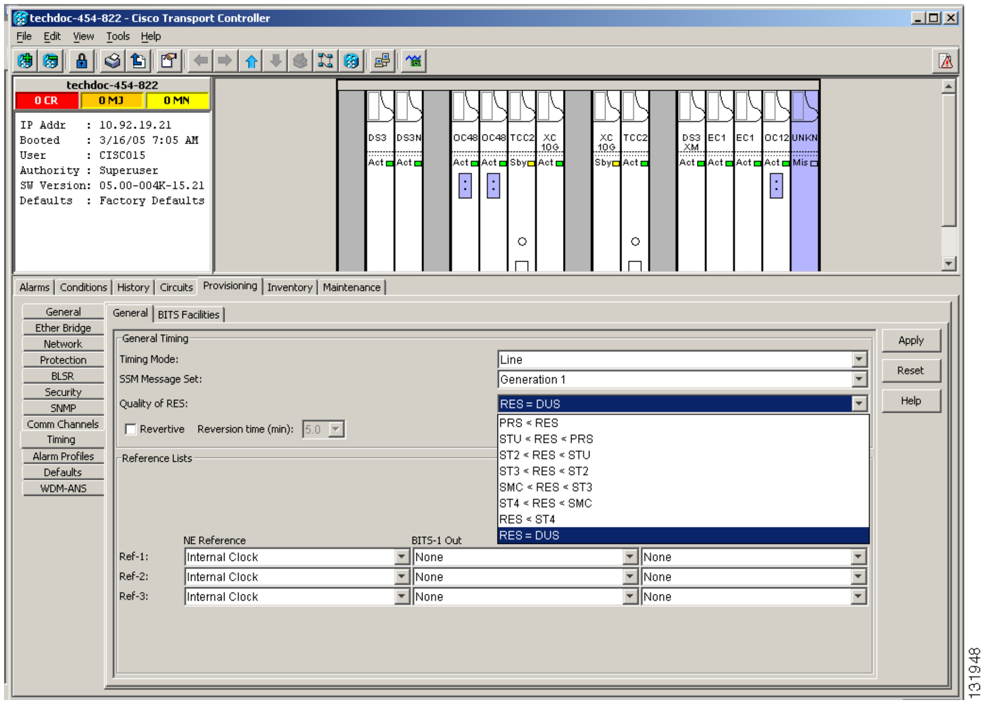
Caution The use of SSM in a timing network does not automatically prevent timing loops. Proper synchronization planning is required.

With Release 5.0 you can configure an SSM value for a timing source (either BITS-IN or Optical Line) by selecting from the "ADMIN. SSM" selection box in the BITS Facilities subtab of the node view, Provisioning > Timing tabs. This feature is useful when the selected external timing source has no SSM information. When you select the Admin SSM value, all switching decisions are subsequently made based on your selection. The same SSM value is transmitted out of the interface configured for BITS Out, and in transmit Optical S1. The DS1 BITS type with framing type SF(D4) only supports Admin SSM. The 64KHz+8KHz clock also only supports Admin SSM. ESF Framing must have Sync Messaging turned off (uncheck the check box) in order to enable Admin SSM selection. SONET nodes use the SSM Generation II message set, as defined in Table 4 of ANSI T1.101-1999.

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 7-43 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 7-43 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 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.

2R and 3R DWDM Spans

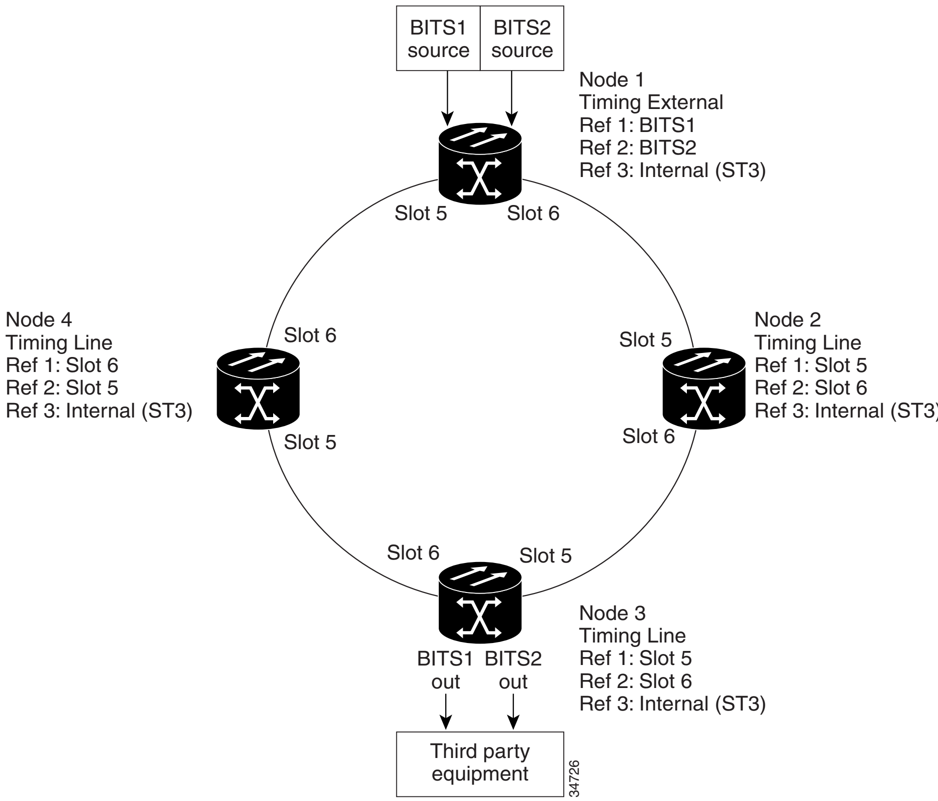
In spans with 2R (Re-shape and Re-amplify, but not Re-time) DWDM systems the synchronization characteristics are simply passed-through (i.e., jitter is passed through) and there is no effect on network synchronization. However, with 3R (Re-shape and Re-amplify, Re-time) DWDM systems, the re-timing must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

Network Timing Example

Figure 7-44 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 7-44 ONS 15454 Network Timing Example



Synchronization 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.

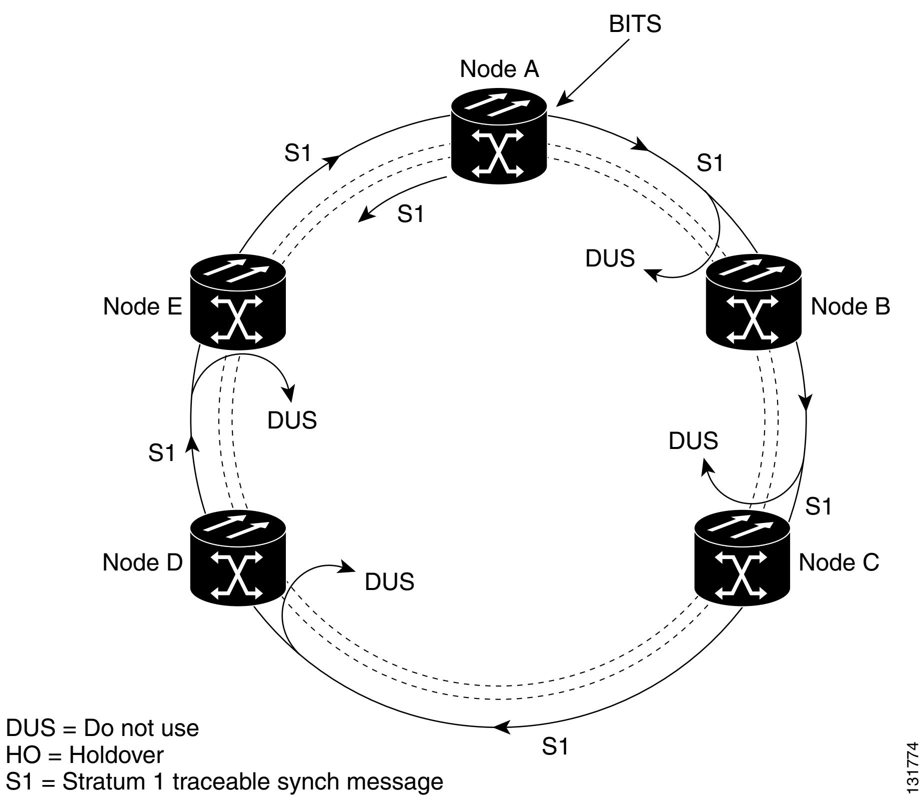
- Free-run Mode: The ONS 15454 is considered to be in Free-run state when it is operating on its own internal clock. Free-run accuracy for the ONS 15454 and most SONET nodes is stratum 3. The minimum accuracy for any SONET node must be better than the SONET Minimum Clock (SMC), which is +/- 20ppm.

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.

Synchronization Switching Example

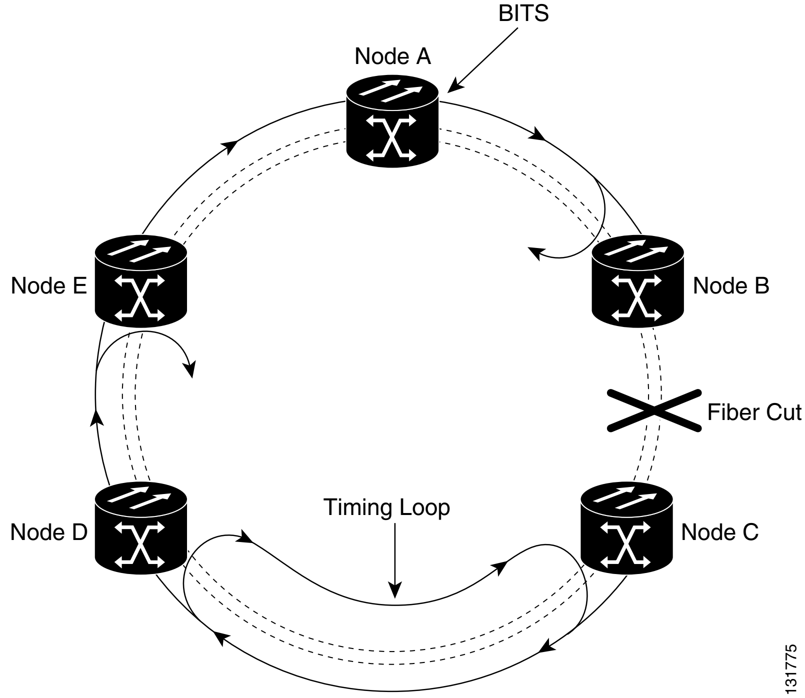
The Cisco ONS 15454 generates the synchronization message in the outgoing SONET signals. The synchronization messaging allows the ONS 15454 nodes in a ring to maintain their correct configuration. In Figure 7-45, the BITS clock is connected to Node A and timing is maintained around the ring from Node 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 7-45 Normal Operation



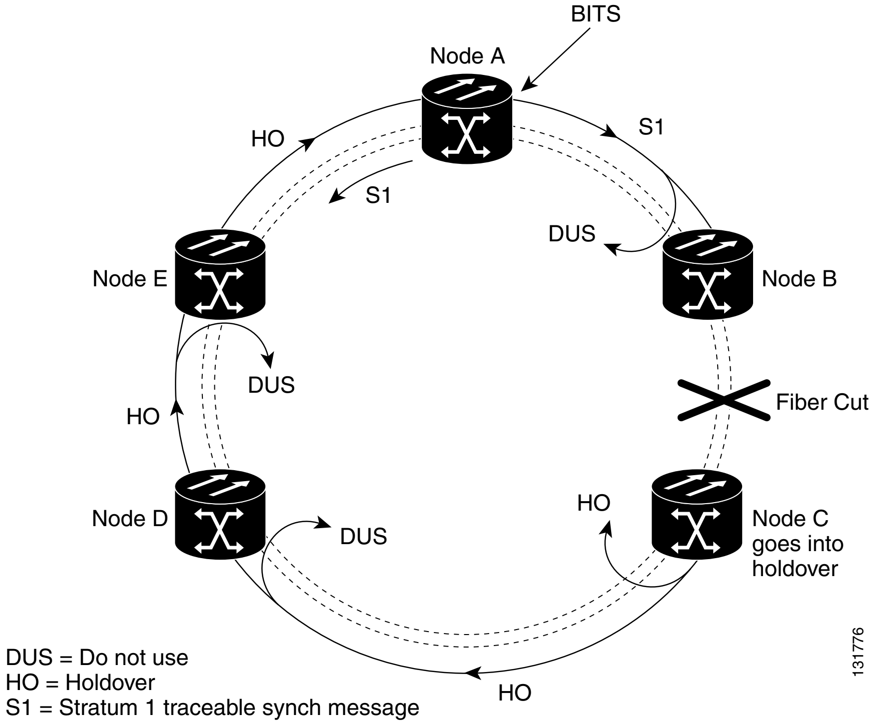
Fiber is cut between Node B and Node C, causing a failure. A ring failure in a system without SSM that uses simple reference switching results in a timing loop shown in Figure 7-46.

Figure 7-46 Ring Failure and Timing Loop



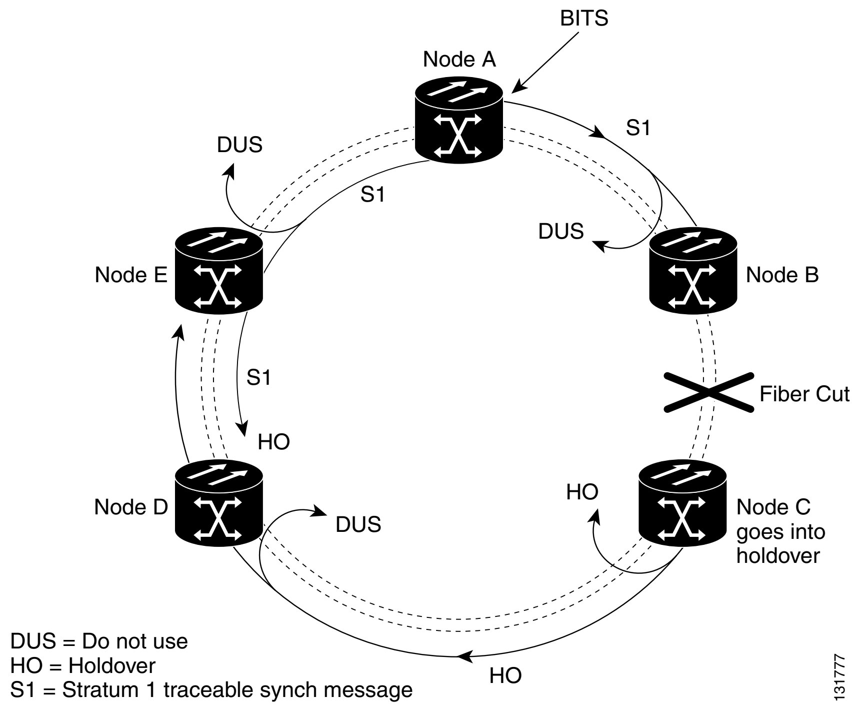
In a system using SSM, the fiber cut in Figure 7-47 interrupts the timing signal around the ring. Since Node C was the receiving clock from Node B (line timed), and has lost signal, Node C goes into short-term holdover and uses its internal clock.

Figure 7-47 Ring Failure with SSM



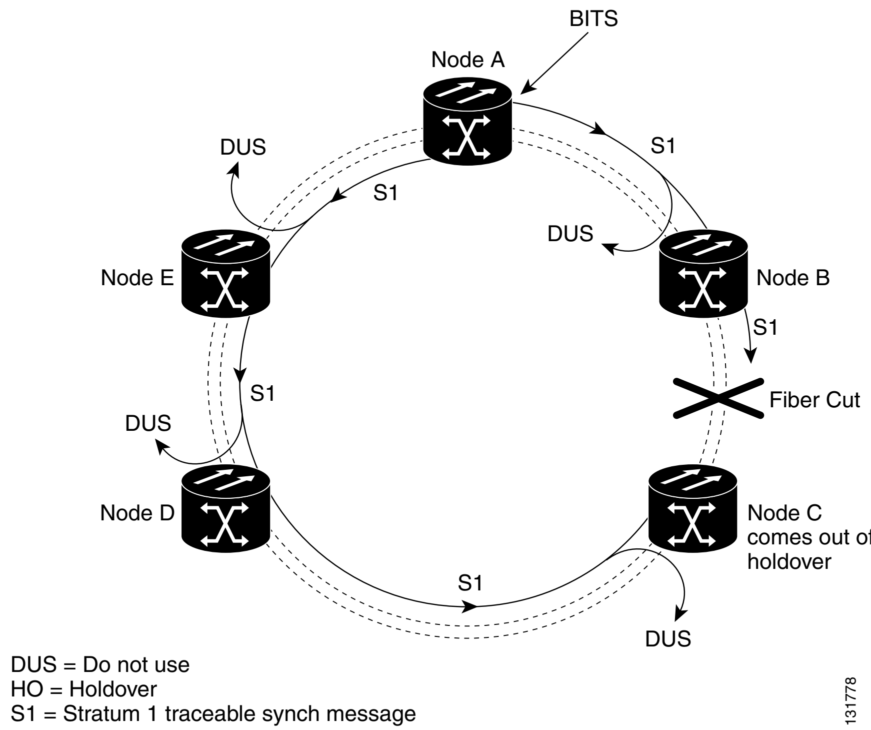
In Figure 7-48, synchronization message 1 is now being sent to Node E directly from Node A (counterclockwise) instead of clockwise around the ring. At this point, Node E switches to lime timing from Node A.

Figure 7-48 Synchronization Switch



Synchronization message S1 continues to Nodes E, D, and C in the counterclockwise direction as shown in Figure 7-49. 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 7-49 Synchronization Reconfigures Around the Ring



Synchronization 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.

Card Protection Configurations

The ONS 15454 provides 1+1 protection for OC-N cards and a variety of electrical card protection methods. This section describes the card protection configurations supported by the ONS 15454.

OC-N Card Protection

The ONS 15454 provides two optical card protection methods, 1+1 protection and optimized 1+1 protection. Specific optical card protection schemes depend on the optical cards in use.

OC-N 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 bidirectional 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.

1+1 Protection

Any OC-N card can use 1+1 protection. With 1+1 port-to-port protection, 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 OC-12 must be paired with another single-port OC-12, and a four-port OC-12 must be paired with another four-port OC-12. You cannot create a 1+1 protection group if one card is single-port and the other is multiport, even if the OC-N rates are the same. The protection takes place on the port level, and 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. In other words, all the ports on the protect card are used in the protection scheme.

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. 1+1 protection is unidirectional and nonrevertive by default; revertive switching is easily provisioned using CTC.

Optimized 1+1 Protection

Optimized 1+1 protection is used in networks that mainly use the linear 1+1 bidirectional protection scheme. Optimized 1+1 is a line-level protection scheme using two lines, working and protect. One of the two lines assumes the role of the primary channel, where traffic is selected, and the other line assumes the role of secondary channel, which protects the primary channel. Traffic switches from the primary channel to the secondary channel based on either line conditions or an external switching command performed by the user. After the line condition clears, the traffic remains on the secondary channel. The secondary channel is automatically renamed as the primary channel and the former primary channel is automatically renamed as the secondary channel.

Unlike 1+1 span protection, 1+1 optimized span protection does not use the revertive or nonrevertive feature. Also, 1+1 optimized span protection does not use the Manual switch command. The 1+1 optimized span protection scheme is supported only on the Cisco ONS 15454 SONET using either OC3-4 cards or OC3-8 cards with ports that are provisioned for SDH payloads.

Optimized 1+1 is fully compliant with Nippon Telegraph and Telephone Corporation (NTT) specifications. With optimized 1+1 port-to-port protection, 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 installed 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 four-port OC-3 must be paired with another four-port OC-3, and an eight-port OC-3 must be paired with another eight-port OC-3. You cannot create an optimized 1+1 protection group if the number of ports do not match, even if the OC-N rates are the same.

The protection takes place on the port level, and 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.

Electrical Card Protection

This section covers the general concept of electrical card protection. Specific electrical card protection schemes depend on the type of electrical card as well as the electrical interface assembly (EIA) type used on the ONS 15454 backplane. Table 7-49 details the specific electrical card protection schemes.

In the table, high-density (HD) card type include the DS3/EC1-48 card. Low-density (LD) card types include the following:

- DS1-14, DS1N-14
- DS3-12, DS3N-12
- DS3-12E, DS3N-12E
- DS3XM-6
- DS3XM-12
- EC1-12

Caution When a protection switch moves traffic from the working/active electrical card to the protect/standby electrical card, ports on the new active/standby card cannot be placed out of service as long as traffic is switched. Lost traffic can result when a port is taken out of service, even if the standby card no longer carries traffic.

Table 7-49 Electrical Card Protection By EIA Type

Protection Type	Card Type	EIA Side	Standard BNC Card Slots	High-Density BNC Card Slots	MiniBNC Card Slots	SMB Card Slots	AMP Champ Card Slots	UBIC-H and UBIC-V Card Slots
Unprotected	LD-Working	A	2, 4	1, 2, 4, 5	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6
		B	14, 16	13, 14, 16, 17	12, 13, 14, 15, 16, 17	12, 13, 14, 15, 16, 17	12, 13, 14, 15, 16, 17	12, 13, 14, 15, 16, 17
	HD-Working	A	—	—	1, 2	—	—	1, 2
		B	—	—	16, 17	—	—	16, 17
1:1	LD-Working	A	2, 4	2, 4	2, 4, 6	2, 4, 6	2, 4, 6	2, 4, 6
		B	14, 16	14, 16	12, 14, 16	12, 14, 16	12, 14, 16	12, 14, 16
	LD- Portect	A	1, 3	1, 3	1, 3, 5	1, 3, 5	1, 3, 5	1, 3, 5
		B	15, 17	15, 17	13, 15, 17	13, 15, 17	13, 15, 17	13, 15, 17

Table 7-49 Electrical Card Protection By EIA Type (continued)

Protection Type	Card Type	EIA Side	Standard BNC Card Slots	High-Density BNC Card Slots	MiniBNC Card Slots	SMB Card Slots	AMP Champ Card Slots	UBIC-H and UBIC-V Card Slots
1:N	LD-Working	A	—	1, 2, 4, 5	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5, 6
		B	—	13, 14, 16, 17	12, 13, 14, 15, 16, 17	12, 13, 14, 15, 16, 17	12, 13, 14, 15, 16, 17	12, 13, 14, 15, 16, 17
	LD- Portect	A	—	—	3	3	3	3
		B	—	—	15	15	15	15
	HD-Working	A	—	—	1, 2	—	—	1, 2
		B	—	—	16, 17	—	—	16, 17
	HD Protect	A	—	—	3	—	—	3
		B	—	—	15	—	—	15

1:1 Protection

In 1:1 protection, a working card in an even-numbered slot is paired with a protect card in an odd-numbered slot 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.

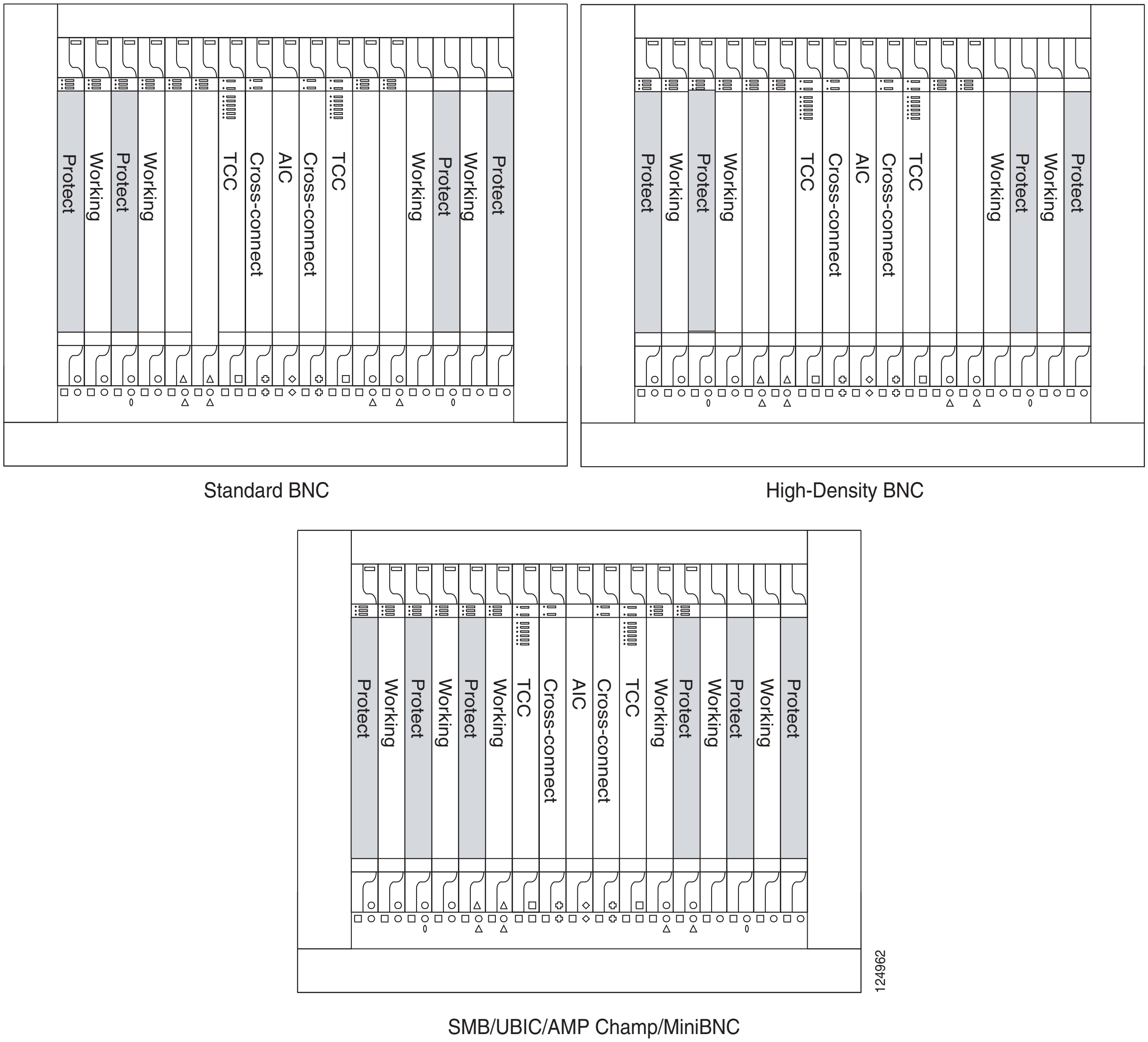
Table 7-50 provides supported 1:1 protection configurations by electrical card type.

Table 7-50 1:1 Protection Configurations Supported by Electrical Cards

Working Card	Protect Card	Working Slots	Protection Slots
DS1-14 or DS1N-14	DS1-14 or DS1N-14	2, 4, 6, 12, 14, 16	1, 3, 5, 13, 15, 17
DS3-12 or DS3N-12	DS3-12 or DS3N-12	2, 4, 6, 12, 14, 16	1, 3, 5, 13, 15, 17
DS3-12E or DS3N-12E	DS3-12E or DS3N-12E	2, 4, 6, 12, 14, 16	1, 3, 5, 13, 15, 17
DS3XM-6	DS3XM-6	2, 4, 6, 12, 14, 16	1, 3, 5, 13, 15, 17
DS3XM-12	DS3XM-12	2, 4, 6, 12, 14, 16	1, 3, 5, 13, 15, 17

Figure 7-50 shows 1:1 low-density card protection configurations support by type of EIA.

Figure 7-50 1:1 Protection Configurations for Low-Density Electrical Cards Supported by EIA Types



1:N Protection

1:N protection allows a single card to protect up to five working cards of the same DS-N level. 1:N cards have added circuitry to act as the protect 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.

Table 7-51 provides the supported 1:N configurations by electrical card, as well as the card types that can be used for working and protection cards.

Table 7-51 1:N Protection Configurations Supported by Electrical Card

Working Card	Protect Card	Number of Cards Supported In A Protection Group	Working Slots	Protect Slots
DS1-14	DS1N-14	< 5	1, 2, 4, 5, 6	3
			12, 13, 14, 16, 17	15
DS3-12	DS3N-12	< 5	1, 2, 4, 5, 6	3
			12, 13, 14, 16, 17	15
DS3-12E	DS3N-12E	< 5	1, 2, 4, 5, 6	3
			12, 13, 14, 16, 17	15
DS3/EC1-48	DS3/EC1-48	< 2	1[1], 2[2]	3
			16[3], 17[4]	15
DS3XM-12	DS3XM-12	< 5 (Ported Mode)	1, 2, 4, 5, 6	3
			12, 13, 14, 16, 17	15
		< 7 (Portless Mode[5])	1, 2, 4, 14, 15 16, 17	3
			1, 2, 3, 4, 14, 16, 17	15

1. A high-density electrical card inserted in Slot 1 restricts the use of Slots 5 and 6 to only optical, data, or storage cards.
2. A high-density electrical card inserted in Slot 2 restricts the use of Slots 4 and 6 to only optical, data, or storage cards.
3. A high-density electrical card inserted in Slot 16 restricts the use of Slot 14 to only optical, data, or storage cards.
4. A high-density electrical card inserted in Slot 17 restricts the use of Slots 12 and 13 to only optical, data, or storage cards.
5. Portless DS-3 Transmux operation does not terminate the DS-3 signal on the EIA panel.

1:N Protection Guidelines

The following rules apply to 1:N protection groups in the ONS 15454:

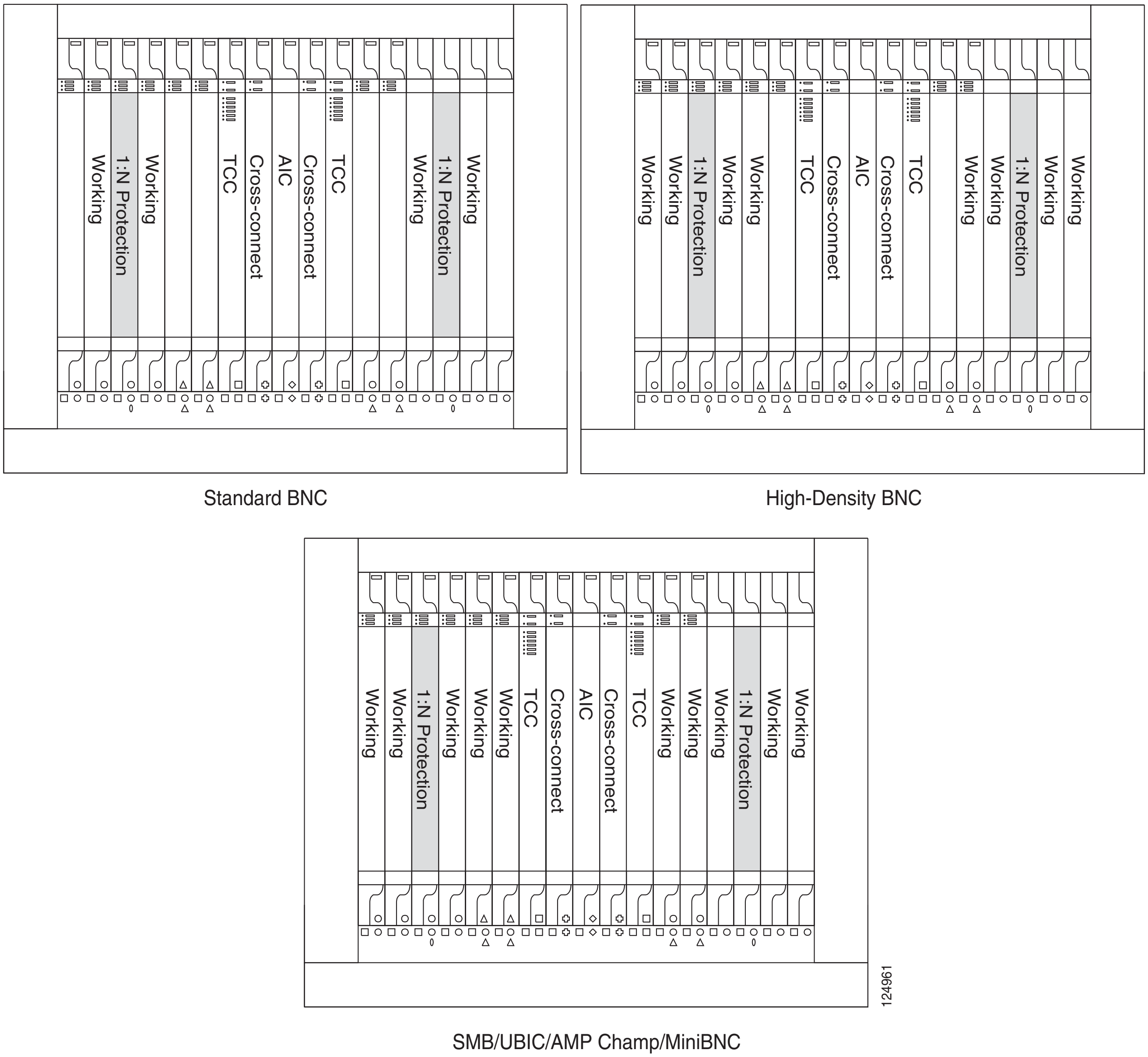
- Working and protect card groups must reside in the same card bank (side A or side B) of the assembly shelf.
- The 1:N protect card must reside in Slot 3 for side A and Slot 15 for side B.
- Working cards may sit on either or both sides of the protect card
- The ONS 15454 supports 1:N equipment protection 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.

Figure 7-51 shows 1:N protection configurations supported for low-density electrical cards by type of EIA.

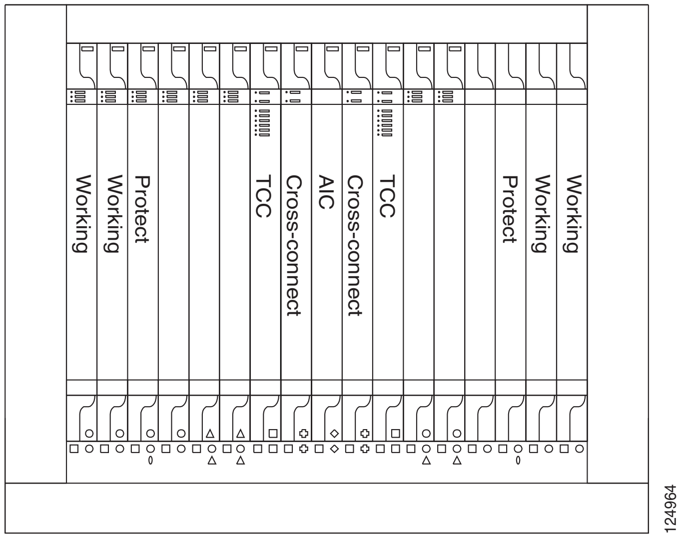
Figure 7-51 1:N Protection Configuration Supporteds for Low-Density Electrical Cards by EIA Types



Note EC1-12 cards do not support 1:N protection.

Figure 7-52 shows 1:N high-density card protection configurations support by type of EIA.

Figure 7-52 1:N Protection Configurations for High-Density Electrical Cards Supported by EIA Types



UBIC/MiniBNC

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.

Unprotected Cards

Unprotected cards are not included in a protection scheme; therefore, a card failure or a signal error results in lost data. Because no bandwidth lies in reserve for protection, unprotected schemes maximize the available ONS 15454 bandwidth.

Figure 7-53 shows unprotected low-density electrical card configurations supported by type of EIA.

Figure 7-53 Unprotected Low-Density Electrical Card Configurations Supported by EIA Types

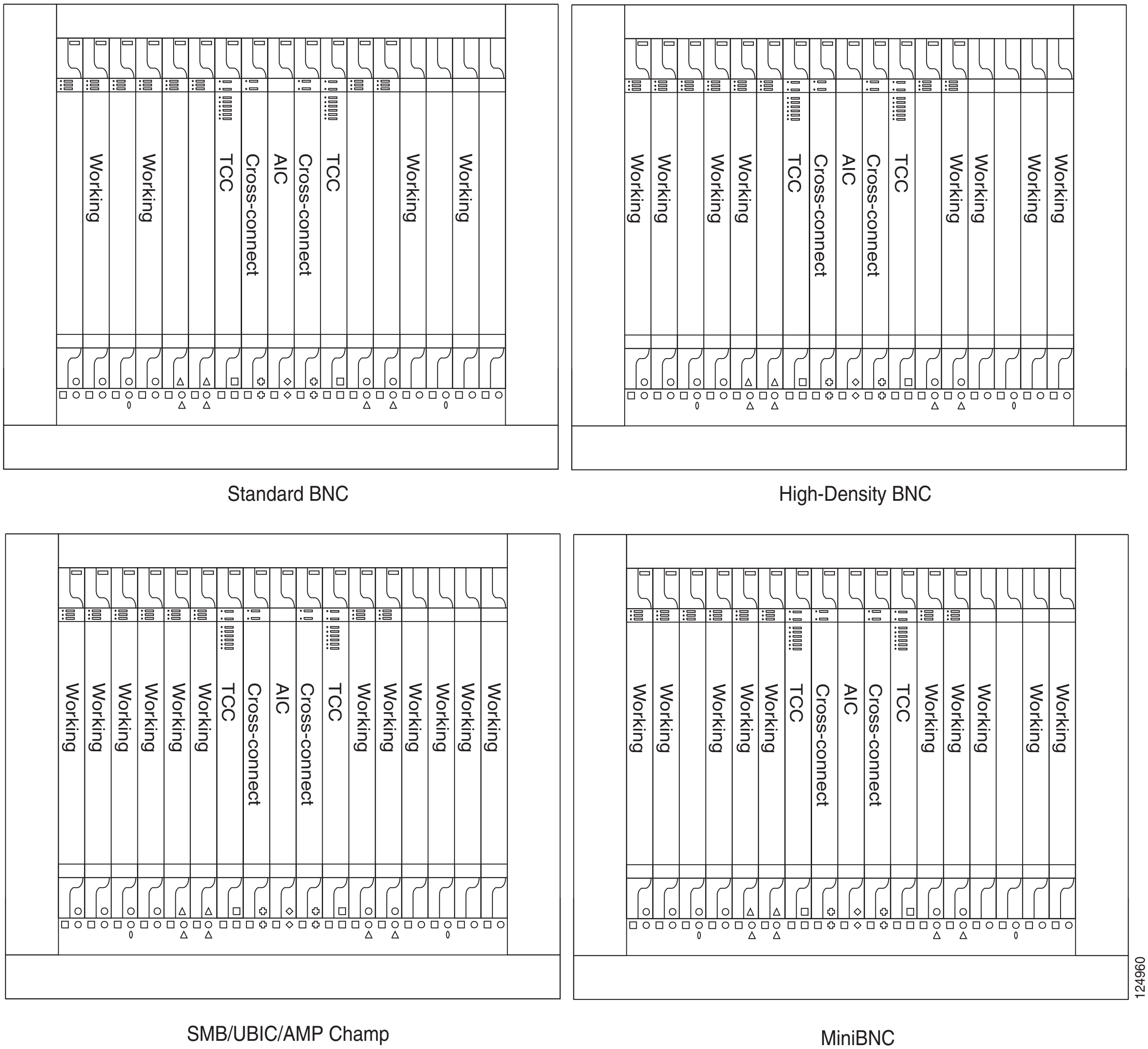
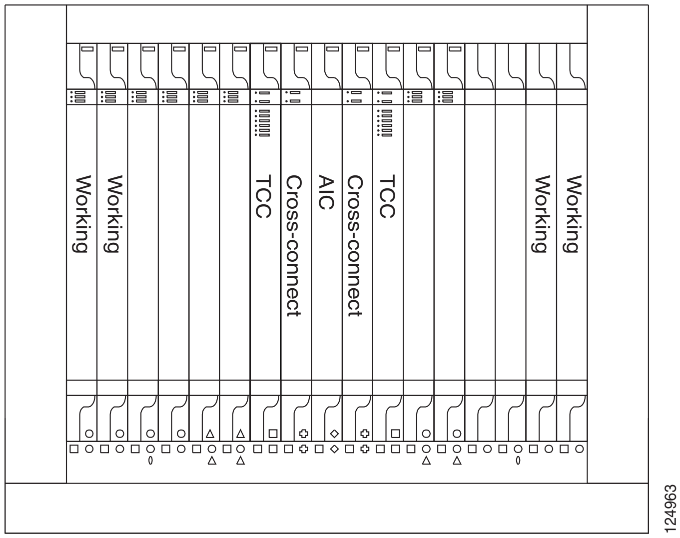


Figure 7-54 shows unprotected high-density electrical card configurations supported by type of EIA.

Figure 7-54 Unprotected High-Density Electrical Card Configurations Supported by EIA Types



UBIC/MiniBNC

External Switching Commands

The external switching commands on the ONS 15454 are Manual, Force, and Lockout. If you choose a Manual switch, the command will switch traffic only if the path has an error rate less than the signal degrade (SD) bit error rate threshold. A Force switch will switch traffic even if the path has SD or signal fail (SF) conditions; however, a Force switch will not override an SF on a 1+1 protection channel.

Transponder and Muxponder Card Protection

Two types of protection options are available for the ONS 15454 transponder and muxponder cards:

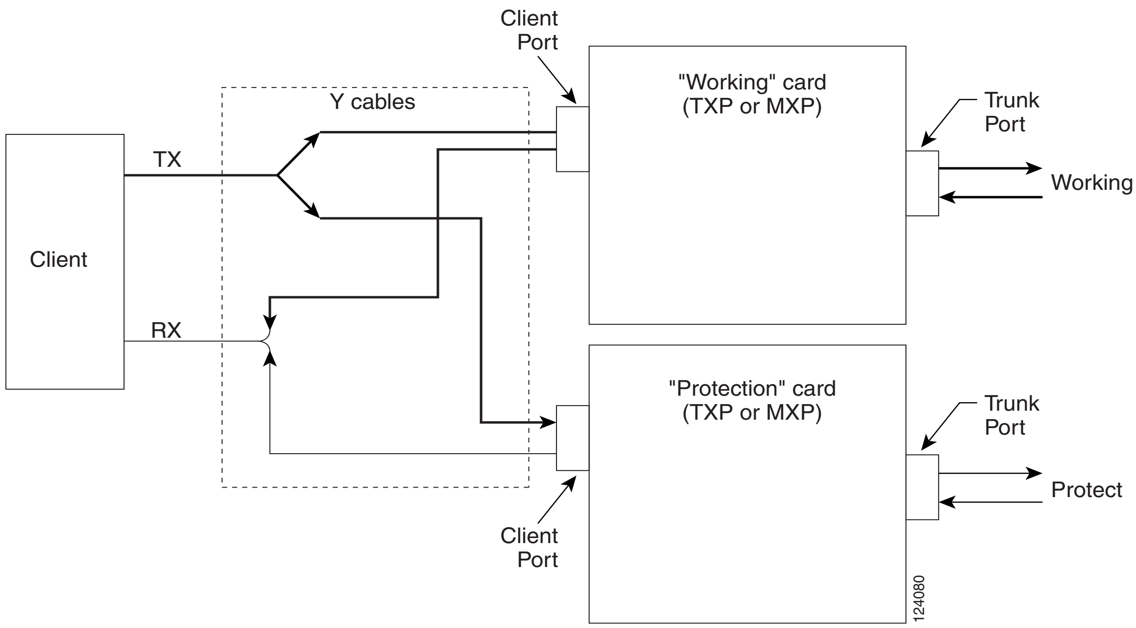
- Y-cable protection
- Splitter protection

Y-Cable Protection

Y-cable protection is available for the ONS 15454 transponder and muxponder cards (TXP_MR_10G, TXP_MR_2.5G, MXP_MR_2.5G, and MXP_2.5G_10G). To create Y-cable protection, you create a Y-cable protection group for two TXP or MXP cards in CTC, then connect the client ports of the two cards physically with a Y-cable. The single client signal is sent into the receive (Rx) Y-cable and is split between the two TXP or MXP cards. The two transmit (Tx) signals from the client side of the TXP or MXP cards are combined in the TX Y-cable into a single client signal. Only the active card signal passes through as the single TX client signal. The other card must have its laser turned off to avoid signal degradation where the Y-cable joins. Figure 7-55 shows the Y-cable signal flow.

Note Loss of Signal-Payload (LOS-P) alarms, also called Incoming Payload Signal Absent alarms, can occur on a split signal if the ports are not in a Y-cable protection group.

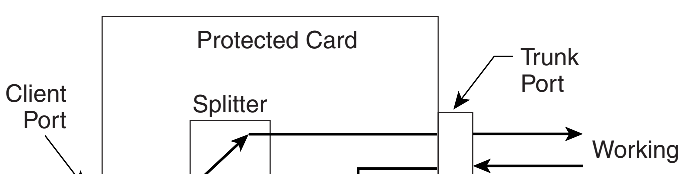
Figure 7-55 Y-Cable Protection



Splitter Protection

Splitter protection, shown in Figure 7-56, is provided with the TXPP_MR_2.5G and MXPP_MR_2.5G cards. To implement splitter protection, a client injects a single signal into the client Rx port. An optical splitter internal to the card then splits the signal into two separate signals and routes them to the two trunk Tx ports. The two signals are transmitted over diverse optical paths. The far-end MXPP or TXPP card uses an optical switch to choose one of the two trunk Rx port signals and injects it into the Tx client port. When using splitter protection with two MXPP or TXPP cards, there are two different optical signals that flow over diverse paths in each direction. In case of failure, the far-end switch must choose the appropriate signal using its built-in optical switch. The triggers for a protection switch are LOS, LOF, SF, or SD.

Figure 7-56 Splitter Protection



Ethernet Protection

Cisco ONS 15454 Ethernet cards use the IEEE 802.1D Spanning Tree Protocol (STP) and IEEE 802.1W Rapid Spanning Tree Protocol (RSTP) for Layer 2 protection, and uses SONET for Layer 1 protection.

Spanning Tree

STP is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two stations. Spanning-tree operation is transparent to end stations, which cannot detect whether they are connected to a single LAN segment or a switched LAN of multiple segments.

When you create fault-tolerant internetworks, you must have a loop-free path between all nodes in a network. The spanning-tree algorithm calculates the best loop-free path throughout a switched Layer 2 network. Switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The switches do not forward these frames, but use the frames to construct a loop-free path.

Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Switches might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network.

Spanning tree defines a tree with a root switch and a loop-free path from the root to all switches in the Layer 2 network. Spanning tree forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path.

When two interfaces on a switch are part of a loop, the spanning-tree port priority and path cost settings determine which interface is put in the forwarding state and which is put in the blocking state. The port priority value represents the location of an interface in the network topology and how well it is located to pass traffic. The path cost value represents media speed.

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.

Spanning Tree Parameters

Table 7-52 shows the 802.1D STP parameters for the Ethernet cards.

Table 7-52 802.1D 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

Table 7-52 802.1D Spanning Tree Parameters (continued)

Parameter	Description	Default	Range
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	NA	NA
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 IEEE 802.1T spanning tree extensions shown in Table 7-53.

Table 7-53 IEEE 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

RSTP provides rapid convergence of the spanning tree. It improves the fault tolerance of the network because a failure in one instance (forwarding path) does not affect other instances (forwarding paths). The most common initial deployment of RSTP is in the backbone and distribution layers of a Layer 2 switched network; this deployment provides the highly available network required in a service-provider environment.

RSTP improves the operation of the spanning tree while maintaining backward compatibility with equipment that is based on the (original) IEEE 802.1D spanning tree.

RSTP takes advantage of point-to-point wiring and provides rapid convergence of the spanning tree. Reconfiguration of the spanning tree can occur in less than 2 second (in contrast to 50 seconds with the default settings in the IEEE 802.1D spanning tree), which is critical for networks carrying delay-sensitive traffic such as voice and video.

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 7-54 lists the Ethernet topologies where SONET protection can be used for Ethernet circuits.

Table 7-54 SONET Protection for Ethernet Circuits

Topology	Path Protection	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

In-Service Low-Density to High-Density Upgrades

The ONS 15454 supports in-service upgrades for OC-N spans, OC-N cards, and electrical cards. Design rules for in-Service upgrades for OC-N spans and OC-N cards is covered in Chapter 2 of this document. This section of the document will focus on upgrading low-density electrical cards to high-density electrical cards.

Total DS-1 capacity can be increased from 112 to 224 DS-1 ports per shelf. Total DS-3 and EC-1 capacity can be increased from 48 to 192 ports.

Note The high-capacity DS-1 card will be available in a future release.

Note Support for the high-density EC-1 interface on the DS3/EC1-48 card is planned for a future release.

Upgrade Low-Density Electrical Cards to High-Density Electrical Cards

Only the 15454-SA-HD shelf assembly configured with MiniBNC, UBIC-H, or UBIC-V EIAs supports an in-service upgrade of low density DS-1 and DS-3 cards in a 1:N or 1:1 configuration to high-density electrical cards, which allows you to increase DS-1 and DS-3 capacity without affecting service. Upgrades will not be in-service if the ONS 15454 is configured with any other shelf assembly or other type of EIA.

Note During the upgrade some minor alarms and conditions appear and then clear on their own; however, there should be no Service-Affecting (SA, Major, or Critical) alarms if you are upgrading protected cards. Upgrading an unprotected card can be service affecting.

If future DS-1, DS-3, or EC-1 service demands may require upgrading low-density electrical cards to high-density electrical cards perform the following desing rules:

- Use Software Release 5.0 or higher.
- Configure the ONS 15454 with the high-density (HD) shelf assembly (15454-SA-HD).
- Configure the HD shelf with high-density EIAs (MiniBNC, UBIC-H, or UBIC-V).
- Do not mix different types of low-density electrical cards on the same side of the HD shelf.

- Configure working low-density electrical cards in slots 1 and 2 for the A side of the HD shelf, and 16 and 17 for the B side.
- Configure 1:N protection groups for N <= 2.
- Configure the protection cards in slot 3 for the A side of the HD shelf and slot 15 for the B side of the HD shelf.
- Configure slots 4, 5, 6, 12, 13, and 14 with either OC-N, Ethernet, or SAN cards.

In-service low-density to high-density upgrades are supported for slots 1, 2, and 3 on the A side of the HD shelf, and slots 15, 16, and 17 for the B side. Traffic on low-density DS-3 cards installed in slots 4, 5, 6 and 12, 13, 14 cannot be moved to ports on on the high-density DS3/EC1-48 cards in slots 1 and 2 or 16 and 17 without losing service greater than 50 miliseconds.

Once high-density cards have been activated in slots 1, 2, 3, and 15, 16, and 17, slots 4, 5, 6, and 12, 13, and 14 cannot support electrical cards. Slots 4, 5, 6, and 12, 13, and 14 can support OC-N, Ethernet, or SAN cards.

1:N Protection Groups

In-service low-density to high-density electrical card upgrades require that the working low-density cards be in slots 1, 2, 16, and 17. Slots 3 and 15 are used for 1:N protection groups.

For the A side of the HD shelf (slots 1, 2, 3, 4, 5, and 6), slot 3 will always be the protection card slot for high-density applications. For the B side of the HD shelf (slots 12, 13, 14, 15, 16, and 17), slot 15 will always be the protection card slot for high-density applications.

When performing an upgrade, the protection slot is upgraded first. Since a DS3/EC1-48 card can protect a DS3-12 card, the DS3N-12 protection card in slot 3 (15) is upgraded to a DS3/EC-1-48 card first. Traffic from the DS3-12 card in slot 1 (16) is then switched to the DS3/EC1-48 protect card. The DS3-12 card in slot 1 (16) is then upgraded to a DS3/EC1-48 card and traffic is switched back to slot 1 (16). The process is repeated for slot 2 (17). For detailed low-density to high-density electrical card upgrade procedures, refer to the Cisco ONS 15454 Procedure Guide.

1:1 Protection Groups

In-service low-density to high-density electrical card upgrades require that the working low-density cards be in slots 2 and 16. Slots 3 and 15 will be used for 1:1 protection groups just as described in the 1:N protection groups above.

When performing an upgrade, the protection slot is upgraded first. Since a DS3/EC1-48 card can protect a DS3-12 card, a DS3/EC1-48 is installed in slot 3 (15) first. The old 1:1 protection group is deleted and a new 1:1 protection group is created. Traffic from the DS3-12 card in slot 2 (16) is then switched to the DS3/EC1-48 protect card. The DS3-12 card in slot 1 (17) is upgrades to a DS3/EC1-48 card and traffic is switched back to slot 1 (17). The DS3-12 card in slot 2 (16) is removed.

GBICs and SFPs

The ONS 15454 Ethernet cards use industry standard Small Form-factor Pluggable connectors (SFPs) and Gigabit Interface Converter (GBIC) modular receptacles. The ML-Series Gigabit Ethernet (GE) cards use standard Cisco SFPs. The Gigabit E-Series card and the G-Series card use standard Cisco GBICs. With Software Release 4.1 and later, G-Series cards can also be equipped with dense wavelength division multiplexing (DWDM) and coarse wavelength division multiplexing (CWDM) GBICs to function as Gigabit Ethernet transponders.

For all Ethernet cards, the type of GBIC or SFP plugged into the card is displayed in CTC and TL1. Cisco offers GBICs and SFPs as separate orderable products.

Table 7-55 lists Cisco ONS 15454 Ethernet cards with their compatible GBICs and SFPs.

Table 7-55 GBIC and SFP Card Compatibility

Card	Compatible GBIC or SFP	Cisco Top Assembly Number (TAN)
E1000-2 E1000-2-G	ONS-GC-GE-SX ONS-GC-GE-LX 15454-GBIC-SX 15454E-GBIC-SX 15454-GBIC-LX/LH 15454E-GBIC-LX/LH	30-0759-01 800-06780-01[1] 10-1743-01 30-0703-01
FC-MR-4	ONS-GC-GE-SX ONS-GC-GE-LX 15454-GBIC-SX 15454E-GBIC-SX 15454-GBIC-LX/LH 15454E-GBIC-LX/LH ONS-GX-2FC-MMI ONS-GX-2FC-SML	30-0759-01 800-06780-01 10-1743-01 30-0703-01 10-2015-01 10-2016-01
G1000-4 G1K-4	ONS-GC-GE-SX ONS-GC-GE-LX ONS-GC-GE-ZX 15454-GBIC-SX 15454E-GBIC-SX 15454-GBIC-LX/LH 15454E-GBIC-LX/LH 15454-GBIC-ZX 15454E-GBIC-ZX 15454-GBIC-xx.x[2] 15454E-GBIC-xx.x[2] 15454-GBIC-xxxx[3] 15454E-GBIC-xxxx[3]	30-0759-01 800-06780-01 10-1743-01 30-0703-01 30-0848-01 10-1744-01 10-1845-01 through 10-1876-01 10-1845-01 through 10-1876-01 10-1453-01 through 10-1460-01 10-1453-01 through 10-1460-01
ML1000-2	15454-SFP-LC-SX 15454E-SFP-LC-SX 15454-SFP-LC-LX/LH 15454E-SFP-LC-LX/LH	30-1301-01 30-1301-01 30-1299-01 30-1299-01

1. This TAN is only compatible with ONS 15454-E1000-2 or 15454-E1000-2-G cards.

2. xx.x defines the 32 possible wavelengths.
3. xxxx defines the 8 possible wavelengths.

Table 7-56 lists the transponder and muxponder cards and their compatible SFPs.

Table 7-56 SFP Card Compatibility

Card	Compatible SFP	Cisco Top Assembly Number (TAN)
MXP_2.5G_10G	15454-SFP-OC48-IR=	10-1975-01
MXP_2.5G_10E	ONS-SE-2G-S1=	10-2017-01
MXP_MR_2.5G	15454-SFP-GE+-LX=	10-1832-03
MXPP_MR_2.5G	15454E-SFP-GE+-LX=	10-1832-03
	15454-SFP-GEFC-SX=	10-1833-01
	15454E-SFP-GEFC-S=	10-1833-02
TXP_MR_2.5G	15454-SFP3-1-IR=	10-1828-01
TXPP_MR_2.5G	15454E-SFP-L.1.1=	10-1828-01
	15454-SFP12-4-IR=	10-1976-01
	15454E-SFP-L.4.1=	10-1976-01
	15454-SFP-OC48-IR=	10-1975-01
	15454E-SFP-L.16.1=	10-1975-01
	ONS-SE-2G-S1=	10-2017-01
	15454-SFP-200=	10-1750-01
	15454E-SFP-200=	10-1750-01
	15454-SFP-GEFC-SX=	10-1833-01
	15454E-SFP-GEFC-S=	10-1833-02
	15454-SFP-GE+-LX=	10-1832-01
	15454E-SFP-GE+-LX=	10-1832-02

CHAPTER 8

IP Networking

This chapter describes how you must manage ONS 15454 nodes within a TCP/IP network environment. For IP setup instructions, refer to the *Cisco ONS 15454 Procedure Guide*.

The following topics are covered 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.

You can connect ONS 15454s within an IP environment in any of the following ways:

- 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.
- Static routes can be created 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 SOCKS proxy server controls the visibility and accessibility between CTC computers and ONS 15454 nodes.

IP Addressing Scenarios

ONS 15454 IP addressing generally has nine common scenarios or configurations. Use the following scenarios as building blocks for more complex network configurations. as building blocks for more complex network configurations. Table 8-1 provides a general list of items to check when setting up ONS 15454 nodes in IP networks.

Table 8-1 General ONS 15454 IP Troubleshooting Checklist

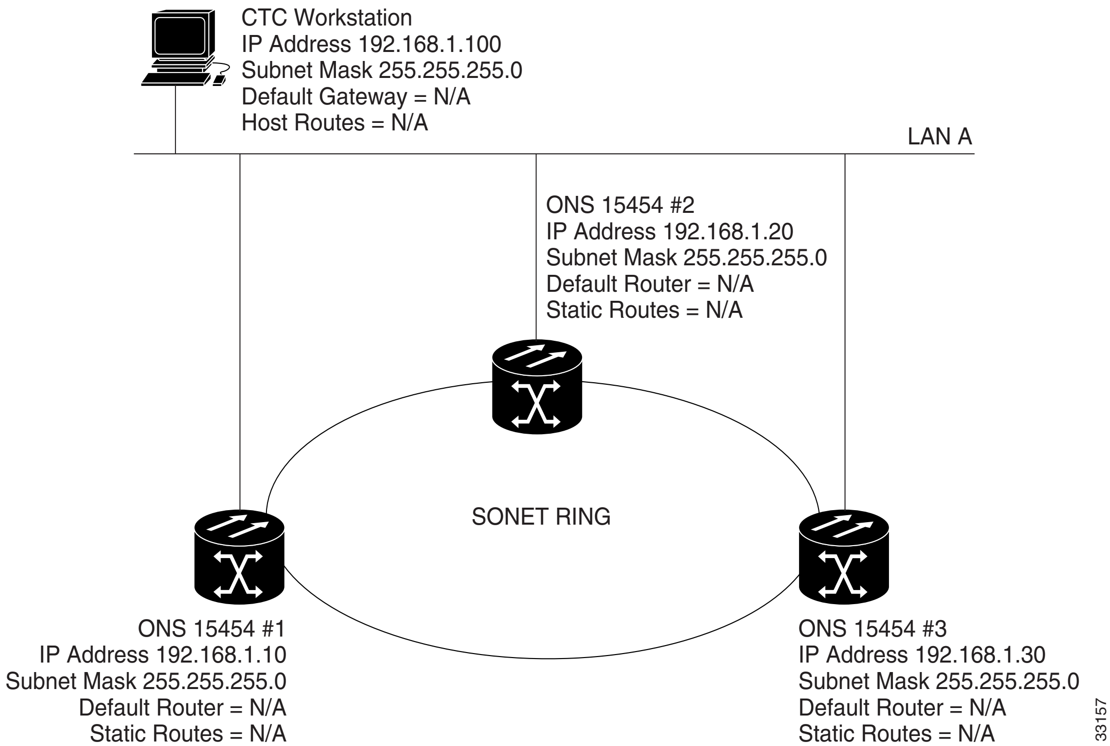
Item	What to Check
Link integrity	Verify that link integrity exists between: • CTC computer and network hub/switch • ONS 15454s (backplane wire-wrap pins or RJ-45 port) and network hub/switch • Router ports and hub/switch ports
ONS 15454 hub/switch ports	If connectivity problems occur, set the hub or switch port that is connected to the ONS 15454 to 10 Mb/s half-duplex.
Ping	Ping the node to test connections between computers and ONS 15454 nodes.
IP addresses/subnet masks	Verify that ONS 15454 IP addresses and subnet masks are set up correctly.
Optical connectivity	Verify that ONS 15454 optical trunk ports are in service and that a DCC is enabled on each trunk port.

Note The TCC2P secure mode option allows two IP addresses to be provisioned for the node, one for the backplane LAN port and one for the TCC2P TCP/IP port. Secure mode IP addressing examples are provided in the "Scenario 9: IP Addressing with Secure Mode Enabled" section. IP addresses shown in the other scenarios assume that secure mode is not enabled. If secure mode is enabled, the IP addresses shown in the examples apply to the backplane LAN port.

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

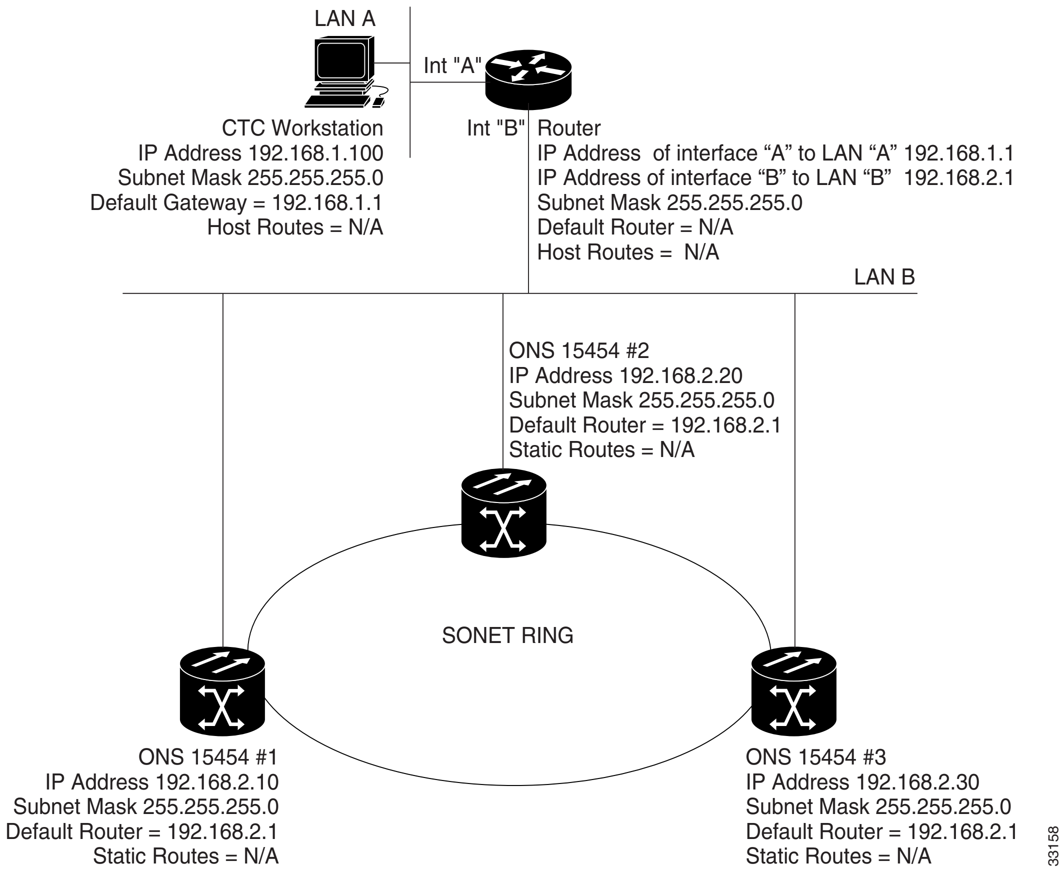


Scenario 2: CTC and ONS 15454 Nodes Connected to a Router

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

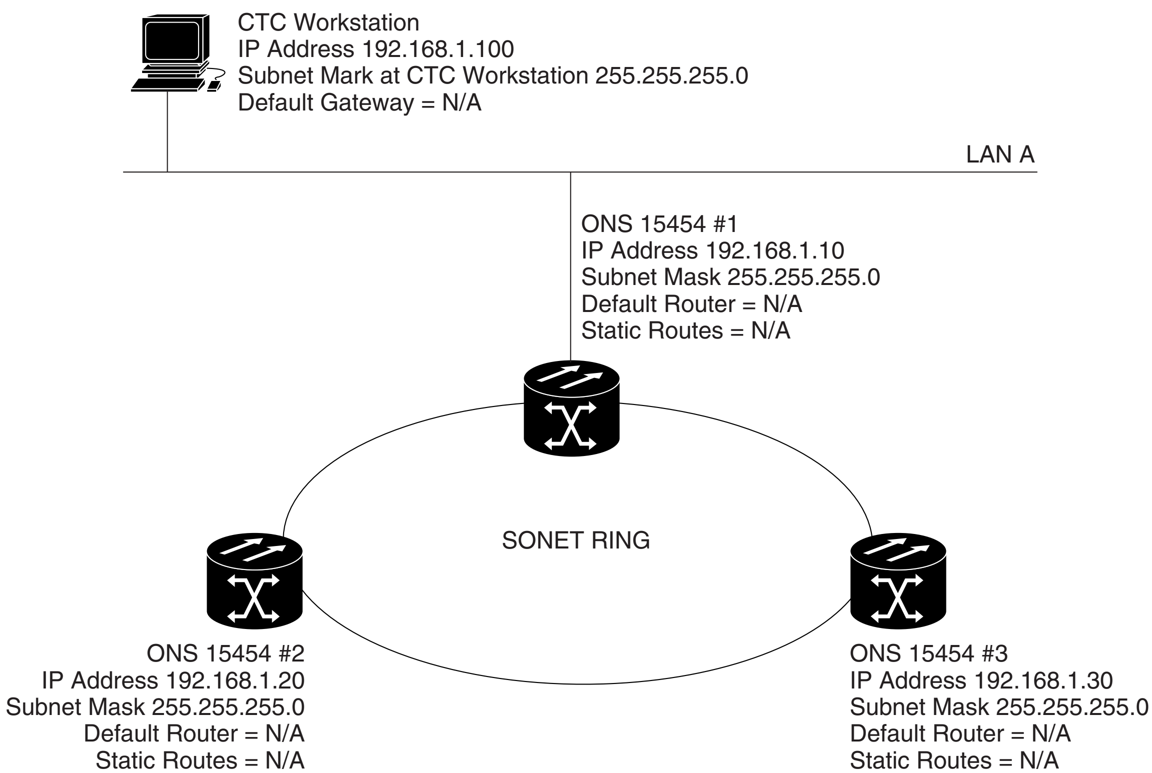
ARP matches higher-level IP addresses to the physical addresses of the destination host. It uses a lookup table (called ARP cache) to perform the translation. When the address is not found in the ARP cache, a broadcast is sent out on the network with a special format called the ARP request. If one of 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 15454s 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 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.

Note 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 SOCKS Proxy Server shown in Scenario 7.

Figure 8-3 Using Proxy ARP

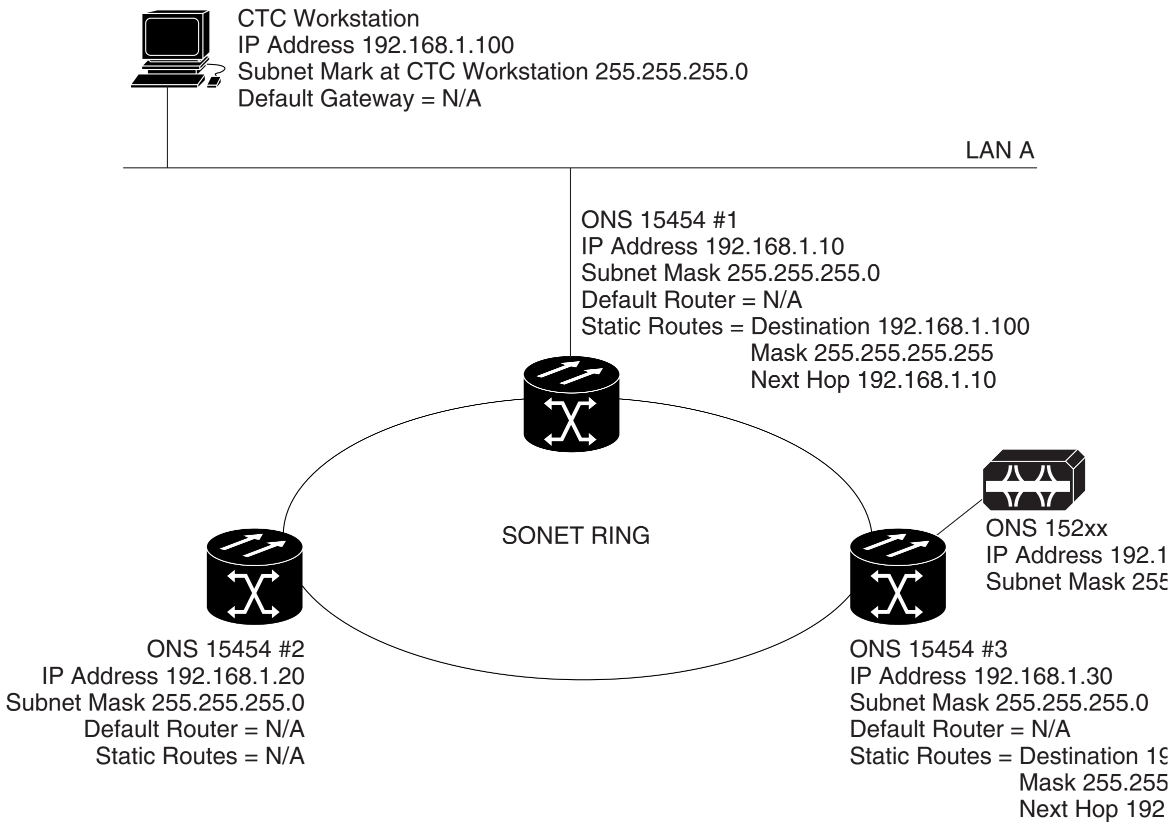


You can also use proxy ARP to communicate with hosts attached to the craft Ethernet ports of DCC-connected nodes (see Figure 8-4). The node with an attached host must have a static route to the host. Static routes are propagated to all DCC peers using OSPF. The existing proxy ARP node is the gateway for additional hosts. Each node examines its routing table for routes to hosts that are not connected to the DCC network but are within the subnet. The existing proxy server replies to ARP requests for these additional hosts with the node MAC address. The existence of the host route in the routing table ensures that the IP packets addressed to the additional hosts are routed properly. Other than establishing a static route between a node and an additional host, no provisioning is necessary. The following restrictions apply:

- Only one node acts as the proxy ARP server for any given additional host.
- A node cannot be the proxy ARP server for a host connected to its Ethernet port.

In Figure 8-4, Node 1 announces to Node 2 and 3 that it can reach the CTC host. Similarly, Node 3 announces that it can reach the ONS 152xx. The ONS 152xx is shown as an example; any network element can be set up as an additional host.

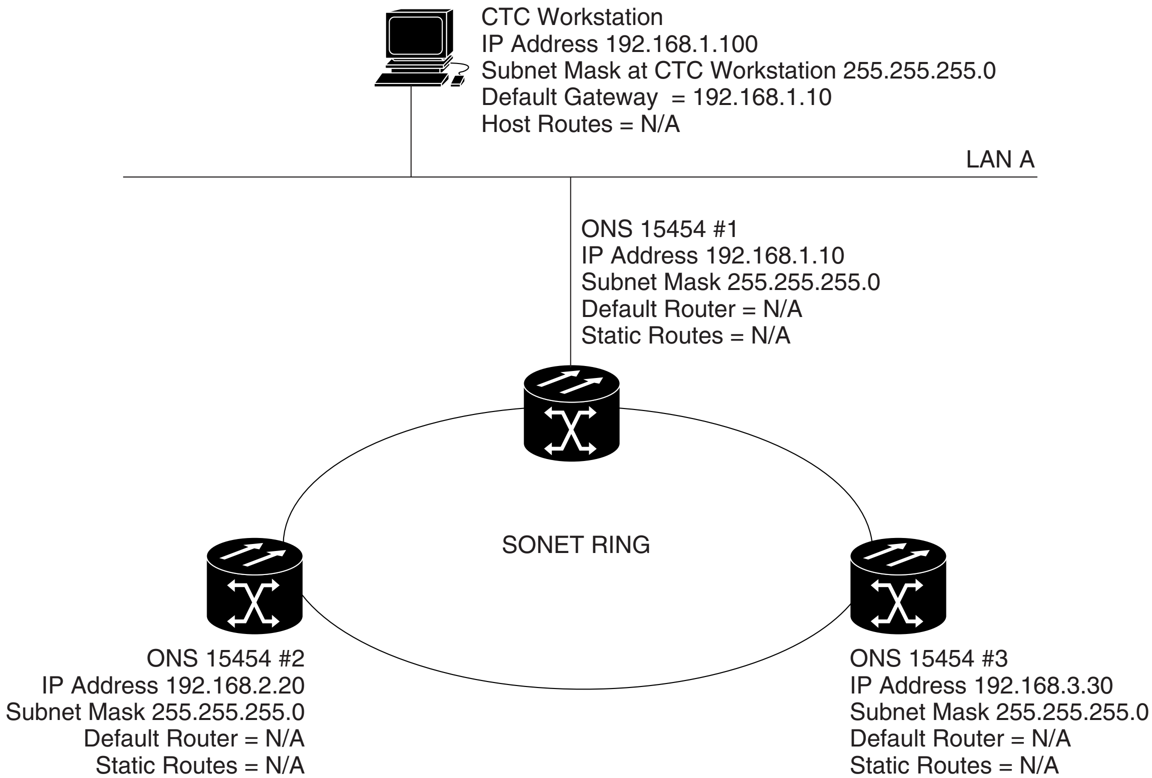
Figure 8-4 Scenario 3: Using Proxy ARP with Static Routing



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 (seeFigure 8-5). 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 8-5 Default Gateway on the CTC Computer



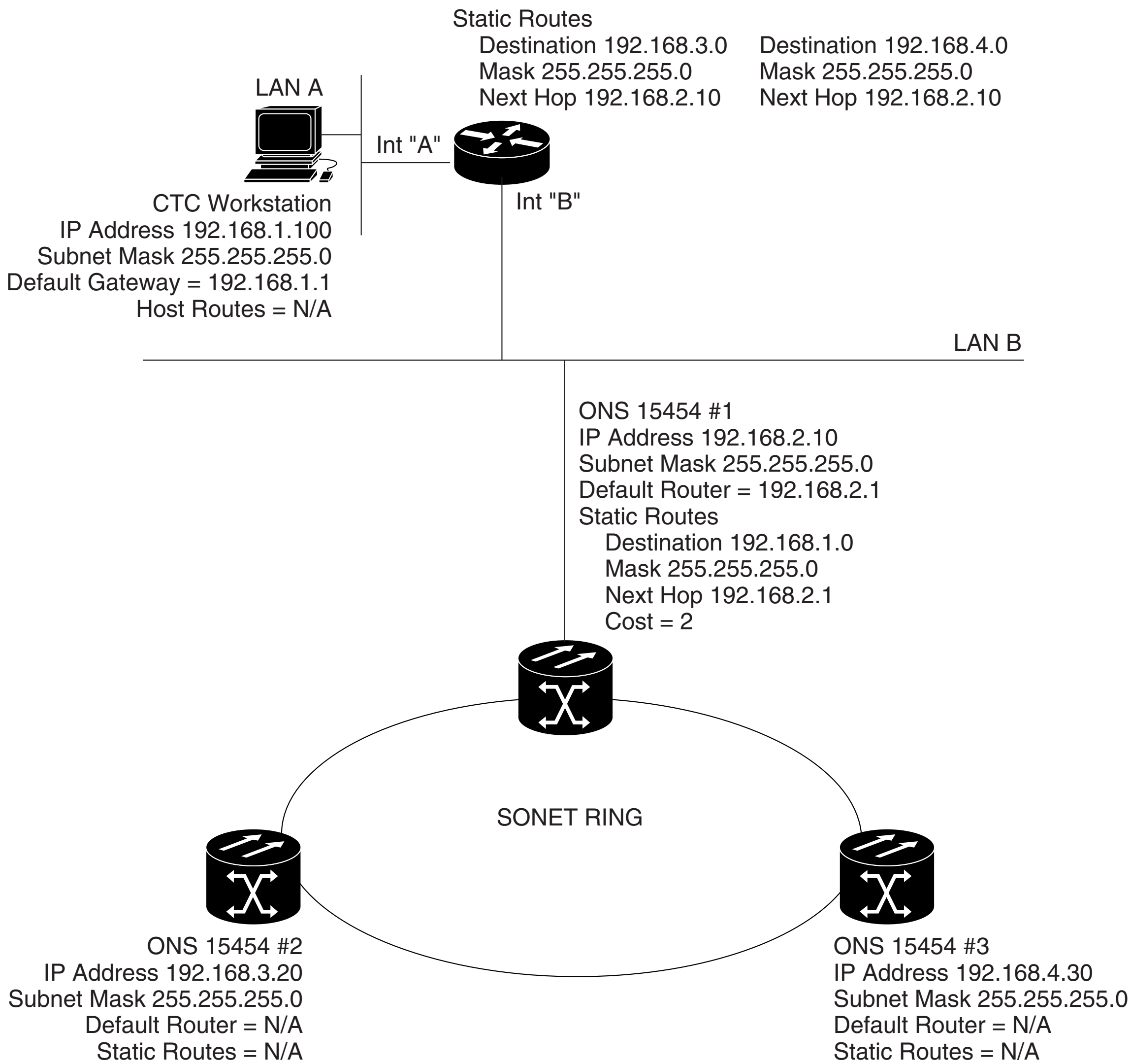
Scenario 5: Using Static Routes to Connect to LANs

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 8-6, 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 8-6 Static Route With One CTC Computer Used as a Destination

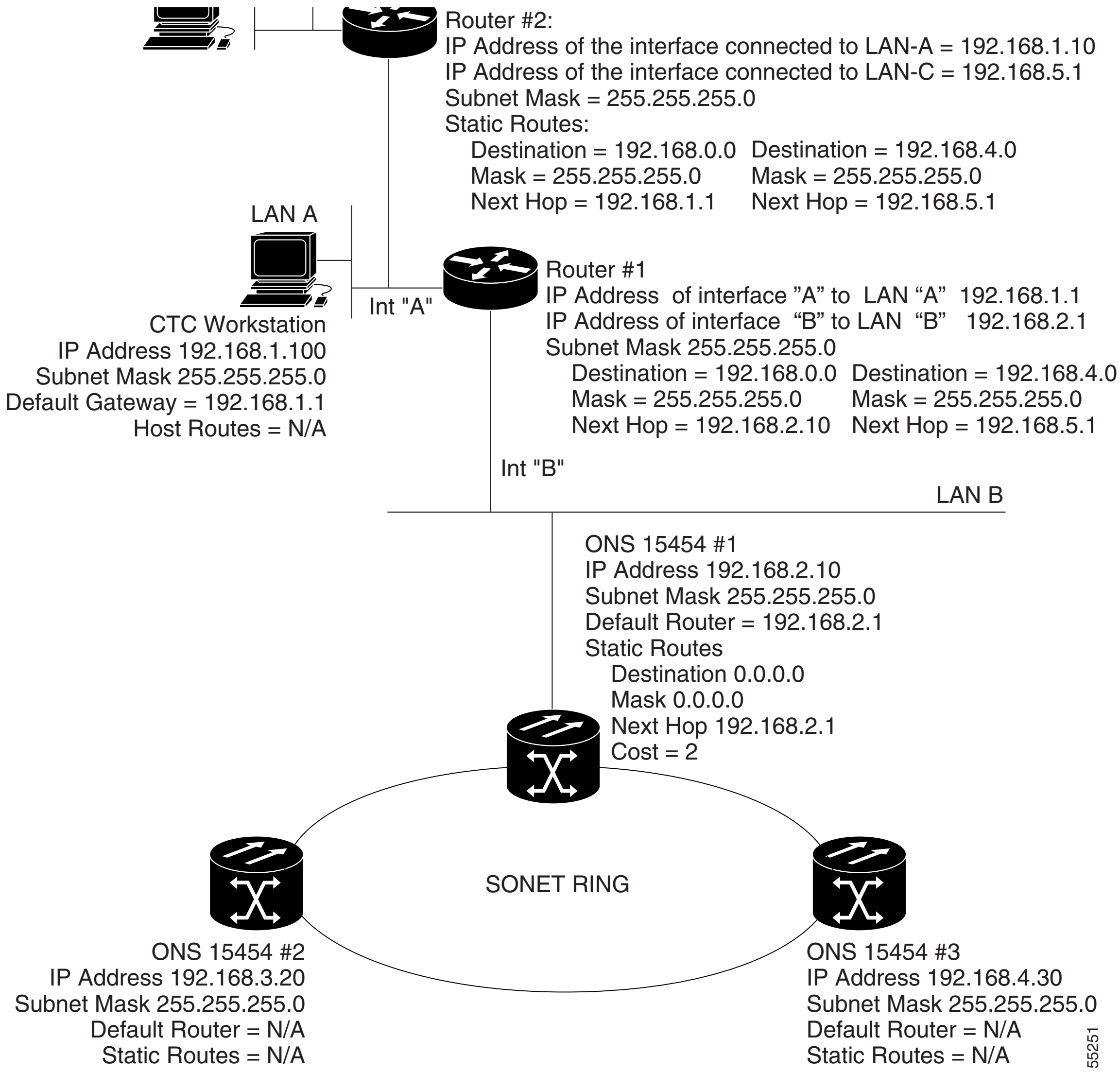


The destination and subnet mask entries control access to the ONS 15454 nodes as follows:

- 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 8-7 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 8-7 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 8-8 shows a network enabled for OSPF. Figure 8-9 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 8-8 OSPF Enabled

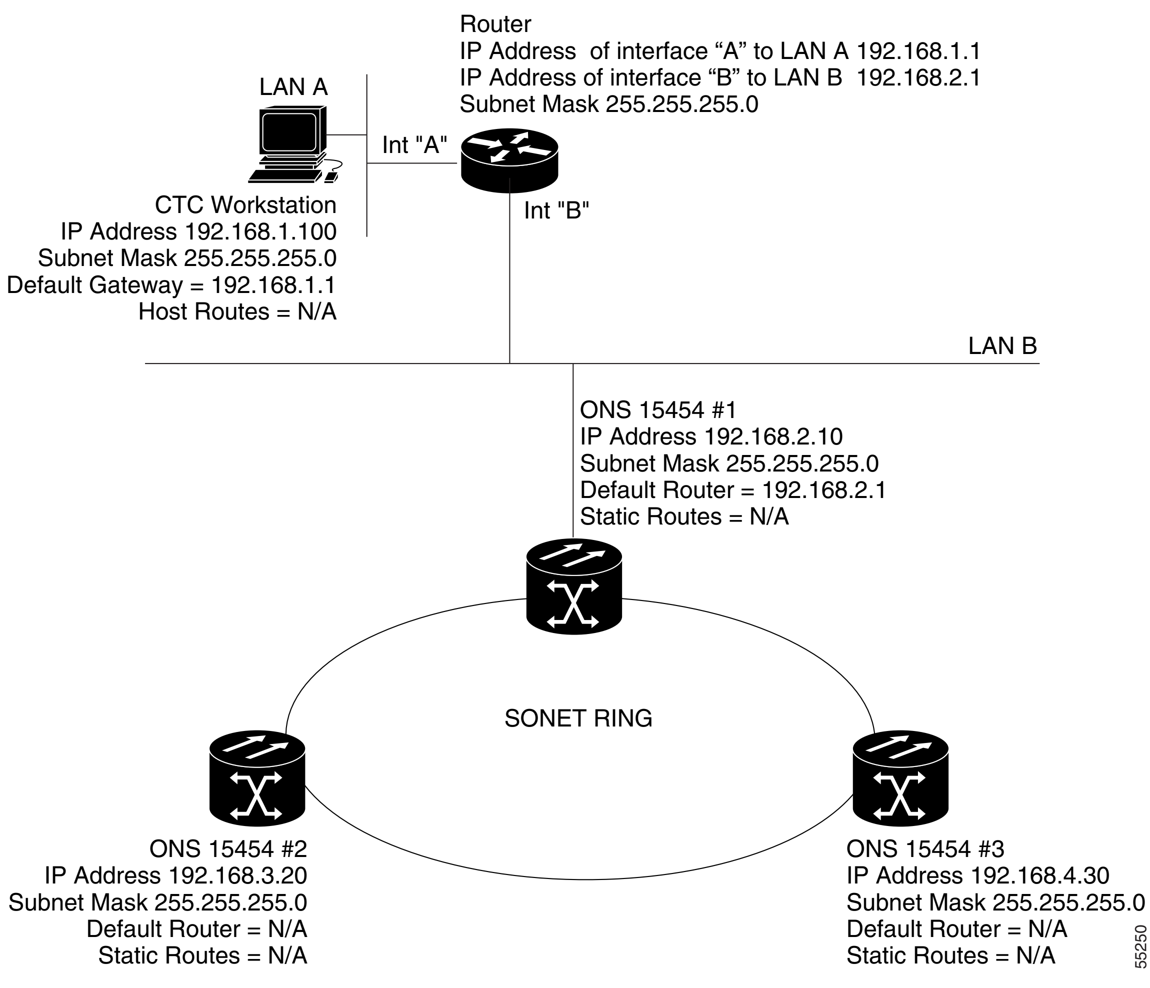
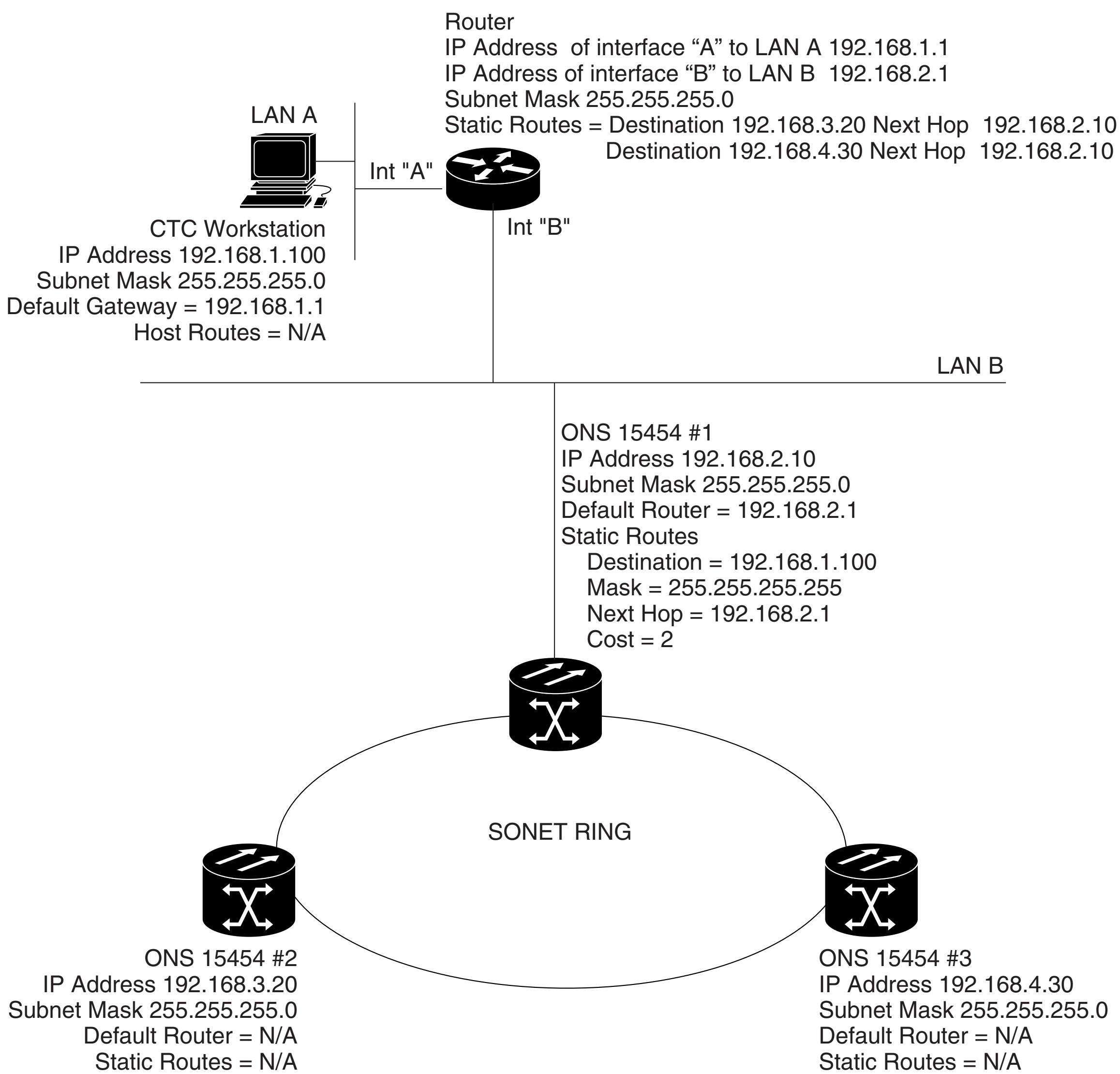


Figure 8-9 OSPF Not Enabled



Scenario 7: Provisioning the ONS 15454 SOCKS Proxy Server

The ONS 15454 SOCKS 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 TCC2/TCC2P 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.
- Processes 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 SOCKS proxy server is provisioned using the Enable SOCKS proxy server on port check box on the Provisioning > Network >General tab (see Figure 8-10). If checked, 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 not selected, the node does not proxy for any CTC clients, although any established proxy connections continue until the CTC client exits. In addition, you can set the SOCKS proxy server as an ENE or a GNE as follows:

Note If you launch CTC against a node through a NAT (Network Address Translation) or PAT (Port Address Translation) 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.

- External Network Element (ENE) - If set as an ENE, the ONS 15454 neither installs nor advertises default or static routes. CTC computers can communicate with the ONS 15454 using the TCC2/TCC2P craft port, but they cannot communicate directly with any other DCC-connected ONS 15454.

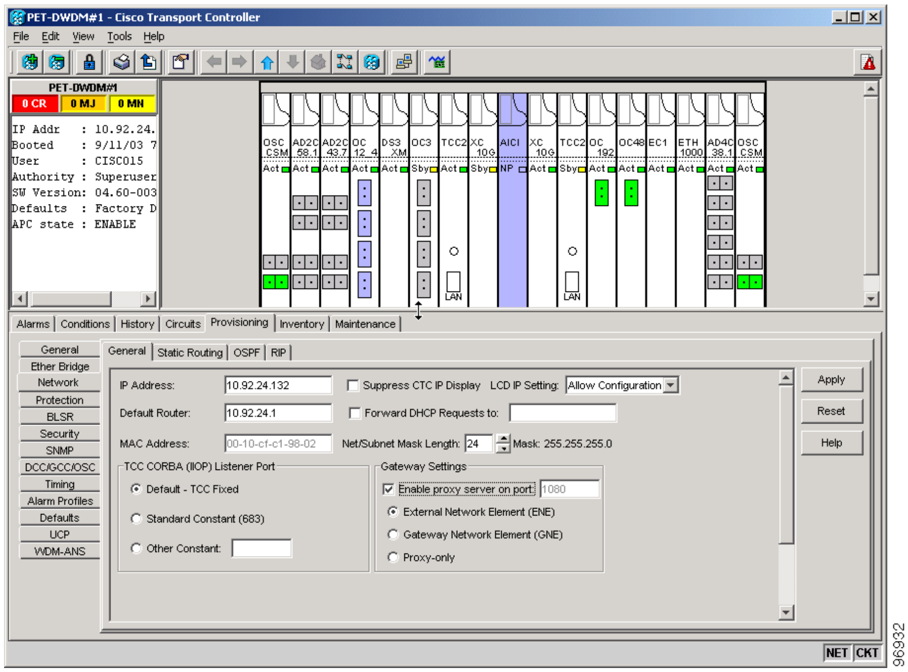
  In addition, firewall is enabled, which means that the node prevents IP traffic from being routed between the DCC and the LAN port. The ONS 15454 can communicate with machines connected to the LAN port or connected through the DCC. However, the DCC-connected machines cannot communicate with the LAN-connected 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.
- Gateway Network Element (GNE) - If set as a GNE, the CTC computer is visible to other DCC-connected nodes and firewall is enabled.
- Proxy-only - If Proxy-only is selected, firewall is not enabled. CTC can communicate with any other DCC-connected ONS 15454 nodes.

Proxy Server Port Reduction

In releases prior to 4.0, CTC was able to manage nodes behind routers that performed 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

4.0 and higher, CTC can now manage nodes behind routers that perform NAT or 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 8-10 SOCKS Proxy Server Gateway Settings



[Figure 8-11](#) shows an ONS 15454 SOCKS proxy server implementation. A GNE ONS 15454 is connected to a central office LAN and to ENE ONS 15454s. 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 collocated, the craft LAN ports could be connected to a hub. However, the hub should have no other network connections.

Figure 8-11 ONS 15454 SOCKS Proxy Server with GNE and ENEs on the Same Subnet

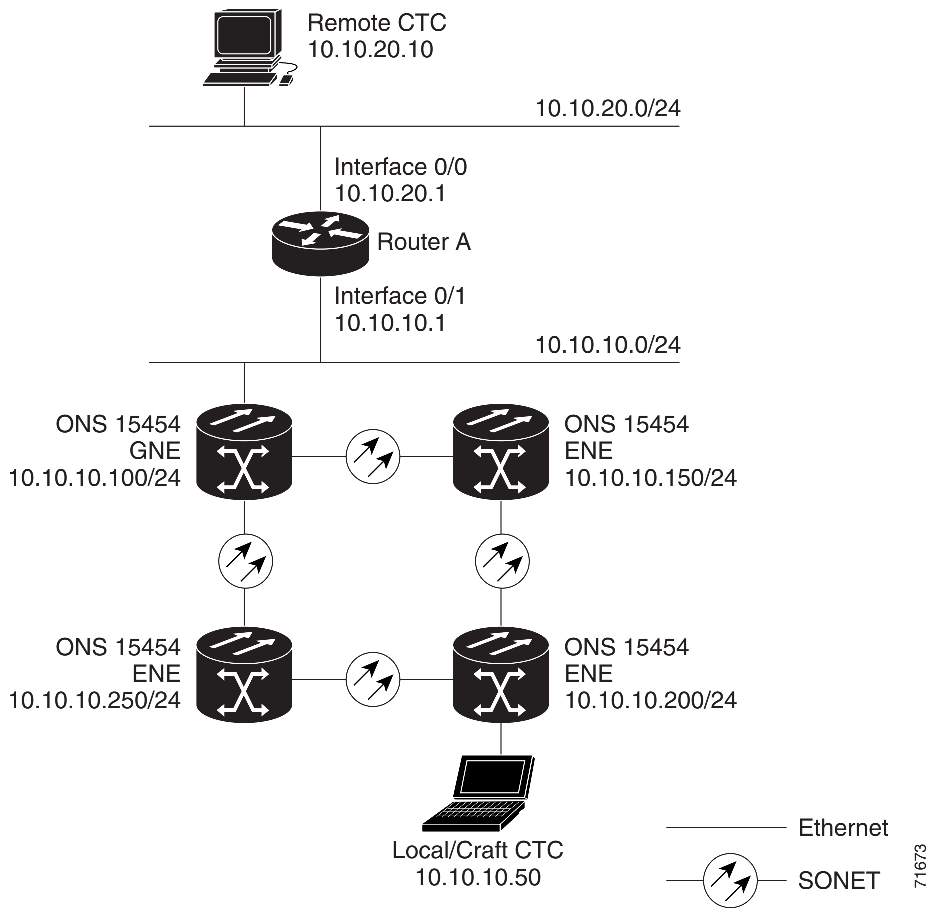


Table 8-2 shows recommended settings for ONS 15454 GNEs and ENEs in the configuration shown in Figure 8-11.

Table 8-2 ONS 15454 Gateway and ENE Settings

Setting	ONS 15454 Gateway NE	ONS 15454 ENE
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 8-12 shows the same SOCKS proxy server implementation with ONS 15454 ENEs on different subnets. Figure 8-13 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 8-2.

Figure 8-12 ONS 15454 SOCKS Proxy Server with GNE and ENEs on Different Subnets

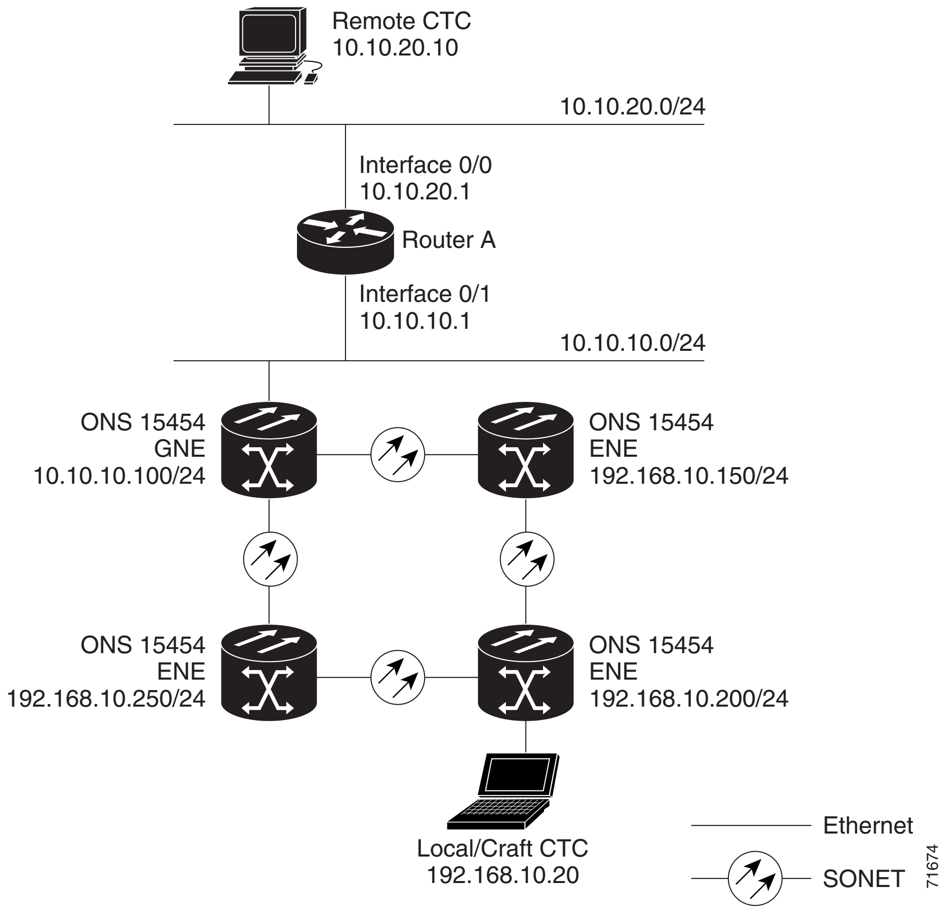


Figure 8-13 ONS 15454 SOCKS Proxy Server With ENEs on Multiple Rings

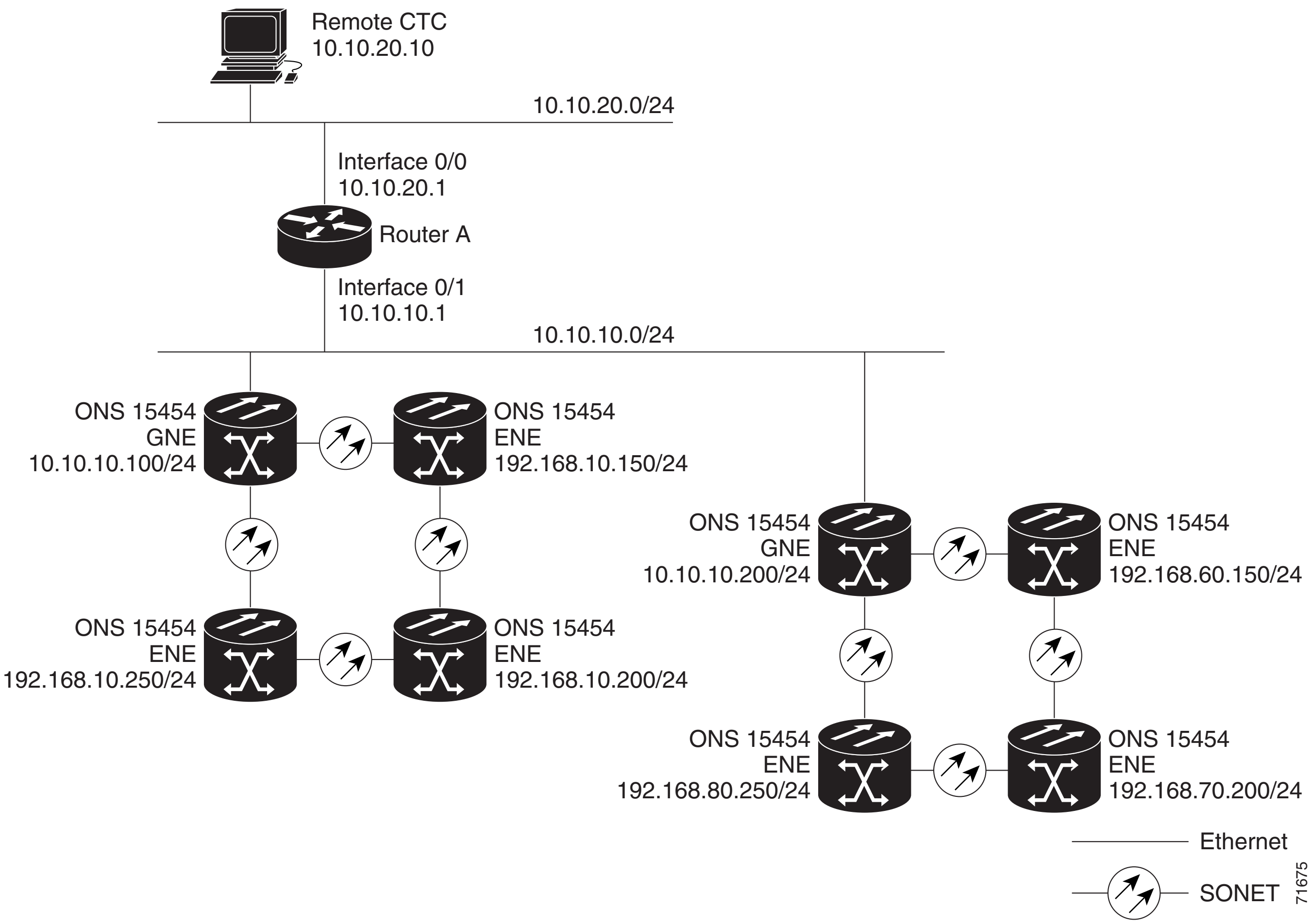


Table 8-3 shows the rules the ONS 15454 follows to filter packets when Enable Firewall is enabled. If the packet is addressed to the ONS 15454, additional rules, shown in Table 8-4, are applied. Rejected packets are silently discarded.

Table 8-3 SOCKS Proxy Server Firewall Filtering Rules

Packets arriving at:	Are accepted if the IP destination address is:
TCC2/TCC2P 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 8-4 SOCKS Proxy Server Firewall Filtering Rules When Packet Addressed to ONS 15454

Packets Arrive At	Accepted	Rejected
TCC2/TCC2P Ethernet Interface	All UDP[1] packets except those in the Rejected column.	UDP packets addressed to the SNMP trap relay port (391).
DCC Interface	• All UDP packets • All TCP[2] packets except those in the Rejected column. • OSPF packets. • ICMP[3] packets.	TCP packets addressed to the telnet port. TCP packets addressed to the proxy server port. All packets other than UDP, TCP, OSPF, ICMP.

1. UDP = User Datagram Protocol
2. TCP = Transmission Control Protocol
3. ICMP = Internet Control Message Protocol

If you implement the SOCKS proxy server, note that all DCC-connected ONS 15454 nodes on the same Ethernet segment must have the same Gateway setting. Mixed values will produce unpredictable results and may leave some nodes unreachable through the shared Ethernet segment.

If nodes become unreachable, 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 and change its provisioning.

Scenario 8: Dual GNEs on a Subnet

The ONS 15454 provides GNE load balancing, which allows CTC to reach ENEs over multiple GNEs without the ENEs being advertised over OSPF. This feature allows a network to quickly recover from the loss of GNE, even if the GNE is on a different subnet. If a GNE fails, all connections through that GNE fail. CTC disconnects from the failed GNE and from all ENEs for which the GNE was a proxy, and then reconnects through the remaining GNEs. GNE load balancing reduces the dependency on the launch GNE and DCC bandwidth, both of which enhance CTC performance. Figure 8-14 shows a network with dual GNEs on the same subnet.

Figure 8-14 Dual GNEs on the Same Subnet

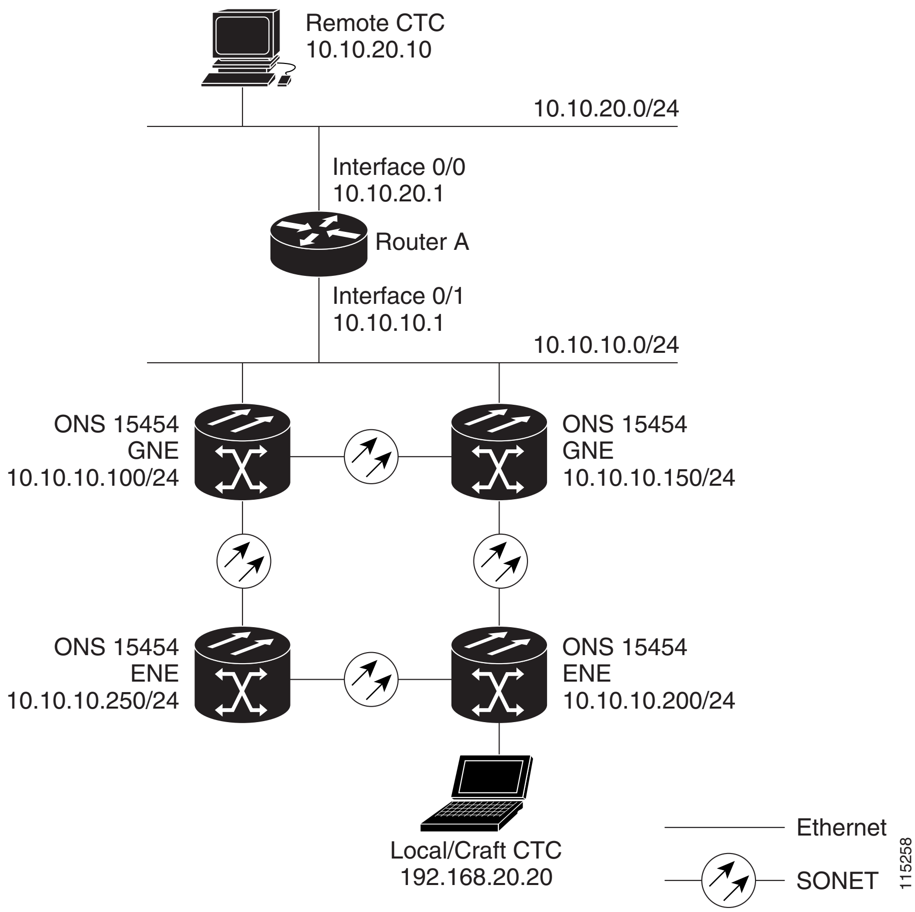
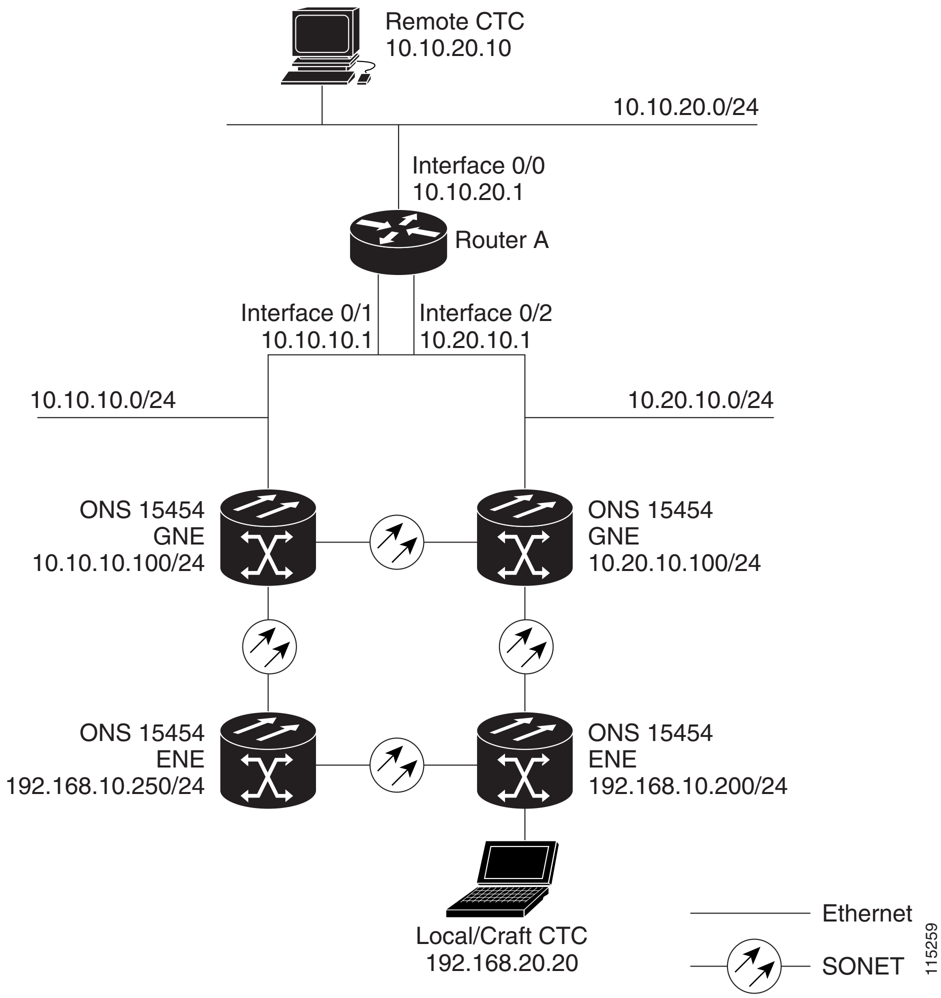


Figure 8-15 shows a network with dual GNEs on different subnets.

Figure 8-15 Dual GNEs on Different Subnets



Scenario 9: IP Addressing with Secure Mode Enabled

TCC2P cards running Software Release 5.0 and higher provide a secure mode option allowing you to provision two IP addresses for the ONS 15454. One IP address is provisioned for the ONS 15454 backplane LAN port. The other IP address is provisioned for the TCC2P TCP/IP Ethernet port. The two IP addresses provide an additional layer of separation between the TCC2P access port and the backplane LAN port. If secure mode is enabled, the IP addresses provisioned for the TCC2P TCP/IP port must follow general IP addressing guidelines. In addition, TCC2P IP addresses must reside on a different subnet from the backplane LAN port and ONS 15454 default router IP addresses.

The IP address assigned to the backplane LAN port becomes a private address, which is used to connect the ONS 15454 GNE to an OSS (Operations Support System) through a central office LAN or private enterprise network. In secure mode, the backplane's LAN IP address is not displayed on the CTC node view or to a technician directly connected to the node by default. This default can be changed to allow the backplane IP address to be viewed on CTC only by a Superuser.

Figure 8-16 shows an example of ONS 15454 nodes on the same subnet with secure mode enabled.

Note Secure mode is not available if TCC2 cards are installed, if only one TCC2P card is installed, or if TCC2P cards are installed with a software release prior to R5.0.

Figure 8-16 ONS 15454 GNE and ENE Nodes on the Same Subnet with Secure Mode Enabled

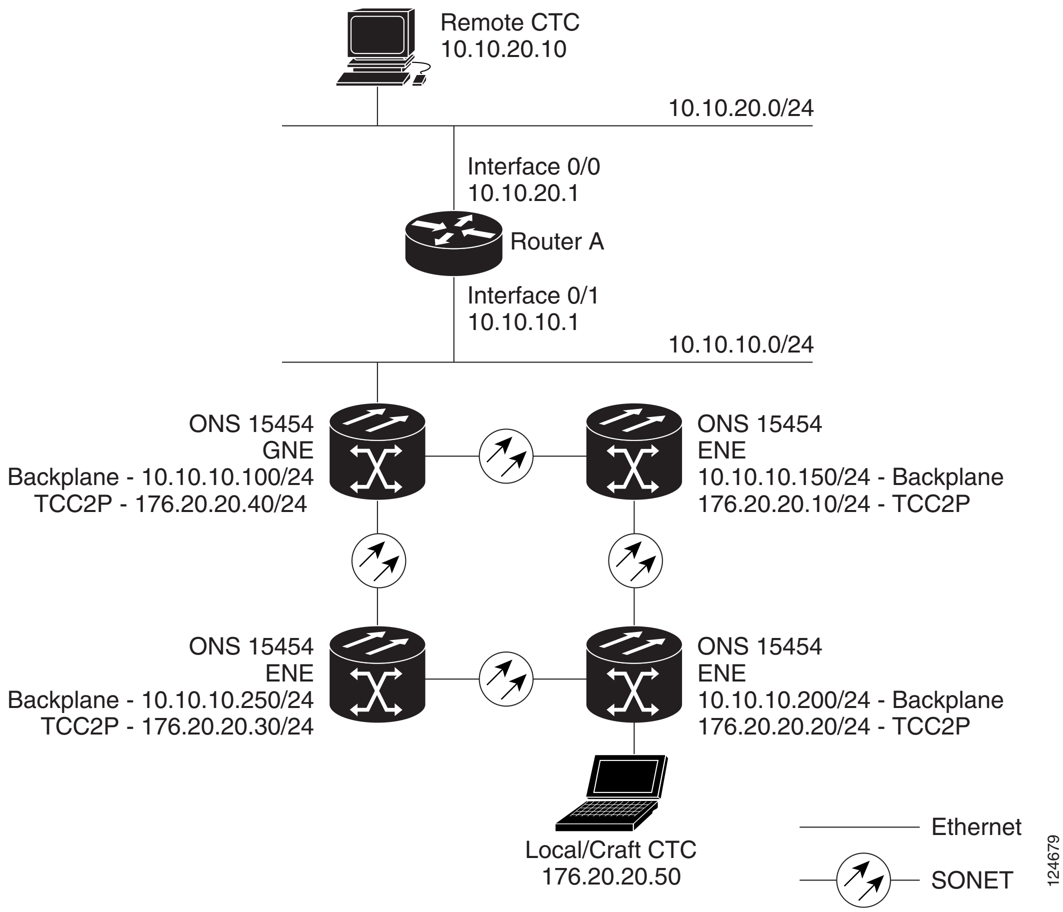
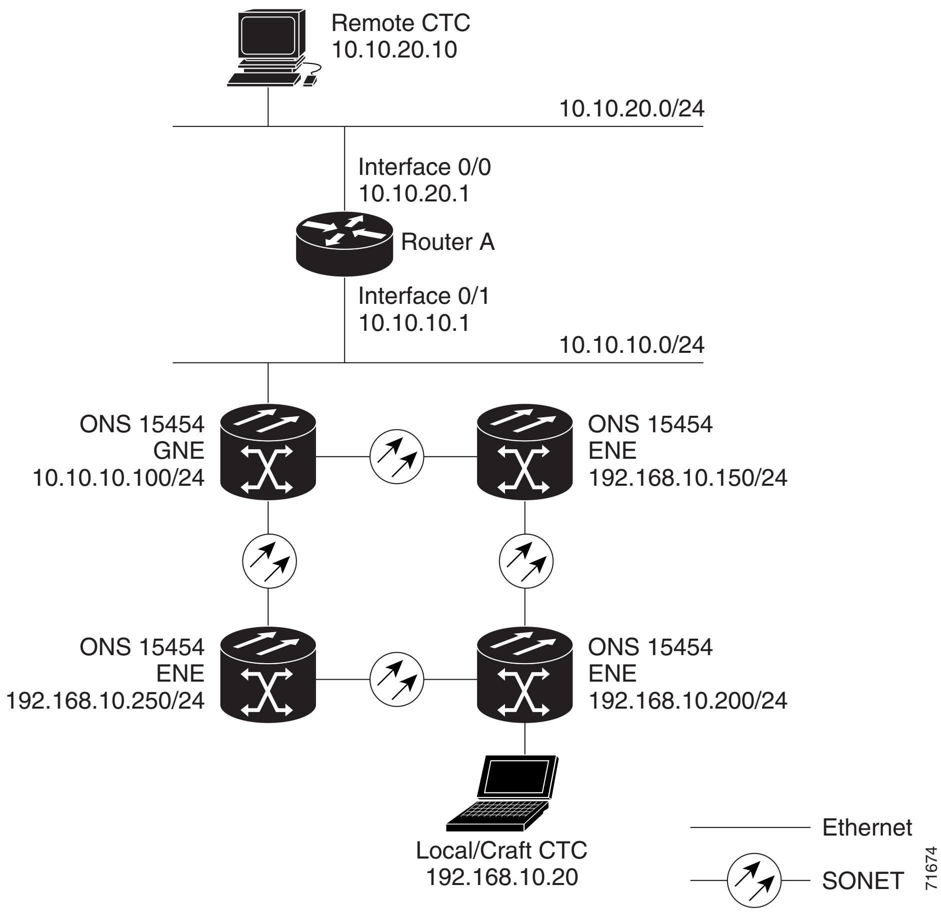


Figure 8-17 shows an example of ONS 15454 nodes connected to a router with secure mode enabled. In each example, TCC2P port addresses are on a different subnet from the node backplane addresses.

Figure 8-17 ONS 15454 GNE and ENEs on Different Subnets with Secure Mode Enabled



Routing Table

ONS 15454 routing information is displayed on the Maintenance > Routing Table tabs (see Figure 8-18. 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 TCC2/TCC2P and 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 8-18 Viewing the ONS 15454 Routing Table

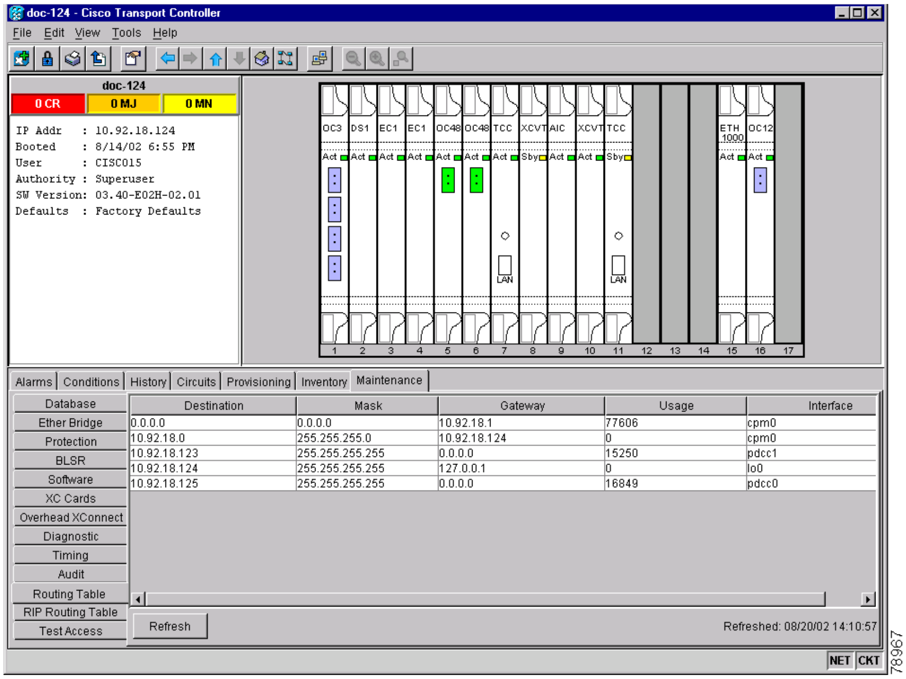


Table 8-5 shows sample routing entries for an ONS 15454.

Table 8-5 Sample Routing Table Entries

Entry	Destination	Mask	Gateway	Usage	Interface
1	0.0.0.0	0.0.0.0	172.20.214.1	265103	cpm0
2	172.20.214.0	255.255.255.0	172.20.214.92	0	cpm0
3	172.20.214.92	255.255.255.255	127.0.0.1	54	lo0
4	172.20.214.93	255.255.255.255	0.0.0.0	16853	pdcc0
5	172.20.214.94	255.255.255.255	172.20.214.93	16853	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 8-6 shows the ports that are used by the TCC2/TCC2P.

Table 8-6 Ports Used by the TCC2/TCC2P

Port	Function	Action[1]
0	Never used	D
20	FTP	D
21	FTP control	D
22	SSH	D
23	Telnet	D
80	HTTP	D
111	SUNRPC	NA
161	SNMP traps destinations	D
162	SNMP traps destinations	D
513	rlogin (not used; but port is in use)	D
683	CORBA IIOP	OK
1080	Proxy server	D

Table 8-6 Ports Used by the TCC2/TCC2P (continued)

Port	Function	Action[1]
2001-2017	I/O card Telnet	D
2018	DCC processor on active TCC2/TCC2P	D
2361	TL1	D
3082	Raw TL1	D
3083	TL1	D
5001	BLSR server port	D
5002	BLSR client port	D
7200	SNMP input port	D
9100	EQM port	D
9401	TCC boot port	D
9999	Flash manager	D
10240-12288	Proxy client	D
57790	Default TCC listener port	OK

1. D = deny, NA = not applicable, OK = do not deny

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 ****

Open GNE

The ONS 15454 can communicate with non-ONS nodes that do not support point-to-point protocol (PPP) vendor extensions or OSPF type 10 opaque link-state advertisements (LSA), both of which are necessary for automatic node and link discovery. An open GNE configuration allows the DCC-based network to function as an IP network for non-ONS nodes.

To configure an open GNE network, you can provision SDCC, LDCC, and GCC terminations to include a far-end, non-ONS node using either the default IP address of 0.0.0.0 or a specified IP address. You provision a far-end, non-ONS node by checking the "Far End is Foreign" check box during SDCC, LDCC, and GCC creation. The default 0.0.0.0 IP address allows the far-end, non-ONS node to provide the IP address; if you set an IP address other than 0.0.0.0, a link is established only if the far-end node identifies itself with that IP address, providing an extra level of security.

By default, the SOCKS proxy server only allows connections to discovered ONS peers and the firewall blocks all IP traffic between the DCC network and LAN. You can, however, provision proxy tunnels to allow up to 12 additional destinations for SOCKS version 5 connections to non-ONS nodes. You can also provision firewall tunnels to allow up to 12 additional destinations for direct IP connectivity between the DCC network and LAN. Proxy and firewall tunnels include both a source and destination subnet. The connection must originate within the source subnet and terminate within the destination subnet before either the SOCKS connection or IP packet flow is allowed.

To set up proxy and firewall subnets in CTC, use the Provisioning > Network > Proxy and Firewalls subtabs. The availability of proxy and/or firewall tunnels depends on the network access settings of the node:

- If the node is configured with the SOCKS proxy server enabled in GNE or ENE mode, you must set up a proxy tunnel and/or a firewall tunnel.
- If the node is configured with the SOCKS proxy server enabled in proxy-only mode, you can set up proxy tunnels. Firewall tunnels are not allowed.
- If the node is configured with the SOCKS proxy server disabled, neither proxy tunnels or firewall tunnels are allowed.

Figure 8-19 shows an example of a foreign node connected to the DCC network. Proxy and firewall tunnels are useful in this example because the GNE would otherwise block IP access between the PC and the foreign node.

Figure 8-19 Proxy and Firewall Tunnels for Foreign Terminations

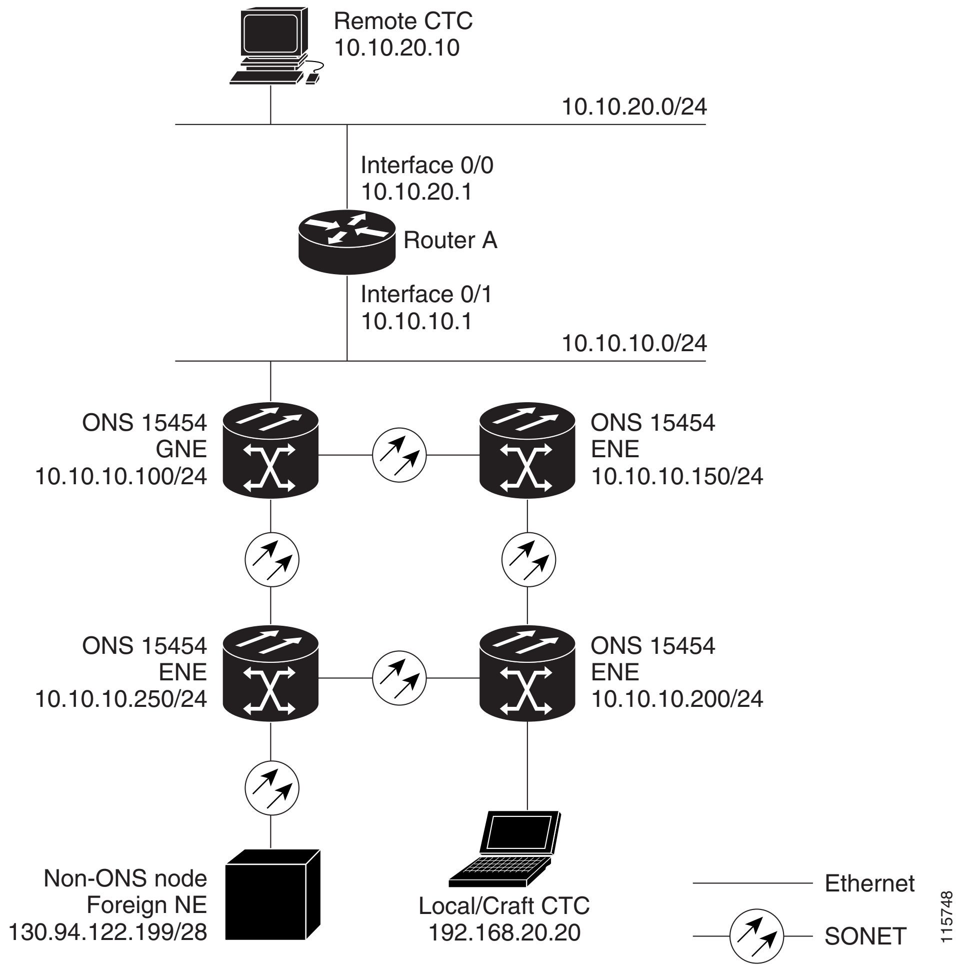
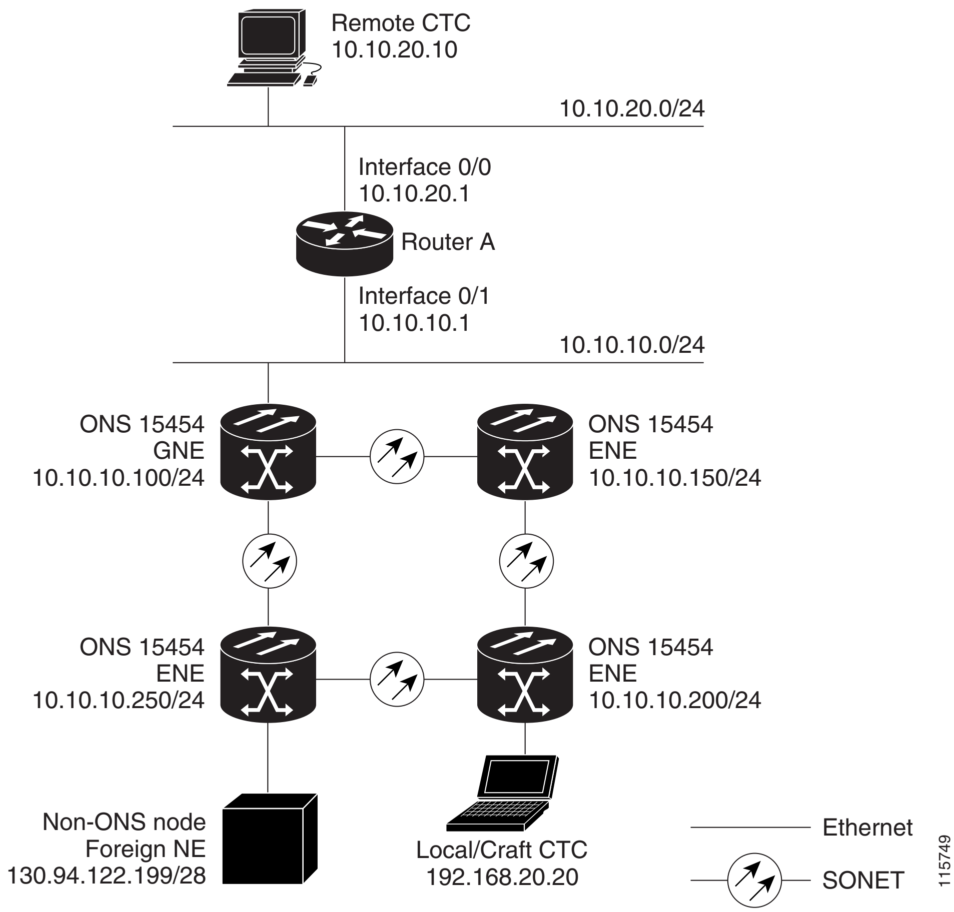


Figure 8-20 shows a remote node connected to an ENE Ethernet port. Proxy and firewall tunnels are useful in this example because the GNE would otherwise block IP access between the PC and foreign node. This configuration also requires a firewall tunnel on the ENE.

Figure 8-20 Foreign Node Connection to an ENE Ethernet Port



Provisionable Patchcords

A provisionable patchcord is a user-provisioned link that is advertised by OSPF throughout the network. Provisionable patchcords, also called virtual links, are needed in the following situations:

- An optical port is connected to a transponder or muxponder client port provisioned in transparent mode.
- An optical ITU port is connected to a DWDM optical channel card.
- Two transponder or muxponder trunk ports are connected to a DWDM optical channel card and the generic control channel (GCC) is carried transparently through the ring.
- Transponder or muxponder client and trunk ports are in a regenerator group, the cards are in transparent mode, and DCC/GCC termination is not available.

Provisionable patchcords are required on both ends of a physical link. The provisioning at each end includes a local patchcord ID, slot/port information, remote IP address, and remote patchcord ID. Patchcords appear as dashed lines in CTC network view.

Table 8-7 lists the supported card combinations for client and trunk ports in a provisionable patchcord.

Table 8-7 Cisco ONS 15454 Client/Trunk Card Combinations for Provisionable Patchcords

Trunk Cards	Client Cards						
	MXP_2.5G_10G TXP_MR_10G	TXP(P)_MR_2.5G	MXP_2.5G_10E TXP_MR_10E	32MUX-O 32DMX-O	32-WSS 32-DMX	ADxC	4MD
MXP_2.5G_10G TXP_MR_10G	—	—	—	Yes	Yes	Yes	Yes
TXP(P)_MR_2.5G	—	—	—	Yes	Yes	Yes	Yes
MXP_2.5G_10E TXP_MR_10E	—	—	—	Yes	Yes	Yes	Yes
MXP(P)_MR_2.5G	—	—	—	Yes	Yes	Yes	Yes
OC-192	Yes	—	Yes	—	—	—	—
OC-48	Yes	Yes	Yes	—	—	—	—
OC-192 ITU	—	—	—	Yes	Yes	Yes	Yes
OC-48 ITU	—	—	—	Yes	Yes	Yes	Yes

Note If the OCSM card is installed in Slot 8, provisionable patchcords from OC-N ports to the following cards are not supported on the same node: MXP_2.5G_10G, TXP_MR_10G, TXP(P)_MR_2.5G, MXP_2.5G_10E, TXP_MR_10E, 32MUX-O, 32DMX-O, 32-WSS, or 32-DMX.

Table 8-8 lists the supported card combinations for client-to-client ports in a patchcord.

Table 8-8 Cisco ONS 15454 Client/Client Card Combinations for Provisionable Patchcords

Client Cards	MXP_2.5G_10G TXP_MR_10G	TXP(P)_MR_2.5G	MXP_2.5G_10E TXP_MR_10E
MXP_2.5G_10G TXP_MR_10G	Yes	—	Yes
TXP(P)_MR_2.5G	—	Yes	—
MXP_2.5G_10E TXP_MR_10E	Yes	—	Yes

Table 8-9 lists the supported card combinations for trunk-to-trunk ports in a patchcord.

Table 8-9 Cisco ONS 15454 Trunk/Trunk Card Combinations for Provisionable Patchcords

Client Cards	MXP_2.5G_10G TXP_MR_10G	TXP(P)_MR_2.5G	MXP_2.5G_10E TXP_MR_10E
MXP_2.5G_10G TXP_MR_10G	Yes	—	Yes

Table 8-9 Cisco ONS 15454 Trunk/Trunk Card Combinations for Provisionable Patchcords (continued)

Client Cards	MXP_2.5G_10G TXP_MR_10G	TXP(P)_MR_2.5G	MXP_2.5G_10E TXP_MR_10E
TXP(P)_MR_2.5G	—	Yes	—
MXP_2.5G_10E TXP_MR_10E	Yes	—	Yes

Optical ports have the following requirements when used in a provisionable patchcord:

- An optical port connected to transponder/muxponder port or add/drop multiplexer or multiplexer/demultiplexer port requires an SDCC/LDCC termination.
- If the optical port is the protection port in a 1+1 group, the working port must have an SDCC/LDCC termination provisioned.
- If the remote end of a patchcord is Y-cable protected or is an add/drop multiplexer or multiplexer/demultiplexer port, an optical port requires two patchcords.

Transponder and muxponder ports have the following requirements when used in a provisionable patchcord:

- Two patchcords are required when a transponder/muxponder port is connected to an add/drop multiplexer or multiplexer/demultiplexer port. CTC automatically prompts the user to set up the second patchcord.
- If a patchcord is on a client port in a regenerator group, the other end of the patchcord must be on the same node and on a port within the same regenerator group.
- A patchcord is allowed on a client port only if the card is in transparent mode.

DWDM cards support provisionable patchcords only on optical channel ports. Each DWDM optical channel port can have only one provisionable patchcord.

Note For TXP, MXP, and DWDM card information refer to the Cisco ONS 15454 DWDM Installation and Operations Guide.

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.

This chapter provides examples of common ONS 15454 Multi-Service Provisioning Platform (MSPP) network applications and shelf configurations. All SONET examples are shown as either ring or 1+1 protected. All DS-1, DS-3, and EC-1 examples are shown either as 1:N (N<5) or 1:1 protected. Ethernet cards are shown unprotected.

The examples shown in this chapter are designed to provide general guidance for creating ONS 15454 node configurations to meet your service needs.

The following topics are covered in this chapter:

Overview

The Cisco ONS 15454 Multi-Service Provisioning Platform (MSPP) combines the best of a traditional SONET TDM (time division multiplexing) system along with statistical multiplexing in a single platform. 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.

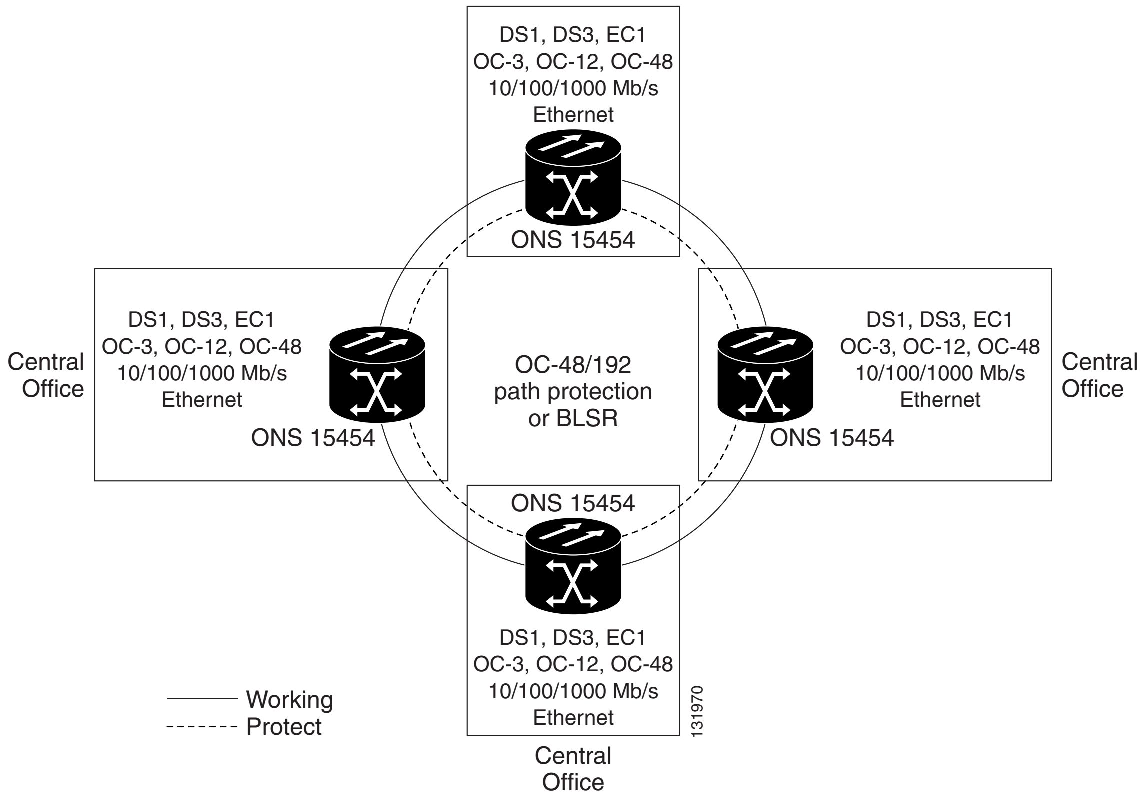
Integrating Dense Wavelength Division Multiplexing (DWDM) transport and wavelength services into the ONS 15454 re-configures the MSPP into a Multi-Service Transport Platform (MSTP). Leveraging on the MSPP and MSTP features and functionalities, customers can use a single ONS 15454 solution to meet cost-effective provisioning and transport requirements ranging from access, interoffice (IOF), and long-haul applications.

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 PC, LAN, or firewall-compliant Ethernet connections, as well as through DCC connections for OAM&P. the Cisco Transport Controller (CTC) and TL1 interfaces makes provisioning and troubleshooting ONS 15454 applications fast, simple, and easy.

Interoffice (IOF) Transport

The ONS 15454 can be easily configured to carry TDM, ATM, data, and digital video services with path protection 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 short reach (SR), intermediate reach (IR), and long reach (LR) optical interface cards along with the ability to support any network topology makes the ONS 15454 ideal for IOF transport applications. Figure 9-1 shows an example of an IOF transport in either a path protection or BLSR configuration.

Figure 9-1 Interoffice Transport



Typcial IOF Node Configurations

Figure 9-2, Figure 9-3, and Figure 9-4 show the shelf layouts for typical OC-192 IOF nodes. Note the empty card slots available to increase the capacity of the shelf.

Figure 9-2 OC-192 IOF Node Configured for 96 DS-3s Using High-Density Cards

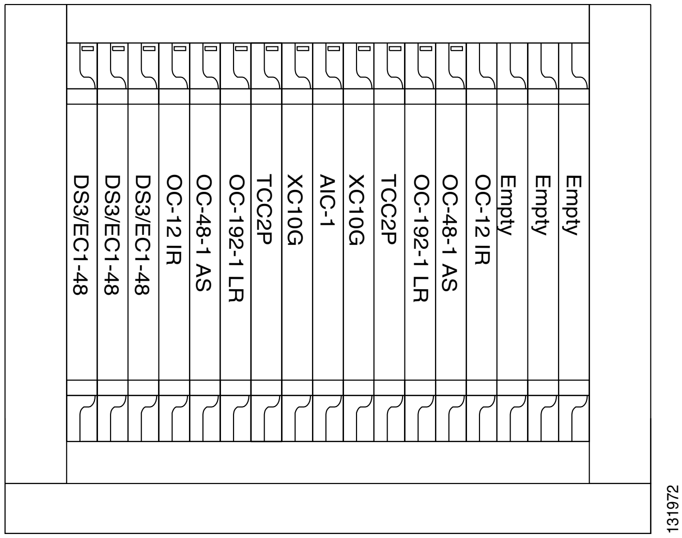


Figure 9-3 OC-192 IOF Node Configured for 24 DS-3s and 24 EC-1s Using Low-Density Cards

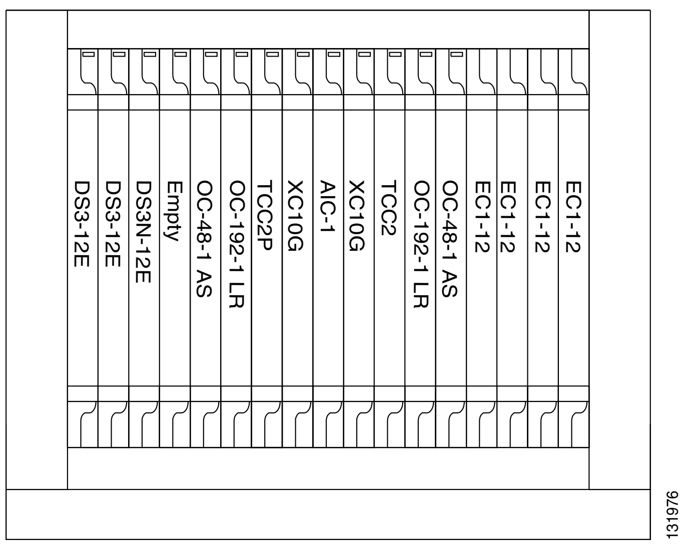
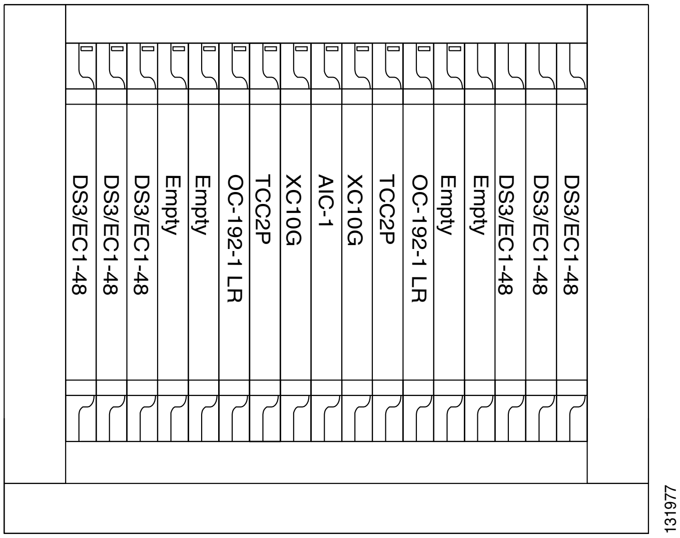


Figure 9-4 OC-192 IOF Node Configured for 192 DS-3/EC-1s or 96 DS-3s and 96 EC-1s Using High-Density Cards



Metro Transport

The ONS 15454 can groom services at the edge of the Metro transport network shown in Figure 9-5, packing the network with information and eliminating the need for multiple cross-connects and routers. Figure 9-6 shows the shelf layout of the ONS 15454 node located at the Interoffice Site.

Figure 9-5 Multi-Service Grooming at the Edge of the Metro Transport Network

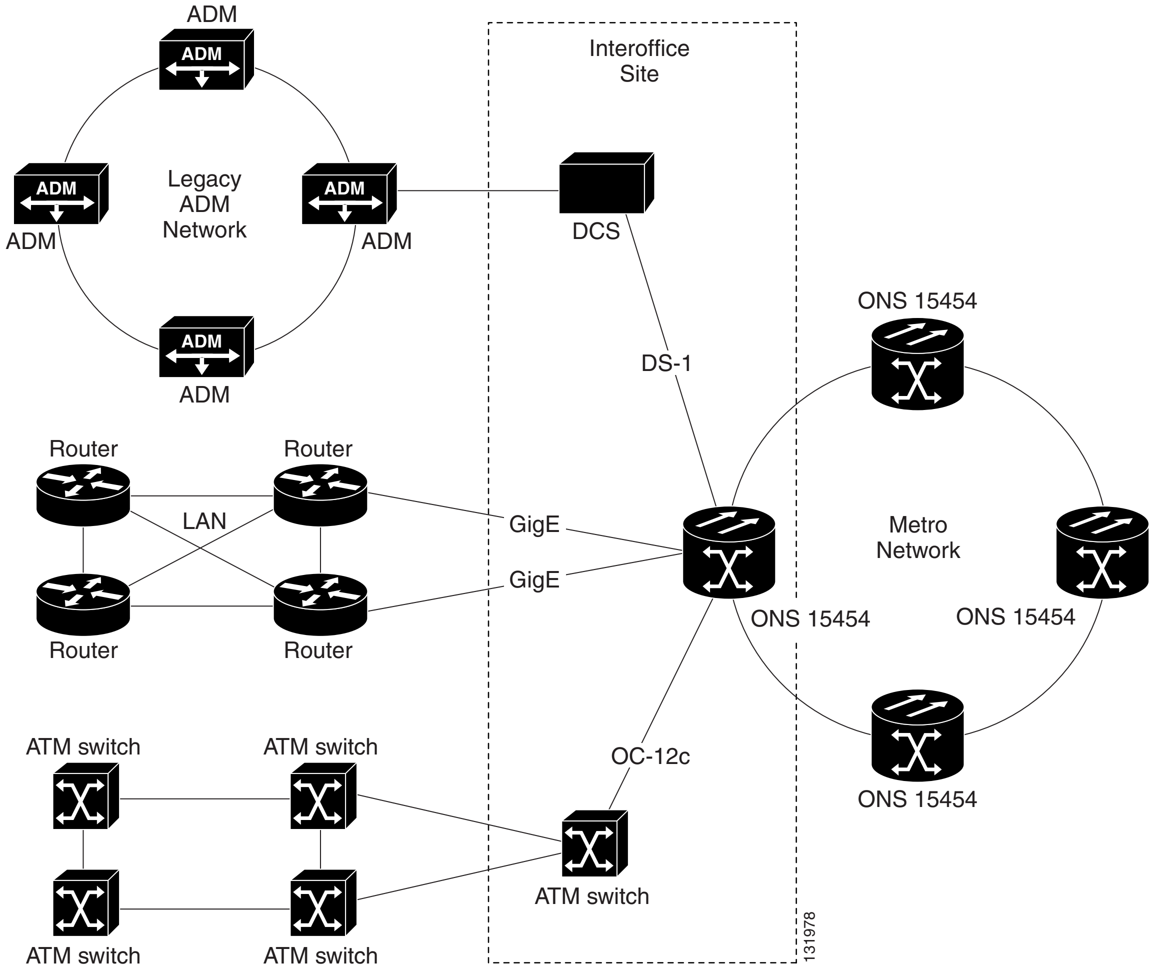
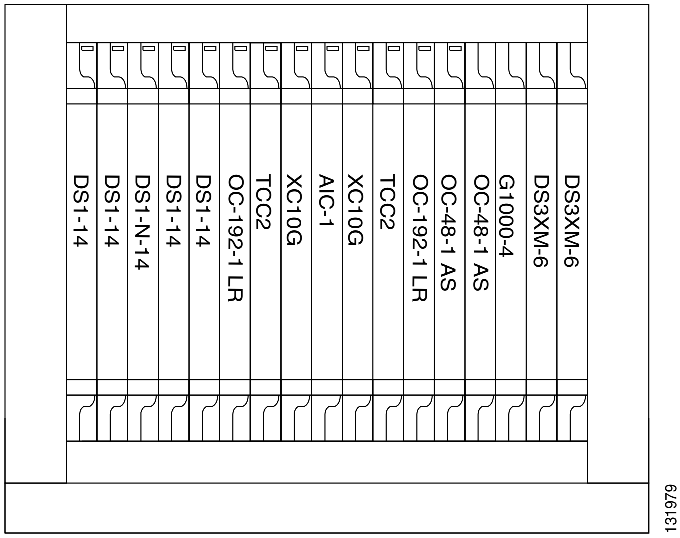


Figure 9-6 Shelf Layout of a Multi-Service Grooming Node



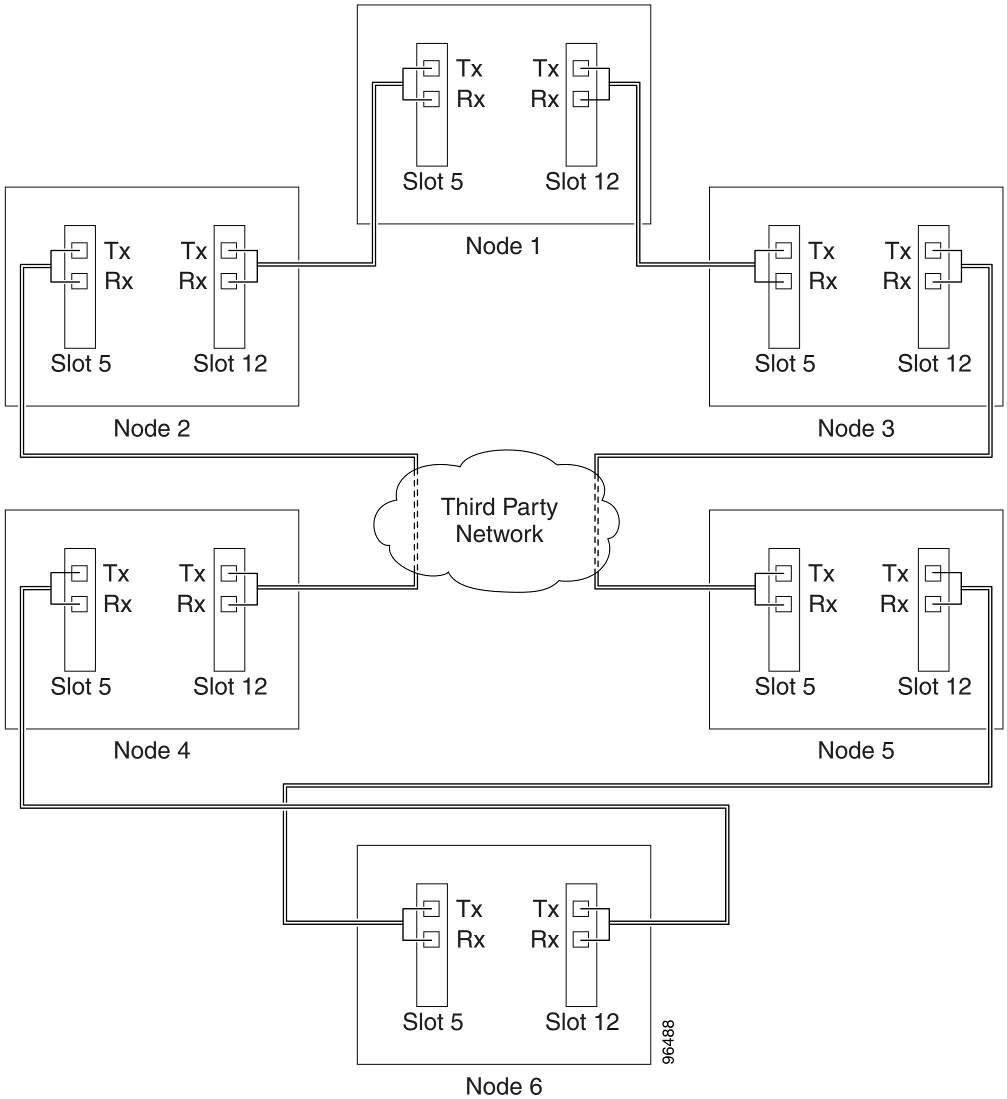
Access Transport

The ONS 15454 provides the flexibility required to link remote sites to a serving 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.

Open-Ended Path Protection Circuit

An open-ended path protection circuit allows you to route a circuit from one ONS 15454 network to another ONS 15454 network through a third party's network. Figure 9-7 shows an example of this topology. Node 1 is connected to ONS 15454 Nodes 2 and 3 through Slots 12 and 5. Trunk cards at Nodes 2 and 3 are connected to the third party's equipment.

Figure 9-7 Open-Ended Path Protection Example



The third party time slots must match the ONS 15454 card time slots to which they are connected. For example, if your trunk card is an OC-48, the third party's card must have STSs 1-48 available. You provision SONET DCC terminations for the ONS 15454 cards/ports that are connected to another ONS 15454. Do not create a DCC termination for the card/port that connects to the third-party's equipment. For example in Figure 9-10, DCC terminations are created at the following cards/ports:

- Nodes 1 and 6 - Slot 5 and Slot 12
- Node 2 and 5 - Slot 12
- Node 3 and 4 - Slot 5

To create an open-ended path protection circuit, you create three circuits. One circuit is created on the source ONS 15454 network. This circuit has one source and two destinations, one at each ONS 15454 that is connected to the third-party network. The second circuit is created on the third-party network so that the circuit travels across the network on two paths to the ONS 15454s. That circuit routes the two circuit signals across the network to ONS 15454 nodes that are connected to the network on other side.

At the destination node network, the third circuit is created with two sources, one at each node connected to the third-party network. A selector at the destination node chooses between the two signals that arrive at the node, similar to a regular path protection circuit.

BLSR DRI

Note A DRI circuit cannot be created if an intermediate node exists on the interconnecting link. However, an intermediate node can be added on the interconnecting link after the DRI circuit is created.

DRI protection circuits act as protection channel access (PCA) circuits. In CTC, you set up DRI protection circuits by selecting the PCA option when setting up primary and secondary nodes during DRI circuit creation.

Figure 9-8 shows ONS 15454 nodes in a traditional BLSR-DRI topology with same-side routing. In Ring 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 8 and 9 are the interconnect nodes. Duplicate signals are sent between Node 4 (Ring 1) and Node 9 (Ring 2), and between Node 3 (Ring 1) and Node 8 (Ring 2). The primary nodes (Nodes 4 and 9) are on the same side, and the secondary nodes (Nodes 3 and 8) provide an alternative route. In Ring 1, traffic at Node 4 is dropped (to Node 9) and continued (to Node 10). Similarly, at Node 9, traffic is dropped (to Node 4) and continued (to Node 5).

Figure 9-8 Traditional BLSR DRI (Same Side Routing)

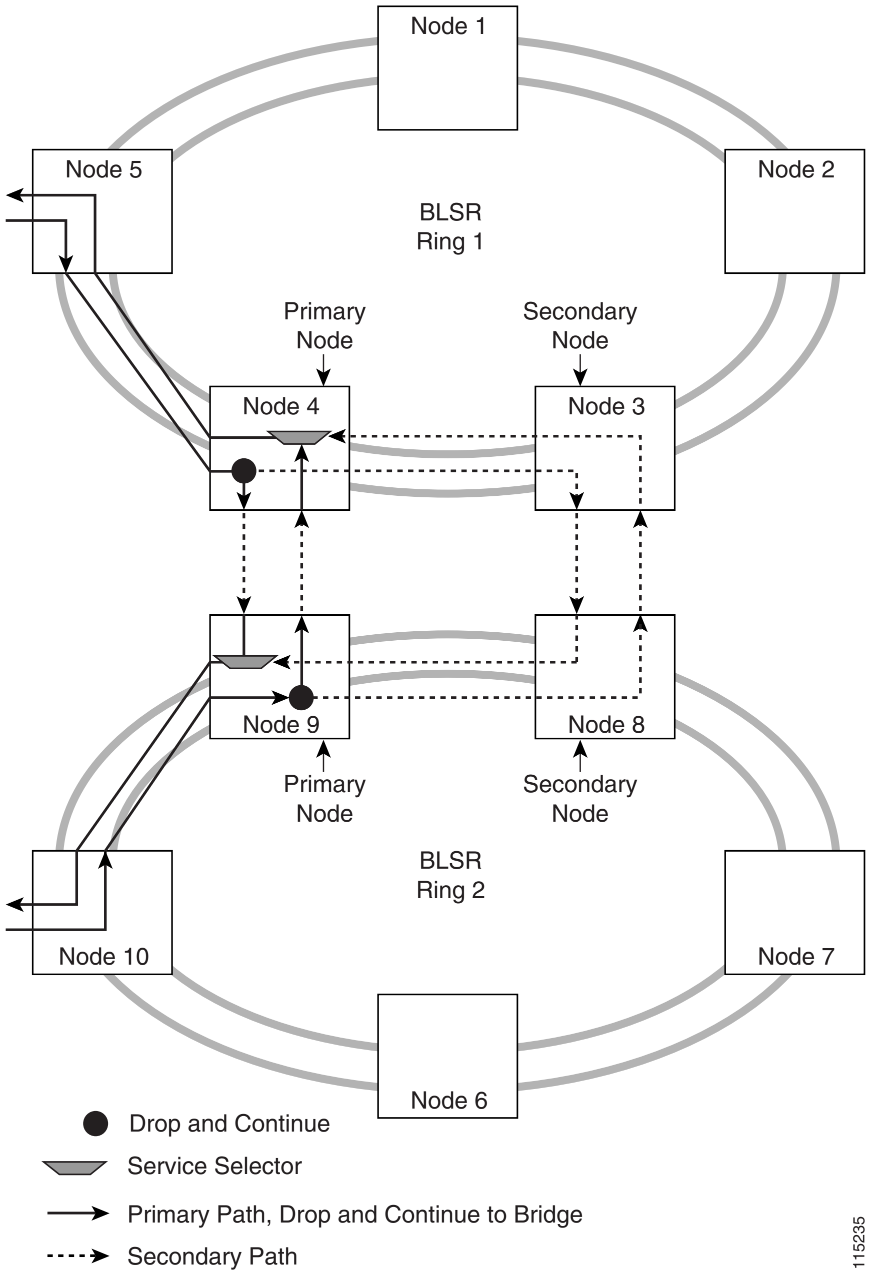


Figure 9-9 shows ONS 15454 nodes in a traditional BLSR-DRI topology with opposite-side routing. In Ring 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 8 and 9 are the interconnect nodes. Duplicate signals are sent from Node 4 (Ring 1) to Node 8 (Ring 2), and between Node 3 (Ring 1) and Node 9 (Ring 2). In Ring 1, traffic at Node 4 is dropped (to Node 9) and continued (to Node 8). Similarly, at Node 8, traffic is dropped (to Node 3) and continued (to Node 4).

Figure 9-9 ONS 15454 Traditional BLSR DRI (Opposite-Side Routing)

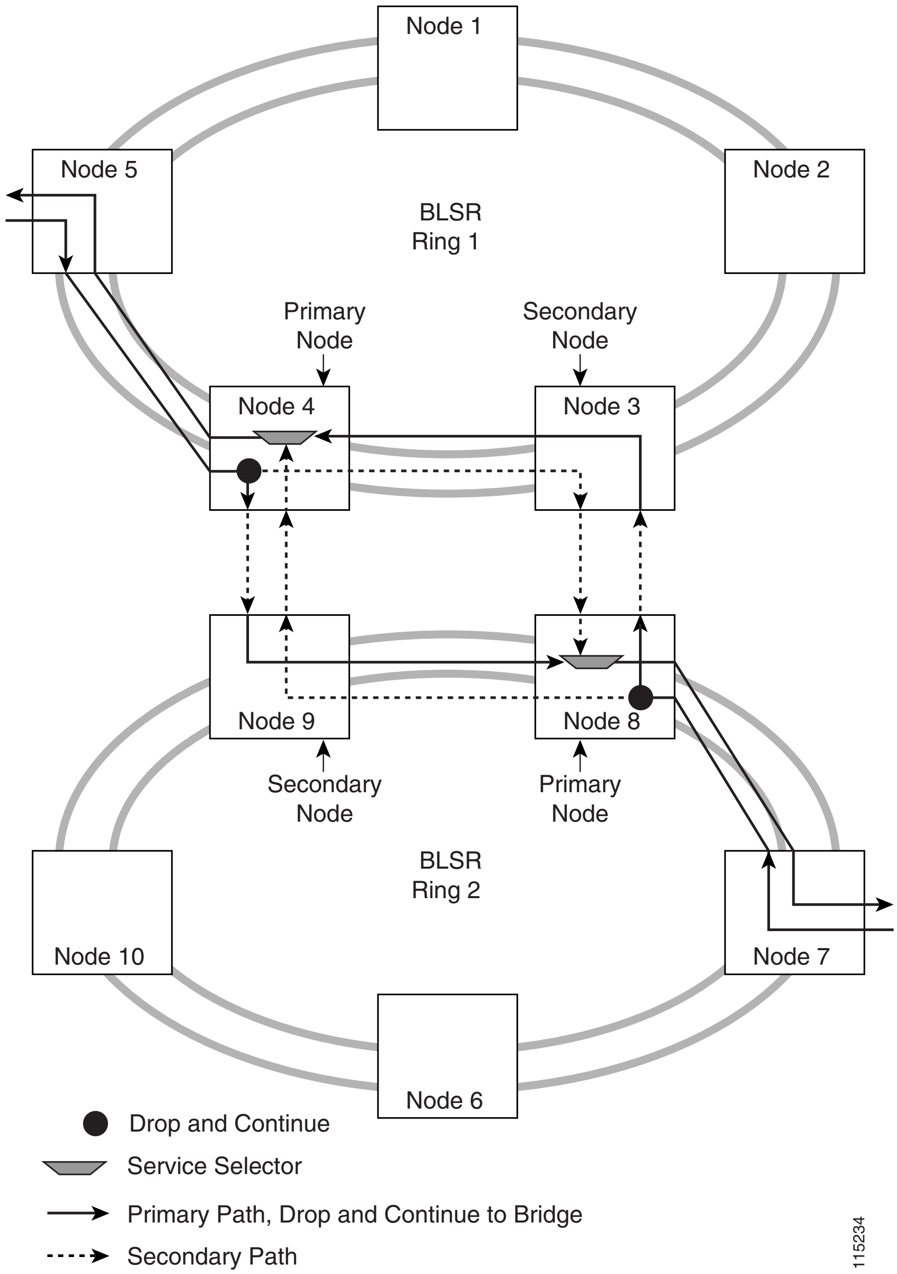
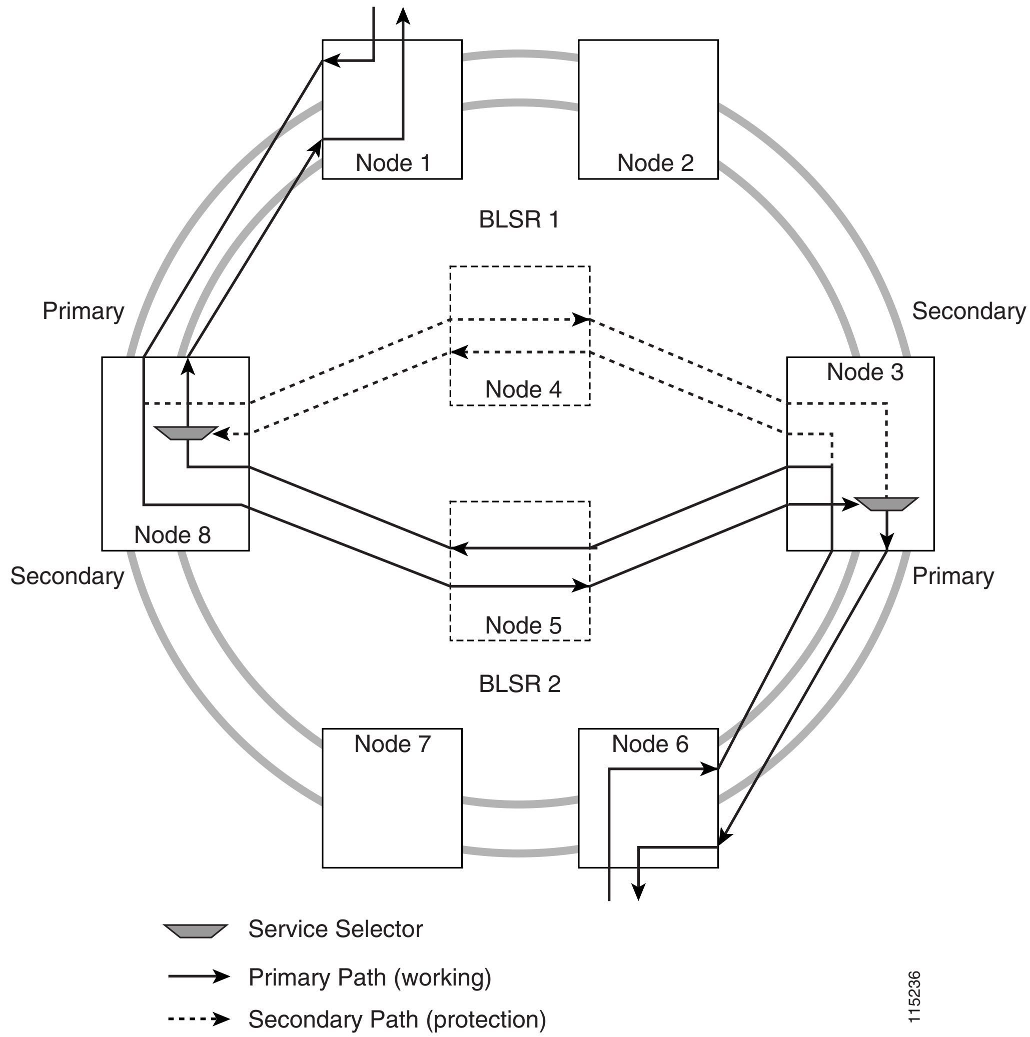


Figure 9-10 shows ONS 15454 nodes in an integrated BLSR-DRI topology. The same drop-and-continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an additional OC-N trunk at the two interconnect nodes. Nodes 3 and 8 are the interconnect nodes.

Figure 9-10 ONS 15454 Integrated BLSR DRI



Path Protection DRI

Figure 9-11 shows ONS 15454 nodes in a traditional drop-and-continue path protection DRI topology. In Ring 1, Nodes 4 and 5 are the interconnect nodes, and in Ring 2, Nodes 6 and 7 are the interconnect nodes. Duplicate signals are sent between Node 4 (Ring 1) and Node 6 (Ring 2), and between Node 5 (Ring 1) and Node 7 (Ring 2). In Ring 1, traffic at Node 4 is dropped (to Node 6) and continued (to Node 5). Similarly, at Node 5, traffic is dropped (to Node 7) and continued (to Node 4).

Figure 9-11 ONS 15454 Traditional Path Protection DRI

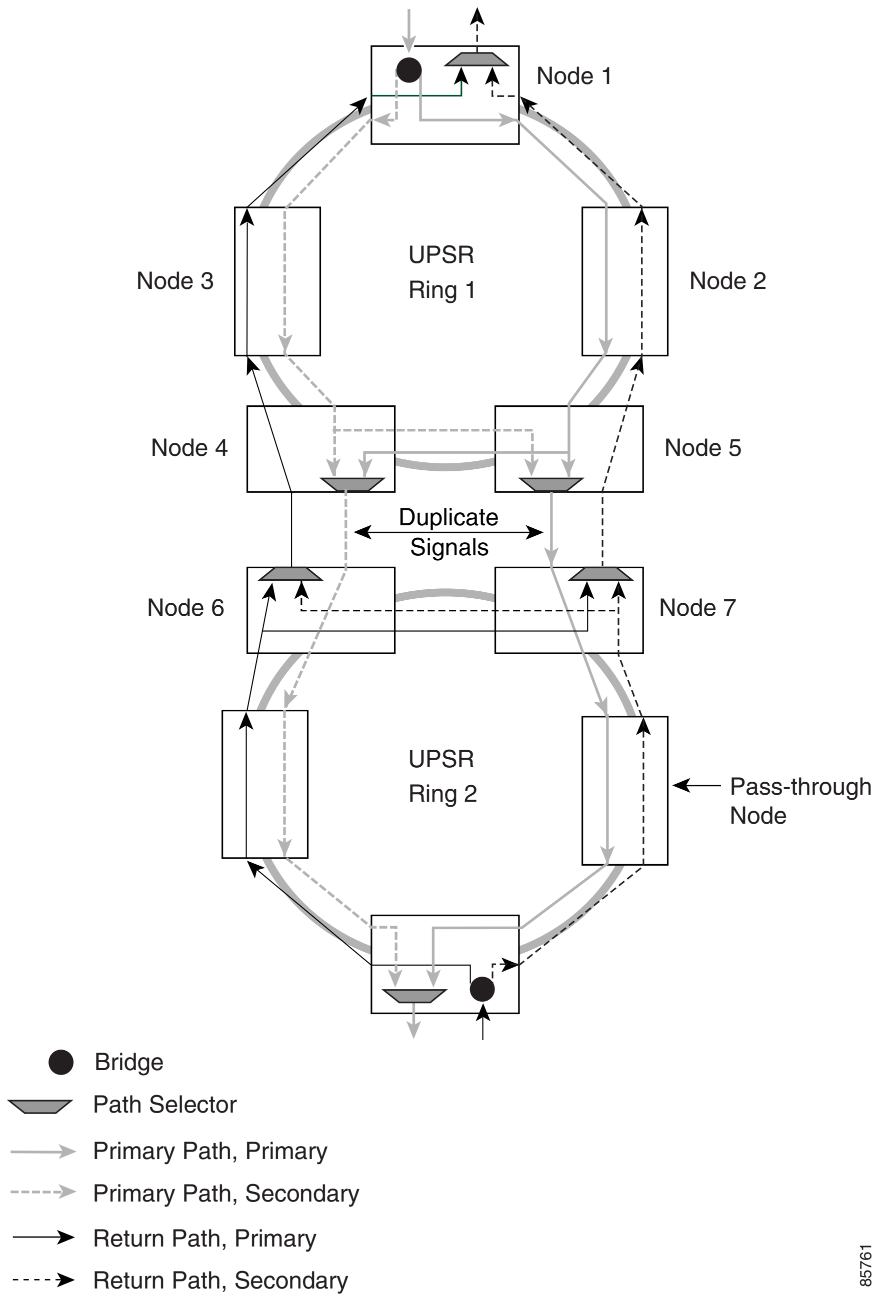
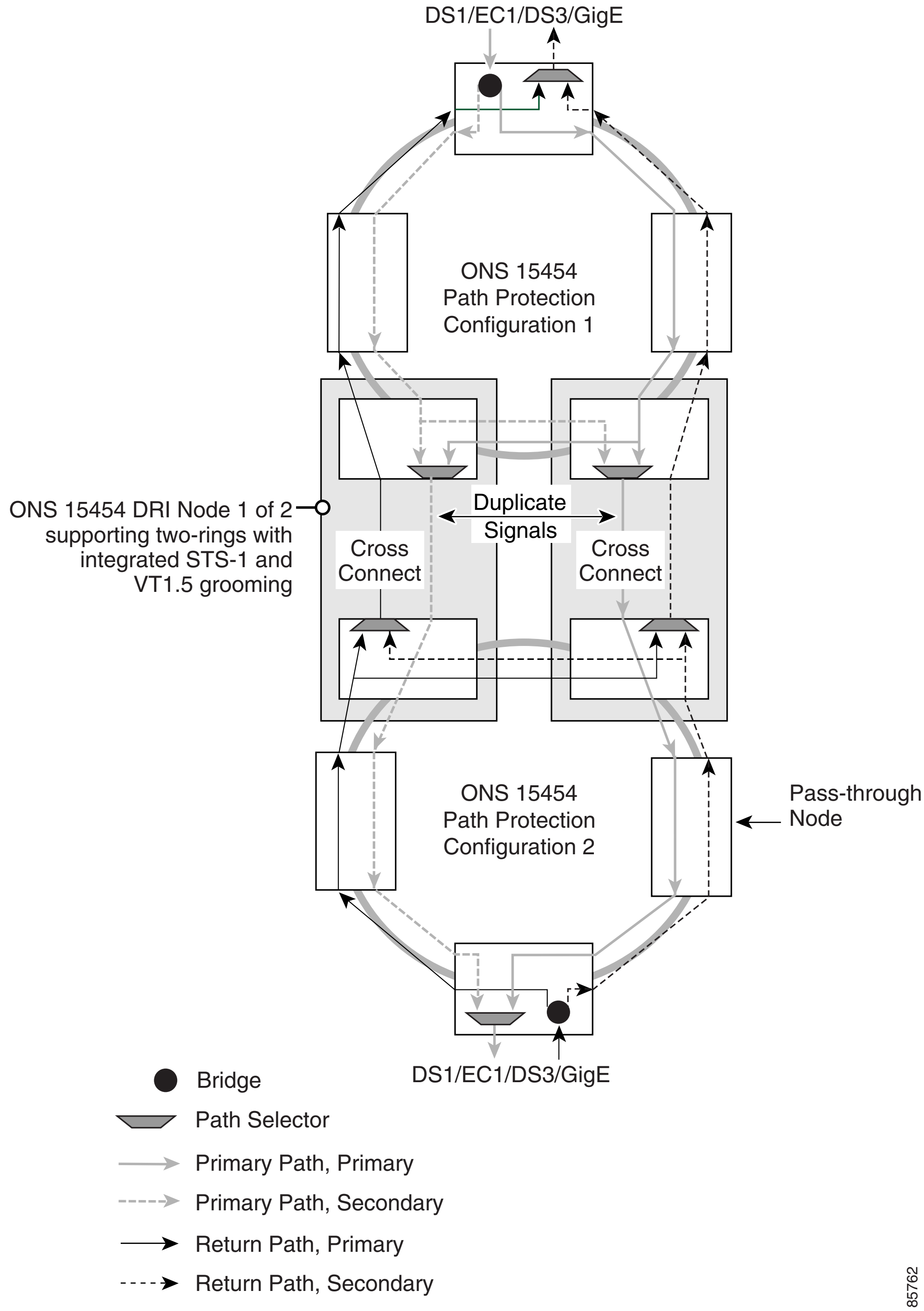


Figure 9-12 shows ONS 15454s in an integrated DRI topology. The same drop-and-continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an additional OC-N trunk at the two interconnect nodes.

Figure 9-12 ONS 15454 Integrated Path Protection DRI



Path Protection/BLSR DRI Handoff Configurations

Path protection configurations and BLSRs can also be interconnected. In BLSR/path protection DRI handoff configurations, primary and secondary nodes can be the circuit source or destination, which is useful when non-DCC optical interconnecting links are present. Figure 9-13 shows an example of a path protection to BLSR traditional DRI handoff.

Figure 9-13 ONS 15454 Path Protection to BLSR Traditional DRI Handoff

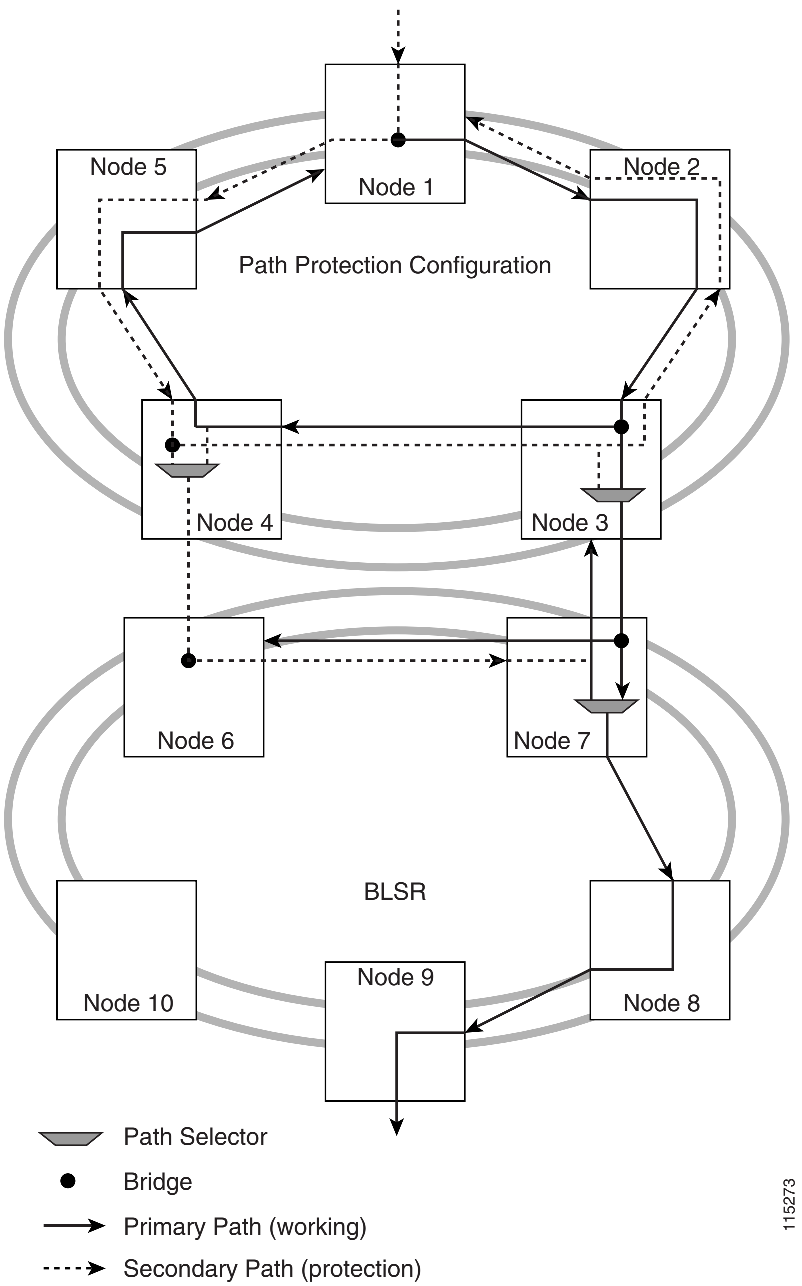
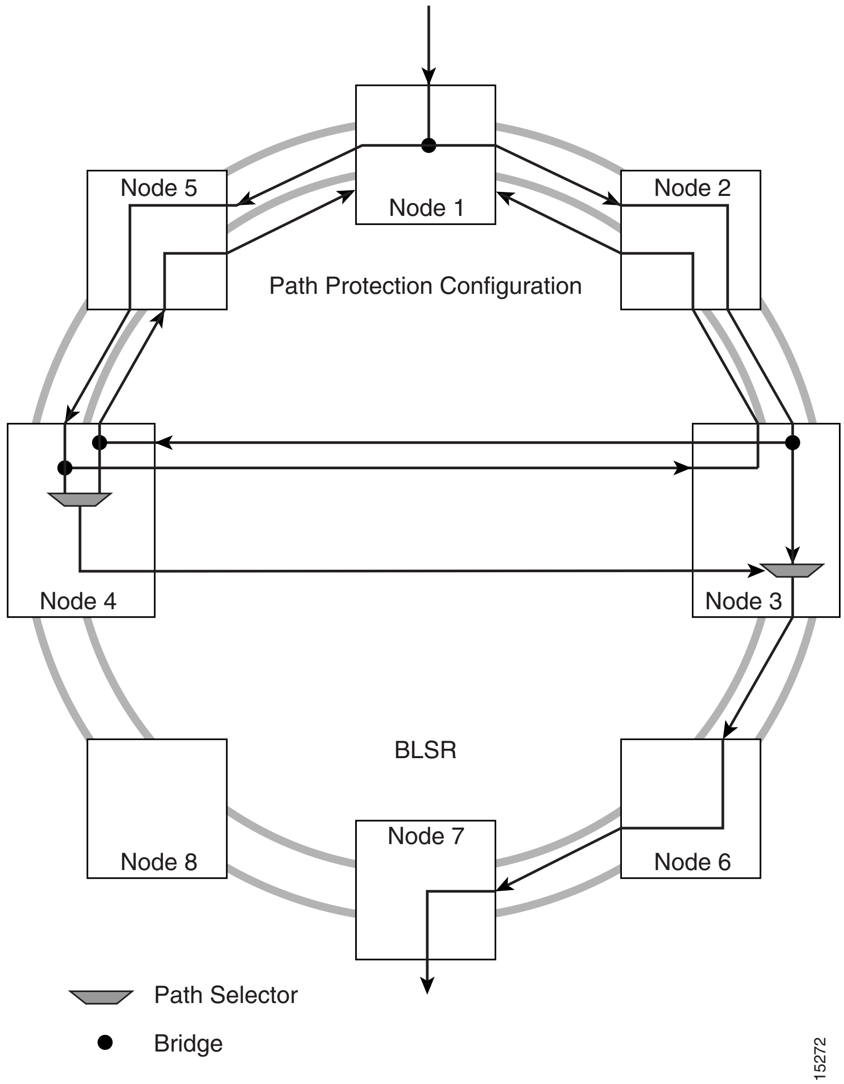


Figure 9-14 shows an example of a path protection to BLSR integrated DRI handoff.

Figure 9-14 ONS 15454 Path Protection to BLSR Integrated DRI Handoff



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. Figure 9-15 shows an OC-192 linear application with 10 DS-1s and 2 DS-3s dropped at nodes 2 and 3. Four OC-192 modules are required at these nodes to handle traffic in both directions.

Figure 9-15 OC-192 Linear ADM 1+1 Protected

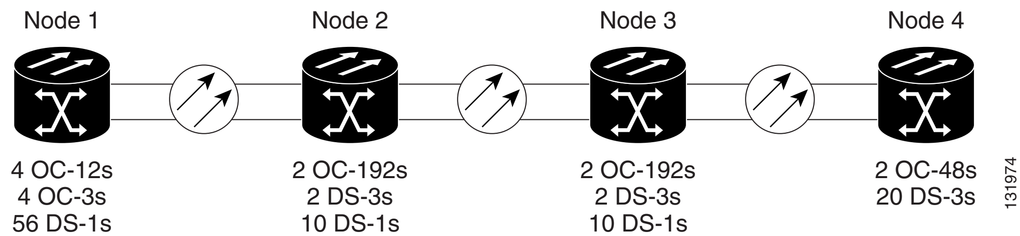
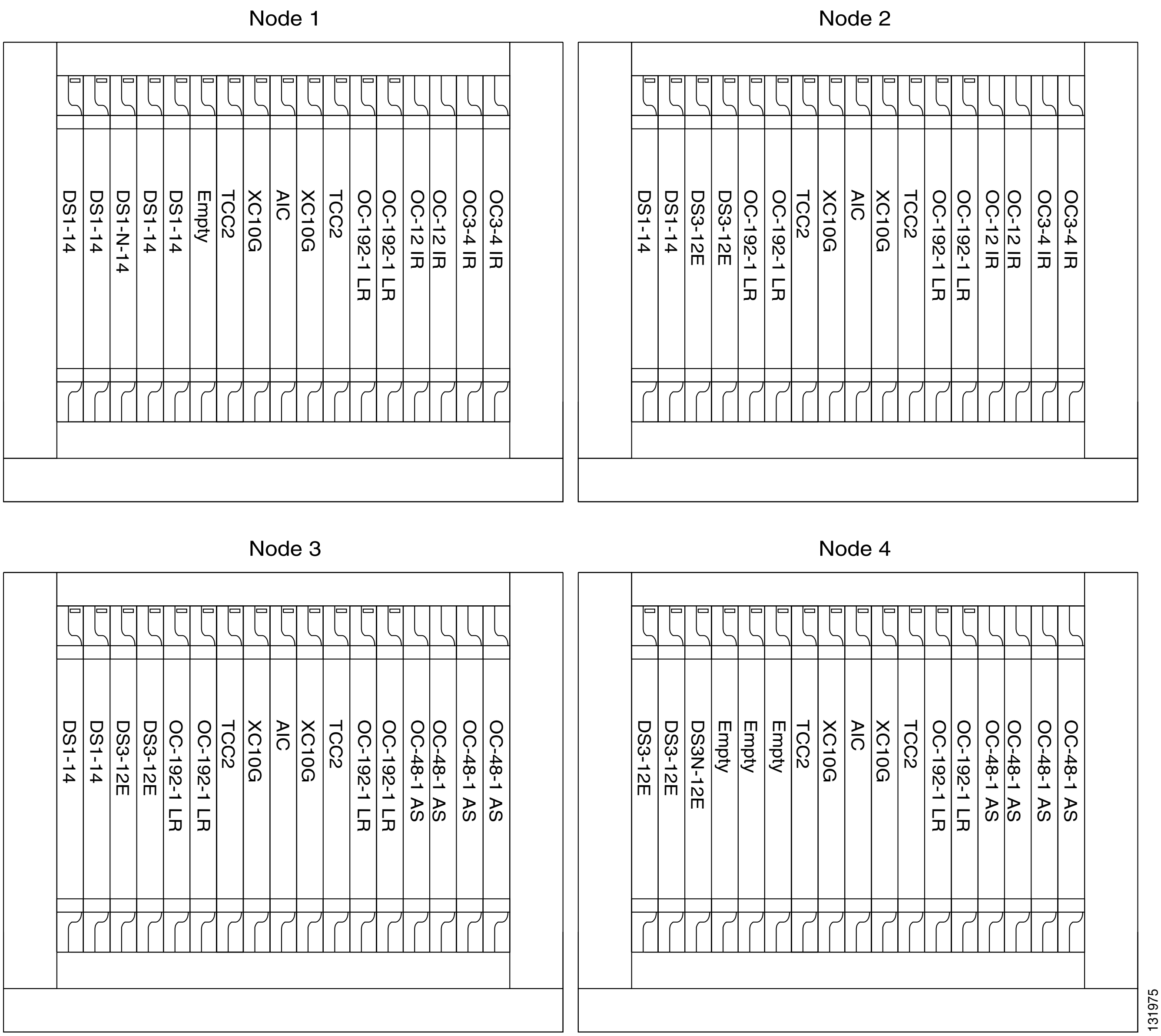


Figure 9-16 shows the shelf layouts for Nodes 1 to 4 in the above example.

Figure 9-16 OC-192 Linear ADM 1+1 Protected Shelf Layouts



The ONS 15454 also supports distributed linear networks. Figure 9-17 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 9-18).

Figure 9-17 Distributed Linear Network

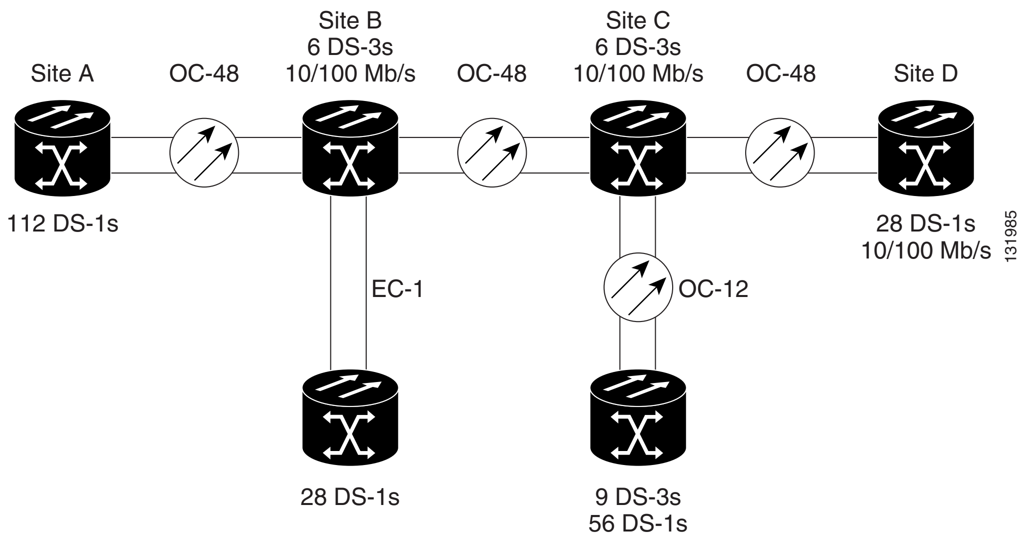
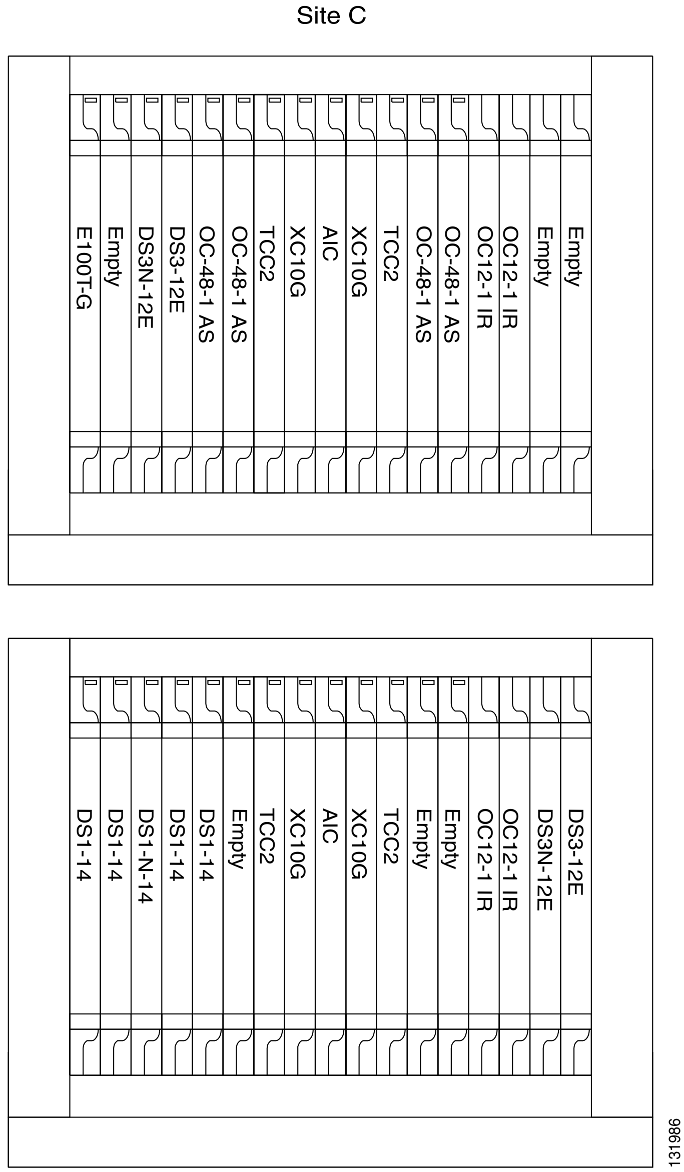


Figure 9-18 Multi-homed Linear ADM Shelf Layout

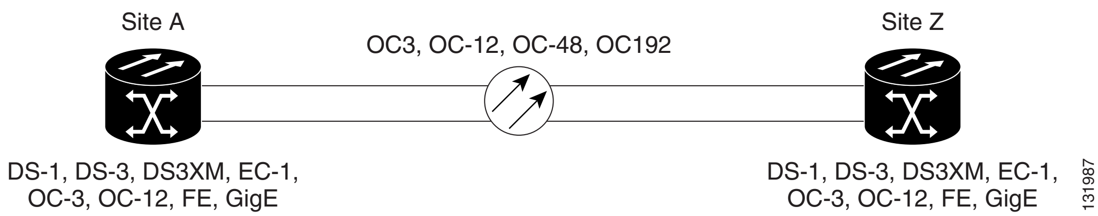


Terminal Mode

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 9-19.

Figure 9-19 Distributed Linear Network



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 9-1 lists the available TM protection schemes for electrical and optical interface cards.

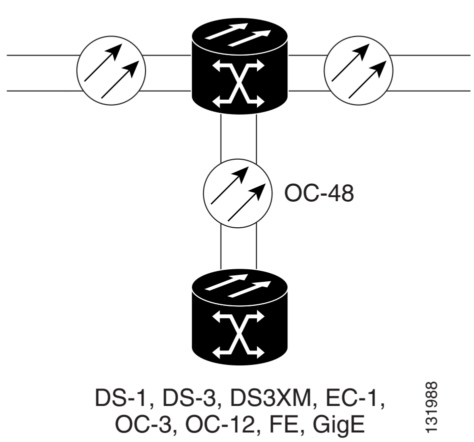
Table 9-1 Terminal Mode Protection Schemes

Protection Scheme Supported	Electrical Cards	Optical Cards
Unprotected	X	X
1:1	X	
1:N	X	
1+1		X
Path protection		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 9-20.

Figure 9-20 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 9-21 shows an optical hub supporting two OC-48, four OC-12, and three OC-3 terminations.

Figure 9-21 Optical Hub Application

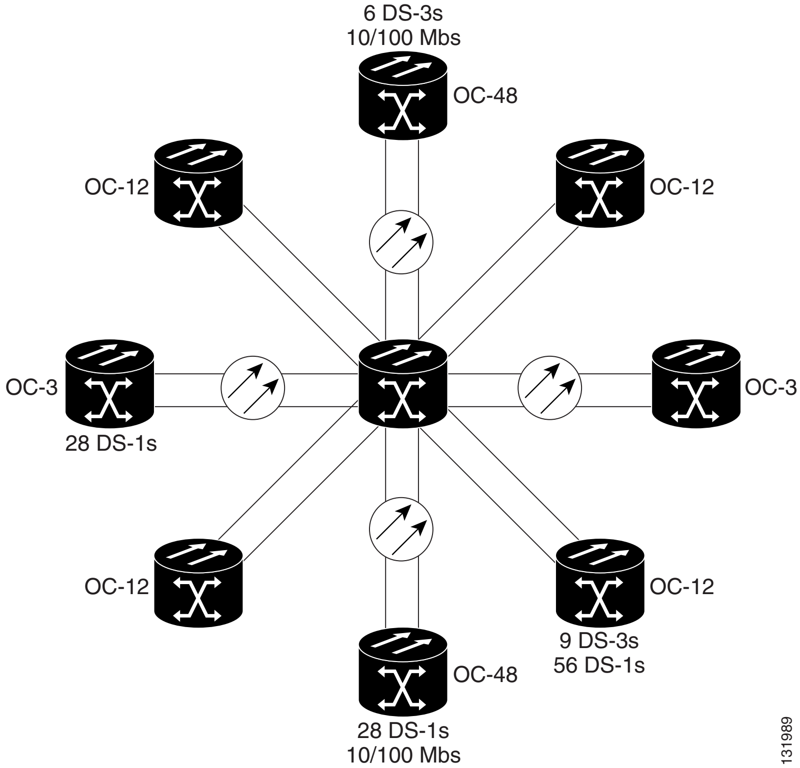
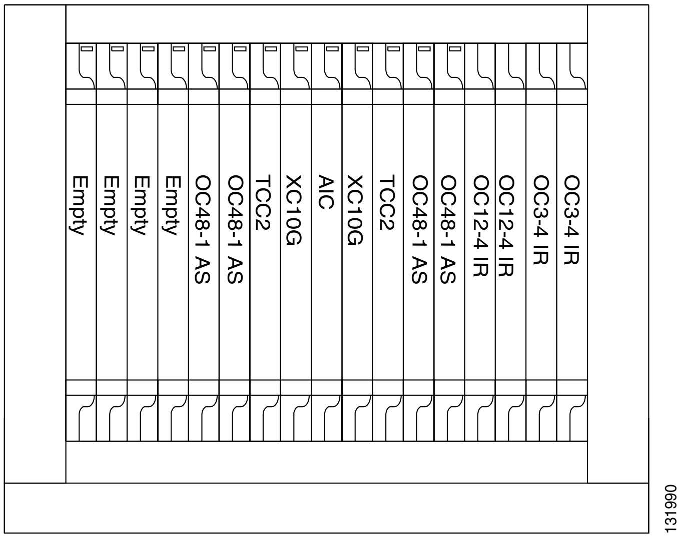


Figure 9-22 shows the shelf layout for the optical hub node in Figure 9-21.

Figure 9-22 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 (XCVT) 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.

Figure 9-23, Figure 9-24, Figure 9-25, and Figure 9-26 show rack and shelf layouts for 3/1 DCS applications:

Figure 9-23 Single Shelf 3/1 DCS 112 DS1 Ports and 6 DS3 Transmux Ports

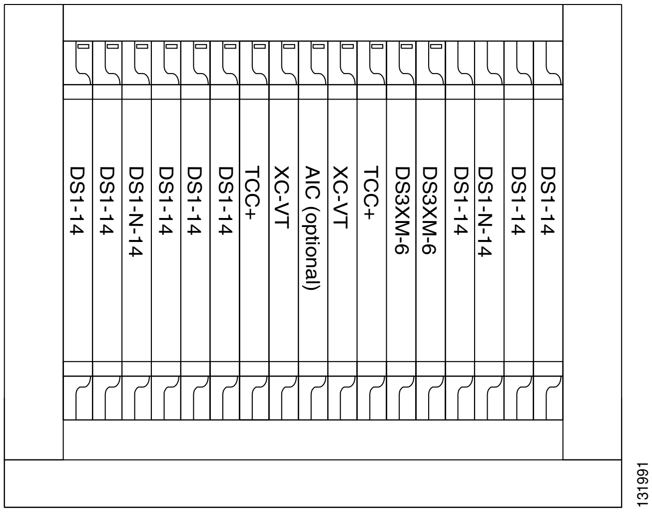


Figure 9-24 Two Shelf 3/1 DCS with 140 DS1 Ports and 18 DS3 Transmux Ports

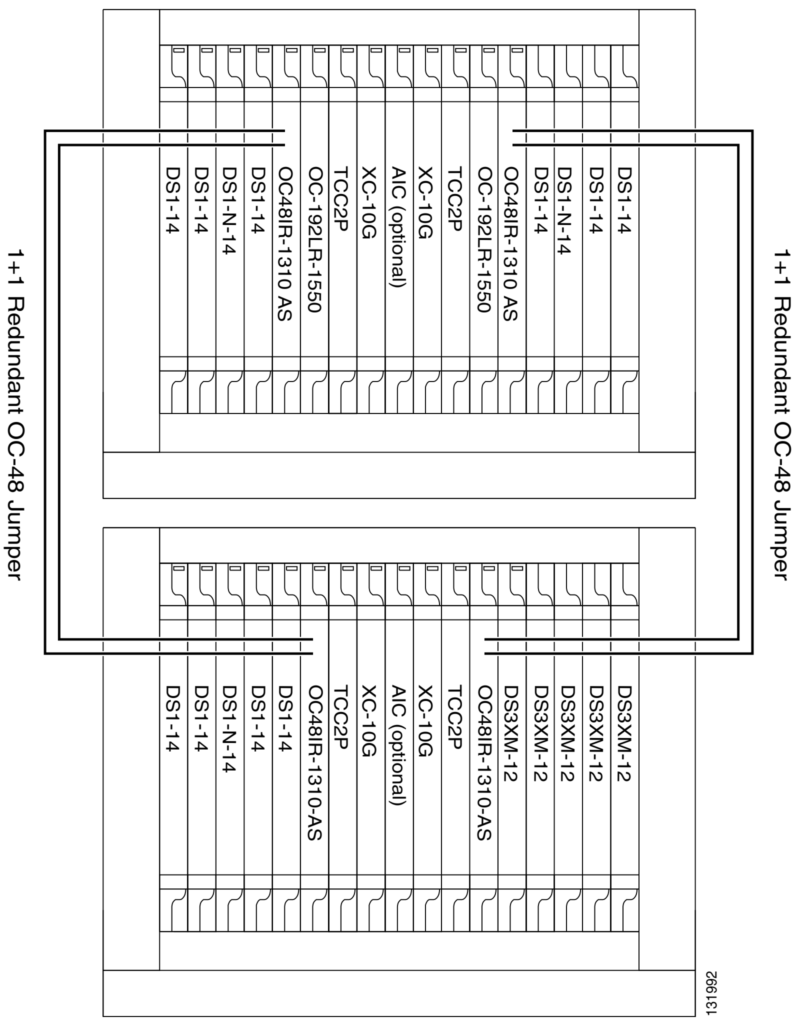


Figure 9-25 Three-shelf 3/1 DCS with 224 DS1 ports, 18 DS3 Transmux ports, and 12 STS1 ports

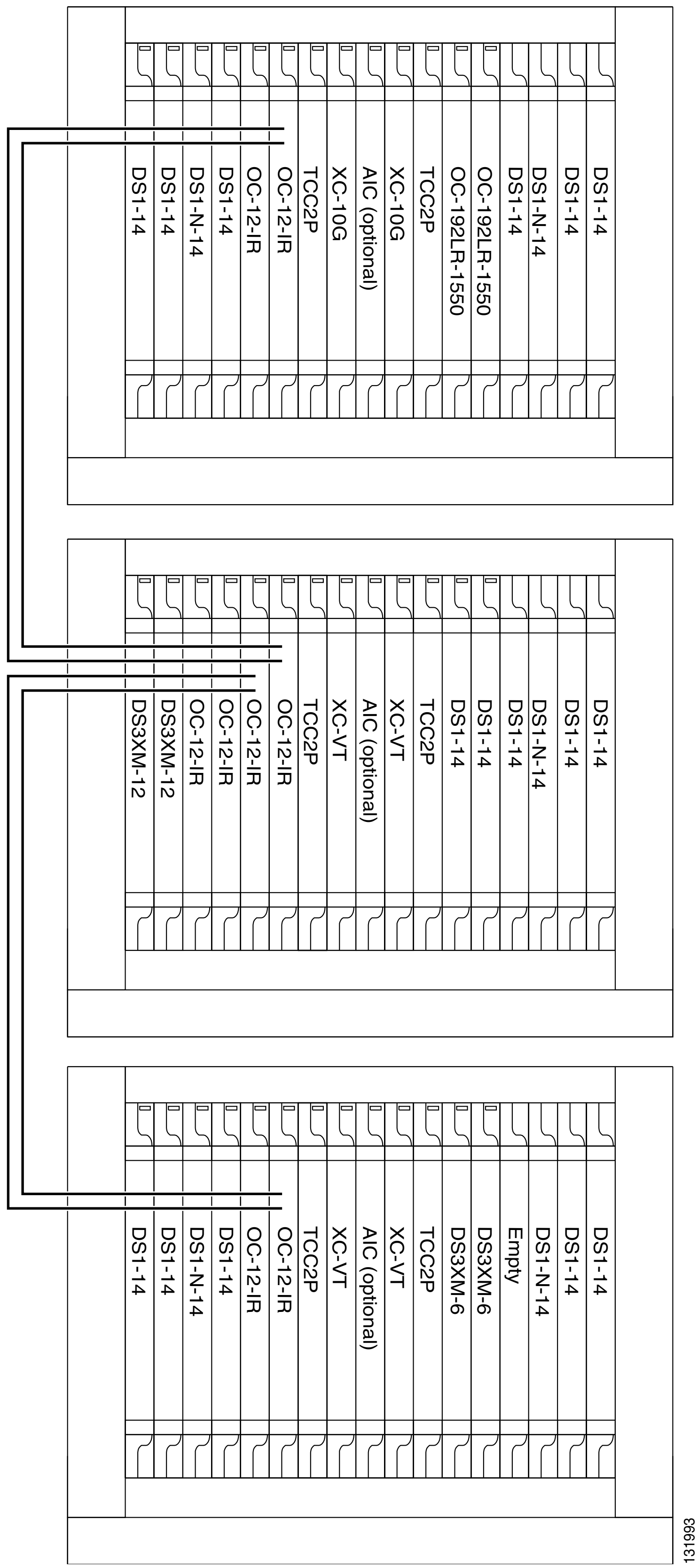
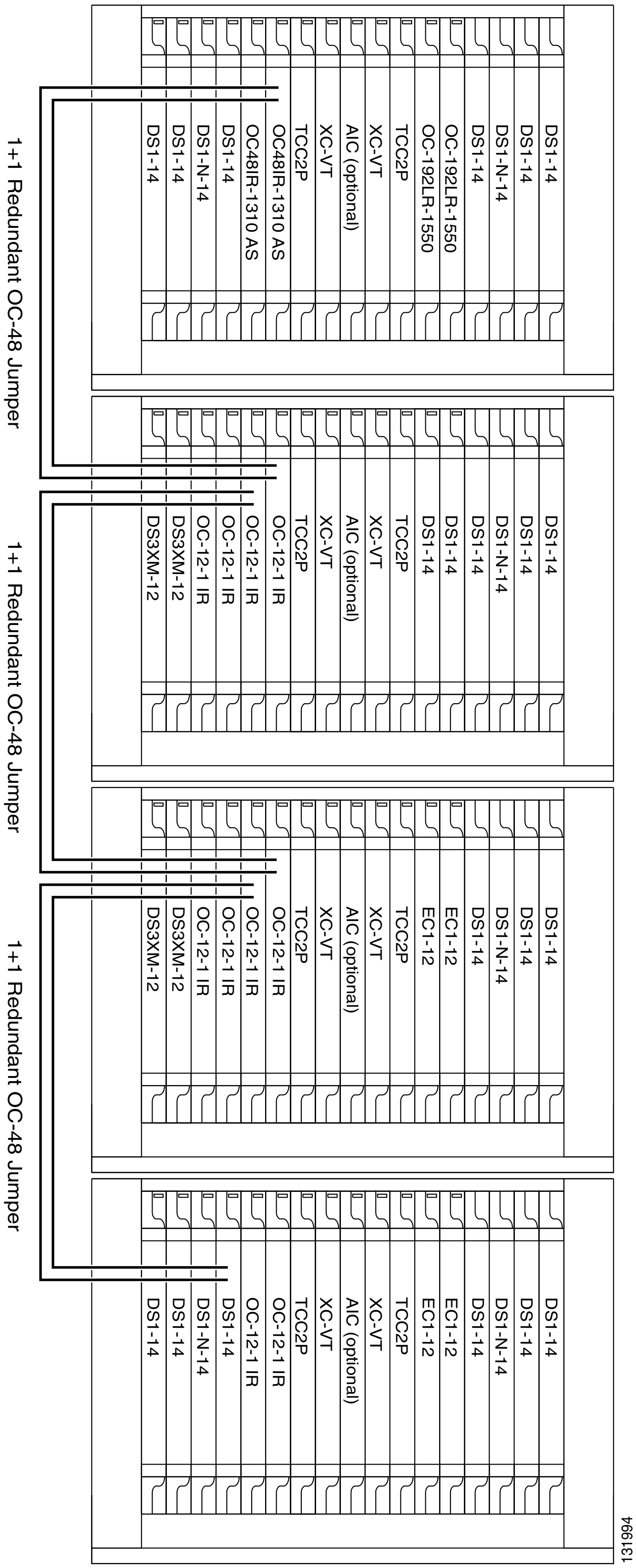


Figure 9-26 Four Shelf 3/1 DCS with 280 DS1 ports, 24 DS3 Transmux Ports, and 24 STS1 Ports



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 9-2 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 9-2 3/3 DCS Configurations and Capacities

Configuration	Tributaries
192 DS3/EC1 Ports	DS-3s or STS-1s
384 DS3/EC1 Ports	DS-3s or STS-1s
576 DS3/EC1 Ports	DS-3s or STS-1s
768 DS3/EC1 Ports	DS-3s or STS-1s

Figure 9-27, Figure 9-28, Figure 9-29, and Figure 9-30 show the rack and shelf layouts for the 3/3 DCS applications:

Figure 9-27 3/3 DCS Application with 192 DS-3/STS-1 Ports

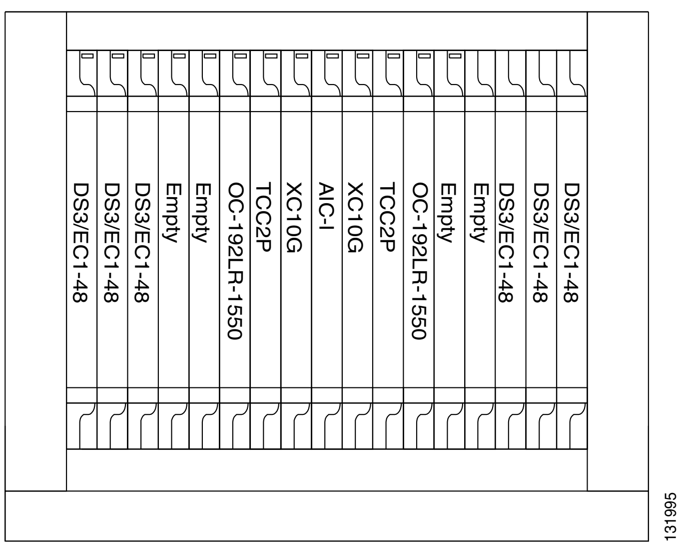


Figure 9-28 3/3 DCS Application with 264 DS-3 Ports

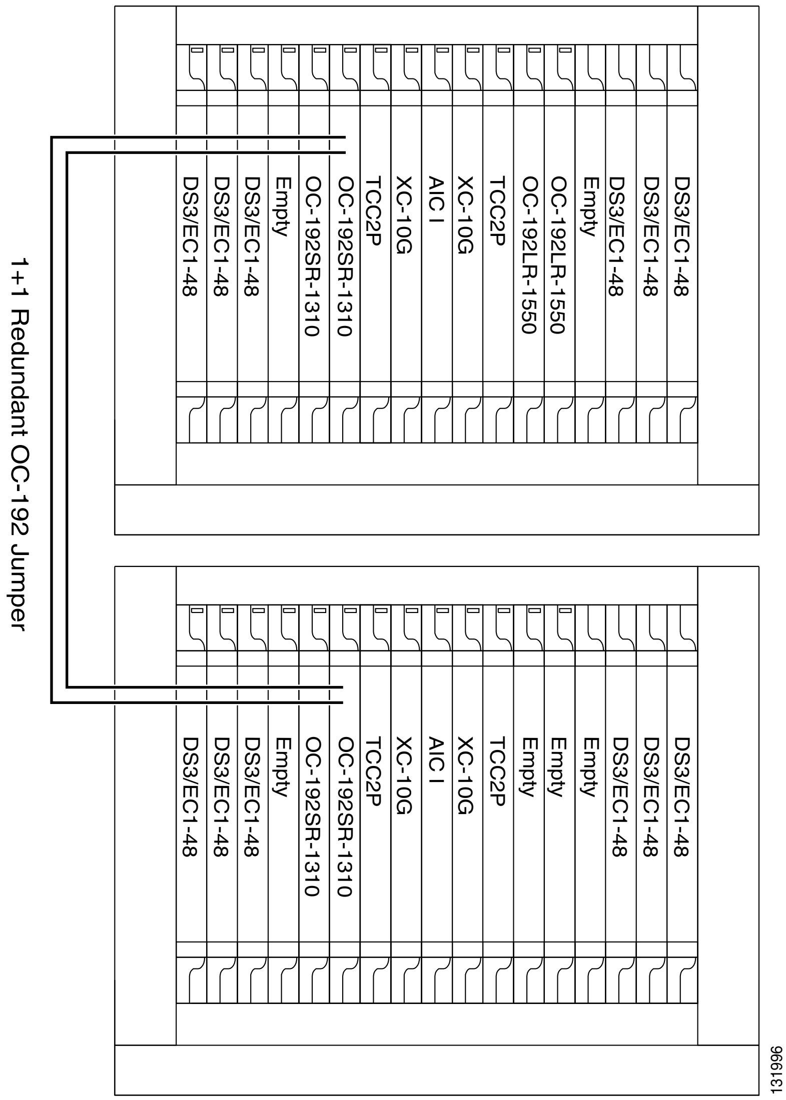


Figure 9-29 3/3 DCS Application with 336 DS-3 Ports

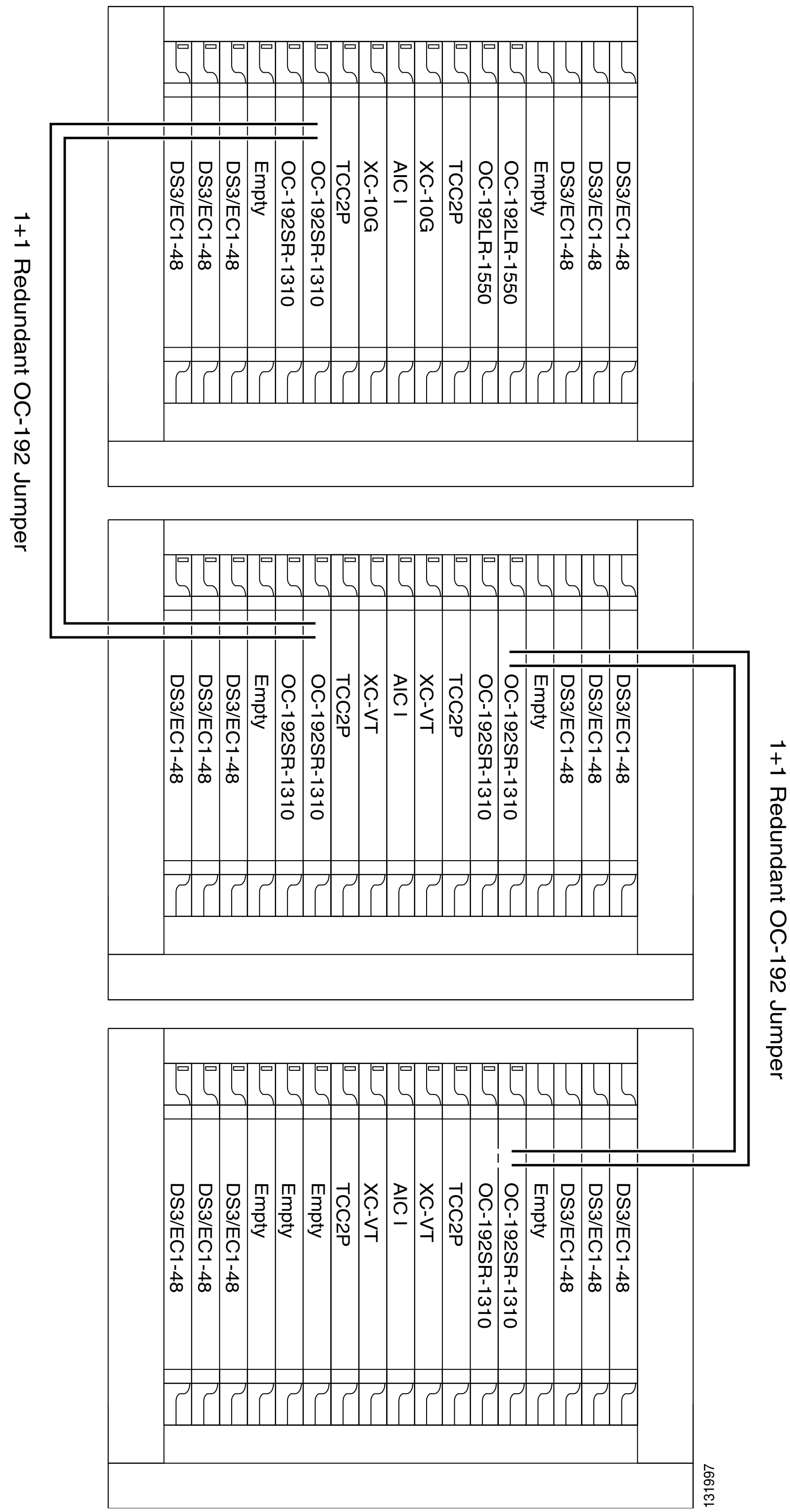
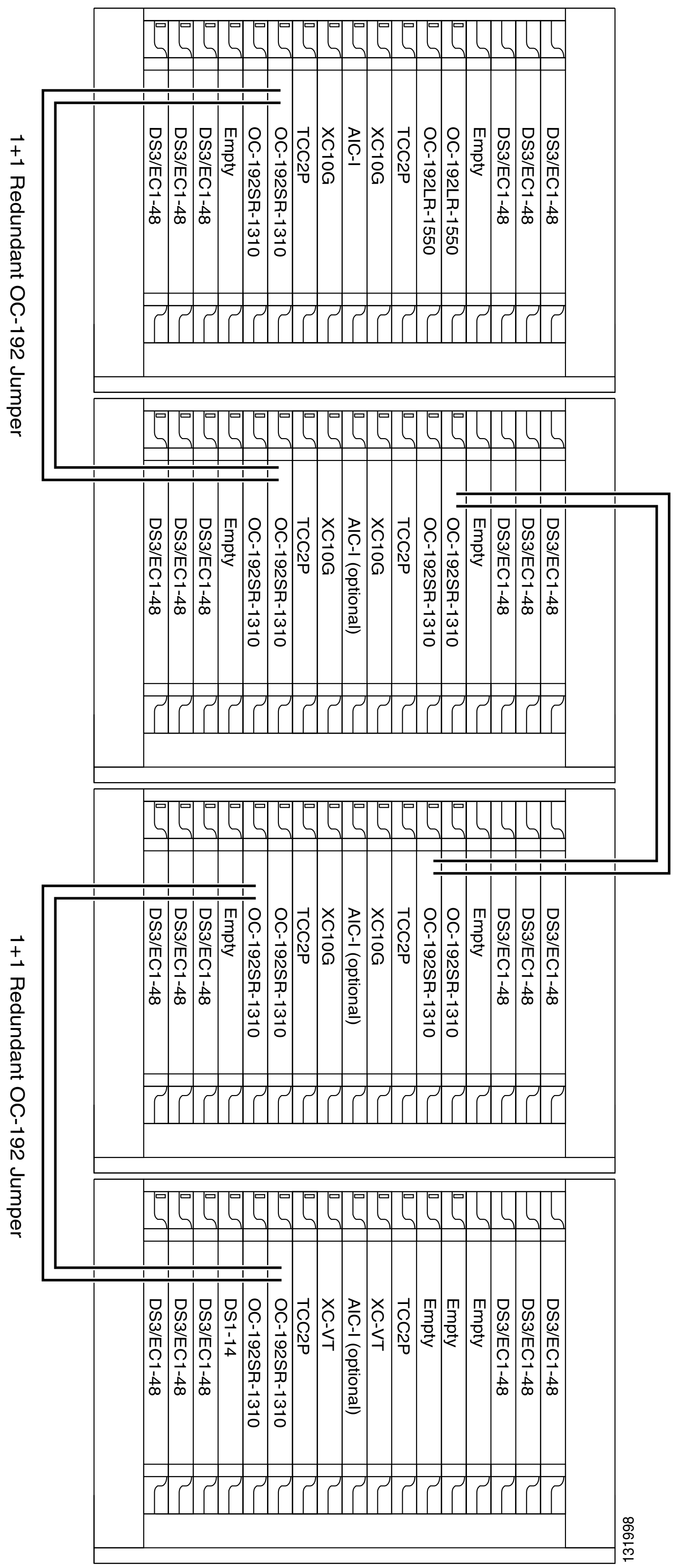


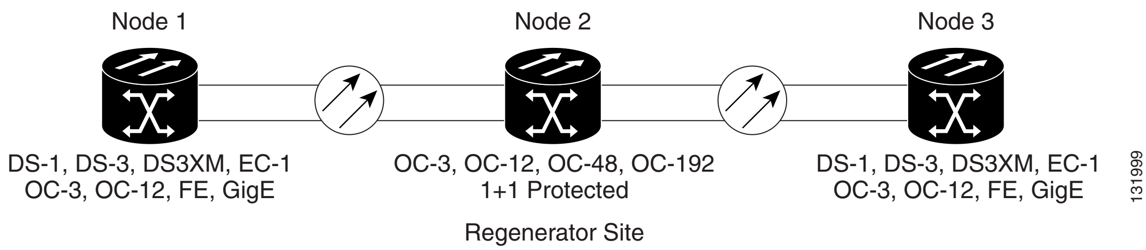
Figure 9-30 3/3 DCS Application with 768 DS-3/STS-1 Ports



Regenerator Site

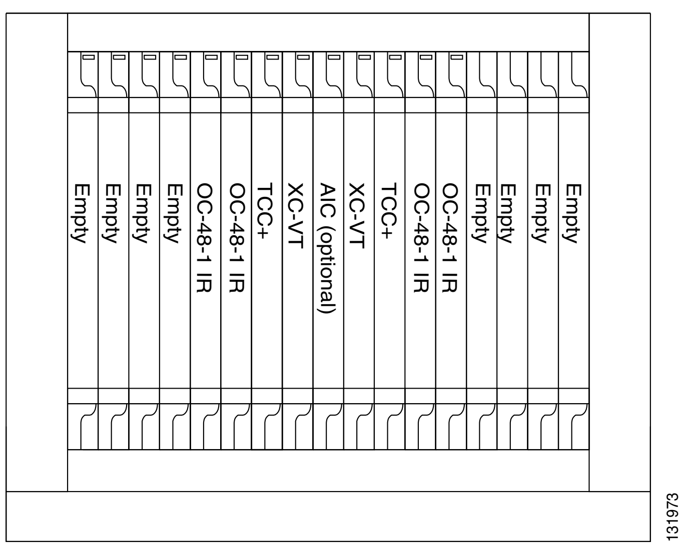
The ONS 15454 can be configured as an effective regenerator. An added benefit of this configuration is that when new services are needed at the regenerator, you simply add an interface card to the ONS 15454 to support the services. This does not require any new software or network engineering, just plug in the interface card and turn up the service. Figure 9-31 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, BLSR, and virtual rings, and PPMN meshes. Adding new interface cards and activating new services is non-service affecting.

Figure 9-31 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 9-32 shows the shelf layout for the ONS 15454 OC-48 regenerator node shown in Figure 9-31.

Figure 9-32 OC-48 Regenerator Node Shelf Layout



Passive DWDM Applications

The ONS 15454 supports 18 different OC48 ELR ITU-T 200 GHz, 37 OC48 ELR ITU-T 100 GHz cards, or OC192 LR ITU-T 1000Hz to provide you with up to 320 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 ITU-T cards with the ONS 15216 passive DWDM filters greatly expands the capabilities of the ONS 15454. Figure 9-33 shows a typical 7ft. x 19in. rack layout for a DWDM hub site using ONS 15454 OC48 ELR ITU-T cards and multiplexers and demultiplexers.

Figure 9-33 DWDM Hub Site Layout

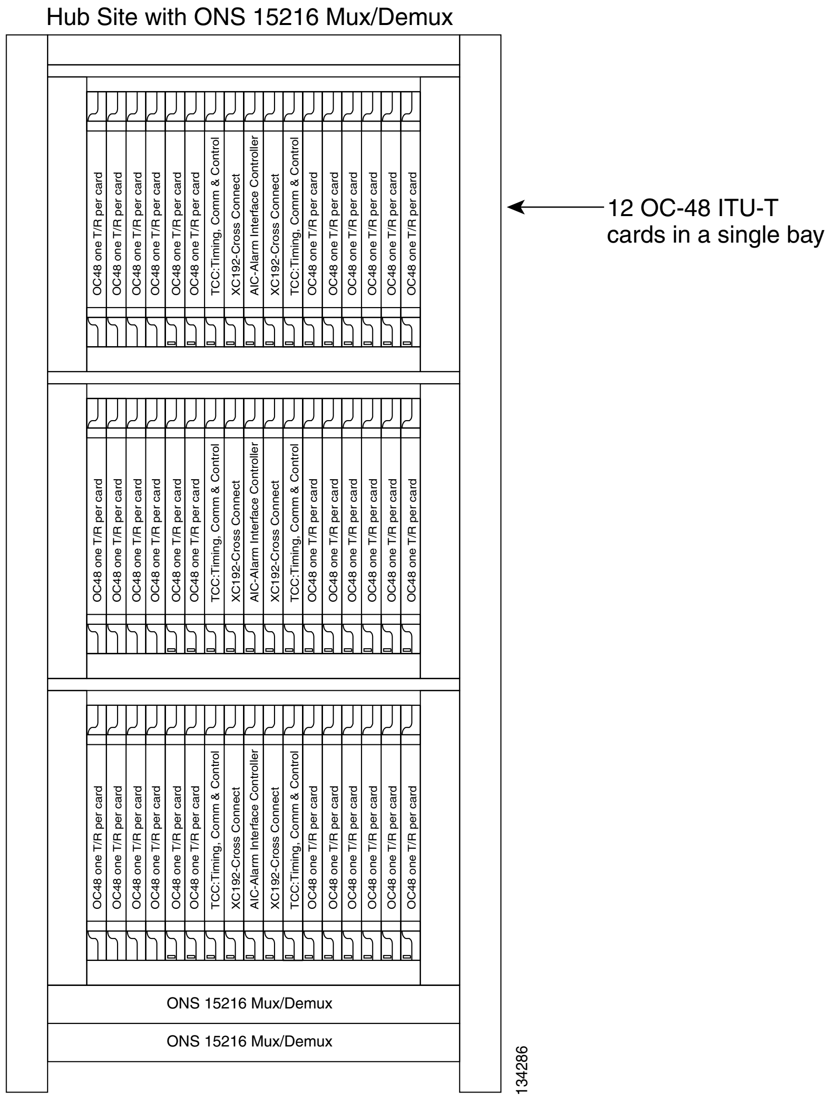
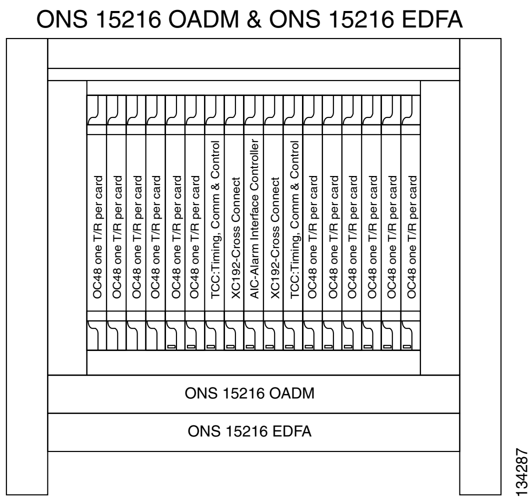


Figure 9-34 is an example of an optical add/drop multiplexer (OADM) site where multiple channels can be dropped an inserted. The 7ft. x 19in. rack is equipped with a single ONS 15454 shelf containing the ONS 15454 OC48 ELR ITU-T optics cards, OADM unit, and EDFA.

Figure 9-34 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 9-35.

Figure 9-35 Passive DWDM Interface

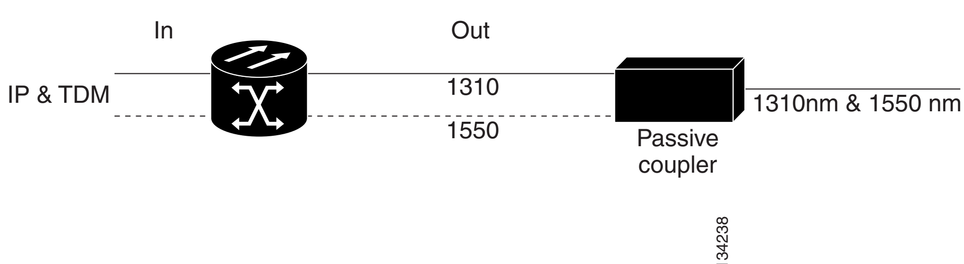
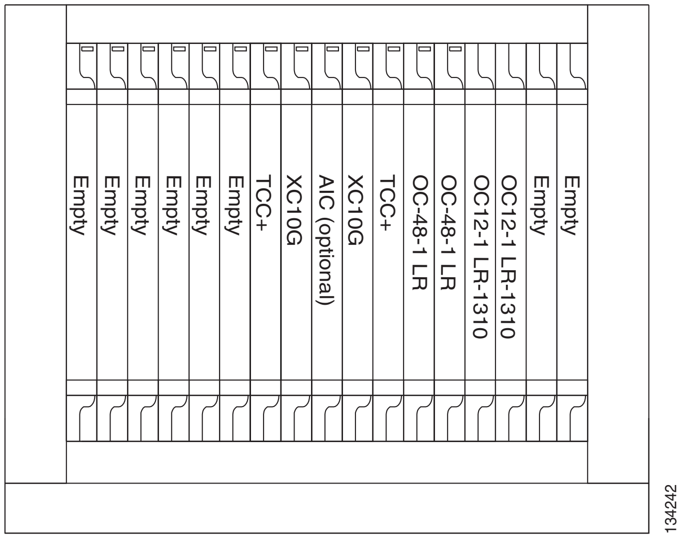


Figure 9-36 shows the shelf layout for an ONS 15454 Passive Wavelength Multiplexing node.

Figure 9-36 Passive Wavelength Multiplexing Node



MSTP DWDM Applications

Cisco ONS 15454 MSTP nodes can be provisioned for metro access and metro core DWDM network applications. Metro access networks are 60 km or less in size. Channels are not equalized and dispersion compensation is not applied. Metro access networks have few spans and very low span loss, so the signal link budget is the limiting factor for performance. Metro core networks can be up to 400 km in size. The channel power is equalized and dispersion compensation is applied. Metro core networks often include multiple spans and amplifiers, so the optical signal-to-noise ratio (OSNR) is the limiting factor for channel performance in metro core networks.

Within DWDM networks, the ONS 15454 uses a communications protocol, called node services protocol (NSP), to communicate with other nodes. NSP automatically updates nodes whenever a change in the network occurs. Each ONS 15454 DWDM node can:

- Identify other ONS 15454 DWDM nodes in the network.
- Identify the different types of DWDM networks.
- Identify when the DWDM network is complete and when it is incomplete.

For ONS 15454 MSTP DWDM node configurations, refer to Chapter 4 in this document.

Ethernet Applications

The Cisco ONS 15454 integrates Ethernet into a SONET time-division multiplexing (TDM) platform. The ONS 15454 supports CE-. E-, G-, and ML-Series Ethernet cards.

The CE-Series card is the CE-100T-8, which is a Layer 1 mapper card with eight 10/100 Ethernet ports. It maps each port to a unique SONET circuit in a point-to-point configuration. The CE-100T-8 card allows you to provision and manage an Ethernet private line service like a traditional SONET line. CE-100T-8 card applications include providing carrier-grade Ethernet private line services and high-availability 10/100 Mb/s data transport.

The CE-100T-8 has eight POS ports, numbered one through eight. Each POS port is statically mapped to a matching Ethernet port. Each POS port terminates an independent contiguous SONET concatenation (CCAT) or virtual SONET concatenation (VCAT). The CE-100T-8 supports circuit sizes from VT1.5-nV (n= 1 to 64) to STS-3c.

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, however Cisco recommends that you place no more than four 12-port Ethernet cards in a single shelf. You can insert these cards in slots 1 - 6 and 12 - 17. 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 Ethernet Card Software Feature and Configuration Guide*.

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). Use Table 9-3 to select the Ethernet card and features for your application. For more information about Cisco ONS 15454 Ethernet cards and software configurations, refer to the *Cisco Ethernet Card Software Feature and Configuration Guide*.

Table 9-3 Supported Ethernet Features

Card Type	10/100 Interfaces	GE Interfaces	Shelf Assembly	Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q in Q VLAN Tagging	GFP Support
CE-100T-8	8	—	15454-SA-ANSI 15454-SA-HD	> R5.0.2	Transparent	Transparent	Transparent	Yes
E100T-12	12	—	All	> R2.0	509	Configurable	Linear Mode	—
E100T-12G	12	—	All	> R2.0	509	Configurable	Linear Mode	—
E1000-2	—	2	All	> R2.0	509	Configurable	Linear Mode	—
E1000-2-G	—	2	All	> R2.0	509	Configurable	Linear Mode	—

Table 9-3 Supported Ethernet Features (continued)

Card Type	10/100 Interfaces	GE Interfaces	Shelf Assembly	Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q in Q VLAN Tagging	GFP Support
G1000-4	—	4	15454-SA-ANSI 15454-SA-HD	> R3.2	Transparent	Transparent	Transparent	—
G1K-4	—	4	15454-SA-ANSI 15454-SA-HD	> R3.2	Transparent	Transparent	Transparent	—
ML100T-12	12	—	15454-SA-ANSI 15454-SA-HD	> R4.0	255 Logical VLANs, 900 VLAN Subinterfaces	Configurable	Yes	Yes
ML1000-2	—	2	15454-SA-ANSI 15454-SA-HD	> R4.0	255 Logical VLANs, 900 VLAN Subinterfaces	Configurable	Yes	Yes[1]

Card Type	VCAT Support	LCAS Support	Maximum Frame Size	Broadcast and Multicast Support	Spanning Tree Support	Resilent Packet Ring (RPR)	Rate Limiting	Maximum Circuit Size
CE-100T-8	HO, LO	Yes	1548 bytes	Point-to-Point1	Transparent	—	VT1.5-nV (n= 1 to 64) to STS-1-2v	STS-3C (100 Mb/s)
E100T-12	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
E100T-12G	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
E1000-2	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
E1000-2-G	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
G1000-4	—	—	10,000 bytes	Point-to-Point[1]	Transparent	—	STS-1 to STS-24C	STS-48C
G1K-4	—	—	10,000 bytes	Point-to-Point[1]	Transparent	—	STS-1 to STS-24C	STS-48C

Table 9-3 Supported Ethernet Features (continued)

Card Type	10/100 Interfaces	GE Interfaces	Shelf Assembly	Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q in Q VLAN Tagging	GFP Support
ML100T-12	HO[2]	SW-LCAS[3]	10,000 bytes	Yes[4]	Yes, 255 STP and RSTP instances	Yes	1 Mb/s increments at port level	STS-24C
ML1000-2	HO[2]	SW-LCAS[3]	10,000 bytes	Yes[4]	Yes, 255 STP and RSTP instances	Yes	1 Mb/s increments at port level	STS-24C

1. Multicast support limited to port-to-port circuits.
2. Requires Software Release 5.0 or higher.
3. Ciso's proprietary software link capacity adjustment scheme (SW-LCAS) is the software implementation of a LCAS-type feature. SW-LCAS differs from LCAS because it is not errorless and uses a different handshaking mechanism.
4. No IGMP snooping, which allows multicast to be treated as broadcast.

Ethernet Private Line

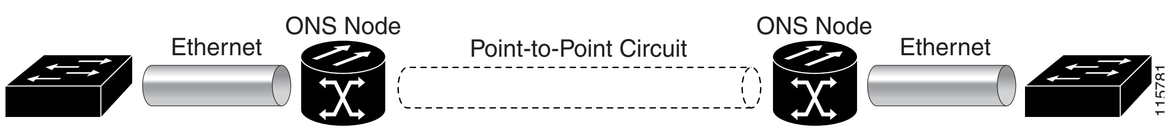
The CE- and G-Series cards allow you to provision and manage an Ethernet private line service like a traditional SONET line. Ethernet private lines provide carrier-grade transparent LAN services (TLS) between two ONS 15454 nodes. No VLAN knowledge or layer 2 provisioning is required in this application. Only simple provisioning of STS cross-connects is required.

The Ethernet frame from the data network is transmitted on the Ethernet cable into the standard RJ-45 port on a CE-100T-8 card. The CE-100T-8 card transparently maps Ethernet frames into the SONET payload using packet-over-SONET (POS) encapsulation. The POS circuit with its encapsulated Ethernet inside is then multiplexed onto an OC-N card like any other SONET STS.

The G1000-4 and G1K4 cards map a single Ethernet port to a single STS circuit. You can independently map the four ports on a 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 that the sum of the circuit sizes that terminate on a card do not exceed STS-48c.

Standard SONET path protection configurations/BLSRs provide less than 50 milliseconds restoration of service for Ethernet private line transport. Figure 9-37 illustrates an example of an Ethernet Private Line application. In this example, data traffic from the Fast Ethernet port of a switch travels across the point-to-point circuit to the Fast Ethernet port of another switch.

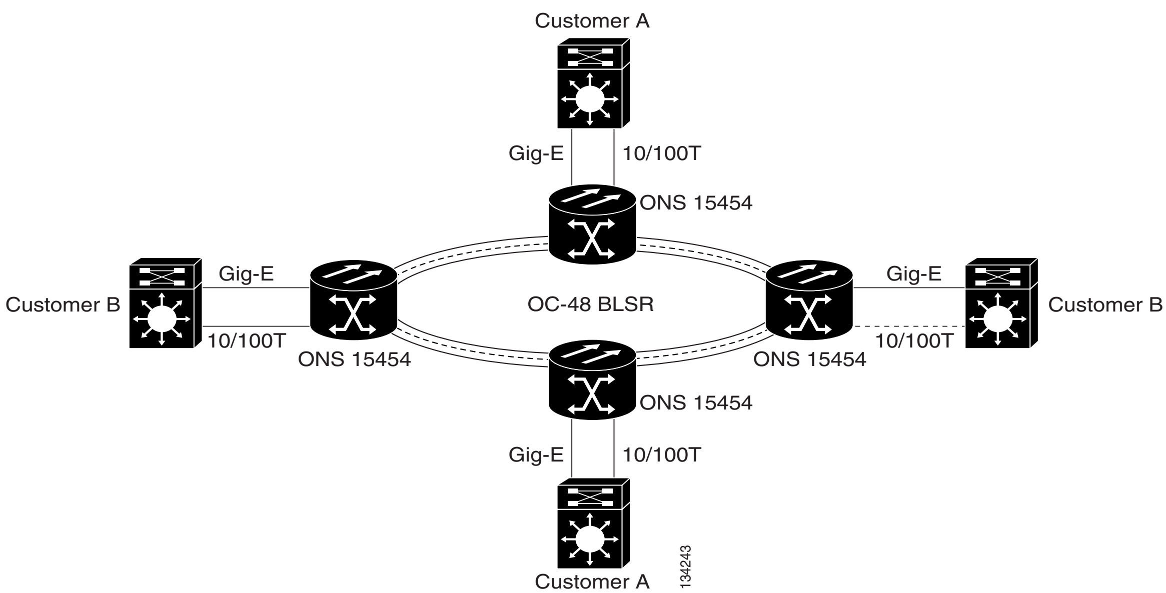
Figure 9-37 Ethernet Private Line



Transparent LAN Service

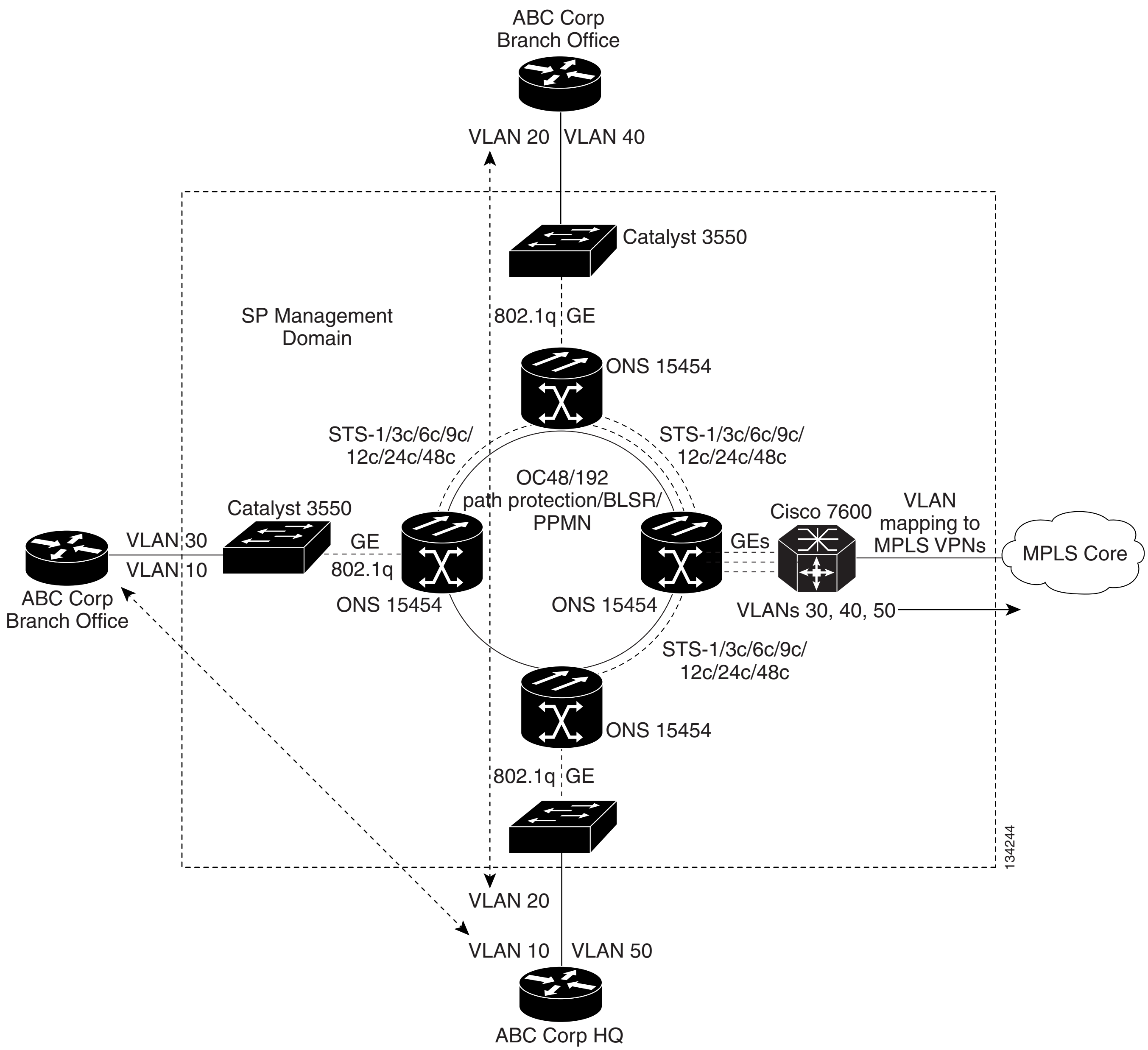
A transparent LAN service (TLS) is a Virtual Ethernet Connection (VEC) that appears to act as an Ethernet wire, where all Ethernet traffic is seen by all remote ends. The customer only sees its end devices and the traffic generated or going through these equipments. In other words, the Metro network 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 9-38.

Figure 9-38 Transparent LAN Service Architecture



As illustrated on the Figure 9-39, several types of services can be delivered through the same client network interface with this architecture. The TLS between the corporate office and the branch offices (VLAN 10 and 20) and Access to MPLS VPNs are delivered over the same UNI and GE 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.

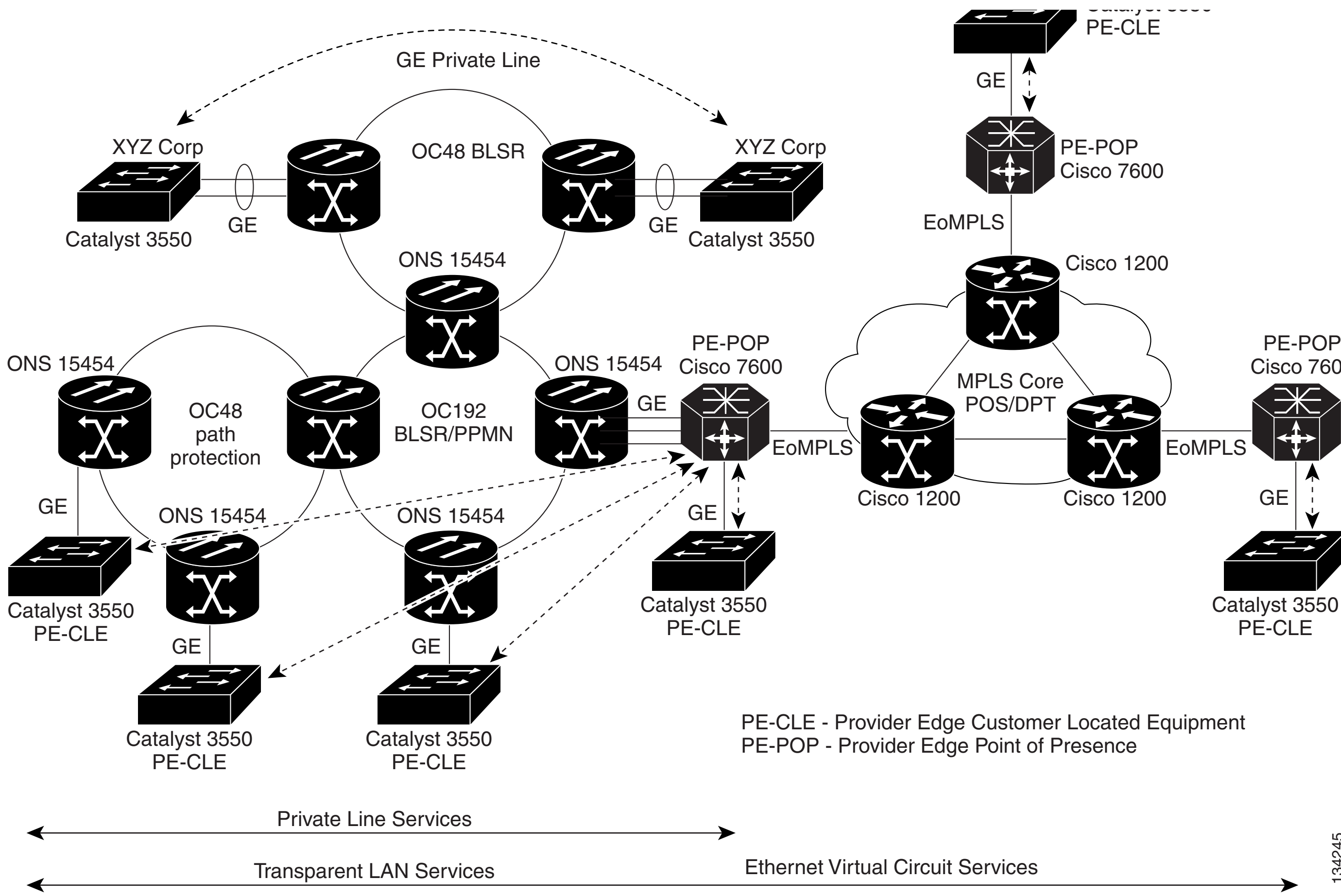
Figure 9-39 Transparent LAN Service Example



Metro Ethernet Solution

A complete Metro Ethernet solution illustrating TLS and GE private line services or Ethernet Virtual Circuit services is shown in Figure 9-40. 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 9-40 Metro Ethernet Solution



Resilient Packet Ring

Resilient Packet Ring (RPR) is an emerging network architecture designed for metro fiber ring networks. This new MAC protocol is designed to overcome the limitations of IEEE 802.1D Spanning Tree Protocol (STP), IEEE 802.1W Rapid Spanning Tree Protocol (RSTP), and SONET in packet-based networks. RPR operates at the Layer 2 level and is compatible with Ethernet and SONET.

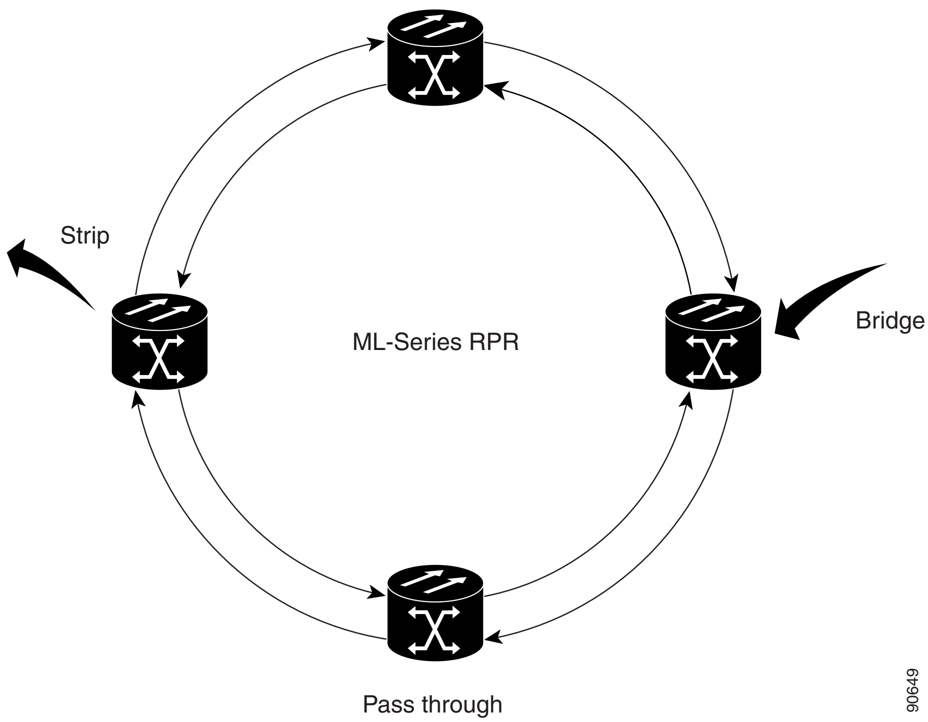
The ML-Series card's RPR relies on the quality of service (QoS) features of the ML-Series card for efficient bandwidth utilization with service level agreement (SLA) support. ML-Series card QoS mechanisms apply to all SONET traffic on the ML-Series card, whether passed-through, bridged, or stripped.

When a ML-Series card is configured with RPR and made part of a shared packet ring (SPR), the ML-Series card assumes it is part of a ring. If a packet is not destined for devices attached to the specific ML-Series, the ML-Series card simply continues to forward this transit traffic along the SONET circuit, relying on the circular path of the ring architecture to guarantee that the packet will eventually arrive at the destination. This eliminates the need to queue and forward the packet flowing through the nondestination ML-Series card. From a Layer 2 or Layer 3 perspective, the entire RPR looks like one shared network segment.

RPR supports operation over protected and unprotected SONET circuits. On unprotected SONET circuits, RPR provides SONET-like protection without the redundant SONET protection path. Eliminating the need for a redundant SONET path frees bandwidth for additional traffic. RPR also incorporates spatial reuse of bandwidth through a hash algorithm for east/west packet transmission. RPR utilizes the entire ring bandwidth and does not need to block ring segments like STP or RSTP.

Because STP or RSTP is not in effect between nodes when RPR is configured, the transmitting RPR port strips its own packets after they return from circling the ring. A hash algorithm is used to determine the direction of the packet around the RPR. Figure 9-41 illustrates how RPR handles this operation.

Figure 9-41 RPR Packet Handling Operations



Configuring ML-Series Cards for RPR

RPR on the Cisco ONS 15454 enables two or more ML-Series cards to become one functional network segment or SPR. The bridged ML-Series cards are connected to each other through point-to-point STS circuits, which use one of the first ML-Series card's POS ports as a source and one of the second ML-Series card's POS ports as a destination. All ML-Series cards in an SPR must be connected directly or indirectly by point-to-point circuits.

The point-to-point circuits use the ONS 15454 SONET network for transport and protection. Provision the point-to-point circuits using Cisco Transport Controller (CTC) or TL1 in the same manner as an ONS 15454 OC-N card STS circuits. The Cisco ONS 15454 Procedure Guide or the Cisco ONS 15454 Procedure Guide provides specific instructions about how to create an automatically routed optical circuit.

When configuring a point-to-point circuit on the ML-Series perform the following:

- Leave all CTC Circuit Creation Wizard options at default, except Fully Protected Path on the Circuit Routing Preferences dialog box, which provides SONET protection and should be unchecked. RPR provides Layer 2 protection for SPR circuits.
- Check Using Required Nodes and Spans to route automatically in the Circuit Routing Preferences dialog box. If the source and destination nodes are adjacent on the ring, exclude all nodes except the source and destination in the Circuit Routing Preferences dialog box. This forces the circuit to be routed directly between source and destination and preserves STS circuits, which would be consumed if the circuit routed through other nodes in the ring. If there is a node or nodes that do not contain an ML-Series card between the two nodes containing ML- Series card, include this node or nodes in the included nodes area in the Circuit Routing Preference dialog box, along with the source and destination nodes.
- Keep in mind that ML-Series card STS circuits do not support unrelated circuit creation options, such as unidirectional traffic, creating cross-connects only (TL1-like), interdomain (unified control plane [UCP]), protected drops, or path protection path selectors.

After the CTC circuit process is complete, begin a Cisco IOS session to configure RPR/SPR on the ML-Series card and interfaces.

Note A best practice is to configure SONET circuits in an east-to-west or west-to-east configuration, from Port 0 (east) to Port 1 (west) or Port 1 (east) to Port 0 (west), around the SONET/SDH ring. Do not configure Port 0 to Port 0 or Port 1 to Port 1. The east-to-west or west-to-east setup is required for the Cisco Transport Manager (CTM) network management software to recognize the ML-Series configuration as an SPR.

Configuring Cisco IOS on the ML-Series Cards for RPR/SPR

You configure RPR on the ML-Series cards by creating an SPR interface from the Cisco IOS CLI. The SPR is a virtual interface, similar to an EtherChannel interface. The POS interfaces are the physical interfaces associated with the RPR SPR interface. An ML-Series card supports a single SPR interface. The SPR interface has a single MAC address and provides all the normal attributes of a Cisco IOS interface, such as support for default routes. An SPR interface is considered a trunk port, and like all trunk ports, subinterfaces must be configured for the SPR interface to become part of a bridge group.

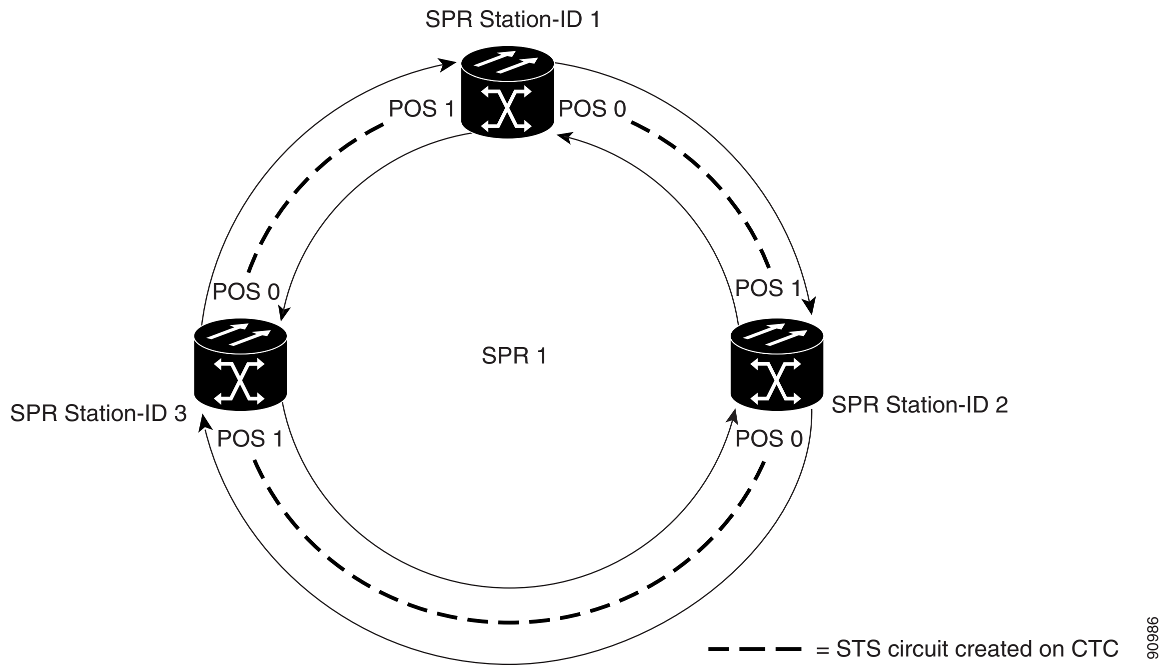
An SPR interface is configured similarly to a EtherChannel (port-channel) interface. The members of the SPR interface must be POS interfaces. Instead of using the channel-group command to define the members, you use the spr-intf-id command. And like port-channel, you configure the SPR interfaces instead of the POS interface.

Caution In configuring an SPR, if one ML-Series card is not configured with an SPR interface, but valid STS circuits connect this ML-Series card to the other ML-Series cards in the SPR, no traffic will flood between the properly configured ML-Series cards in the SPR, and no alarms will indicate this condition. Cisco recommends that you configure all of the ML-Series cards in an SPR before sending traffic.

Caution Do not use native VLANs for carrying traffic with RPR.

To provision RPR and to assign a POS interface on the ML-Series to the SPR, follow the procedures listed in the Cisco Ethernet Card Software Feature and Configuration Guide. Figure 9-42 shows an example of an RPR IOS configuration.

Figure 9-42 RPR Cisco IOS Configuration



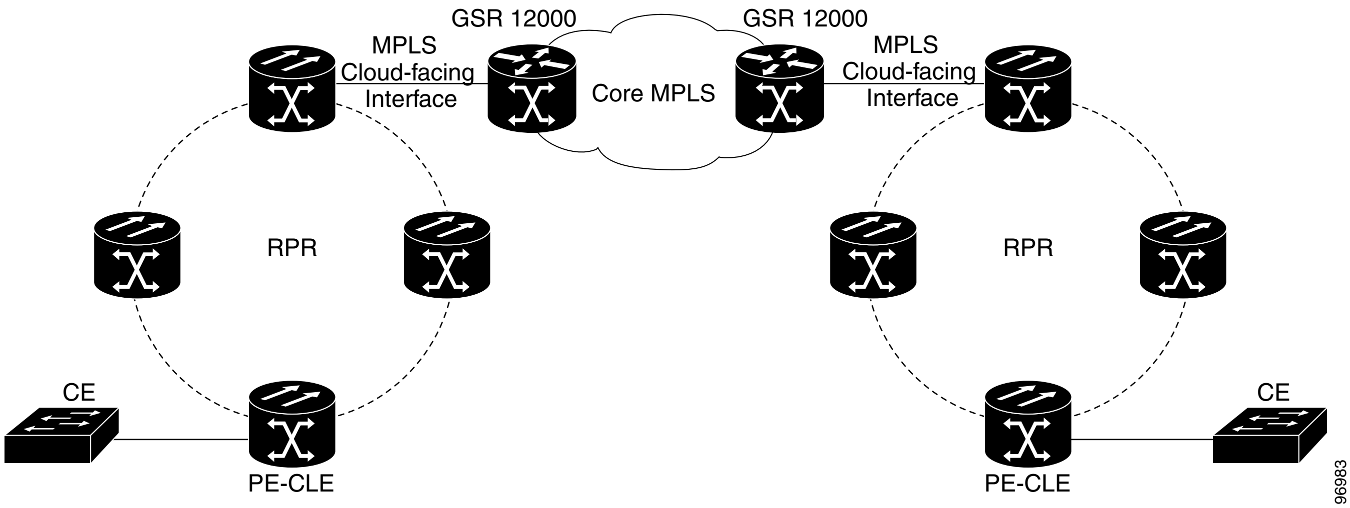
Ethernet over MPLS

Ethernet over MPLS (EoMPLS) provides a tunneling mechanism for Ethernet traffic through an MPLS-enabled Layer 3 core. It encapsulates Ethernet protocol data units (PDUs) inside MPLS packets and using label stacking forwards them across the MPLS network. EoMPLS is an Internet Engineering Task Force (IETF) standard-track protocol based on the Martini draft, specifically the draft-martini-l2circuit-encap-mpls-01 and draft-martini-l2circuit-transport-mpls-05 sections.

EoMPLS allows you to offer customers a virtual Ethernet line service or VLAN service using the service provider's existing MPLS backbone. It also simplifies service provider provisioning, since the provider edge customer-leading edge (PE-CLE) equipment only needs to provide Layer 2 connectivity to the connected customer edge (CE) equipment.

Figure 9-43 shows an example of EoMPLS implemented on a service provider network. In the example, the ML-Series card acts as PE-CLE equipment connecting to the Cisco GSR 12000 Series through an RPR access ring. Point-to-point service is provided to CE equipment in different sites that connect through ML-Series cards to the ML-Series card RPR access ring.

Figure 9-43 EoMPLS Service Provider Network



Implementing EoMPLS on a network requires ML-Series card interfaces to play three major roles. The ML-Series card interface roles must be configured on both sides of the EoMPLS point-to-point service crossing the MPLS core as follows:

- ML-Series card interfaces connect the provider's network directly to the customer edge equipment and are known as the PE-CLE interfaces. This PE-CLE interface on the ML-Series card is FastEthernet or GigabitEthernet and is configured to be an endpoint on the EoMPLS point-to-point session.
- An ML-Series card interface bridges the PE-CLE interface and the RPR network of ML-Series cards. This RPR/SPR interface contains POS ports and is configured for MPLS IP.
- An ML-Series card interface connects to a core MPLS interface. This interface is GigabitEthernet or FastEthernet and connects to the port of a Cisco GSR 12000 Series or similar device that is on the MPLS network. This MPLS cloud-facing interface bridges the SPR interface and the MPLS cloud.

Implementing EoMPLS across a network requires setting up directed Label Distribution Protocol (LDP) sessions (LSPs) between the ingress and egress PE-CLE routers to exchange information for a virtual circuit (VC). Each VC consists of two LSPs, one in each direction, since an LSP is a directed path to carry Layer 2 frames in one direction only.

EoMPLS uses a two-level label stack to transport Layer 2 frames, where the bottom/inner label is the VC label and the top/outer label is the tunnel label. The VC label is provided to the ingress PE-CLE by the egress PE-CLE of a particular LSP to direct traffic to a particular egress interface on the egress PE-CLE. A VC label is assigned by the egress PE-CLE during the VC setup and represents the binding between the egress interface and a unique and configurative VC ID. During a VC setup, the ingress and egress PE-CLE exchange VC label bindings for the specified VC ID.

An EoMPLS VC on the ML-Series card can transport an Ethernet port or an IEEE 802.1Q VLAN over MPLS. A VC type 5 tunnels an Ethernet port and a VC type 4 transports a VLAN over MPLS. In a VC type 5 session, the user can expect any traffic that is received on an ML-Series card PE-CLE port with an mpls Layer 2 transport route command to be tunneled to the remote egress interface on the far-end ML-Series card PE-CLE port. With a VC type 4, a user can expect the tunnel to act as physical extension to that VLAN. The EoMPLS session commands are entered on a VLAN subinterface on the PE-CLE, and only VLAN-tagged traffic received on that port will be tunneled to the remote PE-CLE.

EoMPLS on the ML-Series card has the following characteristics:

- EoMPLS is only supported on FastEthernet and GigabitEthernet interfaces or subinterfaces.
- MPLS tag switching is only supported on SPR interfaces.
- Class of service (CoS) values are mapped to the experimental (EXP) bits in the MPLS label, either statically or by using the IEEE 802.1p bits (default).
- The ingress PE-CLE ML-Series card sets the time-to-live field to 2 and the tunnel label to a value of 255.
- Ingress PE-CLE ML-Series cards set the S bit of the VC label to 1 to indicate that the VC label is at the bottom of the stack.
- Since EoMPLS traffic is carried over the RPR, whatever load balancing is applicable for the traffic ingressing RPR is also applicable for the EoMPLS traffic.
- The Ethernet over MPLS feature is part of the Cisco Any Transport over MPLS (AToM) product set.
- The ML-Series card hosting the EoMPLS endpoint ports must be running the MPLS microcode image to support EoMPLS. For more information on multiple microcode images, see the "Multiple Microcode Images" section in the Cisco Ethernet Card Software Feature and Configuration Guide. Other ML-Series cards in the RPR are not restricted to the MPLS microcode image.

EoMPLS on the ML-Series card has the following restrictions:

- Packet-based load balancing is not supported. Instead, circuit-ID based load balancing is used.
- Zero hop or hairpin VCs are not supported. A single ML-Series card cannot be both the source and destination for a VC.
- MPLS control word for sequencing of data transmission is not supported. Packets must be received and transmitted without control word.
- Sequence checking or resequencing of EoMPLS traffic is not supported. Both depend on the control word to function.
- Maximum transmission unit (MTU) fragmentation is not supported.
- Explicit-null label for back-to-back LDP sessions is not supported.

Caution Since MTU fragmentation is not supported across the MPLS backbone, the network operator must make sure the MTU of all intermediate links between endpoints is sufficient to carry the largest Layer 2 PDU.

Configuring EoMPLS

The ML-Series peer cards on both endpoints of the EoMPLS point-to-point service must be configured. Perform the following configuration tasks to enable EoMPLS:

- VC Type 4 Configuration on PE-CLE Port (Either VC type 4 or VC type 5 is required).
- VC Type 5 Configuration on PE-CLE Port (Either VC type 4 or VC type 5 is required).
- EoMPLS Configuration on PE-CLE SPR Interface.
- Bridge Group Configuration on MPLS Cloud-facing Port.
- Setting the Priority of Packets with the EXP,

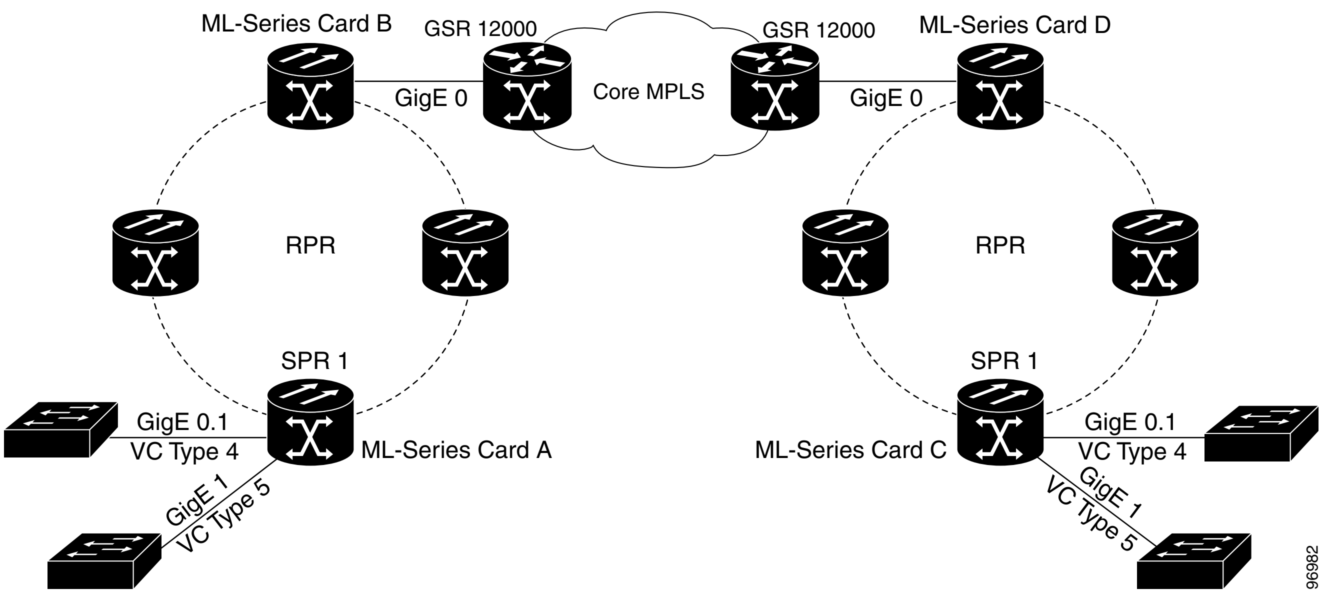
These are the guidelines for configuring EoMPLS:

- Loopback addresses are used to specify the peer ML-Series card's IP address.
- LDP configuration is required. The default Tag Distribution Protocol (TDP) will not work.

- EoMPLS uses LDP targeted session between the ML-Series cards to create the EoMPLS VCs.
- The MPLS backbone must use an Interior Gateway Protocol (IGP) routing protocol, for example, Intermediate System-to-Intermediate System (IS-IS) Protocol or Open Shortest Path First (OSPF).
- Tag switching of IP packets must be enabled on the SPR interface for the PE-CLE ML-Series card.

Figure 9-44 illustrates the sample network that the configuration commands reference.

Figure 9-44 EoMPLS Configuration Example



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 9-45 or over a Shared Packet Ring shown in Figure 9-46.

Figure 9-45 Point-to-Point Cable Modem Aggregation

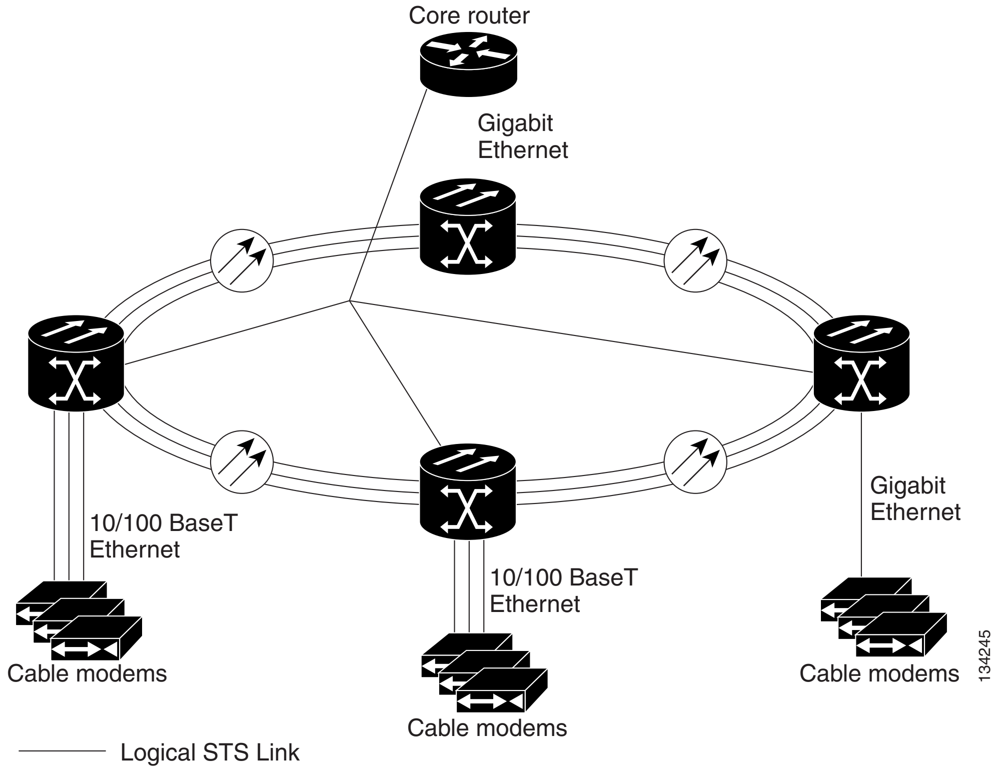
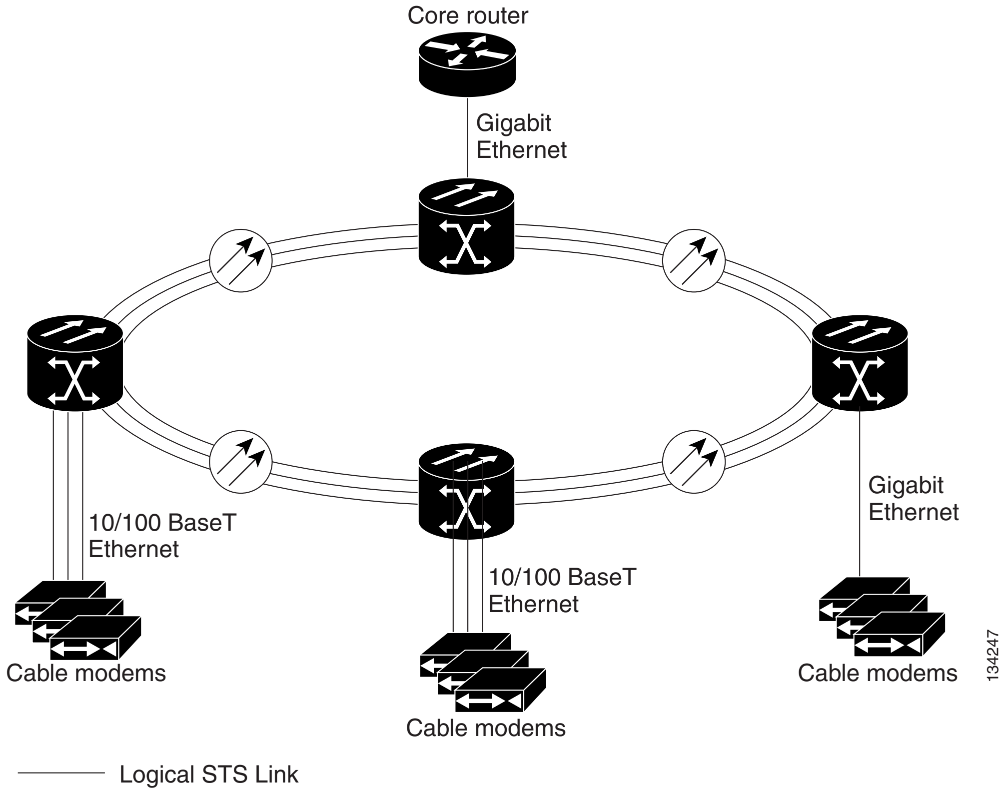


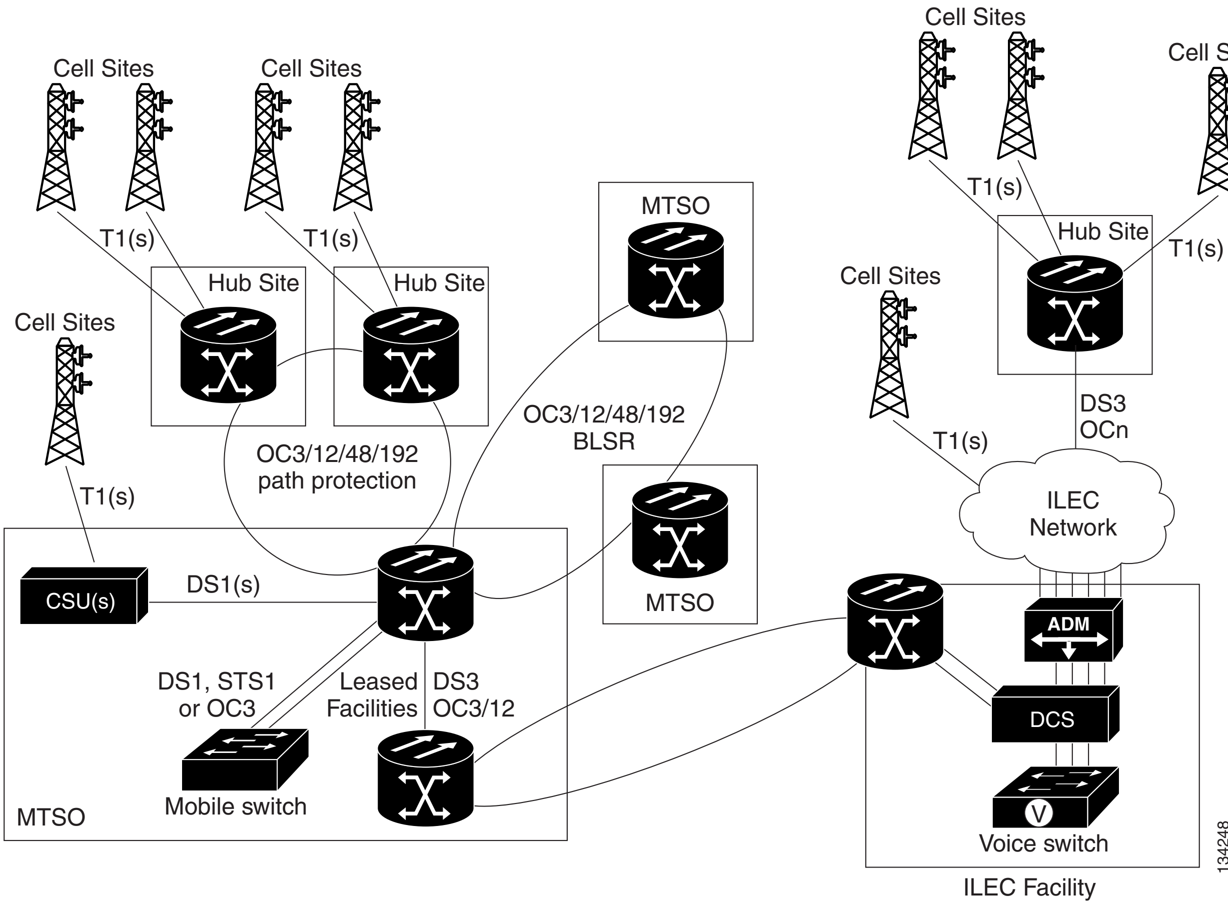
Figure 9-46 Shared Packet Ring Cable Modem Aggregation



Wireless Networking

The ONS 15454 provides cost-effective transport of services between mobile telephone switch offices (MTSOs) and hub sites. In Figure 9-47, the ONS 15454 provides T1 links from the cell sites to the hub sites and SONET transport between the MTSO sites and ILEC transport facilities. It also provides the optical bandwidth management between each MTSO site.

Figure 9-47 Wireless Networking Optical Bandwidth Management



Video Transport

The ONS 15454 provides the flexibility required to support the next generation hybrid fiber coax (HFC) and IP video networks.

HFC Networks

Next generation HFC networks are based on the regional hub concept and includes the following attributes:

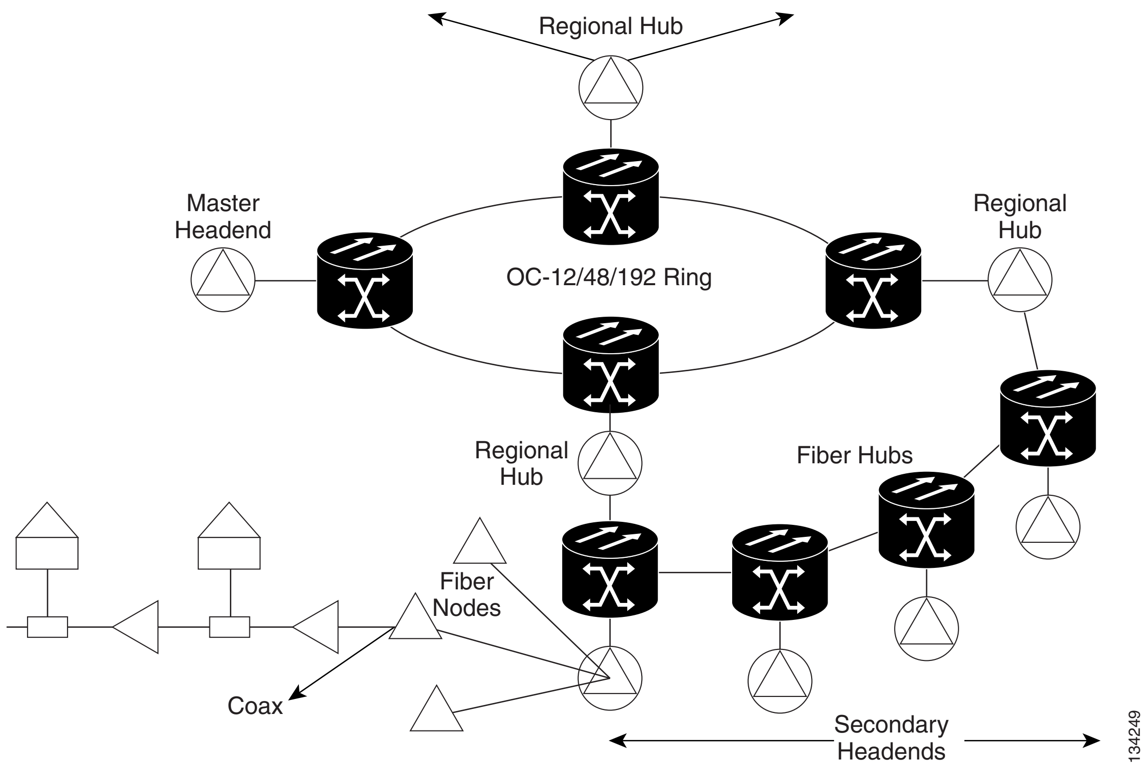
- A master headend offering the ability to combine voice, data, and video into ATM cells for transmission on a SONET network to secondary headends and regional hubs.
- Centralized regional hubs which allow sharing of common equipment among multiple system operators (MSOs) within the region.
- Fiber rings 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.

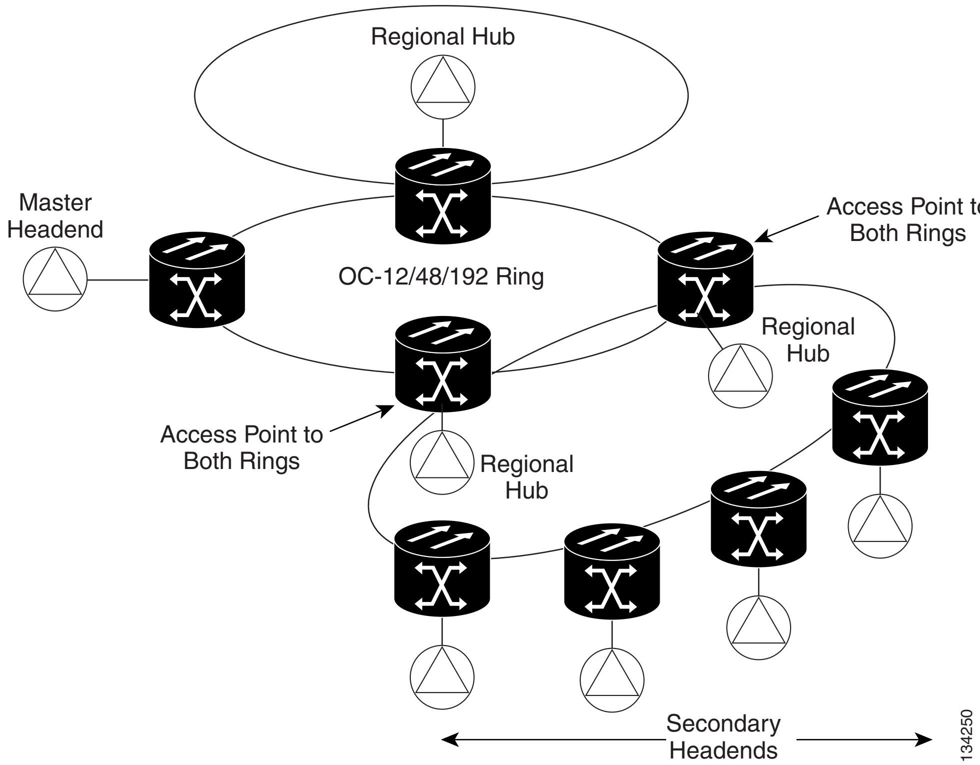
In Figure 9-48, the ONS 15454 MSPP is used to transport voice over IP (VoIP), high-speed data access, and video signals from the Master Headend to all Regional Headends and Fiber Hubs using SONET point-to-point and drop and continue circuits.

Figure 9-48 Next Generation HFC Network Architecture



Redundant systems can be installed to avoid single points of failure, as shown in Figure 9-49.

Figure 9-49 Avoiding Single Points of Failure

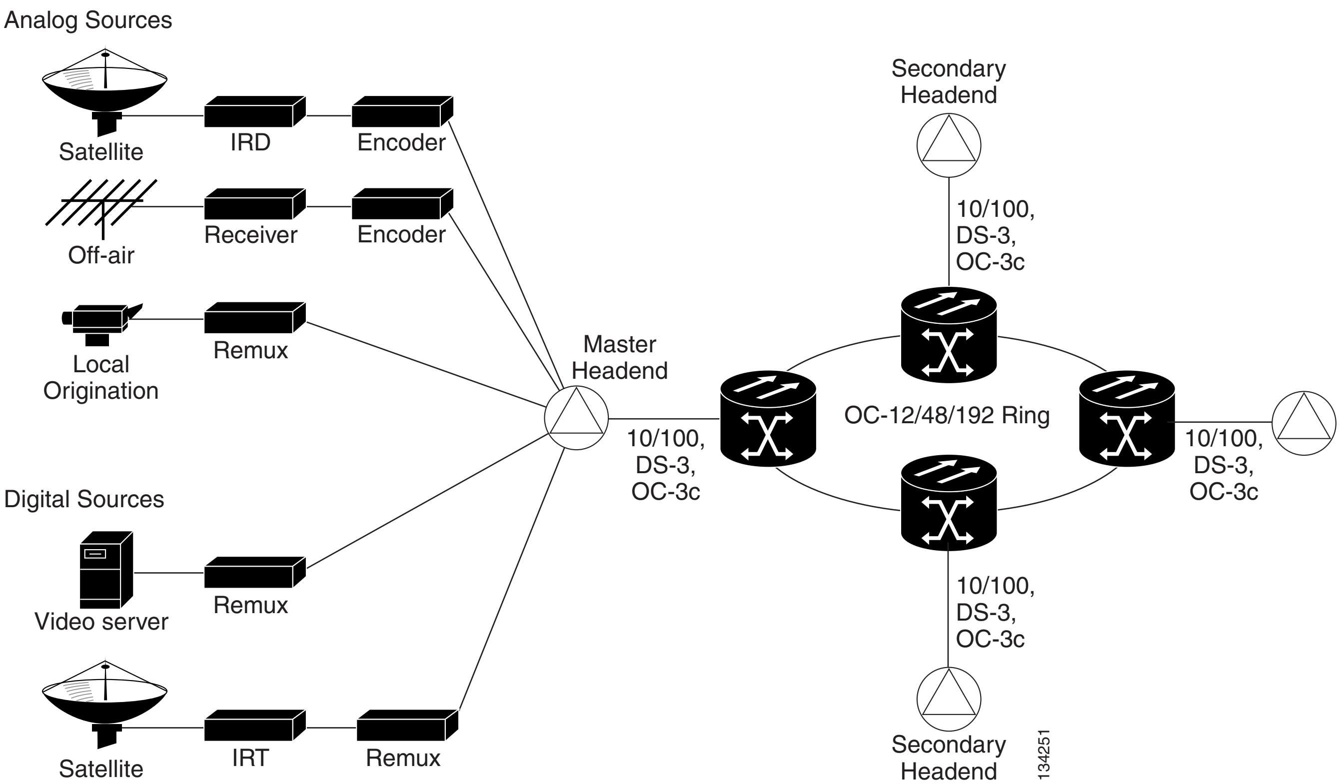


MSOs have been trading systems to create contiguous serving areas. These contiguous serving areas form a region. A region may have 10 to 20 different cable systems connected to a Regional Hub.

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 9-50, the ONS 15454 transports the standard channel line up over a SONET path protection to each Secondary Headend through its drop and continue capability.

Figure 9-50 Headend Consolidation

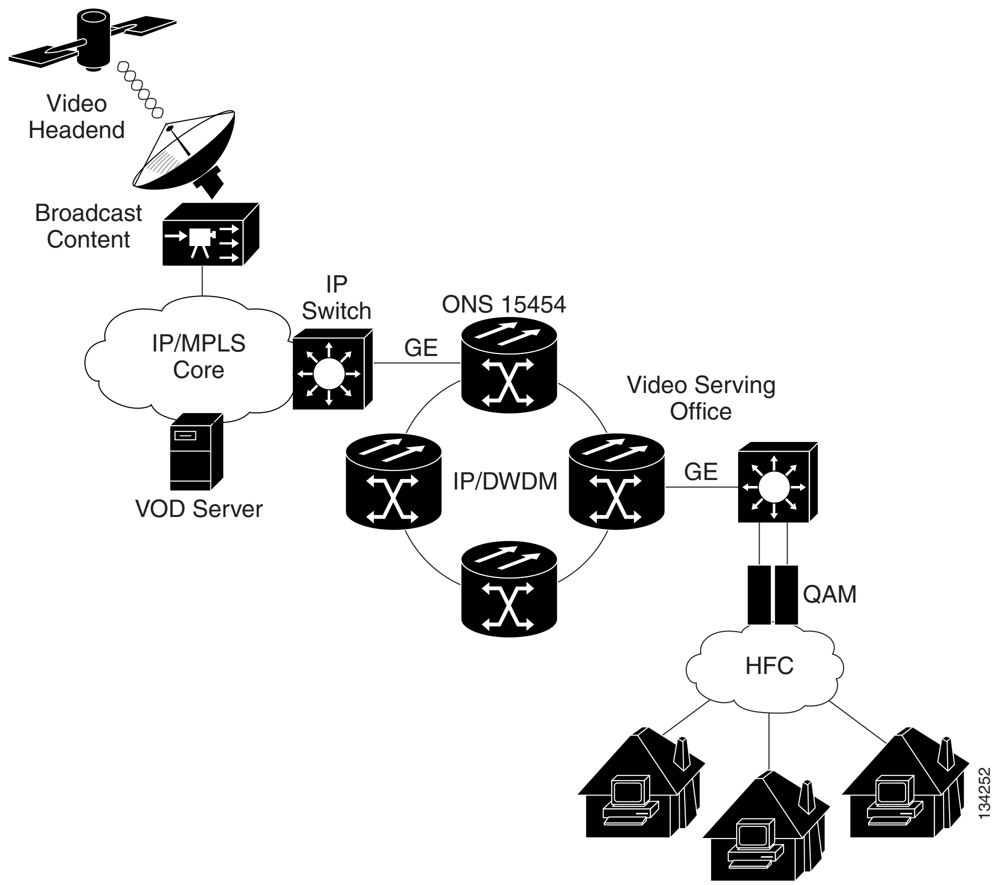


Video Over IP

Cable MSOs have been deploying separate networks for delivering cable television services and IP-based services such as high-speed data and IP telephony. The Video over IP architecture enables video services to be distributed via the IP network, enabling network consolidation and functionality not possible with the traditional video transport solutions.

The Video over IP architecture leverages the current digital video systems being deployed today while exploiting the benefits of IP networks for distributing broadcast video and video-on-demand (VOD) from the video hendend offices (VHOs) and video serving offices (VSOs) to the HFC access network. The inherent routing capability of the Video over IP architecture provides flexibility in the placement of video sources and improves network efficiency by enabling any video source to deliver content to any set-top box (STB). A reference architecture for Video over IP is depicted in Figure 9-51.

Figure 9-51 Video Over IP Reference Architecture



Many MSOs have a single unidirectional optical link between the headend and distribution hubs. DWDM (as opposed to CWDM) is typically chosen as the optical multiplexing technology, because the distance between the headend and distribution hubs often exceeds the CWDM range.

Gigabit Ethernet VOD can use DWDM optical components that are cost reduced to include DWDM lasers on ONS 15454 nodes that are used for transport. For example, the ONS 15454 nodes shown in Figure 9-52 are configured with G-Series Ethernet cards provisioned in the Gigabit Ethernet tranponder mode for efficient delivery VOD channels.

Figure 9-52 Efficient Distribution of VOD Channels

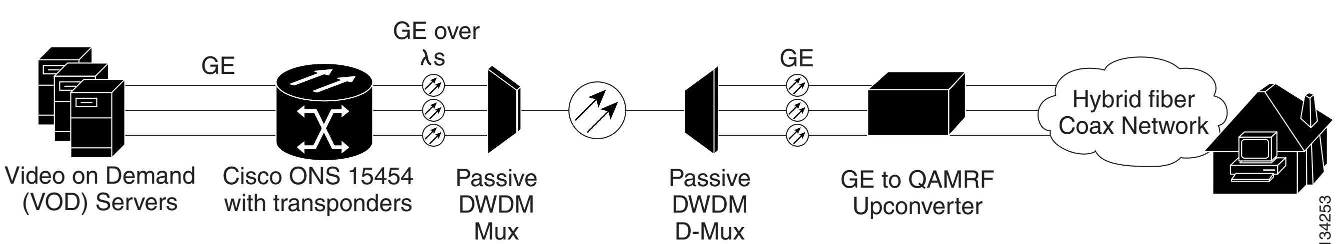
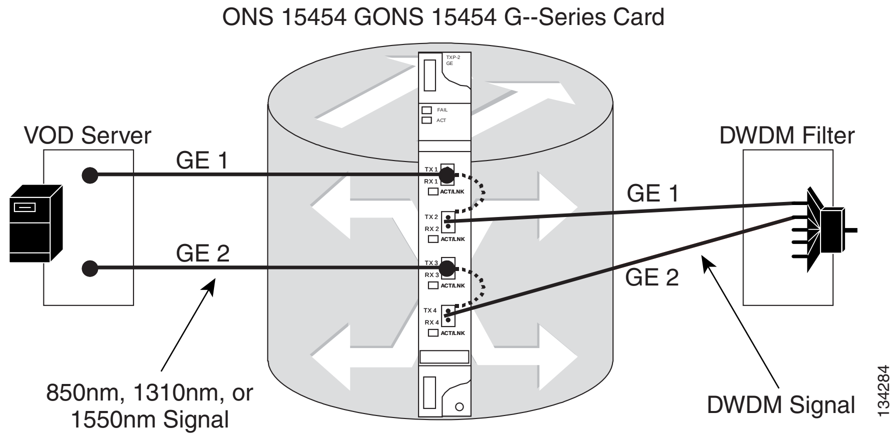


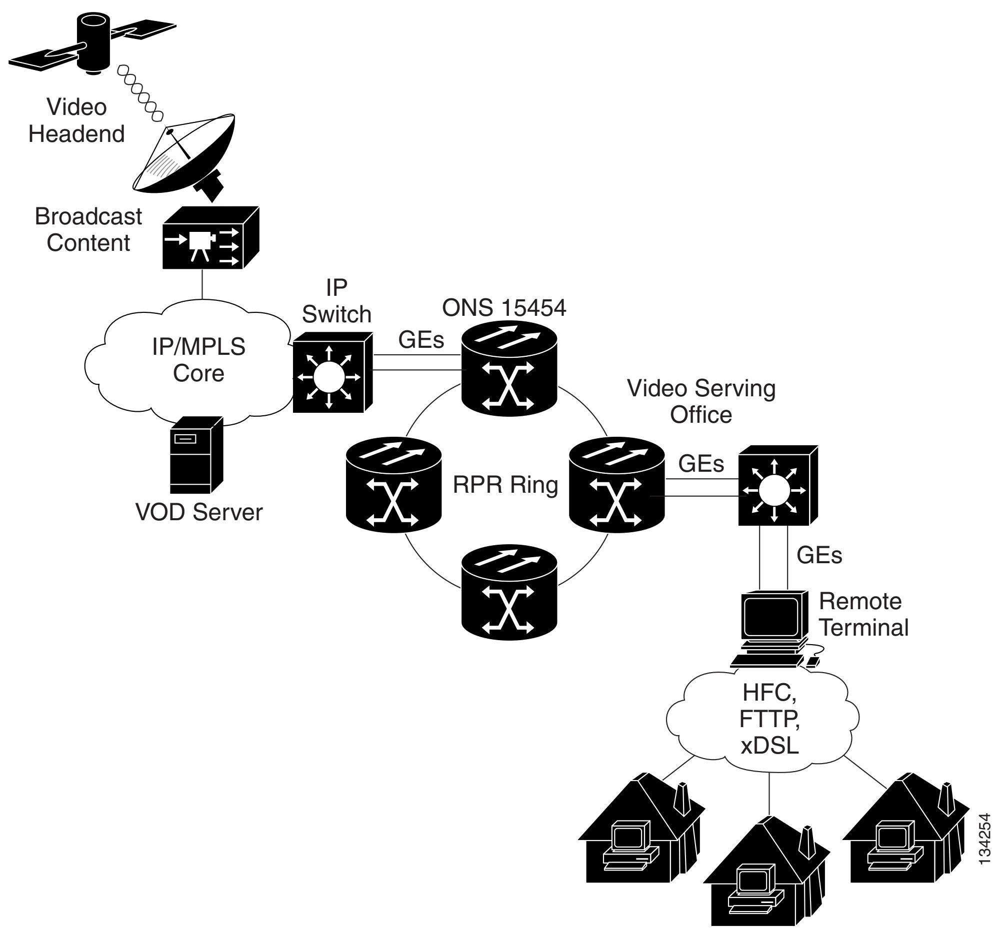
Figure 9-53 shows the basic wiring between the VOD server, G-Series Ethernet card, and the passive DWDM multiplexer.

Figure 9-53 Basic Gigabit Ethernet Transponder Wiring Diagram



You can also use ONS 15454 separate GE channels on ML-Series cards configured for RPR to distribute multi-cast broadcast and uni-cast VOD traffic between the VHOs and SVOs as illustrated in Figure 9-54. The access facilities between the VSO and remote terminals can either be HFC, FTTP, or xDSL.

Figure 9-54 RPR Video Distribution Architecture



SAN Extension Options

Storage Area Networks (SANs) consolidate data storage needs, increase storage efficiency, and reduce capital and operational costs (CapEx and OpEx). SAN extension enables disaster recovery and business continuance applications by transporting SAN protocols over long distances and thereby interconnecting isolated storage islands.

The following options are available for extending SAN over metro or WAN distances:

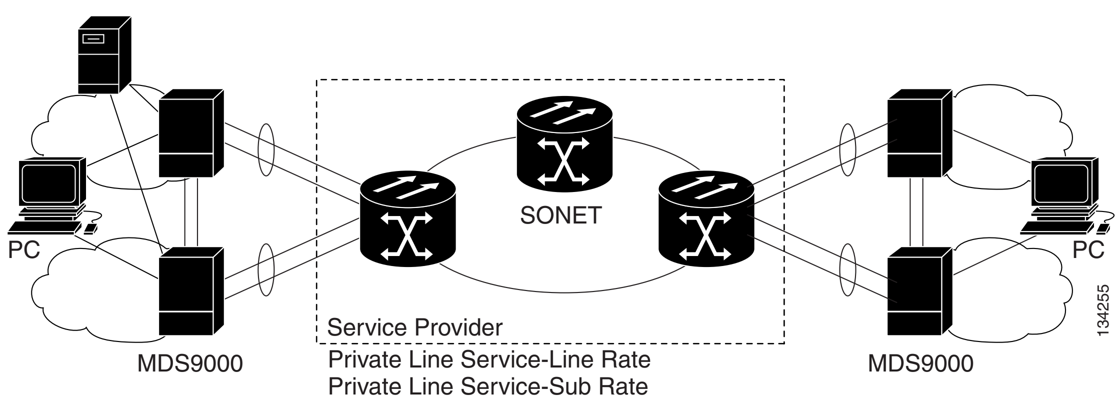
- Dark fiber - Distances are limited by the transmitter power, OSNR, and system receiver sensitivity.
- FC over DWDM - Delivers high bandwidth with low latency but at high cost. Deployed within metro rings with distances less than 200 kms. DWDM networks can be extended much further using amplifiers and dispersion compensation units, but the limitations of the FC protocol and business continuance applications may limit implementation to 100 kms or less.
- FC over IP - IP networks can extend SAN protocols over large areas, but applications with stringent requirements may not function efficiently due to the unpredictable nature of large TCP/IP networks. In well engineered IP networks, asynchronous applications perform extremely well.
- FC over SONET - SONET networks provide the primary optical backbone for most service providers. FC traffic can be integrated seamlessly with TDM and Ethernet traffic over a SONET/SDH network, with bandwidth assigned based on application requirements. A SONET/SDH network provides low latency and may extend FC over a large area.

SAN Extension services can be further classified as private line services and wire line services.

Private Line Services

SONET-based storage services can extend the SAN extension solutions to distances over 2000 Km by using spoofing techniques and are not subject to the buffer credit limitations imposed by storage switches and directors. SONET sub-rate support and 50 msec recovery time is ideal for supporting SLA's for a large number of enterprise applications. Figure 9-55 shows a typical SONET-based network providing both line rate and sub-rate services.

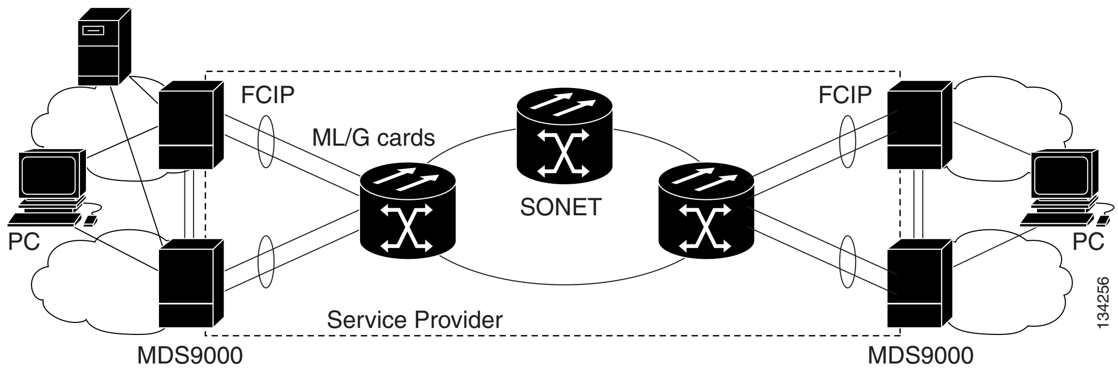
Figure 9-55 SONET-Based Private Line Service



Wire Line Services (FCIP Over SONET)

Wire Line Services over SONET is another viable low-cost way to extend SAN traffic. FCIP can be implemented using Layer 3 components of the ML-Series card on the ONS 15454. ONS 15454 networks can offer the multiplexing capability of IP and the protection of SONET. The ONS 15454 is also ideal for both asynchronous and synchronous applications. A typical service architecture is shown in Figure 9-56.

Figure 9-56 FCIP Over SONET—Point to Point



APPENDIX A

Compliance

This appendix lists ONS 15454 compliance with regulatory and industry standards relevant to Class A, Type 2 and Type 4 devices.

The following topics are covered in this chapter:

- Compliance Matrix, page A-1
- OSMINE Process, page A-3

Compliance Matrix

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

Table A-1 Compliance Matrix (continued)

Discipline	Country	Specification
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

- 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

- 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

This release has not been tested with OSMINE processes.

ONS 15454 Software Release 3.0

- Content
  - DS3
- TIRKS (19.4)
  - Final OSIA (R3.0/R3.1 Issue 2 is available
  - CLEI Codes completed
  - Supports non-adjacent optical slot protection
  - Does not support Limited VT Matrix
- NMA (10.1)
  - Final OSIA is available
  - NMA Test Plan is available)
  - Templates and M&P are available
  - System Test Report is available
- Transport (2.0)
  - Test Report is available
- Transport
  - Does not support non-adjacent optical slot protection until Software Release 3.3

ONS 15454 Software Release 3.1

- Content
  - OC192 LR, OC48 AS, XC10G, 10G Backplane/FTA, Limited VT Matrix
- TIRKS (19.4)
  - Final OSIA (R3.0/R3.1 Issue 2) is available

- Final OSIA (R3.0/R3.1 Issue 3) for HECIG changes (see Hybrid HECIG Issue) is available
- 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.
- CLEI Codes completed
- Support for Limited VT matrix for path protection, 1+1 and Linear Chain
- VT Matrix Circuit Descriptions

- NMA (10.1)
  - Support for Limited VT matrix for path protection, 1+1 and Linear Chain
  - Final OSIA is available
  - NMA Test Plan is available)
  - Templates and M&P are available
  - System Test Report is available
- Transport (2.1) (2.2.1)
  - Transport R2.1 Test Report is available
  - HECIG retest in Transport 2.2.1, Release Content Letter is available
  - No support for Limited VT matrix for path protection, 1+1 and Linear Chain until Software Release 3.2
  - Does not support non-adjacent optical slot protection until Software Release 3.3

ONS 15454 Software Release 3.2

This release has not been tested with the OSMINE process.

ONS 15454 Software Release 3.3

- 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, 1+1 and Linear Chain
  - Transport R2.4 Test Report is available

ONS 15454 Software Release 3.4

- 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

ONS 15454 Software Release 4.0

- 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, 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 available

ONS 15454 Software Release 4.1

This release has not been tested with the OSMINE processes. However, R4.0 OSMINE can be reused for R4.1.

ONS 15454 Software Release 4.5

- Content
  - Multi-rate (100 Mb/s to 2.5 Gb/s)100GHz Transponder (32 versions), Preamplifier, Booster Amplifier, 32 channel Multiplexer - C Band - Odd channels, 32 channel Demultiplexer - C Band - Odd channels, 4-channel Mux/Demux - C Band -OADM node (8 versions), 1channel (32 versions) OADM filter at 100GHz grid, 2 channels (16 versions) OADM filter at 100 GHz grid, 4 channels (8 versions) OADM filter at 100 GHz grid, 1Band OADM filter (8 versions), 4 Bands OADM filter (2 versions), Optical Service Channel Module, Optical Service Channel Module + Combiner/Separator, Dispersion Compensator negative - C band (7 versions), 2.5 Gb/s 100GHz Escon Data Mux, GE and FC 2.5 Gb/s 100GHz Data Mux, Dual-Port GigE Transponder
- TIRKS (19.8)
  - Final OSIA Issue 1 is available
- NMA support for R4.5 is included with R4.6
- Transport support for R4.5 is included with R4.6

ONS 15454 Software Release 4.6

- Content
  - Multi-rate (100 Mb/s to 2.5 Gb/s) 100GHz Transponder, Preamplifier, Booster Amplifier, 32 channel Multiplexer - C Band - Odd channels, 32 channel Demultiplexer - C Band - Odd channels, 4-channel Mux/Demux - C Band -OADM node, 1channel OADM filter at 100GHz grid, 2 channels OADM filter at 100 GHz grid, 4 channels OADM filter at 100 GHz grid, 1Band OADM filter, 4 Bands OADM filter, Optical Service Channel Module, Combiner and Separator with OSC Module, DS3/DS1 Signal Degrade Alarm + E1/E3, 6 Char BLSR/MSSPRing ID, Alarm on Firewall turned off, FC-4, Dual-Port GigE Transponder WDM GBICs, Support/Testing of Hair-pinning, Support/Testing of Performance Monitoring, Retest of 10G to OC192/STM64 ITU Transponder, Retest of 4x 2.5G to OC192/STM64 ELR ITU Muxponder, VCAT on FC_MR-4, HD Shelf, UBIC-V
- TIRKS (19.9)
  - Final OSIA Issue 1 is available
  - Final OSIA Issue 2 for FC_MR-4 is available
- NMA (13.0)
  - Final OSIA is available
  - NMA Test Plan is available
  - Templates and M&P are available
  - System Test Report is available
- Transport (3.1)

- Transport Release 3.1 is available
- Transport R3.1 Final Requirements are available
- Transport R3.1 Test Report is available

ONS 15454 Software Release 4.7

This release has not been tested by OSMINE processes. However, this release is supported by R5.0 OSMINE processes.

ONS 15454 Software Release 5.0

- Content
  - TCC2P, 48 Port DS3/EC1, 2.5 Gbit/s 100Ghz Datamux, DS3XM-12, 10GE/OC192/STM64 Transponder & 4x2.5G 10G Muxponder, 96-port (TX and RX) mini-BNC EIA panels, UBIC-H, CE-100-8, OC48 SR SFP, DRI BLSR, In-Service Topology Upgrades, ROADM Operational Enhancements, 32-WSS, 32-DMX, Bidirectional OCH, SL (FC-4) Enhancements, VT 1+1 Matrix Enhancements, Diagnostics (NMA for diag alarms), TL1 Improvement - name of CC via TL1, ML GFP, ESM, Provisionable Patchcord, OSNR/Power Monitoring per channel
- GFDS
  - Client Signal Direct Connect WDM Network, 2 Path Circuit with Independent Routing for Optical Networks, VCAT Split Routing, Slot Bandwidth Management
- TIRKS (20.0)
  - Final OSIA Issue 1 is available
  - Final OSIA Issue 2 is available
  - Final OSIA Issue 3 for SBM GFDS, HD configuration, and OC3-4 slot restriction support will be available March 2005
- NMA (14.0)
  - Final OSIA is available
  - Final NMA deliverables delayed until March 2005 due to NMA System Retest
  - NMA Test Plan will be available March 2005
  - System Test Report will be available March 2005
  - Templates and M&P will be available March 2005
- Transport (3.4)
  - Transport R3.4 Test Report is available
  - Transport R3.4 Final Requirements document is available

APPENDIX B

SONET Primer

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

The following topics are covered in this chapter:

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

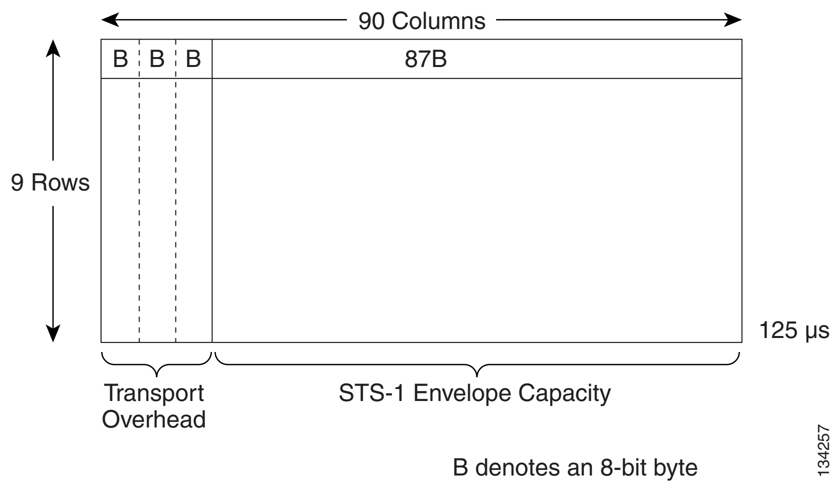
Table B-1 STS-1 Signal Hierarchy (continued)

STS-N Signal	OC-N Signal	Bit Rate	Channel Capacity
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

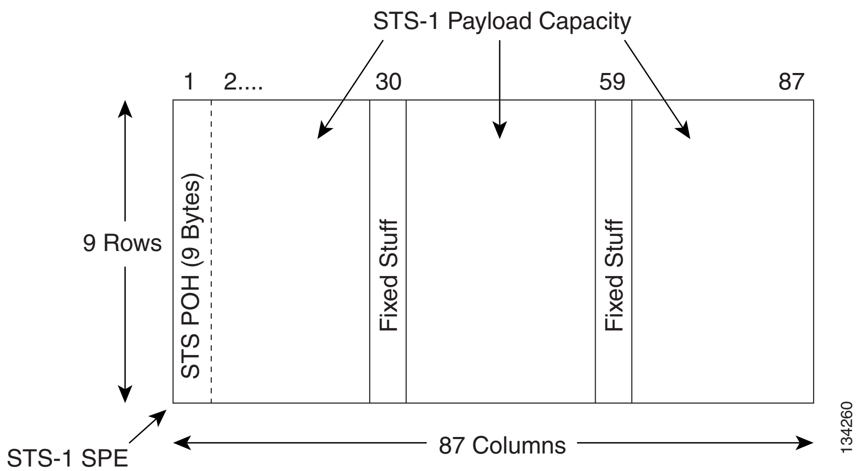


The first three columns in each of the nine rows carry the section and line overhead bytes. Collectively, these 27 bytes are referred to as Transport Overhead. Transport Overhead is composed of section overhead and line overhead. The STS-1 path overhead is part of the synchronous payload envelope. The 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 transported 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



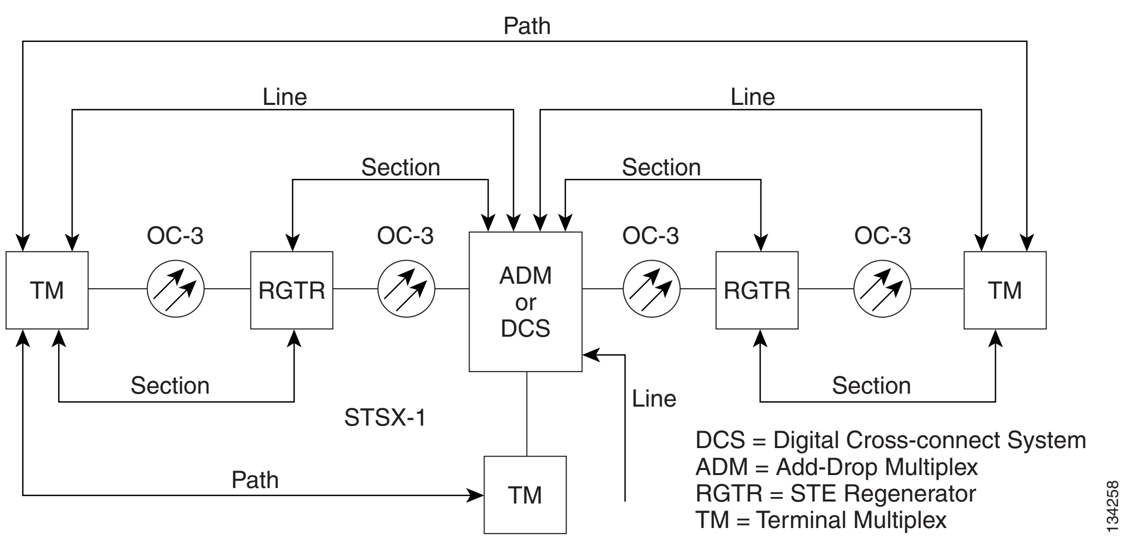
SONET Layers

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 3 (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

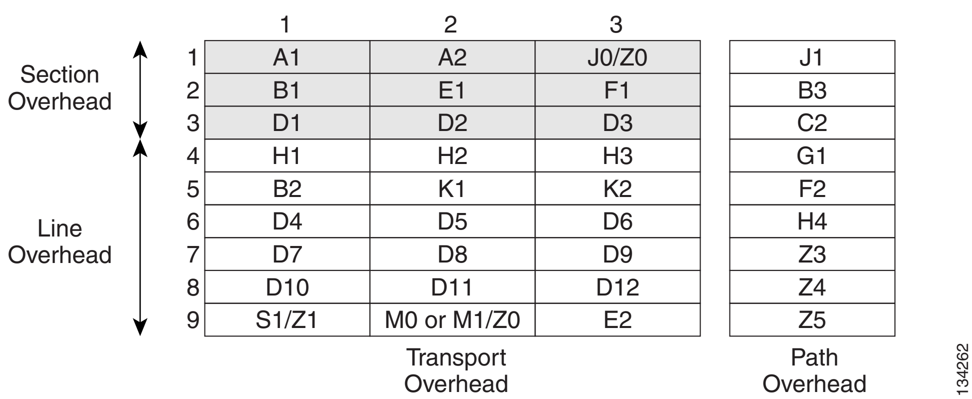


Table B-3 Description of Section Overhead Bytes

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.

Table B-3 Description of Section Overhead Bytes (continued)

Byte	Description
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 3 (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

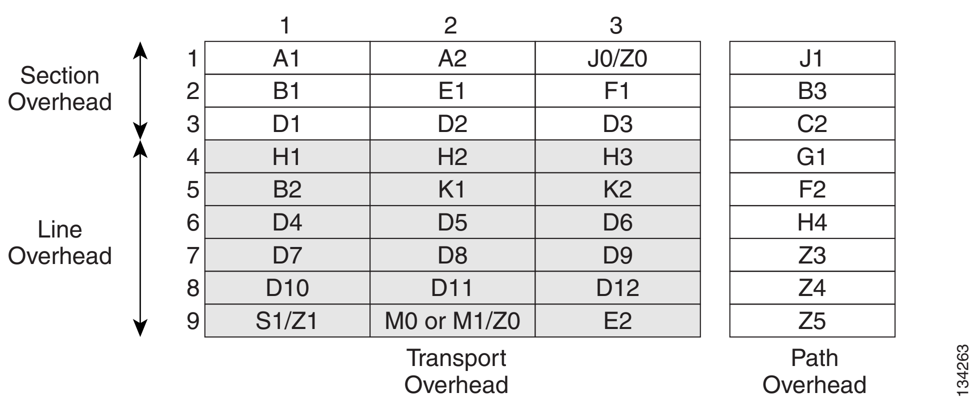


Table B-4 Description of Line Overhead Bytes

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<N<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>3), and is used for a REI-L function.

Table B-4 Description of Line Overhead Bytes (continued)

Byte	Description
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<N<48). These bytes are allocated for future growth. Note that an OC-1 or STS-1 electrical signal does not contain a Z2 byte.
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

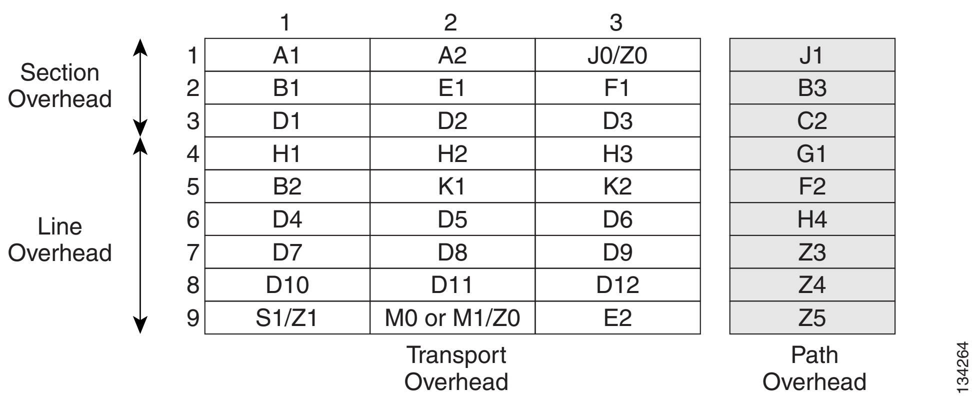


Table B-5 Description of Path Overhead Bytes

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.

Table B-5 Description of Path Overhead Bytes (continued)

Byte	Description
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.

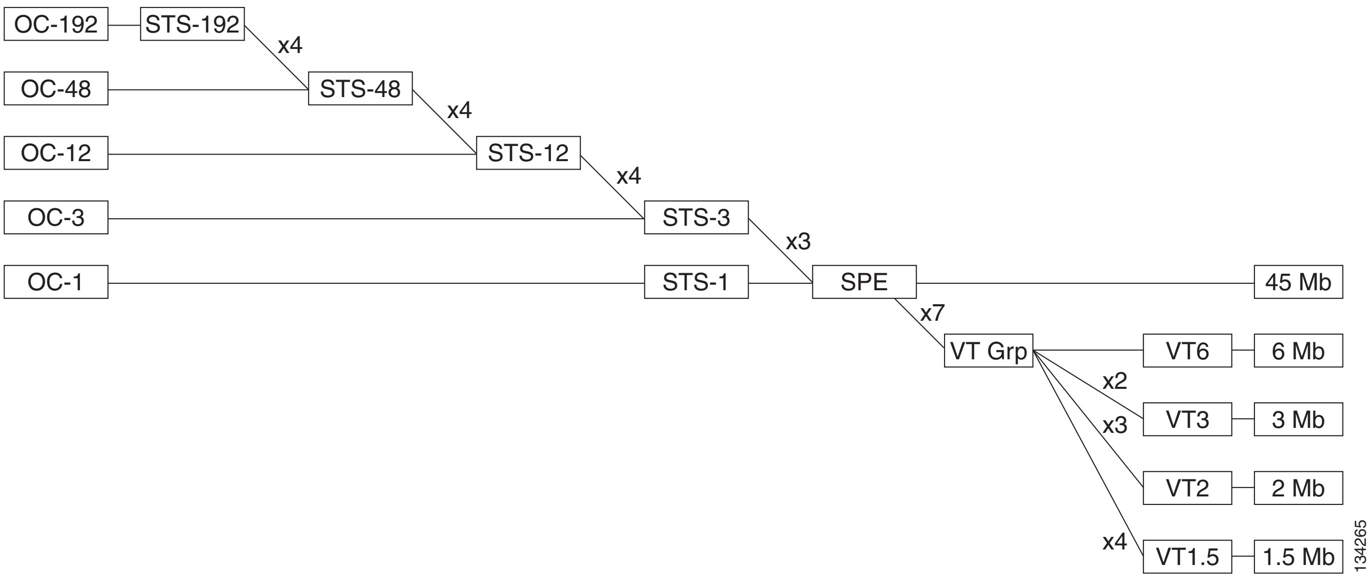
Synchronous Multiplexing

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.

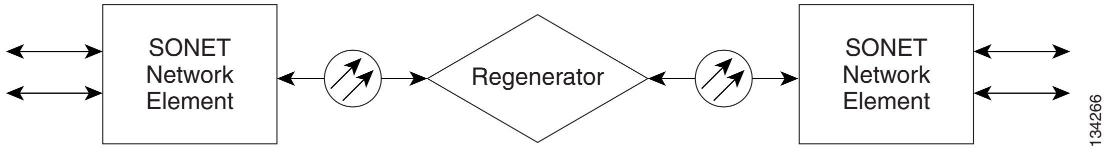
SONET Network Configurations

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.

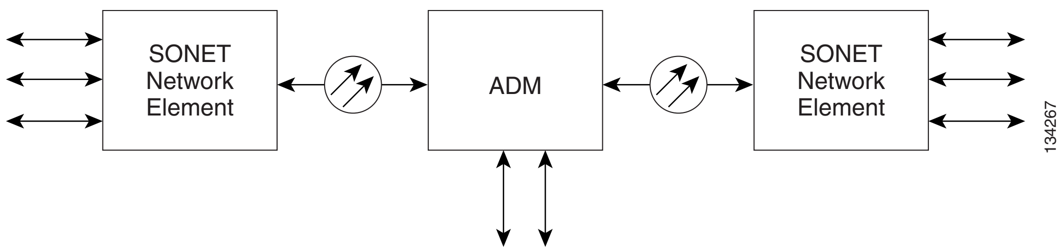
Figure B-8 Point-to-Point Network Configuration



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

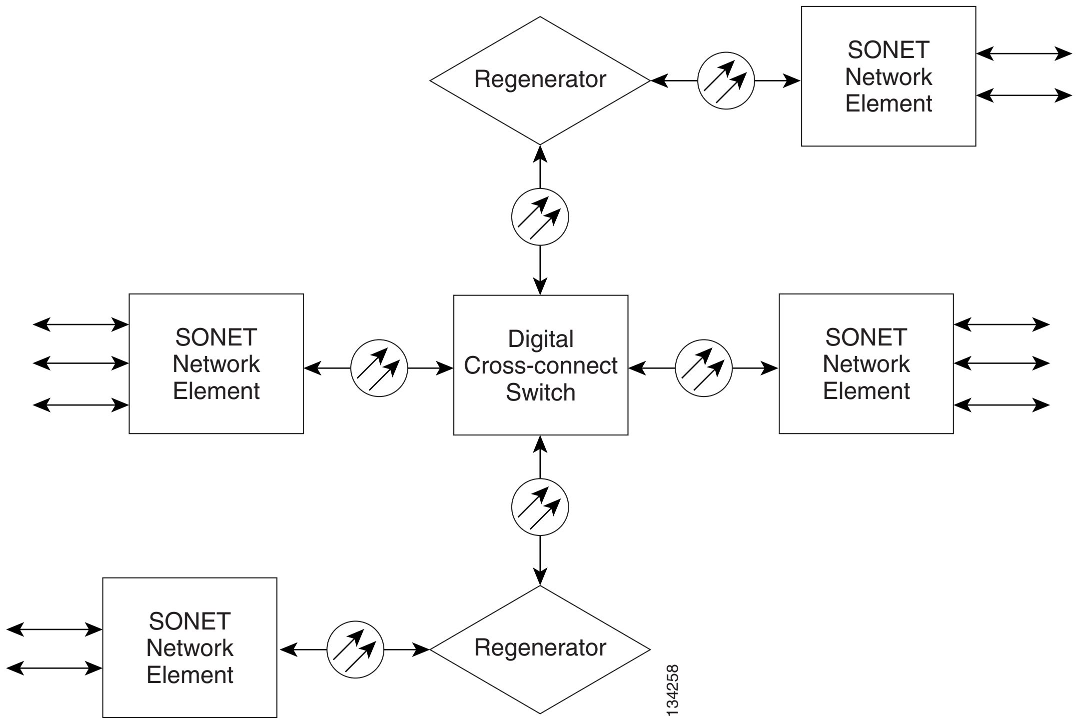


Hub

The hub configuration accommodates unexpected growth and change more easily than simple point-to-point networks. The hub configuration shown in Figure B-10 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

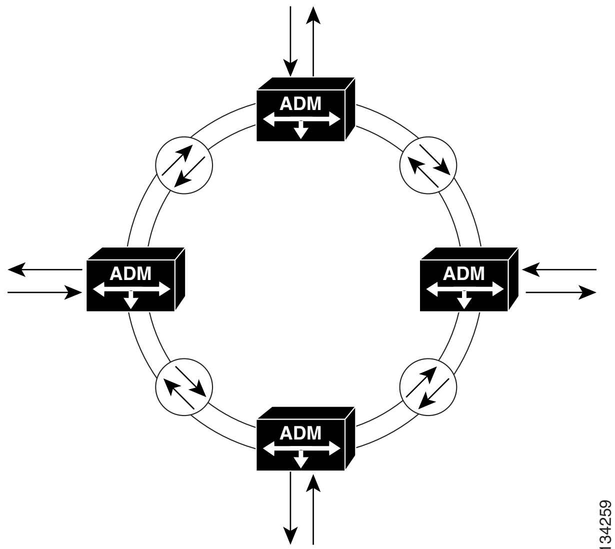


Ring

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, Taiwan, 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 Table B-7 and Table 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

Table B-8 Non-Synchronous Hierarchies (continued)

ANSI Rate			ITU-T Rate		
Signal	**Bit Rate**	**Channels**	**Signal**	**Bit Rate**	**Channels**
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

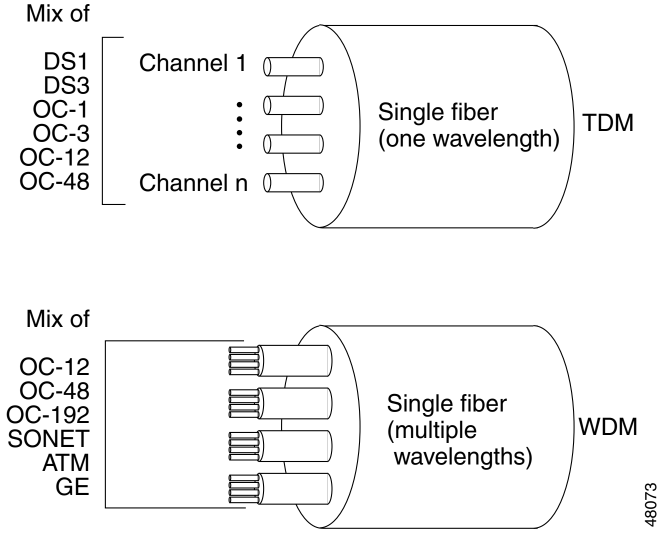
This appendix provides an introduction into dense wave division multiplexing (DWDM) principles.

The following topics are covered in this chapter:

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

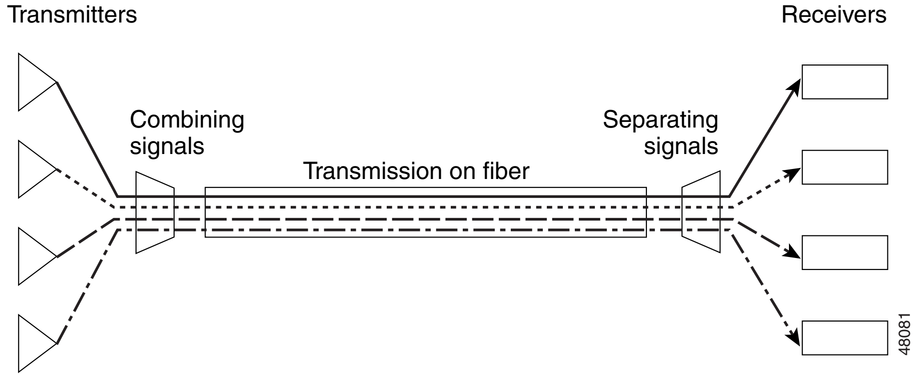
DWDM has been very successful in the backbone. It was first deployed on long-haul routes in a time of fiber scarcity. Then the equipment savings made it the solution of choice for new long-haul routes, even when ample fiber was available. While DWDM can relieve fiber exhaust in the metropolitan area, 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.

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.

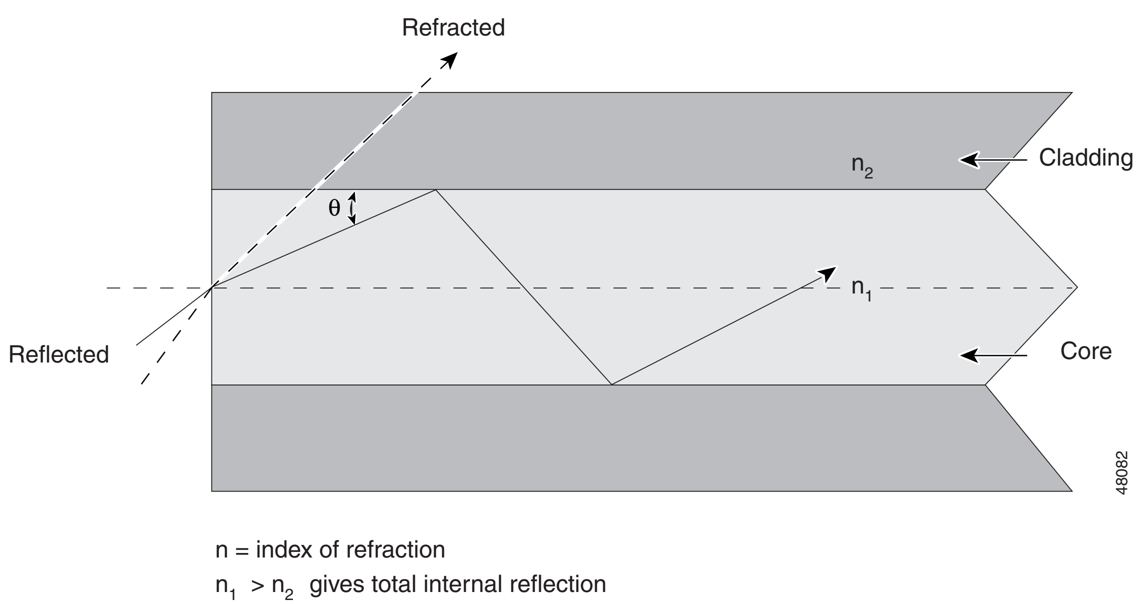
Light is either reflected (it bounces back) or refracted (its angle is altered while passing through a different medium) depending upon the angle of incidence (the angle at which light strikes the interface between an optically denser and optically thinner material).

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

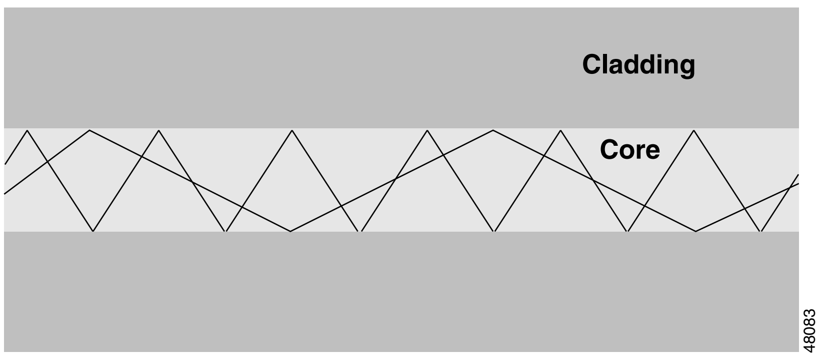


An optical fiber consists of two different types of highly pure, solid glass (silica) - the core and the cladding-that are mixed with specific elements, called dopants, to adjust their refractive indices. The difference between the refractive indices of the two materials causes most of the transmitted 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.

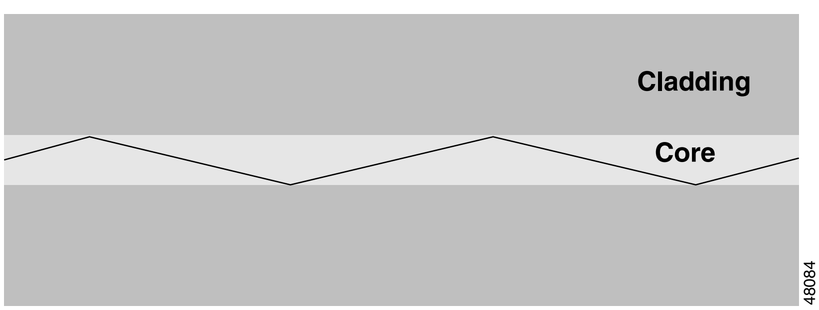
Figure C-4 Reflected Light in Step-Index Multimode Fiber



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:

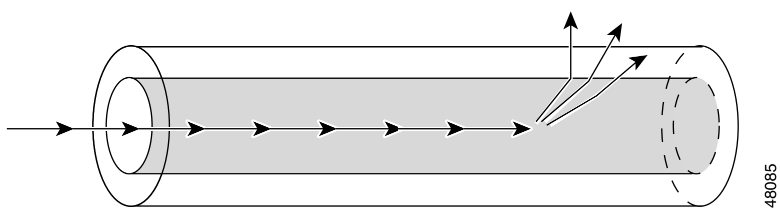
- Attenuation - decay of signal strength, or loss of light power, as the signal propagates through the Fiber.
- Chromatic dispersion - spreading of light pulses as they travel down the fiber.
- Nonlinearities - cumulative effects from the interaction of light with the material through which it travels, 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.

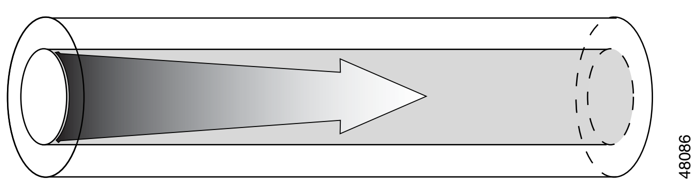
Figure C-6 Rayleigh Scattering



Fundamentals Technology Optical Fibers

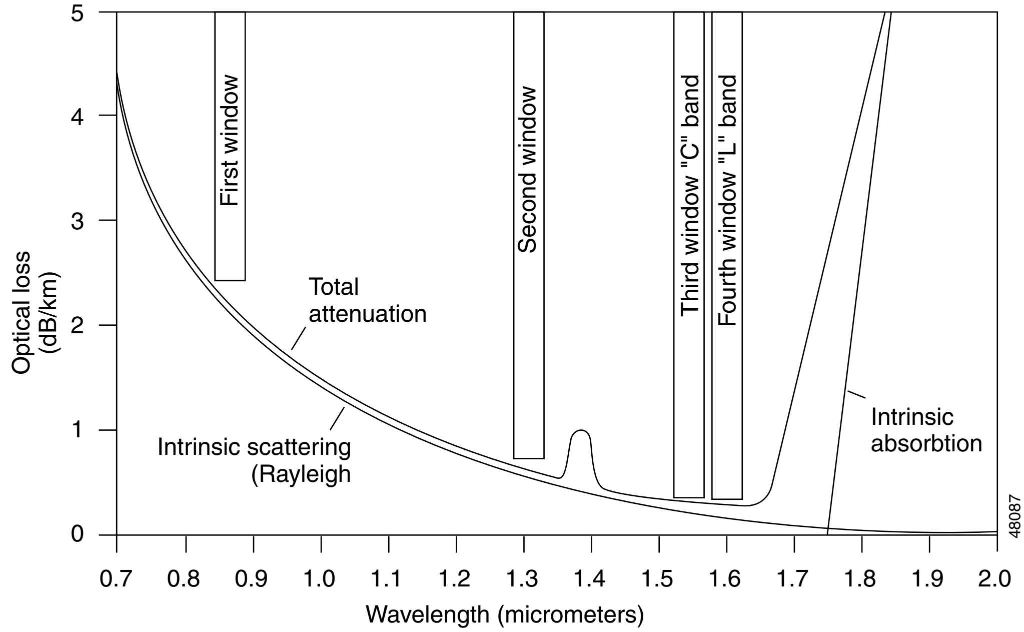
The intrinsic properties of the material itself, the impurities in the glass, and any atomic defects in the glass cause attenuation due to absorption. These impurities absorb the optical energy, causing the light to become dimmer (see Figure C-7). While Rayleigh scattering is important at shorter wavelengths, 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

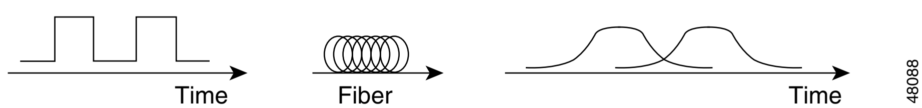


Attenuation in fiber is compensated primarily through the use of optical amplifiers.

Dispersion

Dispersion is the spreading of light pulses as they travel down optical fiber. Dispersion results in distortion of the signal (see Figure C-9), which limits the bandwidth of the fiber.

Figure C-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.

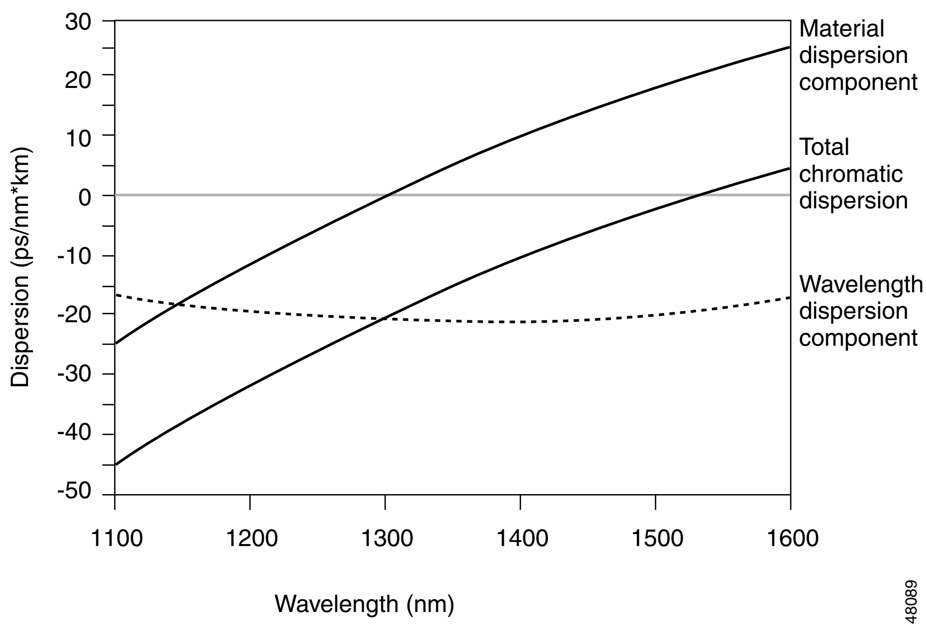
The second component of chromatic dispersion, waveguide dispersion, occurs because of the different refractive indices of the core and the cladding of fiber. The effective refractive index varies with wavelength as follows:

- 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.

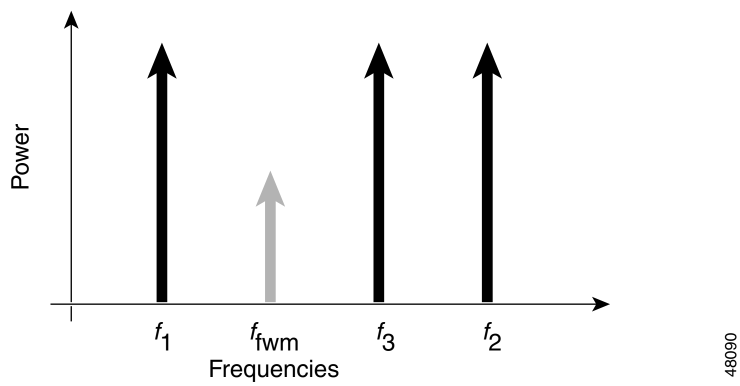
Other Nonlinear Effects

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

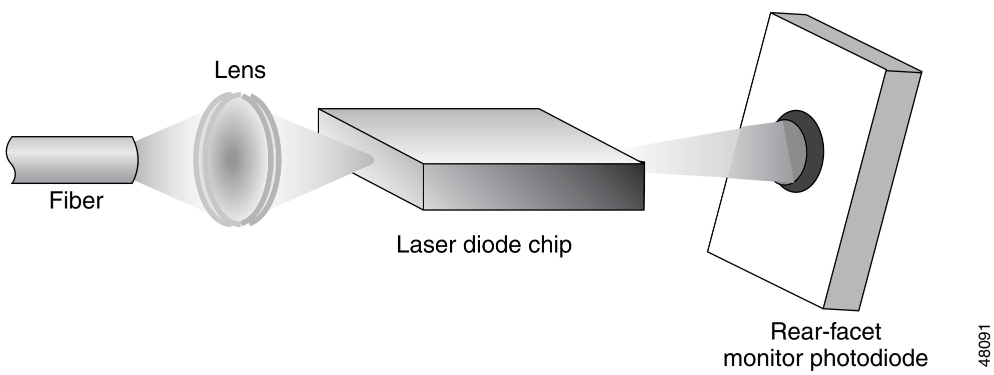
The light source used in the design of a system is an important consideration because it can be one of the most costly elements. Its characteristics are often a strong limiting factor in the final performance of the optical link. Light emitting devices used in optical transmission must be compact, monochromatic, 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.

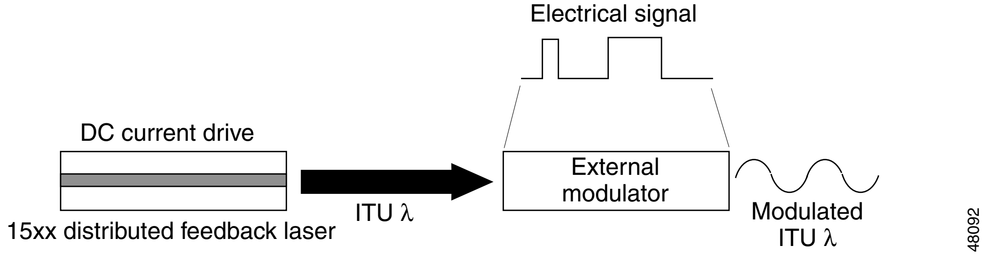
Figure C-12 Typical Laser Design



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

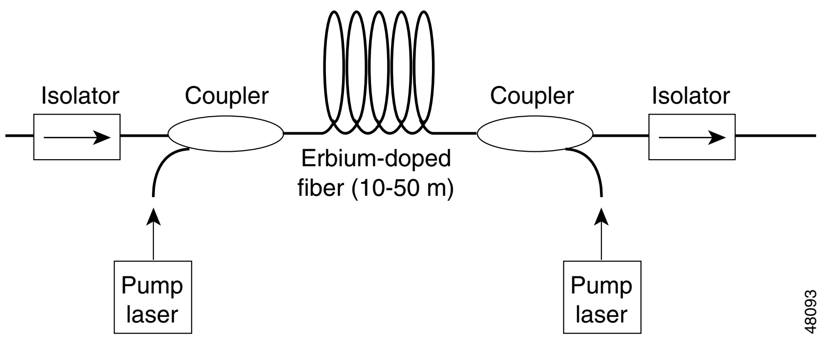
Due to attenuation, there are limits to how long a fiber segment can propagate a signal with integrity before it has to be regenerated. Before the arrival of optical amplifiers (OAs), there had to be a repeater for every signal transmitted. The OA has made it possible to amplify all the wavelengths at 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.

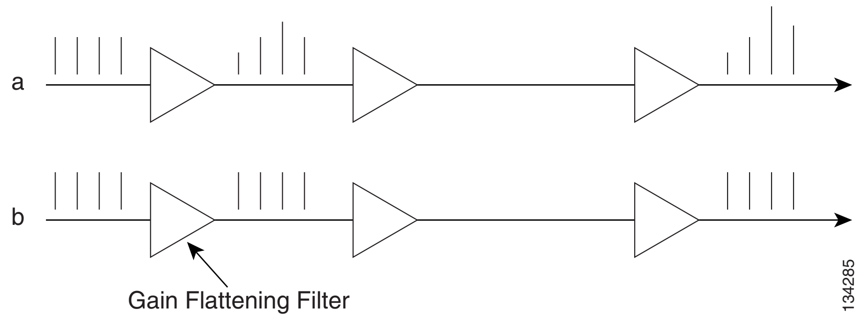
Constant Gain Mode

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

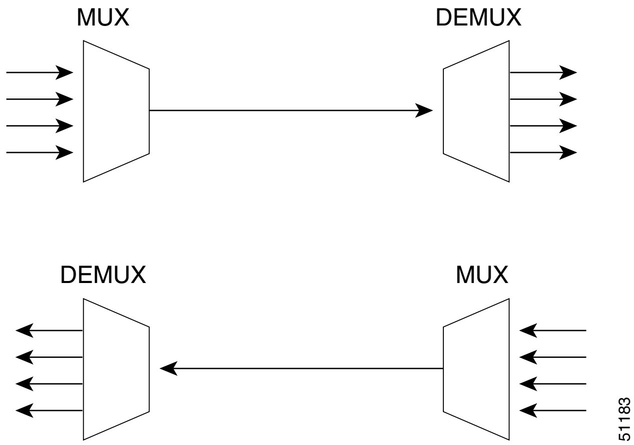
Saturation-protection internal VOA is an internal variable optical attenuator that is placed before the EDFA to attenuate the channel and composite power going into the amplifier gain block. The purpose of the VOA is to protect the EDFA from being driven into saturation. The VOA can be adjusted from 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.

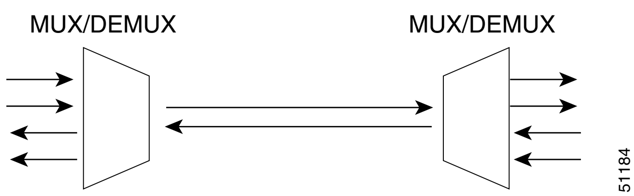
In a unidirectional system (see Figure C-16), there is a multiplexer at the sending end and a demultiplexer at the receiving end. Two systems (back-to-back terminals) would be required at each end for bi-directional communication, and two separate fibers would be needed.

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 Bidirectional System

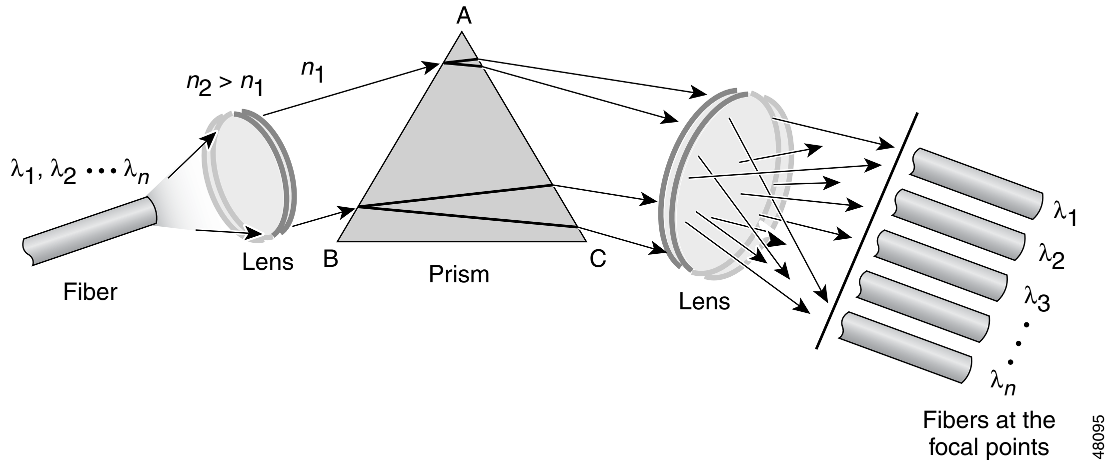


Multiplexers and demultiplexers can be either passive or active in design. Passive designs are based on prisms, diffraction gratings, or filters, while active designs combine passive devices with tunable filters. The primary challenges in these devices are to minimize cross-talk and maximize channel 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

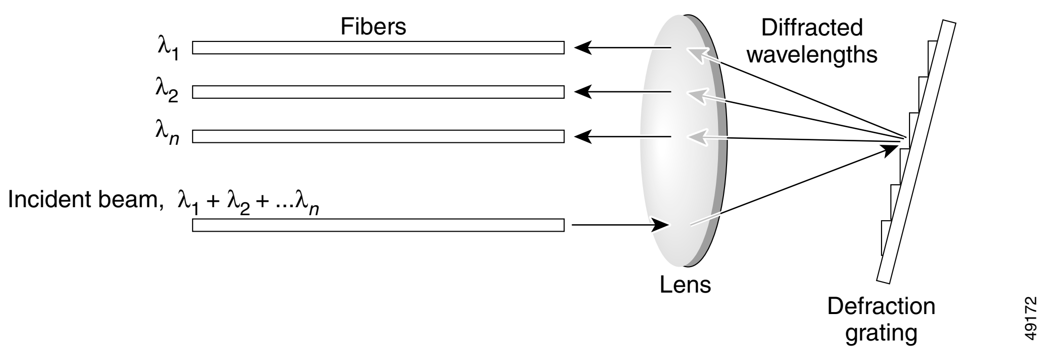
A simple form of multiplexing or demultiplexing of light can be done using a prism. Figure C-18 demonstrates the demultiplexing case. A parallel beam of polychromatic light impinges on a prism surface; each component wavelength is refracted differently. This is the "rainbow" effect. In the output light, 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



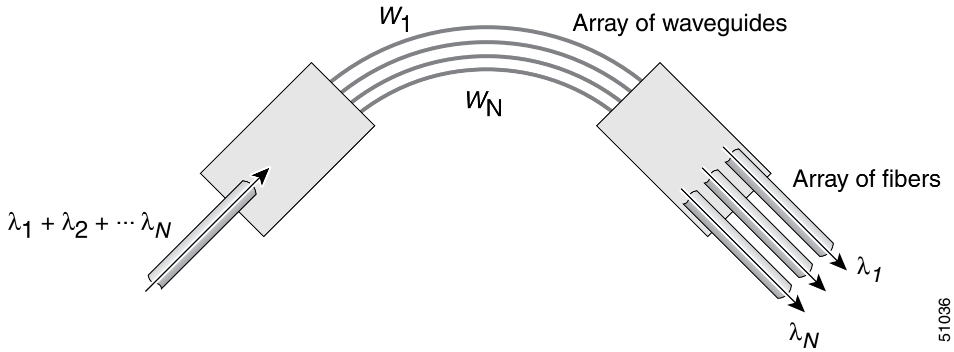
Another technology is based on the principles of diffraction and of optical interference. When a polychromatic light source impinges on a diffraction grating (see Figure C-19), each wavelength is diffracted at a different angle and therefore to a different point in space. Using a lens, these wavelengths can be focused onto individual fibers.

Figure C-19 Waveguide Grating Diffraction



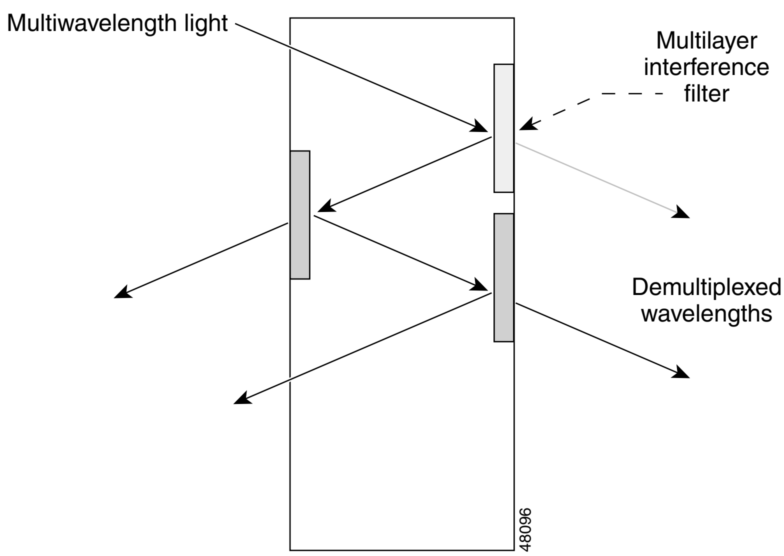
Arrayed waveguide gratings (AWGs) are also based on diffraction principles. An AWG device, sometimes called an optical waveguide router or waveguide grating router, consists of an array of curved-channel waveguides with a fixed difference in the path length between adjacent channels (see Figure C-20). 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 Grating



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 Interference Filters



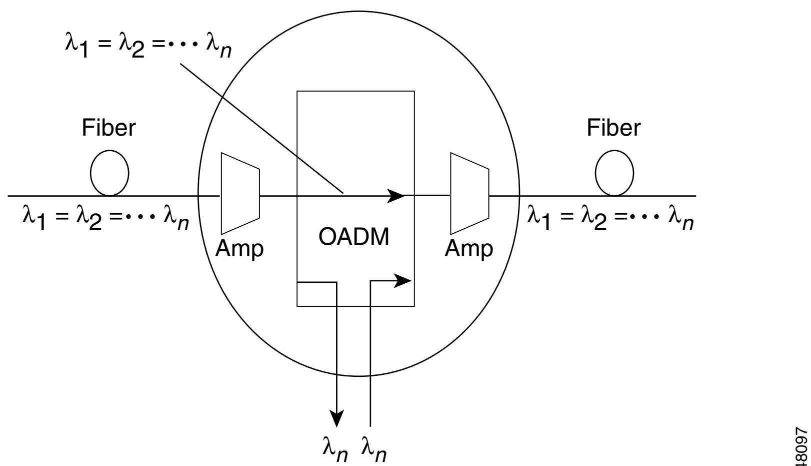
Of these designs, the AWG and thin film interference filters are gaining prominence. Filters offer good stability and isolation between channels at moderate cost, but with a high insertion loss. AWGs are polarization-dependent (which can be compensated), and they exhibit a flat spectral response and 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



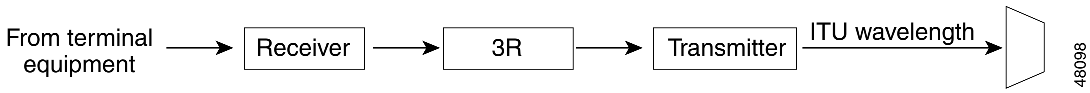
Interfaces to DWDM

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

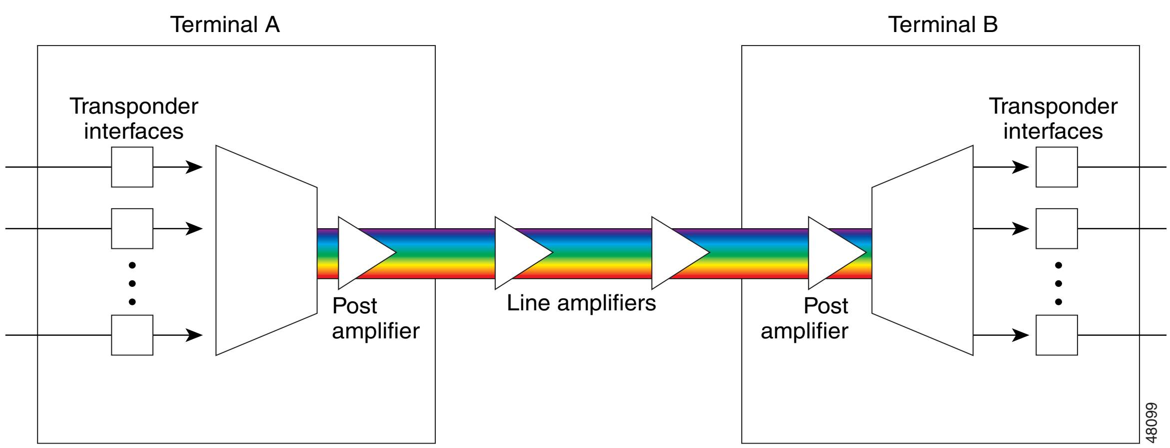


Using the ONS 15454 with its OC48ELR ITU optics cards reduces or eliminates the need for transponders. This architecture provides a cost-effective solution for Metro DWDM network applications.

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

Table C-2 ITU Grid (continued)

Frequency (GHz)	Wavelength (nm)	Frequency (GHz)	Wavelength (nm)	Frequency (GHz)	Wavelength (nm)	Frequency (GHz)	Wavelength (nm)
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

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.

The following topics are covered in this chapter:

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

Table D-1 list the parts maintained by Cisco. See http://cisco.com/en/US/products/hw/optical/ps2006/prod_eol_notices_list.html for the latest list of End-Of-Life and End-Of-Sale notices.

Table D-1 List of Parts

Cisco 15454 Part Number	Part Description
Items Requiring Software Release 5.0 or Greater	
15454-DS3EC1-48=	DS3, 48 Ckt, I-Temp, reqs SA-HD shelf assembly
15454-DS3XM-12=	DS3, Transmux, 12 Ckt, I-Temp
Items Requiring Software Release 4.6 or Greater & all MSTP Product	
15454-FC-MR-4=	Fibre Channel/FICON, 1-/2-Gbps, 4-Ckt, SL-Series
Items Requiring Software Release 4.0 or Greater	
15454-TCC2=	Timing Communications Control Two, I-Temp
15454-OC3I8-1310=	OC3/STM1, IR, 1310, 8 Ckt., LC
15454-ML100T-12=	10/100Mbps Ethernet, 12 Ckt, L2/L3
15454-ML1000-2=	Gigabit Ethernet, 2 Ckt, L2/L3, SFP
Cisco 15454 Shelf Assembly and Configurator (ATO)	
CISCO15454	15454 ATO (Assemble to Order)
15454-SA-HD	15454 SA HD NEBS3 ANSI w/ RCA and Ship Kit
15454-SA-HD=	15454 SA HD NEBS3 ANSI w/ RCA and Ship Kit
15454-FTF2	Shelf Fan Tray Filter, 15454, NEBS-NEBS3-NEBS3E-ANSI shelves
15454-FTF2=	Shelf Fan Tray Filter, 15454, NEBS-NEBS3-NEBS3E-ANSI shelves
15454-FTA3-T	Shelf Fan Tray Assembly,ANSI,15454, HPCFM, I-Temp
15454-FTA3-T=	Shelf Fan Tray Assembly,ANSI,15454, HPCFM, I-Temp
Cisco 15454 Bundles and Kits	

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-2.5G-TC2SK	Triple Play Bundle -Contains 2ea XC-VT and TCC2
15454-10G-TC-SK	Triple Play Bundle -Contains 2ea XC-10G and TCC2
15454-DS1-14-SK	Triple Play Bundle -Contains 2ea DS1-14
15454-G1K-SK	Triple Play Bundle -Contains 2ea G1K-4
15454-2GCOM1-KIT	Includes 2ea TCC2 and XC-VT
15454-10GCOM-KIT	Includes 2ea TCC2 and XC-10G, 1ea FTA3-T
15454-2GCOM2-KIT	Includes 2ea XC-VT and TCC2, 1ea FTA3-T
15454-SPARE2-KIT	Includes 1ea R4.1.3 SWCD, DOC, XC-VT, TCC2 and XC-10G
15454-LS-SPARE-KIT	Includes 1ea DS3-12E, DS3N-12E, OC34IR1310, and OC121IR1310
15454-HD-SPARE-KIT	Inclues 1ea OC3I8-1310 and Oc12I4-1310
15454-SHELF-KIT	Includes 1ea SA-ANSI, FTA3-T, and EIA-BNC-A48
15454-SA-HDAHDB2=	15454-ANSI Shelf Assembly, mounted with BNC-A48 and BNC-B48
15454-4SA-1BNC1=	15454 4-shelf bay assy, SA ANSI, 1 BNCA48, 0 Fan Trays
15454-0SA-FL	15454 0-shelf bay assy W/FAP-LVD
Cisco 15454 Common Control Equipment	
15454-XC-10G	Xconn, 1152 STS, 672 VT
15454-XC-10G=	Xconn, 1152 STS, 672 VT
15454-AIC-I	Alarm Interface Card Enh Intl, I-Temp
15454-AIC-I=	Alarm Interface Card Enh Intl, I-Temp
15454-TCC2	Timing Communications Control Two, I-Temp
15454-TCC2P-K9=	Timing Communications Control Two Plus, I-Temp
15454-TCC2=	Timing Communications Control Two, I-Temp
15454-XC-VT	Xconn, 576 STS, 672 VT. I-Temp
15454-XC-VT=	Xconn, 576 STS, 672 VT, I-Temp
Cisco 15454 Electrical Interface Assemblies (EIAs)	
15454-EIA-UBICV-A	Universal BackPlane Interface w/ Vertical Connector - A side
15454-EIA-UBICV-A=	Universal BackPlane Interface w/ Vertical Connector - A side
15454-EIA-UBICV-B	Universal BackPlane Interface w/ Vertical Connector - B side
15454-EIA-UBICV-B=	Universal BackPlane Interface w/ Vertical Connector - B side
15454-EIA-UBICH-A	Universal Backplane Interface w/ Horizontal Connector - A Side
15454-EIA-UBICH-A=	Universal Backplane Interface w/ Horizontal Connector - A Side
15454-EIA-UBICH-B	Universal Backplane Interface w/ Horizontal Connector - B Side
15454-EIA-UBICH-B=	Universal Backplane Interface w/ Horizontal Connector - Side
15454-EIA-1AMPA84	HD Elect I/F, 84 AMP, A Side
15454-EIA-1AMPA84=	HD Elect I/F, 84 AMP, A Side

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-EIA-1AMPB84	HD Elect I/F, 84 AMP, B Side
15454-EIA-1AMPB84=	HD Elect I/F, 84 AMP, B Side
15454-EIA-1BNCA24	HD Elect I/F, 24 BNC, A Side
15454-EIA-1BNCA24=	HD Elect I/F, 24 BNC, A Side
15454-EIA-1BNCA48	HD Elect I/F, 48 BNC, A Side
15454-EIA-1BNCA48=	HD Elect I/F, 48 BNC, A Side
15454-EIA-1BNCB24	HD Elect I/F, 24 BNC, B Side
15454-EIA-1BNCB24=	HD Elect I/F, 24 BNC, B Side
15454-EIA-1BNCB48	HD Elect I/F, 48 BNC, B Side
15454-EIA-1BNCB48=	HD Elect I/F, 48 BNC, B Side
15454-EIA-1SMBA84	HD Elect I/F, 84 SMB, A Side
15454-EIA-1SMBA84=	HD Elect I/F, 84 SMB, A Side
15454-EIA-1SMBB84	HD Elect I/F, 84 SMB, B Side
15454-EIA-1SMBB84=	HD Elect I/F, 84 SMB, B Side
15454-EIA-AMP-A84	Elect I/F, 84 AMP, A Side, I-Temp
15454-EIA-AMP-A84=	Elect I/F, 84 AMP, A Side, I-Temp -Not Compatible with SA-HD
15454-EIA-AMP-B84	Elect I/F, 84 AMP, B Side, I-Temp
15454-EIA-AMP-B84=	Elect I/F,84 AMP, B Side, I-Temp -Not Compatible with SA-HD
15454-EIA-BNC-A24	Elect I/F, 24 BNC, A Side, I-Temp
15454-EIA-BNC-A24=	Elect I/F, 24 BNC, A Side, I-Temp -Not Compatible with SA-HD
15454-EIA-BNC-A48	Elect I/F, 48 BNC, A Side, I-Temp
15454-EIA-BNC-A48=	Elect I/F, 48 BNC, A Side, I-Temp-Not Compatible with SA-HD
15454-EIA-BNC-B24	Elect I/F, 24 BNC, B Side, I-Temp
15454-EIA-BNC-B24=	Elect I/F, 24 BNC, B Side, I-Temp-Not Compatible with SA-HD
15454-EIA-BNC-B48	Elect I/F, 48 BNC, B Side, I-Temp
15454-EIA-BNC-B48=	Elect I/F, 48 BNC, B Side, I-Temp -Not Compatible with SA-HD
15454-EIA-SMB-A84	Elect I/F, 84 SMB, A Side, I-Temp
15454-EIA-SMB-A84=	Elect I/F, 84 SMB, A Side, I-Temp -Not Compatible with SA-HD
15454-EIA-SMB-B84	Elect I/F, 84 SMB, B Side, I-Temp
15454-EIA-SMB-B84=	Elect I/F, 84 SMB, B Side, I-Temp -Not Compatible with SA-HD
15454-WW-14	DS1 Elect I/F, 28 SMB-WW Baluns, 14 Ckt.
15454-WW-14=	DS1 Elect I/F, 28 SMB-WW Baluns, 14 Ckt.
Cisco 15454 Electrical Interface Modules	
15454-DS1-14	DS1, DSX, 14 Ckt., I-Temp
15454-DS1-14=	DS1, DSX, 14 Ckt., I-Temp
15454-DS1N-14	DS1, 1:N, DSX, 14 Ckt, I-Temp

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-DS1N-14=	DS1, 1:N, DSX, 14 Ckt, I-Temp
15454-DS3EC1-48	DS3, 48 Ckt, I-Temp, reqs SA-HD shelf assembly
15454-DS3EC1-48=	DS3, 48 Ckt, I-Temp, reqs SA-HD shelf assembly
15454-DS3-12E	DS3, DSX, Enhanced PM, 12 Ckt, I-Temp
15454-DS3-12E=	DS3, DSX, Enhanced PM, 12 Ckt, I-Temp
15454-DS3N-12E	DS3, 1:N, DSX, Enhanced PM, 12 Ckt, I-Temp
15454-DS3N-12E=	DS3, 1:N, DSX, Enhanced PM, 12 Ckt, I-Temp
15454-DS3N-12	DS3, 1:N, DSX, 12 Ckt, I-Temp
15454-DS3N-12=	DS3, 1:N, DSX, 12 Ckt, I-Temp
15454-DS3-12	DS3, DSX, 12 Ckt, Enh Test, I-Temp
15454-DS3-12=	DS3, DSX, 12 Ckt, Enh Test, I-Temp
15454-DS3XM-12	DS3, DSX Transmux, 12 Ckt, I-Temp
15454-DS3XM-12=	DS3, DSX Transmux, 12 Ckt, I-Temp
15454-DS3XM-6	DS3, DSX Transmux, 6 Ckt, I-Temp
15454-DS3XM-6=	DS3, DSX Transmux, 6 Ckt, I-Temp
15454-EC1-12	EC1, 12 Ckt, I-Temp
15454-EC1-12=	EC1, 12 Ckt, I-Temp
Cisco 15454 SONET Interface Modules	
15454-OC34IR1310	OC3, IR, 1310, 4 Ckt, SC, I-Temp
15454-OC34IR1310=	OC3, IR, 1310, 4 Ckt, SC, I-Temp
15454-OC3I8-1310	OC3/STM1, IR, 1310, 8 Ckt, LC
15454-OC3I8-1310=	OC3/STM1, IR, 1310, 8 Ckt., LC
15454-OC121IR1310	OC12, IR, 1310, 1 Ckt, SC, I-Temp
15454-OC121IR1310=	OC12, IR, 1310, 1 Ckt, SC, I-Temp
15454-OC12I4-1310	OC12/STM4, IR, 1310, 4 Ckt., SC
15454-OC12I4-1310=	OC12/STM4, IR, 1310, 4 Ckt., SC
15454-OC121LR1310	OC12, LR, 1310, 1 Ckt, SC, I-Temp
15454-OC121LR1310=	OC12, LR, 1310, 1 Ckt, SC, I-Temp
15454-OC121LR1550	OC12, LR, 1550, 1 Ckt, SC, I-Temp
15454-OC121LR1550=	OC12, LR, 1550, 1 Ckt, SC, I-Temp
15454-OC48IR1310A	OC48, IR, 1310, 1 Ckt, Any Slot, SC
15454-OC48IR1310A=	OC48, IR, 1310, 1 Ckt, Any Slot, SC
15454-OC481IR1310	OC48, IR, 1310, 1 Ckt, SC
15454-OC481IR1310=	OC48, IR, 1310, 1 Ckt, SC
15454-OC48LR1550A	OC48, LR, 1550, 1 Ckt., Any Slot, SC
15454-OC48LR1550A=	OC48, LR, 1550, 1 Ckt., Any Slot, SC

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-OC481LR1550	OC48, LR, 1550, 1 Ckt, SC
15454-OC481LR1550=	OC48, LR, 1550, 1 Ckt, SC
15454-OC192SR1310	OC192 SR/STM64 IO, 1310, 1 Ckt., SC
15454-OC192SR1310=	OC192 SR/STM64 IO, 1310, 1 Ckt., SC
15454-OC192IR1550	OC192 IR/STM64 SH, 1550, 1 Ckt., SC
15454-OC192IR1550=	OC192 IR/STM64 SH, 1550, 1 Ckt., SC
15454-OC192LR1550	OC192, LR, 1550, 1 Ckt, SC
Cisco 15454 SONET Interface Modules	
15454-OC192LR1550=	OC192, LR, 1550, 1 Ckt, SC
15454-OC192LR2	OC192, LR, 1550, 1 Ckt, SC
15454-OC192LR2=	OC192, LR, 1550, 1 Ckt, SC
Integrated DWDM - 100GHz- (Shorter Lead Time)	
15454-O48E-1-47.7	OC48/STM16, ELR, 1547.72, 100 GHz, 1Ckt., SC
15454-O48E-1-47.7=	OC48/STM16, ELR, 1547.72, 100 GHz, 1Ckt., SC
15454-O48E-1-49.3	OC48/STM16, ELR, 1549.32, 100 GHz,1Ckt,(200 GHz 15216 only)
15454-O48E-1-49.3=	OC48/STM16, ELR, 1549.32, 100 GHz,1Ckt,(200 GHz 15216 Only)
15454-O48E-1-50.9	OC48/STM16, ELR, 1550.92, 100 GHz, 1Ckt., SC
15454-O48E-1-50.9=	OC48/STM16, ELR, 1550.92, 100 GHz, 1Ckt., SC
15454-O48E-1-60.6	OC48/STM16, ELR, 1560.61, 100GHz, 1Ckt., SC
15454-O48E-1-60.6=	OC48/STM16, ELR, 1560.61, 100GHz, 1Ckt., SC
15454-O48E-1-58.9	OC48/STM16, ELR, 1558.98, 100GHz, 1Ckt., SC
15454-O48E-1-58.9=	OC48/STM16, ELR, 1558.98, 100GHz, 1Ckt., SC
15454-O48E-1-57.3	OC48/STM16, ELR, 1557.36, 100GHz,1Ckt,(200 GHz 15216 only)
15454-O48E-1-57.3=	OC48/STM16, ELR, 1557.36, 100GHz,1Ckt,(200 GHz 15216 only)
15454-192L-1-50.1	OC192 LR/STM64 LH, 1550.12, 100GHz, 1 Ckt., SC
15454-192L-1-50.1=	OC192 LR/STM64 LH, 1550.12, 100GHz, 1 Ckt., SC
15454-192L-1-50.9	OC192 LR/STM64 LH, 1550.92, 100GHz, 1 Ckt., SC
15454-192L-1-50.9=	OC192 LR/STM64 LH, 1550.92, 100GHz, 1 Ckt., SC
15454-192L-1-51.7	OC192 LR/STM64 LH, 1551.72, 100GHz, 1 Ckt., SC
15454-192L-1-51.7=	OC192 LR/STM64 LH, 1551.72, 100GHz, 1 Ckt., SC
15454-192L-1-52.5	OC192 LR/STM64 LH, 1552.52, 100GHz, 1 Ckt., SC
15454-192L-1-52.5=	OC192 LR/STM64 LH, 1552.52, 100GHz, 1 Ckt., SC
15454-192L-1-54.1	OC192 LR/STM64 LH, 1554.13, 100GHz, 1 Ckt., SC

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-192L-1-54.1=	OC192 LR/STM64 LH, 1554.13, 100GHz, 1 Ckt., SC
15454-192L-1-54.9	OC192 LR/STM64 LH, 1554.94, 100GHz, 1 Ckt., SC
15454-192L-1-54.9=	OC192 LR/STM64 LH, 1554.94, 100GHz, 1 Ckt., SC
15454-192L-1-55.7	OC192 LR/STM64 LH, 1555.75, 100GHz, 1 Ckt., SC
15454-192L-1-55.7=	OC192 LR/STM64 LH, 1555.75, 100GHz, 1 Ckt., SC
15454-192L-1-56.5	OC192 LR/STM64 LH, 1556.55, 100GHz, 1 Ckt., SC
15454-192L-1-56.5=	OC192 LR/STM64 LH, 1556.55, 100GHz, 1 Ckt., SC
15454-192L-1-58.1	OC192 LR, 1558.17, 100GHz, 1 Ckt., SC
15454-192L-1-58.1=	OC192 LR, 1558.17, 100GHz, 1 Ckt., SC
15454-192L-1-58.9	OC192 LR, 1558.98, 100GHz, 1 Ckt., SC
15454-192L-1-58.9=	OC192 LR, 1558.98, 100GHz, 1 Ckt., SC
15454-192L-1-59.7	OC192 LR, 1559.79, 100GHz, 1 Ckt., SC
15454-192L-1-59.7=	OC192 LR, 1559.79, 100GHz, 1 Ckt., SC
15454-192L-1-60.6	OC192 LR, 1560.61, 100GHz, 1 Ckt., SC
15454-192L-1-60.6=	OC192 LR, 1560.61, 100GHz, 1 Ckt., SC
Integrated DWDM - 100GHz- (Longer Lead Time)	
15454-O48E-1-28.7	OC48/STM16, ELR, 1528.7,100GHz,1Ckt,(not supported by 15216)
15454-O48E-1-28.7=	OC48/STM16, ELR, 1528.7,100GHz,1Ckt,(not supported by 15216)
15454-O48E-1-30.3	OC48/STM16, ELR, 1530.33, 100 GHz, 1Ckt., SC
15454-O48E-1-30.3=	OC48/STM16, ELR, 1530.33, 100 GHz, 1Ckt., SC
15454-O48E-1-31.1	OC48/STM16, ELR, 1531.12, 100 GHz, 1Ckt., SC
15454-O48E-1-31.1=	OC48/STM16, ELR, 1531.12, 100 GHz, 1Ckt., SC
15454-O48E-1-31.9	OC48/STM16, ELR, 1531.90, 100 GHz, 1Ckt., SC
15454-O48E-1-31.9=	OC48/STM16, ELR, 1531.90, 100 GHz, 1Ckt., SC
15454-O48E-1-32.6	OC48/STM16, ELR, 1532.68, 100 GHz, 1Ckt., SC
15454-O48E-1-32.6=	OC48/STM16, ELR, 1532.68, 100 GHz, 1Ckt., SC
15454-O48E-1-33.4	OC48/STM16, ELR,1533.47,100 GHz,1Ckt,(200 GHz 15216 only)
15454-O48E-1-33.4=	OC48/STM16, ELR,1533.47,100 GHz,1Ckt,(200 GHz 15216 only)
15454-O48E-1-34.2	OC48/STM16, ELR, 1534.25, 100 GHz, 1Ckt., SC
15454-O48E-1-34.2=	OC48/STM16, ELR, 1534.25, 100 GHz, 1Ckt., SC
15454-O48E-1-35.0	OC48/STM16, ELR, 1535.04, 100 GHz, 1Ckt., SC
15454-O48E-1-35.0=	OC48/STM16, ELR, 1535.04, 100 GHz, 1Ckt., SC
15454-O48E-1-35.8	OC48/STM16, ELR, 1535.82, 100 GHz, 1Ckt., SC

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-O48E-1-35.8=	OC48/STM16, ELR, 1535.82, 100 GHz, 1Ckt., SC
15454-O48E-1-36.6	OC48/STM16, ELR, 1536.61, 100 GHz, 1Ckt., SC
15454-O48E-1-36.6=	OC48/STM16, ELR, 1536.61, 100 GHz, 1Ckt., SC
15454-O48E-1-38.1	OC48/STM16, ELR, 1538.19, 100 GHz, 1Ckt., SC
15454-O48E-1-38.1=	OC48/STM16, ELR, 1538.19, 100 GHz, 1Ckt., SC
15454-O48E-1-38.9	OC48/STM16, ELR, 1538.98, 100 GHz, 1Ckt., SC
15454-O48E-1-38.9=	OC48/STM16, ELR, 1538.98, 100 GHz, 1Ckt., SC
15454-O48E-1-39.7	OC48/STM16, ELR, 1539.77, 100 GHz, 1Ckt., SC
15454-O48E-1-39.7=	OC48/STM16, ELR, 1539.77, 100 GHz, 1Ckt., SC
15454-O48E-1-40.5	OC48/STM16, ELR, 1540.56, 100 GHz, 1Ckt., SC
15454-O48E-1-40.5=	OC48/STM16, ELR, 1540.56, 100 GHz, 1Ckt., SC
15454-O48E-1-42.1	OC48/STM16, ELR, 1542.14, 100 GHz, 1Ckt., SC
15454-O48E-1-42.1=	OC48/STM16, ELR, 1542.14, 100 GHz, 1Ckt., SC
15454-O48E-1-41.3	OC48/STM16, ELR, 1541.35, 100 GHz,1Ckt,(200 GHz 15216 only)
15454-O48E-1-41.3=	OC48/STM16, ELR, 1541.35, 100 GHz,1Ckt,(200 GHz 15216 only)
15454-O48E-1-42.9	OC48/STM16, ELR, 1542.94, 100 GHz, 1Ckt., SC
15454-O48E-1-42.9=	OC48/STM16, ELR, 1542.94, 100 GHz, 1Ckt., SC
15454-O48E-1-43.7	OC48/STM16, ELR, 1543.73, 100 GHz, 1Ckt., SC
15454-O48E-1-43.7=	OC48/STM16, ELR, 1543.73, 100 GHz, 1Ckt., SC
15454-O48E-1-44.5	OC48/STM16, ELR, 1544.53, 100 GHz, 1Ckt., SC
15454-O48E-1-44.5=	OC48/STM16, ELR, 1544.53, 100 GHz, 1Ckt., SC
15454-O48E-1-46.9	OC48/STM16, ELR, 1546.92, 100 GHz, 1Ckt., SC
15454-O48E-1-46.9=	OC48/STM16, ELR, 1546.92, 100 GHz, 1Ckt., SC
15454-O48E-1-46.1	OC48/STM16, ELR, 1546.12, 100 GHz, 1Ckt., SC
15454-O48E-1-46.1=	OC48/STM16, ELR, 1546.12, 100 GHz, 1Ckt., SC
15454-O48E-1-48.5	OC48/STM16, ELR, 1548.51, 100 GHz, 1Ckt., SC
15454-O48E-1-48.5=	OC48/STM16, ELR, 1548.51, 100 GHz, 1Ckt., SC
15454-O48E-1-50.1	OC48/STM16, ELR, 1550.12, 100 GHz, 1Ckt., SC
15454-O48E-1-50.1=	OC48/STM16, ELR, 1550.12, 100 GHz, 1Ckt., SC
Integrated DWDM - 100GHz- (Longer Lead Time)	
15454-O48E-1-51.7	OC48/STM16, ELR, 1551.72, 100GHz, 1Ckt., SC
15454-O48E-1-51.7=	OC48/STM16, ELR, 1551.72, 100GHz, 1Ckt., SC
15454-O48E-1-52.5	OC48/STM16, ELR, 1552.52, 100GHz, 1Ckt., SC
15454-O48E-1-52.5=	OC48/STM16, ELR, 1552.52, 100GHz, 1Ckt., SC
15454-O48E-1-54.1	OC48/STM16, ELR, 1554.13, 100GHz, 1Ckt., SC

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-O48E-1-54.1=	OC48/STM16, ELR, 1554.13, 100GHz, 1Ckt., SC
15454-O48E-1-54.9	OC48/STM16, ELR, 1554.94, 100GHz, 1Ckt., SC
15454-O48E-1-54.9=	OC48/STM16, ELR, 1554.94, 100GHz, 1Ckt., SC
15454-O48E-1-55.7	OC48/STM16, ELR, 1555.75, 100GHz, 1Ckt., SC
15454-O48E-1-55.7=	OC48/STM16, ELR, 1555.75, 100GHz, 1Ckt., SC
15454-O48E-1-56.5	OC48/STM16, ELR, 1556.55, 100GHz, 1Ckt., SC
15454-O48E-1-56.5=	OC48/STM16, ELR, 1556.55, 100GHz, 1Ckt., SC
15454-O48E-1-58.1	OC48/STM16, ELR, 1558.17, 100GHz, 1Ckt., SC
15454-O48E-1-58.1=	OC48/STM16, ELR, 1558.17, 100GHz, 1Ckt., SC
15454-O48E-1-59.7	OC48/STM16, ELR, 1559.79, 100GHz, 1Ckt., SC
15454-O48E-1-59.7=	OC48/STM16, ELR, 1559.79, 100GHz, 1Ckt., SC
15454-192L-1-30.3	OC192 LR/STM64 LH, 1531.12, 100GHz, 1 Ckt., SC
15454-192L-1-30.3=	OC192 LR/STM64 LH, 1531.12, 100GHz, 1 Ckt., SC
15454-192L-1-31.1	OC192 LR/STM64 LH, 1531.12, 100GHz, 1 Ckt., SC
15454-192L-1-31.1=	OC192 LR/STM64 LH, 1531.12, 100GHz, 1 Ckt., SC
15454-192L-1-31.9	OC192 LR/STM64 LH, 1531.90, 100GHz, 1 Ckt., SC
15454-192L-1-31.9=	OC192 LR/STM64 LH, 1531.90, 100GHz, 1 Ckt., SC
15454-192L-1-32.6	OC192 LR/STM64 LH, 1532.68, 100GHz, 1 Ckt., SC
15454-192L-1-32.6=	OC192 LR/STM64 LH, 1532.68, 100GHz, 1 Ckt., SC
15454-192L-1-34.2	OC192 LR/STM64 LH, 1534.25, 100GHz, 1 Ckt., SC
15454-192L-1-34.2=	OC192 LR/STM64 LH, 1534.25, 100GHz, 1 Ckt., SC
15454-192L-1-35.0	OC192 LR/STM64 LH, 1535.04, 100GHz, 1 Ckt., SC
15454-192L-1-35.0=	OC192 LR/STM64 LH, 1535.04, 100GHz, 1 Ckt., SC
15454-192L-1-35.8	OC192 LR/STM64 LH, 1535.82, 100GHz, 1 Ckt., SC
15454-192L-1-35.8=	OC192 LR/STM64 LH, 1535.82, 100GHz, 1 Ckt., SC
15454-192L-1-36.6	OC192 LR/STM64 LH, 1536.61, 100GHz, 1 Ckt., SC
15454-192L-1-36.6=	OC192 LR/STM64 LH, 1536.61, 100GHz, 1 Ckt., SC
15454-192L-1-38.1	OC192 LR/STM64 LH, 1538.19, 100GHz, 1 Ckt., SC
15454-192L-1-38.1=	OC192 LR/STM64 LH, 1538.19, 100GHz, 1 Ckt., SC
15454-192L-1-38.9	OC192 LR/STM64 LH, 1538.98, 100GHz, 1 Ckt., SC
15454-192L-1-38.9=	OC192 LR/STM64 LH, 1538.98, 100GHz, 1 Ckt., SC
15454-192L-1-39.7	OC192 LR/STM64 LH, 1539.77, 100GHz, 1 Ckt., SC
15454-192L-1-39.7=	OC192 LR/STM64 LH, 1539.77, 100GHz, 1 Ckt., SC
15454-192L-1-40.5	OC192 LR/STM64 LH, 1540.56, 100GHz, 1 Ckt., SC
15454-192L-1-40.5=	OC192 LR/STM64 LH, 1540.56, 100GHz, 1 Ckt., SC
15454-192L-1-42.1	OC192 LR/STM64 LH, 1542.14, 100GHz, 1 Ckt., SC

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-192L-1-42.1=	OC192 LR/STM64 LH, 1542.14, 100GHz, 1 Ckt., SC
15454-192L-1-42.9	OC192 LR/STM64 LH, 1542.94, 100GHz, 1 Ckt., SC
15454-192L-1-42.9=	OC192 LR/STM64 LH, 1542.94, 100GHz, 1 Ckt., SC
15454-192L-1-43.7	OC192 LR/STM64 LH, 1543.73, 100GHz, 1 Ckt., SC
15454-192L-1-43.7=	OC192 LR/STM64 LH, 1543.73, 100GHz, 1 Ckt., SC
Integrated DWDM - 100GHz- (Longer Lead Time)	
15454-192L-1-44.5	OC192 LR/STM64 LH, 1544.53, 100GHz, 1 Ckt., SC
15454-192L-1-44.5=	OC192 LR/STM64 LH, 1544.53, 100GHz, 1 Ckt., SC
15454-192L-1-46.1	OC192 LR/STM64 LH, 1546.12, 100GHz, 1 Ckt., SC
15454-192L-1-46.1=	OC192 LR/STM64 LH, 1546.12, 100GHz, 1 Ckt., SC
15454-192L-1-46.9	OC192 LR/STM64 LH, 1546.92, 100GHz, 1 Ckt., SC
15454-192L-1-46.9=	OC192 LR/STM64 LH, 1546.92, 100GHz, 1 Ckt., SC
15454-192L-1-47.7	OC192 LR/STM64 LH, 1547.72, 100GHz, 1 Ckt., SC
15454-192L-1-47.7=	OC192 LR/STM64 LH, 1547.72, 100GHz, 1 Ckt., SC
15454-192L-1-48.5=	OC192 LR/STM64 LH, 1548.51, 100GHz, 1 Ckt., SC
15454-192L-1-48.5=	OC192 LR/STM64 LH, 1548.51, 100GHz, 1 Ckt., SC
Cisco 15454 Storage Interface Modules	
15454-FC-MR-4	Fibre Channel/FICON, 1-/2-Gbps, 4-Ckt, SL-Series
15454-FC-MR-4=	Fibre Channel/FICON, 1-/2-Gbps, 4-Ckt, SL-Series
Cisco 15454 Ethernet Interface Modules	
15454-CE100T-8	10/100Mb/s Ethernet, 8 Ckt, L1 Mapper
15454-CE100T-8=	10/100Mb/s Ethernet, 8 Ckt, L1 Mapper
15454-G1K-4	Gigabit Ethernet, 4 Ckt., L1, GBIC, XC/XC-VT/XC-10G
15454-G1K-4=	Gigabit Ethernet, 4 Ckt., L1, GBIC, XC/XC-VT/XC-10G
15454-ML100T-12	10/100Mb/s Ethernet, 12 Ckt, L2/L3
15454-ML100T-12=	10/100Mb/s Ethernet, 12 Ckt, L2/L3
15454-ML1000-2	Gigabit Ethernet, 2 Ckt, L2/L3, SFP
15454-ML1000-2=	Gigabit Ethernet, 2 Ckt, L2/L3, SFP
15454-E100T-G	10/100BT, 12 Ckt., XC/XC-VT/XC-10G
15454-E100T-G=	10/100BT, 12 Ckt., XC/XC-VT/XC-10G
15454-E1000-2-G	Gigabit Ethernet, 2 Ckt., L2, GBIC, XC/XC-VT/XC-10G
15454-E1000-2-G=	Gigabit Ethernet, 2 Ckt., L2, GBIC, XC/XC-VT/XC-10G
Cisco 15454 DWDM GBICs - Requires Software Release 4.1.0 or Greater	
15454-GBIC-30.3=	1000BASE-DWDM 1530.33nm GBIC (100GHz ITU grid)
15454-GBIC-31.1=	1000BASE-DWDM 1531.12nm GBIC (100GHz ITU grid)
15454-GBIC-31.9=	1000BASE-DWDM 1531.90nm GBIC (100GHz ITU grid)

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-GBIC-32.6=	1000BASE-DWDM 1532.68nm GBIC (100GHz ITU grid)
15454-GBIC-34.2=	1000BASE-DWDM 1534.25nm GBIC (100GHz ITU grid)
15454-GBIC-35.0=	1000BASE-DWDM 1535.04nm GBIC (100GHz ITU grid)
15454-GBIC-35.8=	1000BASE-DWDM 1535.82nm GBIC (100GHz ITU grid)
15454-GBIC-36.6=	1000BASE-DWDM 1536.61nm GBIC (100GHz ITU grid)
15454-GBIC-38.1=	1000BASE-DWDM 1538.19nm GBIC (100GHz ITU grid)
15454-GBIC-38.9=	1000BASE-DWDM 1538.98nm GBIC (100GHz ITU grid)
15454-GBIC-39.7=	1000BASE-DWDM 1539.77nm GBIC (100GHz ITU grid)
15454-GBIC-40.5=	1000BASE-DWDM 1540.56nm GBIC (100GHz ITU grid)
15454-GBIC-42.1=	1000BASE-DWDM 1542.14nm GBIC (100GHz ITU grid)
15454-GBIC-42.9=	1000BASE-DWDM 1542.94nm GBIC (100GHz ITU grid)
15454-GBIC-43.7=	1000BASE-DWDM 1543.73nm GBIC (100GHz ITU grid)
15454-GBIC-44.5=	1000BASE-DWDM 1544.53nm GBIC (100GHz ITU grid)
15454-GBIC-46.1=	1000BASE-DWDM 1546.12nm GBIC (100GHz ITU grid)
15454-GBIC-46.9=	1000BASE-DWDM 1546.92nm GBIC (100GHz ITU grid)
15454-GBIC-47.7=	1000BASE-DWDM 1547.72nm GBIC (100GHz ITU grid)
15454-GBIC-48.5=	1000BASE-DWDM 1548.51nm GBIC (100GHz ITU grid)
15454-GBIC-50.1=	1000BASE-DWDM 1550.12nm GBIC (100GHz ITU grid)
15454-GBIC-50.9=	1000BASE-DWDM 1550.92nm GBIC (100GHz ITU grid)
15454-GBIC-51.7=	1000BASE-DWDM 1551.72nm GBIC (100GHz ITU grid)
15454-GBIC-52.5=	1000BASE-DWDM 1552.52nm GBIC (100GHz ITU grid)
15454-GBIC-54.1=	1000BASE-DWDM 1554.13nm GBIC (100GHz ITU grid)
15454-GBIC-54.9=	1000BASE-DWDM 1554.94nm GBIC (100GHz ITU grid)
15454-GBIC-55.7=	1000BASE-DWDM 1555.75nm GBIC (100GHz ITU grid)
15454-GBIC-56.5=	1000BASE-DWDM 1556.55nm GBIC (100GHz ITU grid)
15454-GBIC-58.1=	1000BASE-DWDM 1558.17nm GBIC (100GHz ITU grid)
15454-GBIC-58.9=	1000BASE-DWDM 1558.98nm GBIC (100GHz ITU grid)
15454-GBIC-60.6=	1000BASE-DWDM 1560.61nm GBIC (100GHz ITU grid)
Cisco 15454 CWDM GBICs - Requires Software Release 4.1.0 or Greater	
15454-GBIC-1470=	1000BASE-CWDM 1470 nm GBIC (single mode only)
15454-GBIC-1490=	1000BASE-CWDM 1490 nm GBIC (single mode only)
15454-GBIC-1510=	1000BASE-CWDM 1510 nm GBIC (single mode only)
15454-GBIC-1530=	1000BASE-CWDM 1530 nm GBIC (single mode only)
15454-GBIC-1550=	1000BASE-CWDM 1550 nm GBIC (single mode only)
15454-GBIC-59.7=	1000BASE-DWDM 1559.79nm GBIC (100GHz ITU grid)
15454-GBIC-1570=	1000BASE-CWDM 1570 nm GBIC (single mode only)

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-GBIC-1590=	1000BASE-CWDM 1590 nm GBIC (single mode only)
15454-GBIC-1610=	1000BASE-CWDM 1610 nm GBIC (single mode only)
Cisco 15454 Accessories & Spares	
15454-FTA2=	Shelf Fan Tray Assembly, NEBS3E,15454, I-Temp
15454-RCA=	Rear Cover Assy, AB Side,15454
15454-BLANK	Empty slot Filler Panel
15454-BLANK=	Empty slot Filler Panel
15454-CONSOLE-02=	RJ11 to RJ45 Console Cable Adapter, 22 Inches
15454-SFP-LC-LX	1000 Base LX LC, SFP
15454-SFP-LC-LX=	1000 Base LX LC, SFP
15454-SFP-LC-SX	1000 Base SX LC, SFP
15454-SFP-LC-SX=	1000 Base SX LC, SFP
ONS-GX-2FC-MMI	1Gb/s or 2Gb/s, 850nm, SC, MM
ONS-SE-2G-S1	SFP - OC48/STM16 - 1310 SR - SM LC
ONS-SE-2G-S1=	SFP - OC48/STM16 - 1310 SR - SM LC
ONS-GX-2FC-MMI=	1Gb/s or 2Gb/s, 850nm, SC, MM
ONS-GX-2FC-SML	1G 1310nm, SC, SM
ONS-GX-2FC-SML=	1G 1310nm, SC, SM
15454-GBIC-LX	1000Base-LX, SC, SM or MM, standardized for 15454
15454-GBIC-LX=	1000Base-LX, SC, SM or MM, standardized for 15454
15454-GBIC-SX	1000Base-SX, SC, MM, standardized for 15454
15454-GBIC-SX=	1000Base-SX, SC, MM, standardized for 15454
15454-GBIC-ZX	1000Base-ZX, SM, G1000-4 on 15454 only, -5 to +50 DegC
15454-GBIC-ZX=	1000Base-ZX, SM, G1000-4 on 15454 only, -5 to +50 DegC
15454-FIBER-BOOT=	Bag of 15 90 degree fiber retention boots
15454-EMEA-KIT=	EMEA Compliance Kit for ANSI Shelf Assembly
15454-BAY-EXT=	15454 Bay Extender Kit
15454-BAY-COVER=	15454 Bay Side Cover Kit
15454-BAY-GUARD=	15454 Bay End Guard Kit
15454-BAY-ACC=	15454 Bay Accessory Kit
15454-HD-SHIPKIT=	HD Shelf Install Accessories
15454-TIE-BAR-19=	Cable tie-down n bar/guardrail for 19 inch rack
15454-TIE-BAR-23=	Cable tie-down n bar/guardrail for 23 inch rack
15454-SHIPKIT=	Shelf install accessories
15454-SA-GNDKIT=	Spare Door and Ground Cable
15454-FAP-LVD	Fuse and Alarm Panel with dual feed, Low voltage disconnect

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-FAP-LVD=	Fuse and Alarm Panel with dual feed, Low voltage disconnect
15454-BAY-ACCKIT0	Zero Shelf Acckit
15454-BAY-ACCKIT4	Four Shelf Acckit
15454-0SA-RACK	15454 0-Shelf Rack Assembly
15454-4SA-RACK	15454 Bay Assy., 4-Shelves and Rack, No Options
15454-BP-COVER-A	15454 BLANK Backplane Cover, Side A
15454-BP-COVER-A=	15454 BLANK Backplane Cover, Side A
15454-BP-COVER-B	15454 BLANK Backplane Cover, Side B
15454-BP-COVER-B=	15454 BLANK Backplane Cover, Side B
15454-AEP	15454 Alarm Expansion Panel - ANSI support only
15454-AEP=	15454 Alarm Expansion Panel - ANSI support only
Cisco 15454 Relicensing for Used Equipment	
LL-ONS-15454	ONS 15454 Feature Package License
ONS 15454 - Documentation	
15454-DOC5.0.0CD	System Documentation Release 5.0.0 English, CD
15454-DOC5.0.0CD=	System Documentation Release 5.0.0 English, CD
15454-DOC5.0.0PP	System Documentation Release 5.0.0 English, Paper
15454-DOC5.0.0PP=	System Documentation Release 5.0.0 English, Paper
15454-DOC4.6.0CD	System Documentation Release 4.6.0 English, CD
15454-DOC4.6.0CD=	System Documentation Release 4.6.0 English, CD
15454-DOC4.6.0PP	System Documentation Release 4.6.0 English, Paper
15454-DOC4.6.0PP=	System Documentation Release 4.6.0 English, Paper
15454-DOC4.1.0CD	System Documentation Release 4.1.0 English, CD
15454-DOC4.1.0CD=	System Documentation Release Rel. 4.1.0 English, CD
15454-DOC4.1.0PP	System Documentation Release 4.1.0 English, Paper
15454-DOC4.1.0PP=	System Documentation Release 4.1.0 English, Paper
15454-DOC4.0.0CD	System Documentation Release 4.0.0 English, CD
15454-DOC4.0.0CD=	System Documentation Release 4.0.0 English, CD
15454-DOC4.0.0PP	System Documentation Release 4.0.0 English, Paper
15454-DOC4.0.0PP=	System Documentation Release 4.0.0 English, Paper
15454-DOC3.4.0CD	System Documentation Release 3.4.0 English, CD
15454-DOC3.4.0CD=	System Documentation Release 3.4.0 English, CD
15454-DOC3.4.0PP	System Documentation Release 3.4.0 English, Paper
15454-DOC3.4.0PP=	System Documentation Release 3.4.0 English, Paper
15454-DOC3.3.0CD	System Documentation Release 3.3.0 English, CD
15454-DOC3.3.0CD=	System Documentation Release 3.3.0 English, CD

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-DOC3.3.0PP	System Documentation Release 3.3.0 English, Paper
15454-DOC3.3.0PP=	System Documentation Release 3.3.0 English, Paper
15454-DOC3.2.0CD	System Documentation Release 3.2.0 English, CD
15454-DOC3.2.0CD=	System Documentation Release 3.2.0 English, CD
15454-DOC3.2.0PP	System Documentation Release 3.2.0 English, Paper
15454-DOC3.2.0PP=	System Documentation Release 3.2.0 English, Paper
15454-DOC3.1.0CD	System Documentation Release 3.1.0 English, CD
15454-DOC3.1.0CD=	System Documentation Release 3.1.0 English, CD
15454-DOC3.1.0PP	System Documentation Release 3.1.0 English, Paper
15454-DOC3.1.0PP=	System Documentation Release 3.1.0 English, Paper
15454-DOC3.0.0CD	System Documentation Release 3.0.0 English, CD
15454-DOC3.0.0CD=	System Documentation Release 3.0.0 English, CD
15454-DOC3.0.0PP	System Documentation Release 3.0.0 English, Paper
15454-DOC3.0.0PP=	System Documentation Release 3.0.0 English, Paper
15454-DOC2.2.1CD=	System Documentation Release 2.2.1 English, CD
15454-DOC2.2.1PP=	System Documentation Release 2.2.1 English, Paper
DOC-7815224=	ONS 15454 SONET/SDH ML-Ser Multil Ethrnt Crd SW Rel 4.0
DOC-7815224=	ONS 15454 SONET/SDH ML-Ser Multil Ethrnt Crd SW Rel 4.0
DOC-7815241=	Cisco ONS 15454 Procedure Guide, Release 4.0
DOC-7815241=	Cisco ONS 15454 Procedure Guide, Release 4.0
DOC-7815242=	Cisco ONS 15454 Reference Manual, Release 4.0
DOC-7815242=	Cisco ONS 15454 Reference Manual, Release 4.0
DOC-7815243=	Cisco ONS 15454 Troubleshooting Guide, Release 4.0
DOC-7815243=	Cisco ONS 15454 Troubleshooting Guide, Release 4.0
DOC-7815244=	ONS 15454 and ONS 15327 TL1 Command Gd, Rel 4.0
DOC-7815244=	ONS 15454 and ONS 15327 TL1 Command Gd, Rel 4.0
DOC-7815245=	ONS 15454 and ONS 15327 TL1 Cmd Quick Ref Gde, Rel 4.0
DOC-7815245=	ONS 15454 and ONS 15327 TL1 Cmd Quick Ref Gde, Rel 4.0
DOC-7815246=	Cisco ONS 15454 Product Overview, Release 4.0
DOC-7815246=	Cisco ONS 15454 Product Overview, Release 4.0
DOC-7815424=	Cisco ONS 15454 Procedure Guide, R4.0
DOC-7815424=	Cisco ONS 15454 Procedure Guide, R4.0
DOC-7815642=	Cisco ONS 15454 Reference Manual, Release 3.4
DOC-7815642=	Cisco ONS 15454 Reference Manual, Release 3.4
DOC-7815669=	Cisco ONS 15454 Procedure Guide, Release 4.1 and 4.5
DOC-7815669=	Cisco ONS 15454 Procedure Guide, Release 4.1 and 4.5

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
DOC-7815670=	Cisco ONS 15454 Reference Manual, Release 4.1 and 4.5
DOC-7815670=	Cisco ONS 15454 Reference Manual, Release 4.1 and 4.5
DOC-7815671=	Cisco ONS 15454 Troubleshooting Guide, Release 4.1 and 4.5
DOC-7815671=	Cisco ONS 15454 Troubleshooting Guide, Release 4.1 and 4.5
DOC-7815695=	Cisco ONS 15454 and 15327 TL1 Command Gd, Rel 4.1 and 4.5
DOC-7815695=	Cisco ONS 15454 and 15327 TL1 Command Gd, Rel 4.1 and 4.5
DOC-7815696=	ONS 15454 and 15327 TL1 Cmd Quick Ref Gd, Rel 4.1 and 4.5
DOC-7815696=	ONS 15454 and 15327 TL1 Cmd Quick Ref Gd, Rel 4.1 and 4.5
DOC-7815702=	ONS 15454 SONET ML-Series Multilayer Ethnt Card SW Feature
DOC-7815702=	ONS 15454 SONET ML-Series Multilayer Ethnt Card SW Feature
DOC-7815934=	Cisco ONS 15454 Procedure Guide, Release 4.6
DOC-7815934=	Cisco ONS 15454 Procedure Guide, Release 4.6
DOC-7815981=	Cisco ONS 15454 Reference Manual, Release 4.6
DOC-7815981=	Cisco ONS 15454 Reference Manual, Release 4.6
DOC-7815982=	Cisco ONS 15454 Troubleshooting Guide, Release 4.6
DOC-7815982=	Cisco ONS 15454 Troubleshooting Guide, Release 4.6
DOC-7815984=	Cisco ONS 15454 Software Upgrade Guide, Release 4.6
DOC-7815984=	Cisco ONS 15454 Software Upgrade Guide, Release 4.6
DOC-7815990=	Cisco ONS 15454 and ONS 15327 TL1 Command Guide, Rel 4.6
DOC-7815990=	Cisco ONS 15454 and ONS 15327 TL1 Command Guide, Rel 4.6
DOC-7815991=	Cisco ONS 15454 and ONS 15327 TL1 Cmd Quick Ref Gd, Rel 4.6
DOC-7815991=	Cisco ONS 15454 and ONS 15327 TL1 Cmd Quick Ref Gd, Rel 4.6
DOC-7815992=	ONS 15454 SONET ML-Series Multilayer Ethernet SW Rel 4.6
DOC-7815992=	ONS 15454 SONET ML-Series Multilayer Ethernet SW Rel 4.6
DOC-7816097=	Quick Start Guide ONS 15454 and ONS 15327 TL1 for Beginners
DOC-7816097=	Quick Start Guide ONS 15454 and ONS 15327 TL1 for Beginners
DOC-7816240=	Cisco ONS 15454-FAP-LVD Operations Guide, Release 1.0
DOC-7816240=	Cisco ONS 15454-FAP-LVD Operations Guide, Release 1.0
ONS 15454 - System Software	
15454-LIC-UPG	15454 Software Upgrade License
15454-LIC-R5.0.2K9	15454 Upgrade License for R5.0.2, Right To Use License
15454-LIC-R5.0.0K9	15454 Upgrade License for R5.0.0, Right To Use License
15454-LIC-R4.6.1	15454 Upgrade License for R4.6.1, Right To Use License
15454-LIC-R4.1.3	15454 Upgrade License for R4.1.3, Right To Use License
15454-LIC-R4.1.0	15454 Upgrade License for R4.1.0

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-LIC-R4.0.1	15454 Upgrade License for R4.0.1
15454-LIC-R4.0.0	15454 Upgrade License for R4.0.0
15454-LIC-R3.4.2	15454 Upgrade License for R3.4.2
15454-LIC-R3.4.1	15454 Upgrade License for R3.4.1
15454-LIC-R3.4.0	15454 Upgrade License for R3.4.0
15454-LIC-R3.3.0	15454 Upgrade License for R3.3.0
15454-LIC-R3.2.1	15454 Upgrade License for R3.2.1
15454-LIC-R3.2.0	15454 Upgrade License for R3.2.0
15454-LIC-R3.1.0	15454 Upgrade License for R3.1.0
15454-LIC-R3.0.3	15454 Upgrade License for R3.0.3
15454-R5.0.2SWK9	Rel. 5.0.2 Feature Pkg., CD, Right To Use License
15454-R5.0.2SWK9=	Rel. 5.0.2 Feature Pkg., CD, Right To Use License
15454-R5.0.0SWK9	Rel. 5.0.0 Feature Pkg., CD, Right To Use License
15454-R5.0.0SWK9=	Rel. 5.0.0 Feature Pkg., CD, Right To Use License
15454-R4.6.4SWK9	Rel. 4.6.4 Feature Pkg., CD, Right To Use License
15454-R4.6.4SWK9=	Rel. 4.6.4 Feature Pkg., CD, Right To Use License
15454-R4.6.2SWK9	Rel. 4.6.2 Feature Pkg., CD, Right To Use License
15454-R4.6.2SWK9=	Rel. 4.6.2 Feature Pkg., CD, Right To Use License
15454-R4.6.1SWCD	Rel. 4.6.1 Feature Pkg., CD, Right To Use License
15454-R4.6.1SWCD=	Rel. 4.6.1 Feature Pkg., CD, Right To Use License
15454-R4.1.6SWCD	Rel. 4.1.6 Feature Pkg., CD, Right To Use License
15454-R4.1.6SWCD=	Rel. 4.1.6 Feature Pkg., CD, Right To Use License
15454-R4.1.5SWCD	Rel. 4.1.5 Feature Pkg., CD, Right To Use License
15454-R4.1.5SWCD=	Rel. 4.1.5 Feature Pkg., CD, Right To Use License
15454-R4.1.4SWCD	Rel. 4.1.4 Feature Pkg., CD, Right To Use License
15454-R4.1.4SWCD=	Rel. 4.1.4 Feature Pkg., CD, Right To Use License
15454-R4.1.3SWCD	Rel. 4.1.3 Feature Pkg., CD, Right To Use License
15454-R4.1.3SWCD=	Rel. 4.1.3 Feature Pkg., CD, Right To Use License
15454-R4.1.0SWCD	Rel. 4.1.0 Feature Pkg., CD, Right To Use License
15454-R4.1.0SWCD=	Rel. 4.1.0 Feature Pkg., CD, Right To Use License
15454-R4.0.1SWCD	Rel. 4.0.1 Feature Pkg., CD, Right To Use License
15454-R4.0.1SWCD=	Rel. 4.0.1 Feature Pkg., CD, Right To Use License
15454-R4.0.0SWCD	Rel. 4.0.0 Feature Pkg., CD, Right To Use License
15454-R4.0.0SWCD=	Rel. 4.0.0 Feature Pkg., CD, Right To Use License
15454-R3.4.2SWCD	Rel. 3.4.2 Feature Pkg., CD, Right To Use License
15454-R3.4.1SWCD	Rel. 3.4.1 Feature Pkg., CD, Right To Use License

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-R3.4.1SWCD=	Rel. 3.4.1 Feature Pkg., CD, Right To Use License
15454-R3.4.0SW/CD	Rel. 3.4.0 Feature Pkg., CD, Right To Use License
15454-R3.4.0SW/CD=	Rel. 3.4.0 Feature Pkg., CD, Right To Use License
15454-R3.3.0SW/CD	Rel. 3.3.0 Feature Pkg., CD, Right To Use License
ONS 15454 - System Software	
15454-R3.3.0SW/CD=	Rel. 3.3.0 Feature Pkg., CD, Right To Use License
15454-R3.2.1SW/CD	Rel. 3.2.1 Feature Pkg., CD, Right To Use License
15454-R3.2.1SW/CD=	Rel. 3.2.1 Feature Pkg., CD, Right To Use License
15454-R3.2.0SW/CD	Rel. 3.2.0 Feature Pkg., CD, Right To Use License
15454-R3.2.0SW/CD=	Rel. 3.2.0 Feature Pkg., CD, Right To Use License
15454-R3.1.0SW/CD	Rel. 3.1.0 Feature Pkg., CD, Right To Use License
15454-R3.1.0SW/CD=	Rel. 3.1.0 Feature Pkg., CD, Right To Use License
15454-R3.0.3SW/CD	Rel. 3.0.3 Feature Pkg., CD, Right To Use License
15454-R3.0.3SW/CD=	Rel. 3.0.3 Feature Pkg., CD, Right To Use License
15454-R2.3.3SW/CD=	Rel. 2.3.3 Feature Pkg., CD, Right To Use License
15454-R2.2.2SWCD=	Rel. 2.2.2 Feature Pkg., CD, Right To Use License
SF15454-R5.0.2K9	Rel. 5.0.2 SW, Pre-loaded on TCC
SF15454-R5.0.0K9	Rel. 5.0.0 SW, Pre-loaded on TCC
SF15454-R4.6.4K9	Rel. 4.6.4 SW, Pre-loaded on TCC
SF15454-R4.6.2K9	Rel. 4.6.2 SW, Pre-loaded on TCC
SF15454-R4.6.1K9	Rel. 4.6.1 SW, Pre-loaded on TCC
SF15454-R4.1.6	Rel. 4.1.6 SW, Pre-loaded on TCC
SF15454-R4.1.5	Rel. 4.1.5 SW, Pre-loaded on TCC
SF15454-R4.1.4	Rel. 4.1.4 SW, Pre-loaded on TCC
SF15454-R4.1.3	Rel. 4.1.3 SW, Pre-loaded on TCC
SF15454-R4.1.0	Rel. 4.1.0 SW, Pre-loaded on TCC
SF15454-R4.0.1	Rel. 4.0.1 SW, Pre-loaded on TCC
SF15454-R4.0.0	Rel. 4.0.0 SW, Pre-loaded on TCC
SF15454-R3.4.2	Rel. 3.4.2 SW, Pre-loaded on TCC
SF15454-R3.4.1	Rel. 3.4.1 SW, Pre-loaded on TCC
SF15454-R3.4.0	Rel. 3.4.0 SW, Pre-loaded on TCC
SF15454-R3.3.0	Rel. 3.3.0 SW, Pre-loaded on TCC
SF15454-R3.2.1	Rel. 3.2.1 SW, Pre-loaded on TCC
SF15454-R3.2.0	Rel. 3.2.0 SW, Pre-loaded on TCC
SF15454-R3.1.0	Rel. 3.1.0 SW, Pre-loaded on TCC
SF15454-R3.0.3	Rel. 3.0.3 SW, Pre-loaded on TCC

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
SF15454-R2.2.2	Rel. 2.2.2 SW, Pre-loaded on TCC
Cisco 15454 Cable Assemblies	
15454-CADS1-V-ID=	DS1Cable Assembly - 250 ft
15454-CADS1-V-LD=	DS1Cable Assembly - 655 ft
15454-CADS1-V-SD=	DS1Cable Assembly - 150 ft
15454-CADS3-V-ID=	DS3 Cable Assembly-225 ft
15454-CADS3-V-LD=	DS3 Cable Assembly-450 ft
15454-CADS3-V-SD=	DS3 Cable Assembly- 75 ft
15454-CADS3-H-25=	DS3 Cable Assembly, UBIC-H - 25 ft
15454-CADS1-H-25=	DS1 Cable Assembly, UBIC-H - 25 ft
15454-CADS1-H-50=	DS1 Cable Assembly, UBIC-H - 50 ft
15454-CADS1-H-75=	DS1 Cable Assembly, UBIC-H - 75 ft
15454-CADS1-H-100=	DS1 Cable Assembly, UBIC-H - 100 ft
15454-CADS1-H-150=	DS1 Cable Assembly, UBIC-H - 150 ft
15454-CADS1-H-200=	DS1 Cable Assembly, UBIC-H - 200 ft
15454-CADS1-H-250=	DS1 Cable Assembly, UBIC-H - 250 ft
15454-CADS1-H-350=	DS1 Cable Assembly, UBIC-H - 350 ft
15454-CADS1-H-450=	DS1 Cable Assembly, UBIC-H - 450 ft
15454-CADS1-H-550=	DS1 Cable Assembly, UBIC-H - 550 ft
15454-CADS1-H-655=	DS1 Cable Assembly, UBIC-H - 655 ft
15454-CADS3-H-50=	DS3 Cable Assembly, UBIC-H - 50 ft
15454-CADS3-H-75=	DS3 Cable Assembly, UBIC-H - 75 ft
15454-CADS3-H-100=	DS3 Cable Assembly, UBIC-H - 100 ft
15454-CADS3-H-125=	DS3 Cable Assembly, UBIC-H - 125 ft
15454-CADS3-H-150=	DS3 Cable Assembly, UBIC-H - 150 ft
15454-CADS3-H-175=	DS3 Cable Assembly, UBIC-H - 175 ft
15454-CADS3-H-200=	DS3 Cable Assembly, UBIC-H - 200 ft
15454-CADS3-H-225=	DS3 Cable Assembly, UBIC-H - 225 ft
15454-CADS3-H-250=	DS3 Cable Assembly, UBIC-H - 250 ft
15454-CADS3-H-300=	DS3 Cable Assembly, UBIC-H - 300 ft
15454-CADS3-H-350=	DS3 Cable Assembly, UBIC-H - 350 ft
15454-CADS3-H-450=	DS3 Cable Assembly, UBIC-H - 450 ft
15454-CA-HDBNC-30=	Cable Assy, HD-BNC, 30 FT
15454-CA-HDBNC-75=	Cable Assy, HDBNC, 75 FT
15454-AMP-WW-100=	Cable Assy, AMP-WW, 100 FT
15454-AMP-WW-250=	Cable Assy, AMP-WW, 250 FT

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-AMP-WW-30=	Cable Assy, AMP-WW, 30 FT
15454-AMP-WW-50=	Cable Assy, AMP-WW, 50 FT
15454-SMB-BNC-10=	Cable Assy, SMB-BNC, 10 FT
15454-SMB-BNC-30=	Cable Assy, SMB-BNC, 30 FT
15454-SMB-BNC-50=	Cable Assy, SMB-BNC, 50 FT
MSTP SOLUTIONS - SW and Documentation	
15454-WDM4.7.0K9=	Rel. 4.7.0 MSTP Feature Pkg., CD, DWDM ONLY DEPLOYMENTS
SF15454-W4.7.0K9	Rel. 4.7.0 SW, MSTP, Pre-loaded on TCC,DWDM ONLY DEPLOYMENTS
15454-MSTP-D4.7C=	Sys. Doc,MSTP, Rel. 4.7.0 English, CD, DWDM ONLY DEPLOYMENTS
15454-MSTP-D4.7P=	Sys. Doc,MSTP, Rel. 4.7.0 English, PP, DWDM ONLY DEPLOYMENTS
15454-R4.6.2SWK9	Rel. 4.6.2 Feature Pkg., CD, Right To Use License
15454-R4.6.2SWK9=	Rel. 4.6.2 Feature Pkg., CD, Right To Use License
SF15454-R4.6.2K9	Rel. 4.6.2 SW, Pre-loaded on TCC
15454-LIC-R4.6.2K9	15454 Upgrade License for R4.6.2, Right To Use License
15454-R4.6.1SWK9	Rel. 4.6.1 Feature Pkg., CD, Right To Use License
15454-R4.6.1SWK9=	Rel. 4.6.1 Feature Pkg., CD, Right To Use License
SF15454-R4.6.1K9	Rel. 4.6.1 SW, Pre-loaded on TCC
15454-LIC-R4.6.1K9	15454 Upgrade License for R4.6.1, Right To Use License
15454-DOC4.6.0CD=	Sys. Doc. Rel. 4.6.0 English, CD
15454-DOC4.6.0PP=	Sys. Doc. Rel. 4.6.0 English, Paper
MSTP Solution - 15454 WDM Common/Control and Accessories	
15454-OSC-CSM=	ONS 15454 Combiner and Separator with OSC Module
15454-OSCM=	ONS 15454 Optical Service Channel Module
15454-PP-64-LC=	Patch Panel Shelf - 64 Connectors - LC/UPC
15454-FBR-STRG=	Fiber Storage Shelf
15454-AIR-RAMP=	ONS 15454 Air Ramp / Baffle for the ANSI Chassis
15454-MPO-8LC-2=	Multi-fiber patchcord - MPO to 8xLC - 2m
15454-LC-LC-2=	Fiber patchcord - LC to LC - 2m
2.5G Multiservice Aggregation Card - (Shorter Lead Time)	
15454-DM-L1-38.1=	2.5Gbps Multi-rate DataMuxponder 4ch 1538.19-1540.56
15454-DM-L1-42.1=	2.5Gbps Multi-rate DataMuxponder 4ch 1542.14-1544.53
15454-DM-L1-54.1=	2.5Gbps Multi-rate DataMuxponder 4ch 1554.13-1556.55
15454-DM-L1-58.1=	2.5Gbps Multi-rate DataMuxponder 4ch 1558.17-1560.61

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-DMP-L1-38.1=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1538.19-1540.56
15454-DMP-L1-42.1=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1542.14-1544.53
15454-DMP-L1-54.1=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1554.13-1556.55
15454-DMP-L1-58.1=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1558.17-1560.61
2.5G Multiservice Aggregation Card - (Longer Lead Time)	
15454-DM-L1-30.3=	2.5Gbps Multi-rate DataMuxponder 4ch 1530.33-1532.68
15454-DM-L1-34.2=	2.5Gbps Multi-rate DataMuxponder 4ch 1534.25-1536.61
15454-DM-L1-46.1=	2.5Gbps Multi-rate DataMuxponder 4ch 1546.12-1548.51
15454-DM-L1-50.1=	2.5Gbps Multi-rate DataMuxponder 4ch 1550.12-1552.52
15454-DMP-L1-30.3=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1530.33-1532.68
15454-DMP-L1-34.2=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1534.25-1536.61
15454-DMP-L1-46.1=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1546.12-1548.51
15454-DMP-L1-50.1=	2.5G Multi-rate DataMuxpdr FiberSwtched 4ch 1550.12-1552.52
MSTP Solution - Unprotected Multi-Rate Transponder	
15454-MR-L1-30.3=	Multi-Rate Txp 100M-2.5G 100G 4ch 1530.33-1532.68
15454-MR-L1-34.2=	Multi-Rate Txp 100M-2.5G 100G 4ch 1534.25-1536.61
15454-MR-L1-38.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1538.19-1540.56
15454-MR-L1-42.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1542.14-1544.53
15454-MR-L1-46.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1546.12-1548.51
15454-MR-L1-50.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1550.12-1552.52
15454-MR-L1-54.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1554.13-1556.55
15454-MR-L1-58.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1558.17-1560.61
MSTP Solution - Protected Multi-Rate Transponder	
15454-MRP-L1-30.3=	Multi-Rate Txp 100M-2.5G 100G 4ch 1530.33-1532.68 Protected
15454-MRP-L1-34.2=	Multi-Rate Txp 100M-2.5G 100G 4ch 1534.25-1536.61 Protected
15454-MRP-L1-38.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1538.19-1540.56 Protected
15454-MRP-L1-42.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1542.14-1544.53 Protected
15454-MRP-L1-46.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1546.12-1548.51 Protected
15454-MRP-L1-50.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1550.12-1552.52 Protected
15454-MRP-L1-54.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1554.13-1556.55 Protected
15454-MRP-L1-58.1=	Multi-Rate Txp 100M-2.5G 100G 4ch 1558.17-1560.61 Protected
MSTP Solution - 10G MultiRate Transponder	
15454-10E-L1-30.3=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1530.33-1532.68
15454-10E-L1-34.2=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1534.25-1536.61
15454-10E-L1-38.1=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1538.19-1540.56
15454-10E-L1-42.1=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1542.14-1544.53

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-10E-L1-46.1=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1546.12-1548.51
15454-10E-L1-50.1=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1550.12-1552.52
15454-10E-L1-54.1=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1554.13-1556.55
15454-10E-L1-58.1=	Multi-Rate Txp 10G/10GE - EFEC - 4ch 1558.17-1560.61
MSTP Solution - 4 x 2.5G Muxponder	
15454-10ME-30.3=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1530.33-1532.68
15454-10ME-34.2=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1534.25-1536.61
15454-10ME-38.1=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1538.19-1540.56
15454-10ME-42.1=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1542.14-1544.53
15454-10ME-46.1=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1546.12-1548.51
15454-10ME-50.1=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1550.12-1552.52
15454-10ME-54.1=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1554.13-1556.55
15454-10ME-58.1=	4 x 2.5 Gbs - 10Gbs Muxpdr - EFEC - Tunable 1558.17-1560.61
MSTP Solution - Sonet SFP's	
15454-SFP-OC48-IR=	SFP - OC-48 - 1310nm IR - SM - LC
15454-SFP12-4-IR=	SFP - OC-12 - 1310nm IR - SM - LC
15454-SFP3-1-IR=	SFP - OC-3/D1-SDI - 1310nm IR - SM - LC
15454-SFP-200=	SFP-ESCON - 1310nm - MM - LC
MSTP Solution - Data SFP's	
15454-SFP-GEFC-SX=	SFP - GE/1G-FC/2G-FC - 850nm - MM - LC
15454-SFP-GE+-LX=	SFP - GE/1G-FC/2G-FC/HDTV - 1310nm - SM - LC
MSTP Solution - Amplifiers	
15454-OPT-BST=	ONS 15454 Optical Booster Amplifier Module
15454-OPT-PRE=	ONS 15454 Optical Pre-Amplifier Module
MSTP Solution - Bundles and Kits	
15454-PRE-SK	MSTP Bundle- Contains 2ea Optical Pre-Amplifier Module
15454-BST-SK	MSTP Bundle - Contains 2ea Optical Booster Amplifier Module
15454-ROADM-SK	ROADM Bundle - Contains 2ea WSS and DMX, 32 Ch -100GHz - Odd
15454-10ME-58-SK	Includes 2ea 15454-10ME-58.1
15454-10E-58-SK	Contains 2ea 15454-10E-L1-58.1 and ONS-XC-10G-S1
MSTP Solution - Mux/Demux	
15454-32DMX-O=	ONS 15454 32 Chs Demultiplexer - 100GHz - Odd
15454-32MUX-O=	ONS 15454 32 Chs Multiplexer - 100GHz - Odd
15454-4MD-30.3=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1530.33nm
15454-4MD-34.2=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1534.25nm
15454-4MD-38.1=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1538.19nm

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-4MD-42.1=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1542.14nm
15454-4MD-46.1=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1546.12nm
15454-4MD-50.1=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1550.12nm
15454-4MD-54.1=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1554.13nm
15454-4MD-58.1=	ONS 15454 4 Chs Mux and Demux - 100GHz - 1558.17nm
MSTP Solution - Requires R4.7SW-Reconfigurable OADM (ROADM)	
15454-32-DMX=	32 Ch DMUX 100 GHz (for use with 32.WSS)
15454-32-DMX	32 Ch DMUX 100 GHz (for use with 32.WSS)
15454-32-WSS=	32 Ch Wavelength Selective Switch
15454-32-WSS	32 Ch Wavelength Selective Switch
MSTP Solution - 1 Channel OADM	
15454-AD-1C-30.3=	ONS 15454 OADM - 1 Chn - 100GHz - 1530.33
15454-AD-1C-31.1=	ONS 15454 OADM - 1 Chn - 100GHz - 1531.12
15454-AD-1C-31.9=	ONS 15454 OADM - 1 Chn - 100GHz - 1531.90
15454-AD-1C-32.6=	ONS 15454 OADM - 1 Chn - 100GHz - 1532.68
15454-AD-1C-34.2=	ONS 15454 OADM - 1 Chn - 100GHz - 1534.25
15454-AD-1C-35.0=	ONS 15454 OADM - 1 Chn - 100GHz - 1535.04
15454-AD-1C-35.8=	ONS 15454 OADM - 1 Chn - 100GHz - 1535.82
15454-AD-1C-36.6=	ONS 15454 OADM - 1 Chn - 100GHz - 1536.61
15454-AD-1C-38.1=	ONS 15454 OADM - 1 Chn - 100GHz - 1538.19
15454-AD-1C-38.9=	ONS 15454 OADM - 1 Chn - 100GHz - 1538.98
15454-AD-1C-39.7=	ONS 15454 OADM - 1 Chn - 100GHz - 1539.77
15454-AD-1C-40.5=	ONS 15454 OADM - 1 Chn - 100GHz - 1540.56
15454-AD-1C-42.1=	ONS 15454 OADM - 1 Chn - 100GHz - 1542.14
15454-AD-1C-42.9=	ONS 15454 OADM - 1 Chn - 100GHz - 1542.94
15454-AD-1C-43.7=	ONS 15454 OADM - 1 Chn - 100GHz - 1543.73
15454-AD-1C-44.5=	ONS 15454 OADM - 1 Chn - 100GHz - 1544.53
15454-AD-1C-46.1=	ONS 15454 OADM - 1 Chn - 100GHz - 1546.12
15454-AD-1C-46.9=	ONS 15454 OADM - 1 Chn - 100GHz - 1546.92
15454-AD-1C-47.7=	ONS 15454 OADM - 1 Chn - 100GHz - 1547.72
15454-AD-1C-48.5=	ONS 15454 OADM - 1 Chn - 100GHz - 1548.51
15454-AD-1C-50.1=	ONS 15454 OADM - 1 Chn - 100GHz - 1550.12
15454-AD-1C-50.9=	ONS 15454 OADM - 1 Chn - 100GHz - 1550.92
15454-AD-1C-51.7=	ONS 15454 OADM - 1 Chn - 100GHz - 1551.72
15454-AD-1C-52.5=	ONS 15454 OADM - 1 Chn - 100GHz - 1552.52
15454-AD-1C-54.1=	ONS 15454 OADM - 1 Chn - 100GHz - 1554.13

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-AD-1C-54.9=	ONS 15454 OADM - 1 Chn - 100GHz - 1554.94
MSTP Solution - 1 Channel OADM	
15454-AD-1C-55.7=	ONS 15454 OADM - 1 Chn - 100GHz - 1555.75
15454-AD-1C-56.5=	ONS 15454 OADM - 1 Chn - 100GHz - 1556.55
15454-AD-1C-58.1=	ONS 15454 OADM - 1 Chn - 100GHz - 1558.17
15454-AD-1C-58.9=	ONS 15454 OADM - 1 Chn - 100GHz - 1558.98
15454-AD-1C-59.7=	ONS 15454 OADM - 1 Chn - 100GHz - 1559.79
15454-AD-1C-60.6=	ONS 15454 OADM - 1 Chn - 100GHz - 1560.61
MSTP Solution - 2 Channel OADM	
15454-AD-2C-30.3=	ONS 15454 OADM - 2 Chs - 100GHz - 1530.33 - 1531.12
15454-AD-2C-31.9=	ONS 15454 OADM - 2 Chs - 100GHz - 1531.90 - 1532.68
15454-AD-2C-34.2=	ONS 15454 OADM - 2 Chs - 100GHz - 1534.25 - 1535.04
15454-AD-2C-35.8=	ONS 15454 OADM - 2 Chs - 100GHz - 1535.82 - 1536.61
15454-AD-2C-38.1=	ONS 15454 OADM - 2 Chs - 100GHz - 1538.19 - 1538.98
15454-AD-2C-39.7=	ONS 15454 OADM - 2 Chs - 100GHz - 1539.77 - 1540.56
15454-AD-2C-42.1=	ONS 15454 OADM - 2 Chs - 100GHz - 1542.14 - 1542.94
15454-AD-2C-43.7=	ONS 15454 OADM - 2 Chs - 100GHz - 1543.73 - 1544.53
15454-AD-2C-46.1=	ONS 15454 OADM - 2 Chs - 100GHz - 1546.12 - 1546.92
15454-AD-2C-47.7=	ONS 15454 OADM - 2 Chs - 100GHz - 1547.72 - 1548.51
15454-AD-2C-50.1=	ONS 15454 OADM - 2 Chs - 100GHz - 1550.12 - 1550.92
15454-AD-2C-51.7=	ONS 15454 OADM - 2 Chs - 100GHz - 1551.72 - 1552.52
15454-AD-2C-54.1=	ONS 15454 OADM - 2 Chs - 100GHz - 1554.13 - 1554.94
15454-AD-2C-55.7=	ONS 15454 OADM - 2 Chs - 100GHz - 1555.75 - 1556.55
15454-AD-2C-58.1=	ONS 15454 OADM - 2 Chs - 100GHz - 1558.17 - 1558.98
15454-AD-2C-59.7=	ONS 15454 OADM - 2 Chs - 100GHz - 1559.79 - 1560.61
MSTP Solution - 4 Channel OADM	
15454-AD-4C-30.3=	ONS 15454 OADM - 4 Chs - 100GHz - 30.33-31.12-31.90-32.68
15454-AD-4C-34.2=	ONS 15454 OADM - 4 Chs - 100GHz - 34.25-35.04-35.82-36.61
15454-AD-4C-38.1=	ONS 15454 OADM - 4 Chs - 100GHz - 38.19-38.98-39.77-40.56
15454-AD-4C-42.1=	ONS 15454 OADM - 4 Chs - 100GHz - 42.14-42.94-43.73-44.53
15454-AD-4C-46.1=	ONS 15454 OADM - 4 Chs - 100GHz - 46.12-46.92-47.72-48.51
15454-AD-4C-50.1=	ONS 15454 OADM - 4 Chs - 100GHz - 50.12-50.92-51.72-52.52
15454-AD-4C-54.1=	ONS 15454 OADM - 4 Chs - 100GHz - 54.13-54.94-55.75-56.55
15454-AD-4C-58.1=	ONS 15454 OADM - 4 Chs - 100GHz - 58.17-58.98-59.79-60.61
MSTP Solution - 1 Band OADM	
15454-AD-1B-30.3=	ONS 15454 OADM - 1 Band - 1530.33nm

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-AD-1B-34.2=	ONS 15454 OADM - 1 Band - 1534.25nm
15454-AD-1B-38.1=	ONS 15454 OADM - 1 Band - 1538.19nm
15454-AD-1B-42.1=	ONS 15454 OADM - 1 Band - 1542.14nm
15454-AD-1B-46.1=	ONS 15454 OADM - 1 Band - 1546.12nm
15454-AD-1B-50.1=	ONS 15454 OADM - 1 Band - 1550.12nm
15454-AD-1B-54.1=	ONS 15454 OADM - 1 Band - 1554.13nm
15454-AD-1B-58.1=	ONS 15454 OADM - 1 Band - 1558.17nm
MSTP Solution - 4 Band OADM	
15454-AD-4B-30.3=	ONS 15454 OADM - 4 Bands - 30.33-34.25-38.19-42.14
15454-AD-4B-46.1=	ONS 15454 OADM - 4 Bands - 46.12-50.12-54.13-58.17
Products for Use With the CTMP Program	
15454-2-TCC2	Bundle for use with CTMP, Contains 2 ea. TCC2s.
15454-2-ML1000-2	Bundle for use with CTMP, Contains 2 ea. ML 1000s
15454-2-ML100T-12	Bundle for use with CTMP, Contains 2 ea. ML 100Ts
15454-2-FC-MR-4	Bundle for use with CTMP, Contains 2 ea.FC-MRs (SL Series)
15454-2-G1K-4	Bundle for use with CTMP, Contains 2 ea. G1Ks
15454-2-OC192S1310	Bundle for use with CTMP, Contains 2 ea.OC192 SR 1310.
15454-2-OC192I1550	Bundle for use with CTMP, Contains 2 ea.OC192 IR 1550.
15454-2-OC48I1310A	Bundle for use with CTMP, Contains 2 ea.OC48 IR1310 Anyslot.
15454-2-OC48L1550A	Bundle for use with CTMP, Contains 2 ea.OC48 LR1550 Anyslot.
15454-2-192L-54.1	Bundle for use with CTMP, Contains 2 ea.OC192L,1554.13
15454-2-192L-56.5	Bundle for use with CTMP, Contains 2 ea.OC192L,1556.55
15454-2-OC192-LR2	Bundle for use with CTMP, Contains 2 ea.OC192 LR 1550.
PRODUCTS PENDING END OF SALE (See Product Bulletin #XXXX)	
15454-SA-ANSI	15454 SA NEBS3 ANSI w/RCA and Ship Kit, EOS 05-2005(2480)
15454-SA-ANSI=	15454 SA NEBS3 ANSI w/RCA and Ship Kit, EOS 05-2005(2480)
15454-EIA-AMP-A84	Elect I/F, 84 AMP, A Side, I-Temp, EOS 05-2005(2481)
15454-EIA-AMP-A84=	Elect I/F, 84 AMP, A Side, I-Temp, EOS 05-2005(2481)
15454-EIA-AMP-B84	Elect I/F, 84 AMP, B Side, I-Temp, EOS 05-2005(2481)
15454-EIA-AMP-B84=	Elect I/F, 84 AMP, B Side, I-Temp, EOS 05-2005(2481)
15454-EIA-BNC-A24	Elect I/F, 24 BNC, A Side, I-Temp, EOS 05-2005(2481)
15454-EIA-BNC-A24=	Elect I/F, 24 BNC, A Side, I-Temp, EOS 05-2005(2481)
15454-EIA-BNC-B24	Elect I/F, 24 BNC, B Side, I-Temp, EOS 05-2005(2481)
15454-EIA-BNC-B24=	Elect I/F, 24 BNC, B Side, I-Temp, EOS 05-2005(2481)
15454-EIA-BNC-A48	Elect I/F, 48 BNC, A Side, I-Temp, EOS 05-2005(2481)
15454-EIA-BNC-A48=	Elect I/F, 48 BNC, A Side, I-Temp, EOS 05-2005(2481)

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-EIA-BNC-B48	Elect I/F, 48 BNC, B Side, I-Temp, EOS 05-2005(2481)
15454-EIA-BNC-B48=	Elect I/F, 48 BNC, B Side, I-Temp, EOS 05-2005(2481)
15454-EIA-SMB-A84	Elect I/F, 84 SMB, A Side, I-Temp, EOS 05-2005(2481)
15454-EIA-SMB-A84=	Elect I/F, 84 SMB, A Side, I-Temp, EOS 05-2005(2481)
15454-EIA-SMB-B84	Elect I/F, 84 SMB, B Side, I-Temp, EOS 05-2005(2481)
15454-EIA-SMB-B84=	Elect I/F, 84 SMB, B Side, I-Temp, EOS 05-2005(2481)
15454-OC481IR1310	OC48, IR, 1310, 1 Ckt, SC, EOS 8-05, (2353)
15454-OC481IR1310=	OC48, IR, 1310, 1 Ckt, SC, EOS 8-05, (2353)
15454-OC481LR1550	OC48, LR, 1550, 1 Ckt, SC, EOS 8-05, (2353)
15454-OC481LR1550=	OC48, LR, 1550, 1 Ckt, SC, EOS 8-05, (2353)
15454-DS3N-12	DS3, 1:N, 12 Ckt, I-Temp, EOS Nov, 2005 (2633)
15454-DS3N-12=	DS3, 1:N, 12 Ckt, I-Temp, EOS Nov, 2005 (2633)
15454-DS3-12	DS3, 12 Ckt., I-Temp, EOS Nov, 2005 (2633)
15454-DS3-12=	DS3, 12 Ckt., I-Temp, EOS Nov, 2005 (2633)
15454-EIA-1BNCA24	HD Elect I/F, 24 BNC, A Side, EOS Nov. 2005 (2632)
15454-EIA-1BNCA24=	HD Elect I/F, 24 BNC, A Side, EOS Nov. 2005 (2632)
15454-EIA-1BNCB24	HD Elect I/F, 24 BNC, B Side, EOS Nov. 2005 (2632)
15454-EIA-1BNCB24=	HD Elect I/F, 24 BNC, B Side, EOS Nov. 2005 (2632)
15454-10T-L1-30.3=	10Gbs Tpx - 100Ghz- Tunable 30.33-31.12, EOS Feb 06 (2763)
15454-10T-L1-31.9=	10Gbs Tpx - 100Ghz- Tunable 31.90-32.68, EOS Feb 06 (2763)
15454-10T-L1-34.2=	10Gbs Tpx - 100Ghz- Tunable 34.25-35.04, EOS Feb 06 (2763)
15454-10T-L1-35.8=	10Gbs Tpx - 100Ghz- Tunable 35.82-36.61, EOS Feb 06 (2763)
15454-10T-L1-38.1=	10Gbs Tpx - 100Ghz- Tunable 38.19-38.98, EOS Feb 06 (2763)
PRODUCTS PENDING END OF SALE (See Product Bulletin #XXXX)	
15454-10T-L1-39.7=	10Gbs Tpx - 100Ghz- Tunable 39.77-40.56, EOS Feb 06 (2763)
15454-10T-L1-42.1=	10Gbs Tpx - 100Ghz- Tunable 42.14-42.94, EOS Feb 06 (2763)
15454-10T-L1-43.7=	10Gbs Tpx - 100Ghz- Tunable 43.73-44.53, EOS Feb 06 (2763)
15454-10T-L1-46.1=	10Gbs Tpx - 100Ghz- Tunable 46.12-46.92, EOS Feb 06 (2763)
15454-10T-L1-47.7=	10Gbs Tpx - 100Ghz- Tunable 47.72-48.51, EOS Feb 06 (2763)
15454-10T-L1-50.1=	10Gbs Tpx - 100Ghz- Tunable 50.12-50.92, EOS Feb 06 (2763)
15454-10T-L1-51.7=	10Gbs Tpx - 100Ghz- Tunable 51.72-52.52, EOS Feb 06 (2763)
15454-10T-L1-54.1=	10Gbs Tpx - 100Ghz- Tunable 54.13-54.94, EOS Feb 06 (2763)
15454-10T-L1-55.7=	10Gbs Tpx - 100Ghz- Tunable 55.75-56.55, EOS Feb 06 (2763)
15454-10T-L1-58.1=	10Gbs Tpx - 100Ghz- Tunable 58.17-58.98, EOS Feb 06 (2763)
15454-10T-L1-59.7=	10Gbs Tpx - 100Ghz- Tunable 59.79-60.61, EOS Feb 06 (2763)

Table D-1 List of Parts (continued)

Cisco 15454 Part Number	Part Description
15454-10M-L1-30.3=	2.5Gbs-10Gbs Muxpdr-100Ghz-Tune 30.33-31.12,EOS Feb 06(2763)
15454-10M-L1-31.9=	2.5Gbs-10Gbs Muxpdr-100Ghz-Tune 31.90-32.68,EOS Feb 06(2763)
15454-10M-L1-34.2=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 34.25-35.04
15454-10M-L1-35.8=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 35.82-36.61
15454-10M-L1-38.1=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 38.19-38.98
15454-10M-L1-39.7=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 39.77-40.56
15454-10M-L1-42.1=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 42.14-42.94
15454-10M-L1-43.7=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 43.73-44.53
15454-10M-L1-46.1=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 46.12-46.92
15454-10M-L1-47.7=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 47.72-48.51
15454-10M-L1-50.1=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 50.12-50.92
15454-10M-L1-51.7=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 51.72-52.52
15454-10M-L1-54.1=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 54.13-54.94
15454-10M-L1-55.7=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 55.75-56.55
15454-10M-L1-58.1=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 58.17-58.98
15454-10M-L1-59.7=	2.5 Gbs - 10Gbs Muxpdr-100Ghz-Tunable 59.79-60.61

APPENDIX E

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
CoS	Class of Service
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
EoMPLS	Ethernet over Multiprotocol Label Switching
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

Q

QoS Quality of Service

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
RPR	Resilient Packet Ring
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
SFP	Small Factor-Form Pluggable
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
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.

EoMPLS EoMPLS is an Internet Engineering Task Force (IETF) standard-track protocol based on the Martini draft, specifically the draft-martini-l2circuit-encap-mpls-01 and draft-martini-l2circuit-transport-mpls-05 sections. EoMPLS provides a tunneling mechanism for Ethernet traffic through an MPLS-enabled Layer 3 core. It encapsulates Ethernet protocol data units (PDUs) inside MPLS packets and using label stacking forwards them across the MPLS network.

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.

Fibre Channel A serial data transfer architecture designed for new mass storage devices and other peripheral devices that require very high bandwidth. Using optical fiber to connect devices, Fibre Channel (FC) supports full-duplex data transfer rates of 100MB/s.

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-running 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.

Path Protection 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.

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 protectionbeyond 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 rest 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 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.

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.

subnetwork 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 networks 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.

tributory 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.

upstream Set of frequencies used to send data from a subscriber to the headend.

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

INDEX

Numerics

A

B

C

D

E

F

G

H

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y