



# Building Multiservice Transport Networks

A comprehensive guide to MSPP network architectures  
and applications using the Cisco ONS 15454

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**Cisco Press**

800 East 96th Street  
Indianapolis, Indiana 46240 USA

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Published by:

Cisco Press

800 East 96th Street

Indianapolis, IN 46240 USA

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Printed in the United States of America 1 2 3 4 5 6 7 8 9 0

First Printing July 2006

Library of Congress Cataloging-in-Publication Number: 2004114023

ISBN: 1-58705-220-2

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# Acknowledgments

**Jim Durkin:** I would like to thank Joe Garcia for his initial idea of writing this book and for his support and recognition during this time-consuming project. I also would like to thank John Kane and Dan Young for their outstanding support. Most of all, I want to thank my beautiful wife and children for their support and patience during the writing of this book. This book is dedicated to John Richards, my uncle, who has been a father figure and mentor to me in my life.

**John Goodman:** This book is dedicated to my wife, Teresa, and to Joe Garcia, who was instrumental in my participation in this project.

**Ron Harris:** This book could not have been possible without the tireless efforts of my editors and technical reviewers. I would like to personally thank Rob Gonzalez and Gabriel Gutierrez for their hard work and tremendous effort in technically reviewing the chapters covering MSTP. I also would like to thank Dan Young and his team of editors for their editorial spirit of excellence while preparing this book for publication. Most important, I owe a tremendous amount of gratitude to my wife and daughters for their support and patience during the compilation of this book.

**Frank Fernández-Posse:** I would like to thank my wife, Ana, for her patience and ongoing support, and my baby son, Alec, for putting a big smile on my face every day. I love you! I am also grateful for being part of a great team in which support is readily available from every member. Special thanks to Jim Durkin for kicking off and managing this effort.

**Michael Rezek:** I would like to acknowledge my wife for the sacrifices she has made to provide me with the time to write this book.

**Mike Wallace:** I'd like to acknowledge all of my co-authors for their patience and assistance in completing this project. I would especially like to acknowledge Jim Durkin for his vision to see the need for this project and for giving me the opportunity to participate. I'd like to thank all the technical reviewers for their diligence, comments, and dedication to make this book a value to those individuals interested in its subject matter. I'd like to dedicate this book to my wonderful wife, Rosanne, for her support and understanding, and also to all of the people (too many to mention) who have been a part of my telecommunications career and education. It has been a great ride!

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# Contents at a Glance

**Introduction   xxii**

**Part I           Building the Foundation for Understanding MSPP Networks   3**

**Chapter 1       Market Drivers for Multiservice Provisioning Platforms   5**

**Chapter 2       Technology Foundation for MSPP Networks   45**

**Chapter 3       Advanced Technologies over Multiservice Provisioning Platforms   81**

**Part II          MSPP Architectures and Designing MSPP Networks   133**

**Chapter 4       Multiservice Provisioning Platform Architectures   135**

**Chapter 5       Multiservice Provisioning Platform Network Design   181**

**Chapter 6       MSPP Network Design Example: Cisco ONS 15454   219**

**Part III         Deploying Ethernet and Storage Services on ONS 15454 MSPP Networks   269**

**Chapter 7       ONS 15454 Ethernet Applications and Provisioning   271**

**Chapter 8       ONS 15454 Storage-Area Networking   309**

**Part IV         Building DWDM Networks Using the ONS 15454   325**

**Chapter 9       Using the ONS 15454 Platform to Support DWDM Transport: MSTP   327**

**Chapter 10      Designing ONS 15454 MSTP Networks   371**

**Chapter 11      Using the ONS 15454 MSTP to Provide Wavelength Services   389**

**Part V          Provisioning and Troubleshooting ONS 15454 Networks   405**

**Chapter 12      Provisioning and Operating an ONS 15454 SONET/SDH Network   407**

**Chapter 13      Troubleshooting ONS 15454 Networks   443**

**Part VI         MSPP Network Management   465**

**Chapter 14      Monitoring Multiple Services on an Multiservice Provisioning Platform Network   467**

**Chapter 15      Large-Scale Network Management   495**

**Index   521**

# Table of Contents

## Introduction xxii

## Part I Building the Foundation for Understanding MSPP Networks 3

### Chapter 1 Market Drivers for Multiservice Provisioning Platforms 5

Market Drivers	8
Increased Demand for Bandwidth by LANs	9
Rapid Delivery of Next-Generation Data and High-Bandwidth Services	11
Ethernet Services	12
DWDM Wavelength Services	15
SAN Services	17
Voice and Video Applications	18
TCO	20
Legacy Optical Platforms	20
MSPP	24
OAM&P	39
GUI	39
End-to-End Provisioning	39
Wizards	40
Alarms	41
Software Downloads	41
Event Logging	41
Capital Expense Reduction	41
Summary	43

### Chapter 2 Technology Foundation for MSPP Networks 45

What Is an MSPP Network?	45
Fiber Optic Basics	45
Optical Fiber	46
Light Propagation in Fiber	46
Reflection and Refraction	47
Index of Refraction (Snell's Law)	47
Types of Optical Fiber: Multimode and Single Mode	48
SONET/SDH Principles	49
Digital Multiplexing and Framing	50
DS1 Frame	52
STS-1 Frame	53
STS-1 Frame and the Synchronous Payload Envelope	54
SONET/SDH Rates and Tributary Mapping	55
SONET Rates	55

SDH Rates	56
Transporting Subrate Channels Using SONET	57
Signals of Higher Rates	60
Byte Interleaving to Create Higher-Rate Signals	61
Concatenation	61
SONET/SDH Equipment	64
SONET Overhead	66
SONET/SDH Transmission Segments	66
Sections	66
Lines	68
Paths	69
Synchronization and Timing	72
Timing	73
Global Positioning System	75
Summary	78

## **Chapter 3** Advanced Technologies over Multiservice Provisioning Platforms 81

Storage	82
A Brief History of Storage	83
Direct Attached Storage	84
Network Attached Storage	85
Storage-Area Networking	86
Business Drivers Creating a Demand for SAN	86
Evolution of SAN	88
Fibre Channel	90
Enterprise Systems Connection	91
Fiber Connection	91
FCIP	94
SAN over MSPP	95
DWDM	98
History of DWDM	98
Fiber-Optic Cable	101
Acceptance of Light onto Fiber	102
Wavelength-Division Multiplexing: Course Wavelength-Division Multiplexing versus DWDM	102
DWDM Integrated in MSPP	103
Active and Passive DWDM	104
Erbium-Doped Fiber Amplifiers	107
DWDM Advantages	107
Protection Options	109
Market Drivers for MSPP-Based DWDM	110

Ethernet	110
A Brief History of Ethernet	110
Fast Ethernet	111
GigE	112
Ethernet Emerges	112
Ethernet over MSPP	113
Why Ethernet over MSPP?	114
Metro Ethernet Services	116
Point-to-Point Ethernet over MSPP	120
Resilient Packet Ring	122
Summary	130

## **Part II      MSPP Architectures and Designing MSPP Networks    133**

### **Chapter 4    Multiservice Provisioning Platform Architectures    135**

Traditional Service-Provider Network Architectures	135
Public Switched Telephone Networks	135
Frame Relay/ATM Networks	138
Connection to the LAN	139
Benefits of Frame Relay	140
Asynchronous Transfer Mode	140
Service Provider SONET Networks	141
IP and MPLS Networks	143
Transport Networks	144
IOF Rings	144
Access Rings	146
Private Rings	146
Heritage Operational Support System	148
TIRKS	148
TEMS	149
NMA	149
Traditional Customer Network Architectures	149
ATM/Frame Relay Networks	150
Customer Synchronous Optical Networks	150
IP and MPLS Networks	151
MSPP Positioning in Service-Provider Network Architectures	152
How MSPP Fits into Existing Networks	153
MSPP IOF Rings	153
MSPP Private Architectures	155
MSPP Access Rings	160
Next-Generation Operational Support Systems	166
Multiservice Switching Platforms	171

MSPP Positioning in Customer Network Architectures 174

Summary 179

## **Chapter 5** Multiservice Provisioning Platform Network Design 181

MSPP Network Design Methodology 181

Protection Design 181

Redundant Power Feeds 182

Common Control Redundancy 182

Tributary Interface Protection 183

Synchronization Source Redundancy 184

Cable Route Diversity 185

Multiple Shelves 185

Protected Network Topologies (Rings) 186

Network Timing Design 186

Timing Sources 186

Timing Reference Selection 188

Synchronization Status Messaging 189

Network Management Considerations 191

MSPP Network Topologies 193

Linear Networks 193

UPSR Networks 195

UPSR Operation 195

UPSR Applications 199

BLSR Networks 200

2-Fiber BLSR Operation 201

2-Fiber BLSR System Capacity 203

Protection Channel Access 205

4-Fiber BLSR Operation 206

4-Fiber BLSR System Capacities 209

BLSR Applications 209

Subtending Rings 209

Subtending Shelves 211

Ring-to-Ring Interconnect Diversity 212

Mesh Networks 214

Summary 216

## **Chapter 6** MSPP Network Design Example: Cisco ONS 15454 219

ONS 15454 Shelf Assembly 219

ONS 15454 Shelf Assembly Backplane Interfaces 220

EIAs 222

Timing, Communications, and Control Cards 225

---

Cross-Connect Cards	228
Cross-Connect Card Bandwidth	229
Alarm Interface Controller Card	230
Environmental Alarms	231
Orderwires	234
Power Supply Voltage Monitoring	235
User Data Channels	235
SONET/SDH Optical Interface Cards	235
Ethernet Interface Cards	238
Transport (Layer 1) Ethernet Service Interfaces	238
G-Series Ethernet Interface Cards	239
CE-Series Ethernet Interface Cards	240
E-Series Ethernet Interface Cards	241
Switching (Layer 2) and Routing (Layer 3) Ethernet Service Interfaces	242
E-Series Ethernet Interface Cards	242
ML-Series Ethernet Interface Cards	242
Electrical Interface Cards	244
DS1-14 and DS1N-14 Interface Cards	245
DS1-56 Interface Card	246
DS3-12, DS3N-12, DS3-12E, and DS3N-12E Interface Cards	246
EC1-12 Interface Cards	246
DS3/EC1-48 Interface Cards	247
DS3XM-6 and DS3XM-12 Interface Card	247
Storage Networking Cards	248
MSPP Network Design Case Study	249
MSPP Ring Network Design	249
OC-192 Ring Transmission Design	255
Network Map	256
Shelf Card Slot Assignments, EIA Equipage, and Tributary Protection Group Configuration	256
Magnolia Central Office (Node 1)	259
UCHS Headquarters (Node 2)	260
Brounsville Main Central Office (Node 3)	260
University Medical Center (Node 4)	260
University Hospital—East (Node 5)	262
Samford Avenue Central Office (Node 6)	262
University Hospital—South (Node 7)	262
UCHS Data Center (Node 8)	264

Jordan Memorial Hospital (Node 9) 264  
Cabling Terminations 264

Summary 267

## **Part III Deploying Ethernet and Storage Services on ONS 15454 MSPP Networks 269**

### **Chapter 7 ONS 15454 Ethernet Applications and Provisioning 271**

ONS 15454 E-Series Interface Cards 272  
    ONS 15454 E-Series Card Modes and Circuit Sizes 273  
    ONS 15454 E-Series Example Application and Provisioning 273

ONS 15454 G-Series Interface Cards 275  
    ONS 15454 G-Series Card Example Application 276  
    Important Features of the ONS 15454 G-Series Card 277  
        Flow Control and Frame Buffering 277  
        Link Aggregation 278  
        Ethernet Link Integrity 278

ONS 15454 CE-Series Interface Cards 279  
    ONS 15454 CE-Series Queuing 279  
    ONS 15454 CE-Series SONET/SDH Circuit Provisioning 281  
    ONS 15454 CE-Series Card Example Application 283

ONS 15454 ML-Series Interface Cards 285  
    ML-Series Card Transport Architecture Examples 287  
        Point-to-Point Transport Architecture 288  
        RPR Transport Architecture 288  
    RPR Operation in the ONS 15454 ML-Series Cards 288  
        ONS 15454 ML-Series RPR Frame Format 291  
        ML-Series Bridge Groups 292  
        RPR Operation 293  
        RPR Operation in Failure Scenarios 297  
        RPR Spatial Reuse 298  
    Provisioning RPR Using the ONS 15454 ML-Series Cards 300  
        CTC RPR Circuit and Framing Mode Provisioning 300  
        ML-Series IOS Configuration File Management 302  
        RPR Provisioning and Verification in the IOS CLI 303

Summary 307

### **Chapter 8 ONS 15454 Storage-Area Networking 309**

SAN Review 309  
    SAN Protocols 310  
    SONET or DWDM? 311

Data Storage Mirroring	311
Synchronous Data Replication	312
Asynchronous Data Replication	313
A Single-Chassis SAN Extension Solution: ONS 15454	314
Storage over Wavelength	315
Storage over SONET	318
Fibre Channel Multirate 4-Port (FC-MR-4) Card	318
1G and 2G FC	319
Overcoming the Round-Trip Delay Limitation in SAN Networks	319
Using VCAT and LCAS	320
SAN Protection	321
Summary	322

## **Part IV     Building DWDM Networks Using the ONS 15454    325**

### **Chapter 9   Using the ONS 15454 Platform to Support DWDM Transport: MSTP    327**

ONS 15454 Shelf Assembly	327
ONS 15454 Shelf Assembly Backplane Interfaces	329
Timing, Communications, and Control Cards	331
Optical Service Channel Module	334
OSC-CSM	335
Alarm Interface Controller Card	335
Environmental Alarms	337
Orderwires	340
Power Supply Voltage Monitoring	340
User Data Channels	340
ONS 15454 MSTP DWDM ITU-T Channel Plan	341
32-Channel Multiplexer Cards	342
32 MUX-O Multiplexer Card	343
32 WSS Multiplexer Card	344
32-Channel Demultiplexer Cards	345
32 DMX-O Demultiplexer Card	346
32 DMX Demultiplexer Card	347
Four-Channel Multiplexer/Demultiplexer Cards	348
Four-Band OADM Filters	350
One-Band OADM Filters	351

Channel OADM Cards	353
ONS 15454 MSTP ROADM	355
ONS 15454 MSTP Transponder/Muxponder Interfaces	356
2.5G Multirate Transponder	356
10G Multirate Transponder	357
4x2.5G Enhanced Muxponder	358
2.5G Multiservice Aggregation Card	358
ONS 15454 MSTP Optical Amplifiers	360
OPT-PRE	360
OPT-BST	362
ONS 15454 MSTP Dispersion Compensation Unit	364
ONS 15454 MSTP Supported Network Configurations	365
Linear Topologies	365
Ring Topologies	366
Hubbed/Multihubbed Rings	367
Meshed Rings	368
Reconfigurable Rings	368
Summary	369

## **Chapter 10** Designing ONS 15454 MSTP Networks 371

ONS 15454 MSTP DWDM Design Considerations	371
ONS 15454 MSTP DWDM Design Rules Examples	374
ONS 15454 MSTP Manual DWDM Design Example	377
Attenuation	379
Chromatic Dispersion	381
OSNR	381
ONS 15454 MSTP MetroPlanner Design Tool	382
Simple/Flexible	384
Comprehensive Analysis	385
Installation/Turn-Up Assistance	385
Summary	387

## **Chapter 11** Using the ONS 15454 MSTP to Provide Wavelength Services 389

Types of Wavelength Services	389
SONET/SDH Services	390
Storage-Area Networking Services	390
Ethernet Services	391
Variable Bit-Rate Services	391

Wavelength Services Protection Options	392
Y-Cable Protection	392
Dual-Transponder Protection	393
DWDM Trunk Split-Routing	394
Implementing Wavelength Services on the ONS 15454 MSTP	395
Fixed-Channel Optical Add/Drop	396
ROADM	397
Managing Wavelength Services on the ONS 15454 MSTP	398
Fault Management	399
Configuration	401
Performance	402
Security	403
Summary	403

## **Part V      Provisioning and Troubleshooting ONS 15454 Networks    405**

### **Chapter 12   Provisioning and Operating an ONS 15454 SONET/SDH Network    407**

Turning Up the ONS 15454	408
Installing and Powering the Shelf	408
Initial Configuration	410
Installing Common Equipment Cards	410
General Network Element Information	412
IP Addressing	415
Security and Users	416
DCC	418
Synchronization and Timing	420
Connecting the Optics	424
Final Configuration	424
Operating and Supporting an MSPP Network	425
Monitoring Alarms and Conditions	425
Alarms	426
Conditions	426
Adding or Removing Interface Modules	426
Provisioning Service	427
Creating Circuits	428
Troubleshooting Alarms or Conditions	432
Acceptance Testing	433
Maintenance	435
Performance Monitoring	435
Database Backup	438

Database Restoration	439
Card Sparing	439
Software Upgrades	439
Software Activation	440
Software Reversion	441

Summary	441
---------	-----

## **Chapter 13** Troubleshooting ONS 15454 Networks 443

Resources to Troubleshoot the ONS 15454	443
Documentation	443
Cisco Transport Controller Online Help	444
Installing Online Help	444
Cisco Technical Assistance Center	446
Locating the Problem and Gathering Details Using CTC	447
Alarms Tab	448
Conditions Tab	449
History Tab	450
Performance Tab	451
Other Data and Items to Check	452
Diagnostics File	452
Database Backup	452
Card Light Emitting Diodes	453
Cabling	454
Power	454
Connectivity	455
Data Gathering Checklist	455
Troubleshooting Tools	456
Loopbacks	456
STS Around the Ring	457
Monitor Circuit	458
Test Access	458
Possible Causes to Common Issues	458
Poor or No Signal of an Electrical Circuit	458
Errors or No Signal of an Optical Link	459
Unable to Log into the ONS 15454	460
Cannot Convert UPSR Ring to BLSR Ring	462
Signal Degrade in Conditions Tab	462
Ethernet Circuit Cannot Carry Traffic	462
Summary	463

## **Part VI MSPP Network Management 465**

### **Chapter 14 Monitoring Multiple Services on a Multiservice Provisioning Platform Network 467**


- MSPP Fault Management 468
  - Using SNMP MIBs for Fault Management 470
    - What Is an SNMP MIB? 470
    - SNMP Traps 472
    - ONS 15454 MIBs 480
    - Setting Up SNMP on the ONS 15454 481
  - Using TL1 for Fault Management 482
    - TL1 Versus SNMP 483
    - Using TL1 for Ethernet Services 484
  - Using CTC for Fault Management 484
- MSPP Performance Management 486
  - Ethernet Performance Monitoring 488
    - What Is RMON? 488
    - Using the RMON to Monitor Ethernet Performance 490
    - Multipoint Ethernet Monitoring 491
- Using Local Craft Interface Application Versus EMS 492
- Summary 493

### **Chapter 15 Large-Scale Network Management 495**


- Overview of Management Layers 497
- Why Use an EMS? 499
  - Using the ONS 15454 Element-Management System 500
    - CTM Architecture 500
    - System Management Capabilities 502
    - Fault-Management Capabilities 503
    - Configuration-Management Capabilities 504
    - Performance-Management Capabilities 505
    - Security-Management Capabilities 507
    - High Availability 509
  - Ethernet Management 509
    - Layer 1 Provisioning 510
    - Layer 2 Provisioning 512
  - Integrating to an OSS Using the Northbound Interface 517
- Summary 518

## **Index 521**

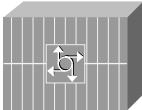
Icons Used in This Book




Communication Server




PC




Access Server




Terminal




File Server




Printer




Laptop




Web Server



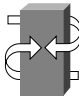
Cisco Works Workstation




Modem




Hub




Gateway




Router




Bridge




Server Load Balancing Device




CSS




Catalyst Switch




Multilayer Switch




ATM Switch



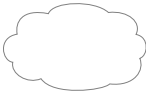
CSM




GSS




ISDN/Frame Relay Switch



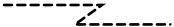
Network Cloud



Line: Ethernet



Line: Serial



Line: Switched Serial

## Command Syntax Conventions

The conventions used to present command syntax in this book are the same conventions used in the IOS Command Reference. The Command Reference describes these conventions as follows:

- **Boldface** indicates commands and keywords that are entered literally as shown. In actual configuration examples and output (not general command syntax), boldface indicates commands that are manually input by the user (such as a **show** command).
- *Italics* indicate arguments for which you supply actual values.
- Vertical bars (|) separate alternative, mutually exclusive elements.
- Square brackets [ ] indicate optional elements.
- Braces { } indicate a required choice.
- Braces within brackets [{ }] indicate a required choice within an optional element.

# Introduction

This book is a rare assemblage, in that it combines the best minds across a number of topics in one central repository. Books that are authored by one or two authors limit the depth and breadth of expertise to only that particular author(s). This book draws on the breadth and depth of each author as it pertains to each topic discussed, enhancing the book's overall value. The authors of this book are Cisco Systems Optical Engineers who have more than 75 years of combined optical networking expertise.

The authors of this book have seen a need to prepare those aspiring to grow their capabilities in multiservice transport networking. The result is this book, *Building Multiservice Transport Networks*. This book provides the reader with information to thoroughly understand and learn the many facets of MSPP and DWDM network architectures and applications with this comprehensive handbook. This includes topics such as designing, configuring, and monitoring multiservice transport networks. A multiservice transport network consists of MSPPs and MSTPs. Cisco's ONS 15454 is an example of a Multiservice Provisioning Platform (MSPP) and a Multiservice Transport Platform (MSTP).

It is important to understand that the Cisco ONS 15454 can be considered as two different products under one product family. The ONS 15454 MSPP is one product, and the other is the ONS 15454 MSTP. MSTP describes the characteristics of the ONS 15454 when used to implement either a fixed-channel OADM or a ROADM-based DWDM network. One of the unique capabilities of the ONS 15454 is that it remains one chassis, one software base, and one set of common control cards to support both MSPP applications and MSTP applications.

Service providers today understand the need for delivering data services—namely, Ethernet and SAN extension. However, most are uncertain of or disagree on the most economical network foundation from which these services should actually be delivered. When placed in newer environments, service providers instinctively leverage past knowledge of network deployments and tend to force-fit new technology into old design schemes. For example, some service providers have always used point-to-point circuits to deliver services, so when customers required Ethernet services, many immediately used private-line, point-to-point circuits to deliver them. Using the ONS 15454, this book shows you how to deliver basic private-line Ethernet service and how to deliver Ethernet multipoint and aggregation services using RPR to enable newer and more efficient service models.

This book also discusses how the MSPP and MSTP fit within the overall network architecture. This is important because many service providers are trying to converge and consolidate their networks. Service providers, such as ILECs, are looking to deliver more services, more efficiently over their network. This book can serve as a handbook that network designers and planners can reference to help develop their plans for network migration.

## Goals and Methods

An important goal of this book is to help you thoroughly understand all the facets of a multiservice transport network. Cisco's ONS 15454 is addressed when discussing this because it is the leading multiservice transport product today. This book provides the necessary background material to ensure that you understand the key aspects of SONET, DWDM, Ethernet, and storage networking.

This book serves as a valuable resource for network professionals engaged in the design, deployment, operation, and troubleshooting of ONS 15454 applications and services, such as TDM, SONET/SDH,

DWDM, Ethernet, and SAN. By providing network diagrams, application examples, and design guidelines, this book is a valuable resource for readers who want a comprehensive book to assist in an MSPP and MSTP network deployment.

In summary, this book's goals are to

- Provide you with an in-depth understanding on multiservice transport networks
- Translate key topics in this book into examples of “why they matter”
- Offer you an end-to-end guide for design, implementation, and maintenance of multiservice transport networks
- Help you design, deploy, and troubleshoot ONS 15454 MSPP and MSTP services
- Provide real-life examples of how to use an MSPP and an MSTP to extend SAN networks
- Understand newer technologies such as RPR and ROADM, and how these can be deployed within an existing ONS 15454 transport architecture
- Review SONET and DWDM fundamentals

## Who Should Read This Book?

This book's primary audience is equipment technicians, network engineers, transport engineers, circuit capacity managers, and network infrastructure planners in the telecommunications industry. Those who install, test, provision, troubleshoot, or manage MSPP networks, or who aspire to do so are also candidates for this book. Additionally, data and telecom managers seeking an understanding of TDM/data product convergence should read this book.

Business development and marketing personnel within the service-provider market can also gain valuable information from this book. This book should facilitate their understanding of how to market and price new services that can be delivered over their network.

## How This Book Is Organized

The book provides a comprehensive view of MSPP and MSTP networks using the Cisco ONS 15454.

Chapters 1 through 15 cover the following topics:

### Part I: “Building the Foundation for Understanding MSPP Networks”

- **Chapter 1, “Market Drivers for Multiservice Provisioning Platforms”**—This chapter builds the case for deploying a MSPP network. This chapter focuses on key reasons why MSPPs are needed and how MSPPs can reduce capital expenditures for service providers. It also discusses another important benefit for using an MSPP: the ease of operations, administration, maintenance, and provisioning (OAMP) of an MSPP.
- **Chapter 2, “Technology Foundation for MSPP Networks”**—This chapter provides an overview of key technologies that must be understood to successfully deploy an MSPP network. These include fiber optics, optical transmission, SONET principles, and synchronization and timing.
- **Chapter 3, “Advanced Technologies over Multiservice Provisioning Platforms”**—This chapter discusses three advanced technologies supported by MSPPs: 1) storage-area networking, 2) dense wavelength-division multiplexing, and 3) Ethernet. For each technology, this

chapter provides a brief history of the evolution of the service and then its integration into the MSPP platform.

## **Part II: “MSPP Architectures and Designing MSPP Networks”**

- **Chapter 4, “Multiservice Provisioning Platform Architectures”**—This chapter describes various MSPP architectures. It reviews traditional network architectures and contrasts these with MSPP architectures. This comparison helps to point out the enormous benefits that MSPPs provide.
- **Chapter 5, “Multiservice Provisioning Platform Network Design”**—This chapter discusses how to design MSPP networks. It examines the key design components, including protection options, synchronization (timing) design, and network management. This chapter also discusses supported MSPP network topologies, such as linear, ring, and mesh configurations.
- **Chapter 6, “MSPP Network Design Example: Cisco ONS 15454”**—This chapter provides a realistic network design example of an MSPP network using the Cisco ONS 15454. It uses an example network demand specification to demonstrate an MSPP network design. The solution uses an ONS 15454 OC-192 ring. As part of the design, this chapter introduces the major components of the ONS 15454 system, including the common control cards, the electrical interface cards, the optical interface cards, the Ethernet interface cards, and the storage networking cards.

## **Part III: “Deploying Ethernet and Storage Services on ONS 15454 MSPP Networks”**

- **Chapter 7, “ONS 15454 Ethernet Applications and Provisioning”**—This chapter discusses Ethernet architectures and applications supported on the ONS 15454, including Ethernet point-to-point and multipoint ring architectures. This chapter discusses the ONS 15454 Ethernet service cards: E Series, CE Series, G Series, and ML Series. Application examples are provided as well, including how to provision Ethernet services. As an example, this chapter discusses how to implement a resilient packet ring (RPR) using the ML-Series cards.
- **Chapter 8, “ONS 15454 Storage-Area Networking”**—This chapter discusses storage-area networking (SAN) extension using the Cisco ONS 15454. You can use 15454 networks to connect storage-area networks between different geographical locations. This is important today because of the need to consolidate data center resources and create architectures for disaster recovery and high availability.

## **Part IV: “Building DWDM Networks Using the ONS 15454”**

- **Chapter 9, “Using the ONS 15454 Platform to Support DWDM Transport: MSTP”**—This chapter highlights the basic building blocks of the ONS 15454 MSTP platform. It describes the key features and functions associated with each ONS 15454 MSTP component, including fixed OADMs and ROADMs cards, transponder/muxponder interface cards, and amplifier interface cards. This chapter provides network topology and shelf configuration examples. Each ONS 15454 MSTP shelf configuration example shows you the most common equipment configurations applicable to today’s networks.
- **Chapter 10, “Designing ONS 15454 MSTP Networks”**—This chapter examines the general design considerations for DWDM networks and relays their importance for ONS 15454 Multiservice Transport Platform (MSTP) DWDM system deployment. Design considerations and

design rules examples are included in this chapter. This chapter describes Cisco's MetroPlanner Design Tool, which you can use to quickly design and assist in turning up an ONS 15454 MSTP network.

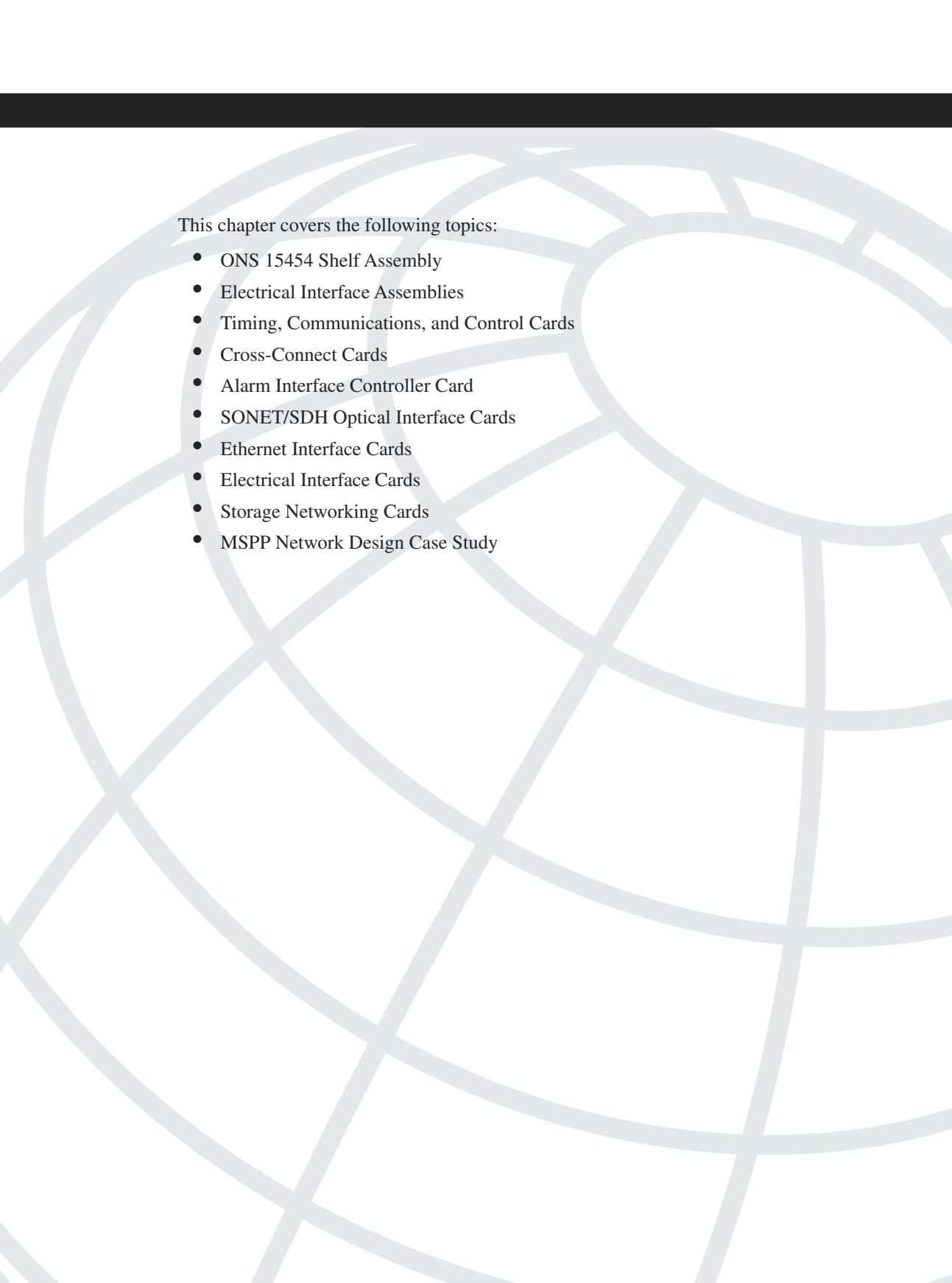
- **Chapter 11, "Using the ONS 15454 MSTP to Provide Wavelength Services"**—This chapter discusses wavelength services using the ONS 15454 MSTP, and it explores the different categories and characteristics of wavelength services as they relate to ONS 15454 MSTP features and functions. You will understand how you can use the ONS 15454 MSTP to provide wavelength services, such as SAN, Ethernet, and SONET, while using different protection schemes. Both fixed-channel optical add/drop and ROADM based networks are discussed.

#### **Part V: "Provisioning and Troubleshooting ONS 15454 Networks"**

- **Chapter 12, "Provisioning and Operating an ONS 15454 SONET/SDH Network"**—This chapter describes how to install, configure, and power up the ONS 15454. It also discusses how to test, maintain, and upgrade software for the ONS 15454.
- **Chapter 13, "Troubleshooting ONS 15454 Networks"**—This chapter provides a high-level approach to troubleshooting ONS 15454 SONET networks. This chapter provides you with a general approach to troubleshooting the most common problems and issues found during turn-up of an ONS 15454 node, as well as ONS 15454 network-related issues.

#### **Part VI: "MSPP Network Management"**

- **Chapter 14, "Monitoring Multiple Services on an Multiservice Provisioning Platform Network"**—This chapter provides an overview of the fault- and performance-management capabilities of the ONS 15454. This chapter also includes a discussion of three key areas that are essential in managing MSPP networks: 1) SNMP MIBs, 2) TL1 support, and 3) performance management. The end of this chapter discusses the key differences in using the local Craft Interface application, called Cisco Transport Controller (CTC), versus an element-management system (EMS).
- **Chapter 15, "Large-Scale Network Management"**—This chapter provides a list of key functions supported by large-scale operational support systems (OSS). After discussing these functions, the following important question is asked and discussed: "Why use an element-management system (EMS)?" This chapter describes Cisco's EMS, called Cisco Transport Manager (CTM), and discusses how CTM provisions Layer 2 Ethernet Multipoint service step by step over an ONS 15454 ring equipped with ML-Series cards.



This chapter covers the following topics:

- ONS 15454 Shelf Assembly
- Electrical Interface Assemblies
- Timing, Communications, and Control Cards
- Cross-Connect Cards
- Alarm Interface Controller Card
- SONET/SDH Optical Interface Cards
- Ethernet Interface Cards
- Electrical Interface Cards
- Storage Networking Cards
- MSPP Network Design Case Study

## MSPP Network Design Example: Cisco ONS 15454

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The Cisco ONS 15454 is a highly flexible and highly scalable multiservice Synchronous Optical Network (SONET)/Synchronous Digital Hierarchy (SDH)/dense wavelength-division multiplexing (DWDM) platform. Service providers and enterprise customers use the ONS 15454 to build highly available transport networks for time-division multiplexing (TDM), Ethernet, storage extension, and wavelength services. In this chapter, you will learn the major components of the ONS 15454 system, including these:

- Shelf assembly
- Common control cards
- Electrical interface cards
- Optical interface cards
- Ethernet interface cards
- Storage networking cards

In addition, an example network demand specification is used throughout this chapter to demonstrate Multiservice Provisioning Platform (MSPP) network design using the ONS 15454.

### ONS 15454 Shelf Assembly

The ONS 15454 Shelf Assembly is a 17-slot chassis with an integrated fan tray, rear electrical terminations, and front optical, Ethernet, and management connections. Slots 1–6 and 12–17 are used for traffic interface cards; Slots 7–11 are reserved for common control cards. Slots 1–6, on the left side as you face the front of the shelf, are considered Side A; Slots 12–17 are considered Side B. This distinction is important for planning backplane interface types (for electrical card terminations), as well as protection group planning. These issues are covered later in this chapter. The bandwidth capacity of each of the 12 traffic slots varies from 622 Mbps to 10 Gbps, depending upon the type of cross-connect card used. See the section titled “Cross-Connect Cards” later in this chapter for a discussion of the various types available. Table 6-1 summarizes the card slot functions and bandwidth capacities for the ONS 15454 shelf assembly.

**Table 6-1** ONS 15454 Shelf Assembly Slot Functions and Bandwidth Capacities

Slot Number	Shelf Side	Slot Use	Slot Bandwidth (XCVT System)	Slot Bandwidth (XC10G or XC-VXC-10G System)
1	A	Multispeed high-density slot	622 Mbps/STS-12	2.5 Gbps/STS-48
2	A	Multispeed high-density slot	622 Mbps/STS-12	2.5 Gbps/STS-48
3	A	Multispeed high-density slot; <i>N</i> -protection slot for 1: <i>N</i> protection groups	622 Mbps/STS-12	2.5 Gbps/STS-48
4	A	Multispeed slot	622 Mbps/STS-12	2.5 Gbps/STS-48
5	A	High-speed slot	2.5 Gbps/STS-48	10 Gbps/STS-192
6	A	High-speed slot	2.5 Gbps/STS-48	10 Gbps/STS-192
7	—	TCC Slot	—	—
8	—	XC Slot	—	—
9	—	AIC Slot	—	—
10	—	XC Slot	—	—
11	—	TCC Slot	—	—
12	B	High-speed slot	2.5 Gbps/STS-48	10 Gbps/STS-192
13	B	High-speed slot	2.5 Gbps/STS-48	10 Gbps/STS-192
14	B	Multispeed slot	622 Mbps/STS-12	2.5 Gbps/STS-48
15	B	Multispeed high-density slot; <i>N</i> -protection slot for 1: <i>N</i> protection groups	622 Mbps/STS-12	2.5 Gbps/STS-48
16	B	Multispeed high-density slot	622 Mbps/STS-12	2.5 Gbps/STS-48
17	B	Multispeed high-density slot	622 Mbps/STS-12	2.5 Gbps/STS-48

## ONS 15454 Shelf Assembly Backplane Interfaces

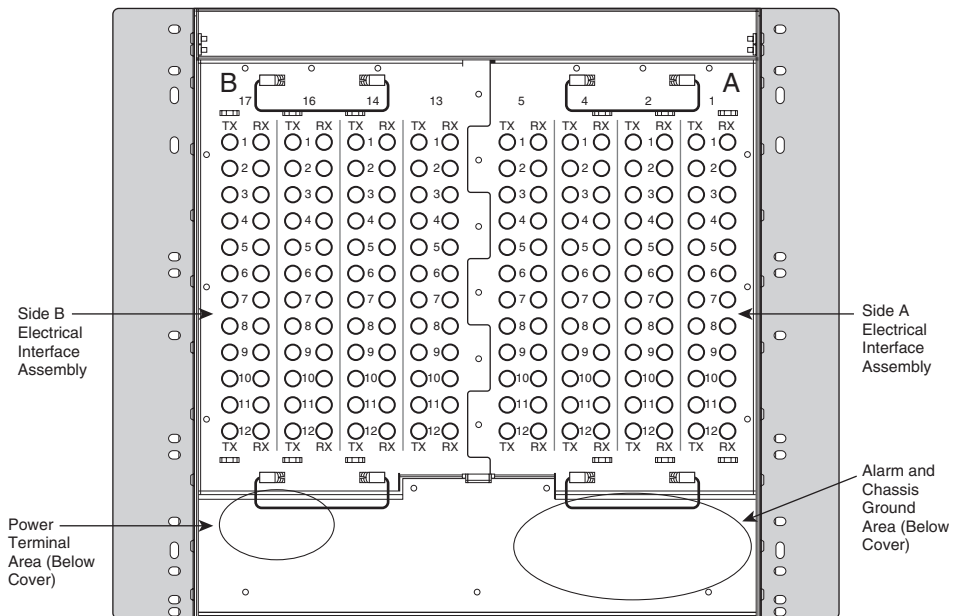
Backplane interfaces of the ONS 15454 chassis can be divided into four general areas:

- Power terminal area
- Alarm and chassis ground area

- Side A Electrical Interface Assembly
- Side B Electrical Interface Assembly

Figure 6-1 shows a diagram that identifies the location of each of these areas as you face the rear of the shelf assembly. Electrical Interface Assemblies (EIAs) are required for terminating electrical traffic signals, such as DS1s and DS3s, on the shelf. EIAs are covered in the next section.

**Figure 6-1** ONS 15454 Backplane Interfaces



The power terminal area consists of four power terminal screws on the lower-left side. The RET1/BAT1 terminals are for the A power connection; the RET2/BAT2 terminals are for the B connection. These connections are redundant; either can power the entire shelf. The A and B designations do not refer to the A and B sides of the shelf.

The alarm and chassis ground area is located in the rear of the chassis on the lower right side. It has the following terminations:

- **Frame ground terminals**—Two terminals with kepnuts are provided for ground-wire lug connection. This connection ensures that the shelf assembly is at the same electrical potential with the office ground.
- **BITS**—(Building Integrated Timing Supply) This consists of four wire-wrap pin pairs for connection to a BITS or for wiring out to external equipment when the BITS-Out feature is used to supply timing from the ONS 15454.

- **LAN**—(Local-area network) A LAN connects the MSPP node to a management workstation or network. It consists of four wire-wrap pin pairs; typically, two pairs are used.
- **Environmental alarms**—Sixteen wire-wrap pin pairs are provided for external alarms and controls. The Alarm Interface Controller card, covered later in this chapter, is required to use these connections.
- **ACO**—Alarm cutoff, a wire-wrap pin pair that is used to deactivate the audible alarms caused by the contact closures on the shelf backplane. This operation is described in the “Timing, Communications, and Control Cards” section, later in this chapter.
- **Modem**—Four pairs of wire-wrap pins are provided for connecting the ONS 15454 to a modem for remote management.
- **Craft**—Two wire-wrap pin pairs are provided for a TL1 craft-management connection. VT100 emulation software is used to communicate with the system by way of this connection.
- **Local alarms**—Eight wire-wrap pin pairs are used for Critical, Major, Minor, and Remote audible and visual alarms.

## EIAs

EIAs are backplane connector panels that must be equipped on the ONS 15454 chassis if you will provide DS1, DS3, or EC-1 services from the node. EIAs are made to fit on either Side A or Side B of the upper section of the backplane. Because Side A consists of the slots that are on the left as you face the front of the shelf assembly, the Side A EIA is installed on the right side as you face the rear. Likewise, the Side B EIA is installed on the left side facing the rear of the shelf assembly.

Various EIAs are available from Cisco, and each side of the shelf can be independently equipped with any type. If no electrical terminations are required for a shelf side, it can be equipped with a blank backplane cover. If there is initially no requirement for electrical connections, and the requirement appears later, the blank backplane cover can be removed and replaced with an EIA while the shelf is powered and in service. You select an EIA based on the type and quantity or density of connections required. These EIA types are available:

- **BNC (Bayonet Neill-Concelman) EIA**—Used for DS3 (clear channel), DS3 Transmux (channelized DS3), and EC-1 services. This EIA type has been made obsolete by newer versions, and Cisco no longer sells it.
- **High-Density (HD) BNC EIA**—Offers the same services as the BNC EIA, with twice the number of available connections.

- **HD mini-BNC EIA**—Offers the same services as the BNC and HD BNC EIAs, with twice as many connections as the HD BNC EIA and four times as many as the BNC EIA. Either the HD mini-BNC EIA or one of the Universal Backplane Interface Connector (UBIC)-type EIAs are required for cabling the HD DS3/EC1 cards.
- **AMP Champ EIA**—Used for DS1 services only.
- **SMB (Sub-Miniature B) EIA**—Can be used for any type of electrical termination, including DS1, DS3, DS3 Transmux, and EC-1.
- **UBIC-V and UBIC-H EIAs**—Can be used for any type and any density electrical interface card termination. These are the most flexible EIA type. The difference between the two is in the orientation of the cable connectors, either vertical (UBIC-V) or horizontal (UBIC-H). Either the UBIC-V or the UBIC-H is required for cabling the high-density DS1 cards.

Table 6-2 provides a summary of the available EIAs, with their associated connector types, supported working shelf slots, and supported electrical interface cards.

**Table 6-2** ONS 15454 Electrical Interface Assemblies

EIA Type	Cards Supported	A-Side Connectors	A-Side Slots	B-Side Connectors	B-Side Slots
BNC	DS3-12E DS3N-12E DS3XM-6 DS3XM-12 EC1-12	24 pairs of BNC connectors (2 slots; 12 pairs/slot)	Slot 2 Slot 4	24 pairs of BNC connectors (2 slots; 12 pairs/slot)	Slot 14 Slot 16
High-Density BNC	DS3-12E DS3N-12E DS3XM-6 DS3XM-12 EC1-12	48 pairs of BNC connectors (4 slots; 12 pairs/slot)	Slot 1 Slot 2 Slot 4 Slot 5	48 pairs of BNC connectors (4 slots; 12 pairs/slot)	Slot 13 Slot 14 Slot 16 Slot 17
High-Density mini-BNC	DS3-12E DS3N-12E DS3XM-6 DS3XM-12 DS3/EC1-48 EC1-12	96 pairs of mini-BNC connectors	Slot 1 Slot 2 Slot 4 Slot 5 Slot 6	96 pairs of mini-BNC connectors	Slot 12 Slot 13 Slot 14 Slot 16 Slot 17

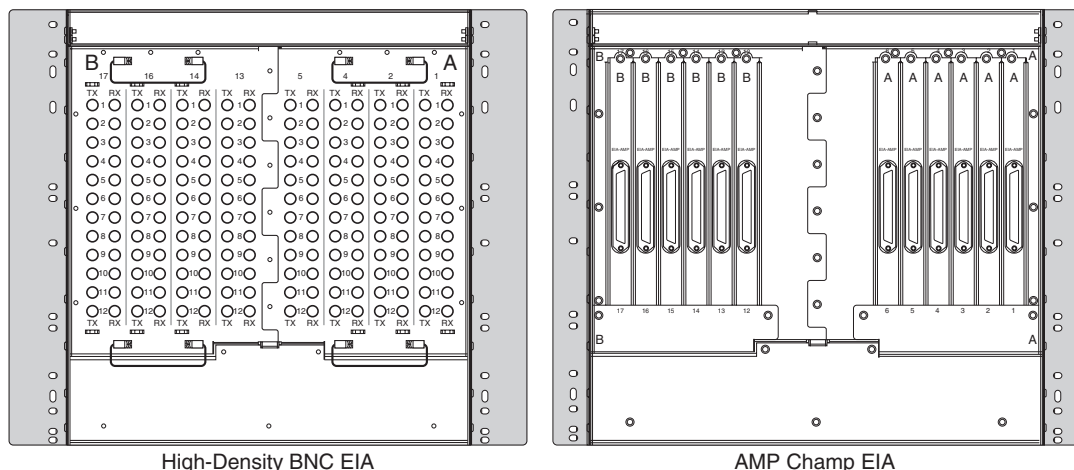
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**Table 6-2** ONS 15454 Electrical Interface Assemblies (Continued)

<b>EIA Type</b>	<b>Cards Supported</b>	<b>A-Side Connectors</b>	<b>A-Side Slots</b>	<b>B-Side Connectors</b>	<b>B-Side Slots</b>
AMP Champ	DS1-14 DS1N-14	6 AMP Champ connectors (1 connector per slot)	Slot 1 Slot 2 Slot 3 Slot 4 Slot 5 Slot 6	6 AMP Champ connectors (1 connector per slot)	Slot 12 Slot 13 Slot 14 Slot 15 Slot 16 Slot 17
SMB	DS1-14 DS1N-14 DS3-12E DS3N-12E DS3XM-6 DS3XM-12 EC1-12	84 pairs of SMB connectors (6 slots; 14 pairs/slot)	Slot 1 Slot 2 Slot 3 Slot 4 Slot 5 Slot 6	84 pairs of SMB connectors (6 slots; 14 pairs/slot)	Slot 12 Slot 13 Slot 14 Slot 15 Slot 16 Slot 17
UBIC-V	DS1-14 DS1N-14 DS1-56 DS3-12E DS3N-12E DS3XM-6 DS3XM-12 DS3/EC1-48 EC1-12	8 pairs of SCSI connectors— vertical orientation	Slot 1 Slot 2 Slot 3 Slot 4 Slot 5 Slot 6	8 pairs of SCSI connectors— vertical orientation	Slot 12 Slot 13 Slot 14 Slot 15 Slot 16 Slot 17
UBIC-H	DS1-14 DS1N-14 DS1-56 DS3-12E DS3N-12E DS3XM-6 DS3XM-12 DS3/EC1-48 EC1-12	8 pairs of SCSI connectors— horizontal orientation	Slot 1 Slot 2 Slot 3 Slot 4 Slot 5 Slot 6	8 pairs of SCSI connectors— horizontal orientation	Slot 12 Slot 13 Slot 14 Slot 15 Slot 16 Slot 17

Figure 6-2 shows two examples of EIAs, the HD BNC and the AMP Champ.

**Figure 6-2** EIA Examples: HD BNC and AMP Champ



## Timing, Communications, and Control Cards

The Timing, Communications, and Control (TCC) cards are required for operation of the ONS 15454 MSPP system and are installed in a redundant pair in shelf Slots 7 and 11. Two current versions are available from Cisco: the Advanced Timing, Communications, and Control card (TCC2), and the Enhanced Advanced Timing, Communications, and Control card (TCC2P). Both perform the same basic functions, but the TCC2P is an updated version of the TCC2 and includes some security enhancements and additional synchronization options that are not available in the TCC2. Both cards have a purple square symbol on their faceplates, which corresponds to matching symbols on the front of the ONS 15454 shelf assembly. This serves as an aid in easily identifying the correct location to install the card. TCC cards are the only card type allowed in Slots 7 and 11, and both slots should always be equipped. Cisco does not support the operation of the ONS 15454 MSPP system with only a single TCC card installed. Although the system technically can function with only a single card, the second card is necessary for redundancy and to allow for continuity of system traffic in case of a failure or reset of the primary card. The system raises the “Protection Unit Not Available” (PROTNA) alarm if the secondary TCC card is not installed.

Two earlier versions of the TCC2 and TCC2P cards exist, called simply the Timing, Communications, and Control (TCC) card and the TCC Plus (TCC+). These older-version TCC cards provide similar functionality to the current cards, but they are much more limited in processing power. Although they may be installed in some existing systems, Cisco no longer produces the TCC or TCC+ versions.

The TCC2 and TCC2P cards perform a variety of critical system functions, which are as follows:

- **System initialization**—The TCC2s/TCC2Ps are the first cards initially installed in the system and are required to initialize system operation.
- **Data communications channels (DCCs) termination and processing**—The DCCs, which allow for communications and remote management between different MSPP network elements, are processed by the TCC2/TCC2P card. The TCC card automatically detects DCC-connected nodes.
- **Software, database, and Internet Protocol (IP) address storage**—The node database, system software, and assigned system IP address (or addresses) are stored in nonvolatile memory on the TCC2/TCC2P card, which allows for quick restoration of service in case of a complete power outage.
- **Alarm reporting**—The TCC2/TCC2P monitors all system elements for alarm conditions and reports their status using the faceplate and fan tray light-emitting diodes (LEDs). It also reports to the management software systems.
- **System timing**—The TCC card monitors timing from all sources (both optical and BITS inputs) for accuracy. The TCC selects the timing source, which is recovered clocking from an optical port, a BITS source, or the internal Stratum level 3 clock.
- **Cell bus origination/termination**—The TCC cards originate and terminate a cell bus, which allows for communication between any two cards in the node and facilitates peer-to-peer communication. These links are important to ensure fast protection switching from a failed card to a redundant-protection card.
- **Diagnostics**—System performance testing is enabled by the TCC cards. This includes the system LED test, which can be run from the faceplate test button on the active TCC or using Cisco Transport Controller (CTC).
- **Power supply voltage monitoring**—An alarm is generated if one or both of the power-supply connections is operating at a voltage outside the specified range. Allowable power supply voltage thresholds are provisionable in CTC.

Figure 6-3 shows a diagram of the faceplate of the TCC2/TCC2P card.

The two card types are identical in appearance, with the exception of the card name labeling. The cards have 10 LEDs on the faceplate, including the following:

- **FAIL**—This red LED that is illuminated during the initialization process. This LED flashes as the card boots up. If the LED does not extinguish, a card failure is indicated.
- **ACT/STBY**—Because the TCC cards are always installed as a redundant pair, one card is always active while the other is in standby state. The active TCC2/TCC2P has a green illuminated ACT/STBY LED; the standby card is amber/yellow.
- **PWR A and B**—These indicate the current state of the A- and B-side power-supply connections. A voltage that is out of range causes the corresponding LED to illuminate red; an acceptable level is indicated with green.

**Figure 6-3** *TCC2/TCC2P Faceplate Diagram*

- **CRIT, MAJ, and MIN**—These indicate the presence of a critical (red), major (red), or minor (amber) alarm (respectively) in the local ONS 15454 node.
- **REM**—This LED turns red if an alarm is present in one or more remote DCC-connected systems.
- **SYNC**—This green SYNC lamp indicates that the node is synchronized to an external reference.

- **ACO**—The Alarm Cutoff lamp is illuminated in green if the ACO button on the faceplate is depressed. The ACO button deactivates the audible alarm closure on the shelf backplane. ACO stops if a new alarm occurs. If the alarm that originated the ACO is cleared, the ACO LED and audible alarm control are reset.

The faceplate also has two push-button controls. The LAMP TEST button initiates a brief system LED test, which lights every LED on each installed card and the fan tray LEDs (with the exception of the FAN FAIL LED, which does not participate in the test).

The RS-232 and Transmission Control Protocol/Internet Protocol (TCP/IP) connectors allow for management connection to the front of the ONS 15454 shelf. TCP/IP is an RJ-45 that allows for a 10Base-T connection to a PC or workstation that uses the CTC management system. A redundant local-area network (LAN) connection is provided via the backplane LAN pins on the rear of the shelf. The RS-232 is an EIA/TIA-232 DB9-type connector used for TL1 management access to the system. The CRAFT wire-wrap pins on the shelf backplane duplicate the functionality of this port.

## Cross-Connect Cards

The cross-connect (XC) cards are required for operation of the ONS 15454 MSPP system and are installed in a redundant pair in shelf Slots 8 and 10. Three versions currently are available from Cisco: XCVT, XC10G, and XC-VXC-10G. Each version has both a high-order (STS-N) cross-connect fabric and a low-order virtual tributary (VT1.5) fabric. All three perform the same basic functions, but they feature varying cross-connect capacities. Table 6-3 summarizes the high-order and low-order cross-connect capacities of the XCVT, XC10G, and XC-VXC-10G cards. The meanings of these capacities are covered later in this section.

**Table 6-3** ONS 15454 XC Card Capacities

Cross-Connect Card	High-Order (STS-1) Capacity	Low-Order (VT1.5) Capacity
XCVT	288	672
XC10G	1152	672
XC-VXC-10G	1152	2688

The XCVT, XC10G, and XC-VXC-10G have green cross symbols on their faceplates, which correspond to matching symbols on the front of the ONS 15454 shelf assembly. This serves as an aid in easily identifying the correct location to install the cards. The XC card types are the only cards allowed in Slots 8 and 10 for the MSPP, and both slots should always be equipped. Cisco does not support the operation of the ONS 15454 MSPP system with only a single XCVT, XC10G, or XC-VXC-10G installed. Although the system will technically function with only a single card, the second card is necessary for redundancy and to allow for continuity of system traffic.

An earlier version of the cross-connect card is called simply the XC card. This older version provides a 288 STS-1 fabric, which is the same size as the high-order fabric in the Cross-Connect Virtual Tributary (XCVT). However, the XC card does not support low-order (VT1.5) grooming, and systems that are equipped with the XC card cannot drop DS1 circuits. Although it can be installed in some existing systems, Cisco no longer produces the XC card.

The XCVT, XC10G, and XC-VXC-10G cards have only two faceplate LEDs. The red FAIL LED illuminates during a reset and flashes during the boot process to indicate that the card's processor is not ready for operation. If the FAIL LED does not extinguish, this is an indication that the card has failed and needs to be replaced. The ACT/STBY LED indicates whether the card is the active (green) or standby (amber) card in the redundant pair.

## Cross-Connect Card Bandwidth

Each of the three cross-connect card types has a high-order (STS-1) and low-order (VT1.5) capacity, as shown in Table 6-3. For example, the XC10G card has an STS-1 capacity of 1152 STS terminations. Each STS-1 circuit requires at least two terminations, one for entering (ingress) and one for exiting (egress) the cross-connect matrix. Therefore, a single Bidirectional Line Switch Ring (BLSR) circuit, a pass-through circuit, or an unprotected circuit consumes two terminations of the available capacity. In a Unidirectional Path-Switched Ring (UPSR) circuit-termination node, an STS-1 circuit consumes three matrix terminations because of the signal bridging that occurs to enable UPSR protection. As an example, a DS3 circuit in a UPSR termination node would use three STS-1 terminations (of the available 1152 for the XC10G or XC-VXC-10G, or the available 288 for the XCVT).

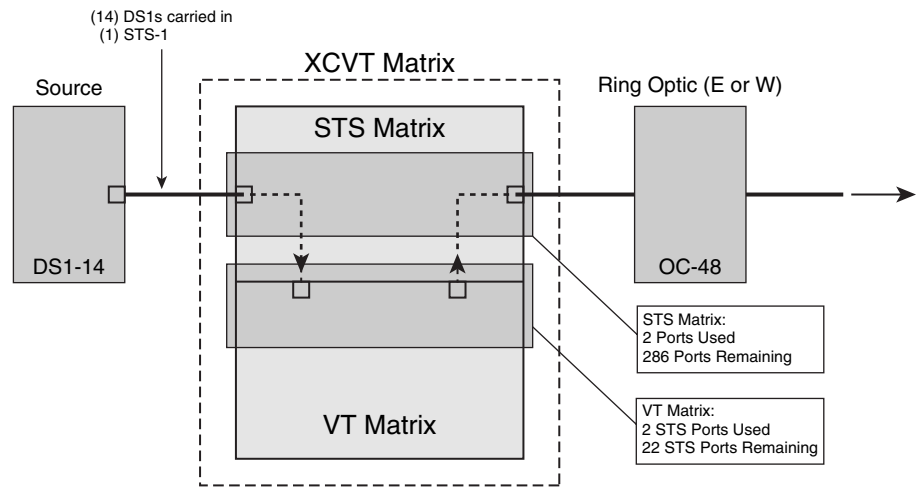
VT1.5-Level cross-connections are made via logical STS ports in the VT matrix of the various cross-connect cards. The XCVT and XC10G VT matrices have 24 logical STS ports ( $24 \text{ STS ports} \times 28 \text{ VT1.5/port} = 672 \text{ VT capacity}$ ); the XC-VXC-10G has 96 logical STS ports ( $96 \text{ STS ports} \times 28 \text{ VT1.5/port} = 2688 \text{ VT capacity}$ ). To fully use the VT matrix capacity, each STS port must carry 28 VT1.5 circuits. Because of this, stranded capacity can occur when using, for example, a DS1-14 card as a circuit source/destination. Because the 14 DS1s from the DS1-14 card's 14 ports are carried to the cross-connect matrix on an STS-1, the remaining 14 VT1.5 capacity within the STS-1 is unused on the VT cross-connect matrix.

To further aid in understanding the way the cross-connect matrixes operate on the ONS 15454, see Figures 6-4 and 6-5. Figure 6-4 shows a VT1.5 circuit from a DS1-14 card in a BLSR termination node; Figure 6-5 shows the same circuit in a UPSR termination node. Note the matrix use information shown for each of the figures.

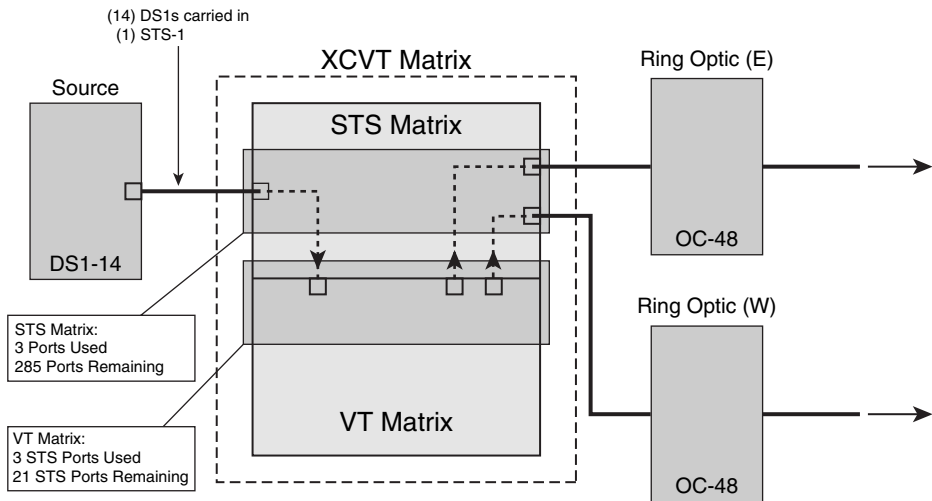
### NOTE

The transition connections between the STS (high-order) matrix and the VT (low-order) matrix are not counted when calculating ports used on the STS (high-order) matrix.

**Figure 6-4** VT Matrix Use for a DS1 Circuit in a BLSR Termination Node



**Figure 6-5** VT Matrix Use for a DS1 Circuit in a UPSR Termination Node



# Alarm Interface Controller Card

The Alarm Interface Controller (AIC-I) card is an optional circuit pack that is installed in shelf Slot 9. The faceplate of the card is marked with a red diamond, corresponding to the symbol marked on the front of the ONS 15454 shelf assembly. This serves as an aid in easily identifying the correct location to install the card. For MSPP sites where the AIC-I

is not required, a BLANK/FILLER is required to maintain proper airflow through the system while operating without the front door, and also to allow the system to meet Network Equipment Building Standards (NEBS), electromagnetic interference (EMI) standards, and electrostatic discharge (ESD) standards.

When is the AIC-I card required? The card provides four main capabilities to the network operator:

- Environmental alarm connection and monitoring
- Embedded voice-communication channels, known as orderwires
- A-Side and B-Side power supply input voltage monitoring
- Access to embedded user data channels

You examine each of these major functions, as well as the associated card faceplate LEDs and cabling connectors, in this section. Figure 6-6 shows the faceplate layout of the AIC-I.

An earlier version of the Alarm Interface Controller is called the AIC (no -I). This older version provides a more limited environmental alarm-monitoring capacity and does not provide user data channel access or input voltage monitoring. Although they may be installed in some existing systems, Cisco no longer produces the AIC version.

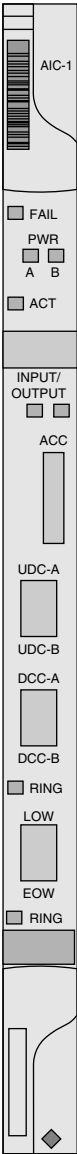
Similarly to all ONS 15454 common control cards, the AIC-I has a FAIL LED and ACT LED on the upper part of the card faceplate, just below the top latch. The FAIL LED is red and indicates that the card's processor is not ready for operation. This LED is normally illuminated during a card reset, and it flashes during the card boot-up process. If the FAIL LED continues to be illuminated, this is an indication that the card hardware has experienced a failure and should be replaced. The ACT (Active) LED is green and illuminates to indicate that the card is in an operational state. Unlike the XC cards and TCC cards, the ACT LED does not have a standby (STBY) state because there is no secondary or back-up card to protect the active AIC-I card. If the card fails, the system can continue to operate normally, with the exception of the functionality provided by the AIC-I.

## Environmental Alarms

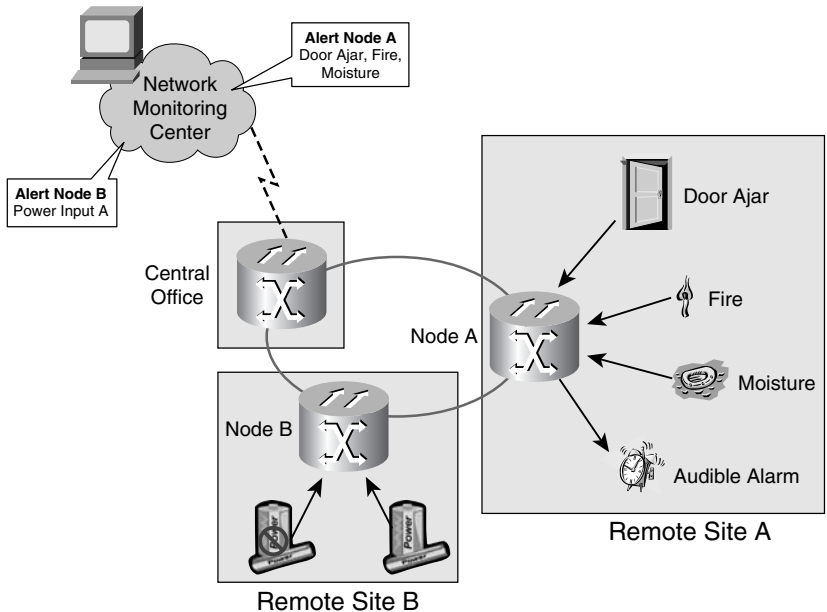
Environmental alarms are associated with events that affect the operation of the system and are specific to the surrounding environment and external support systems at an MSPP node location. These alarms are usually provisioned and monitored at locations other than those staffed and maintained by a carrier (for example, a central office). This can include an end-user customer's telecom equipment room or an outside plant location, such as a controlled-environment vault (CEV) or concrete hut. Some examples of these alarms include power system performance degradation or failure, hazardous condition alarms (for example, smoke, heat, rising water, and so on), and intrusion alarms (for example, unauthorized entry into a secured area). The ONS 15454 can use the alarm-monitoring capability of the AIC-I to report alarms via the SONET overhead back to the network operations center for trouble

resolution or dispatch of maintenance personnel. Figure 6-7 shows an example of this application. A pair of LEDs, labeled as INPUT and OUTPUT, are included on the card faceplate, and illuminate when any input alarm or output control are active.

**Figure 6-6** AIC-I Card Faceplate Diagram

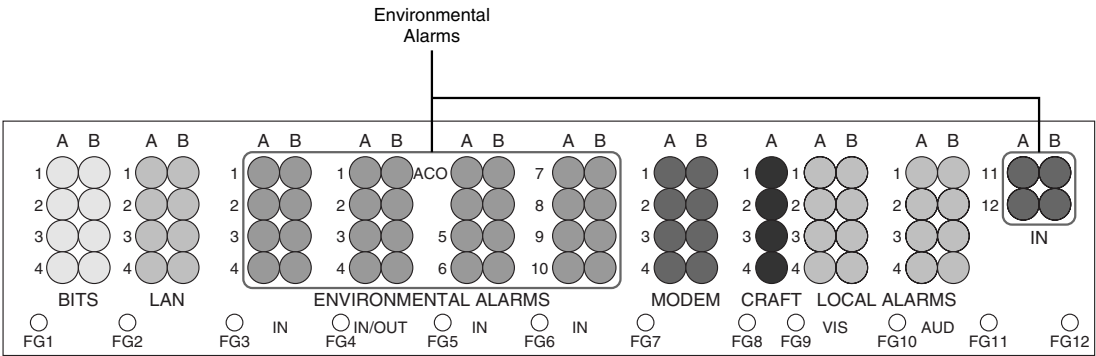


**Figure 6-7** *Environmental Alarms Reported Using AIC-I Card Interfaces*



CTC enables the user to provision several parameters related to the operation of the environmental alarms, including an assigned severity (Critical, Major, Minor, or Not Reported), an alphanumeric alarm description, and the capability to set the alarm to be raised upon detection of an “open” or “closed” condition across the alarm contacts. The AIC-I card provides 12 alarm input connections and 4 additional connections that are provisionable as either inputs or outputs. An output is used to control operation of an external device, such as an alarm-indication lamp or a water pump. The backplane of the ONS 15454 chassis has 16 wire-wrap pin pairs for connection to the external equipment to be monitored or controlled. Figure 6-8 shows these connections.

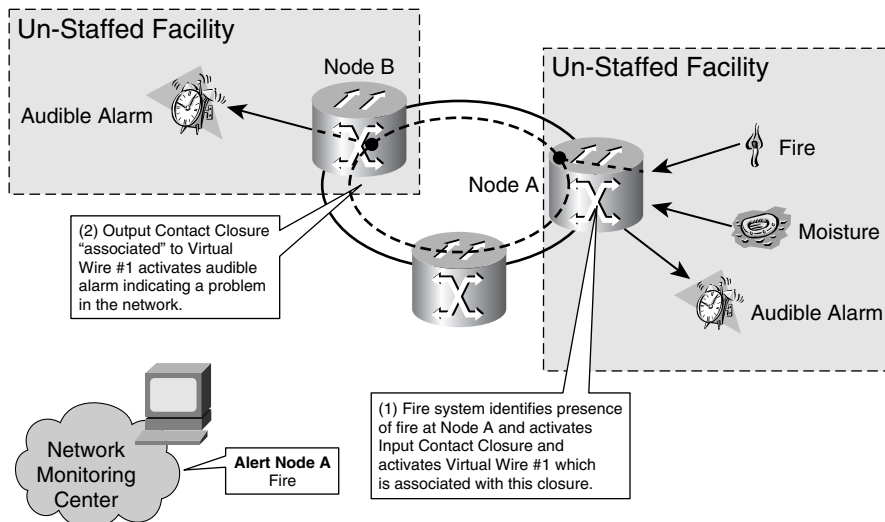
**Figure 6-8** *Backplane Environmental Alarm Connections*



By using an additional piece of hardware, called the Alarm Expansion Panel (AEP), the AIC-I can actually be used to provide up to 32 alarm inputs and 16 outputs, for a total of 48 connections. The AEP is a connector panel that is wired to a subset of the environmental alarm wire-wrap pins and attached to the backplane. Cables can then be installed from the AEP to an external terminal strip for connecting alarm contacts to the system.

One interesting application that involves the use of both an environmental alarm and a control is referred to as a “virtual wire.” A virtual wire enables the user to consider the activation of an incoming environmental alarm as triggering the activation of a control. Figure 6-9 encourages this: One such scenario is shown in Figure 6-9, where the activation of an alarm at the remote location of Node A causes a control to activate an audible alarm at the staffed location of Node B. A virtual wire is used to associate the alarm with the control activation.

**Figure 6-9** *Virtual Wire Operation*



## Orderwires

Orderwires allow technicians to attach a phone to the faceplate of the AIC-I card and communicate with personnel at other ONS 15454 MSPP sites. The AIC-I provides two separate orderwires, known as local and express. These can be used simultaneously, if desired. The local orderwire uses the E1 byte in the Section overhead to provide a 64-kbps voice channel between section-terminating equipment, while the express orderwire uses the E2 byte in the Line overhead to provide a channel between line-terminating equipment. Both orderwires operate as broadcast channels, which means that they essentially behave

as party lines. Anyone who connects to an orderwire channel can communicate with everyone else on the channel.

Phone sets are connected to the AIC-I using the two standard RJ-11 jacks marked LOW (Local Orderwire) and EOW (Express Orderwire). A green LED labeled RING is provided for each jack. The LED lights and a buzzer/ringer sounds when the orderwire channel detects an incoming call.

## Power Supply Voltage Monitoring

The AIC-I monitors the A and B power supply connections to the ONS 15454 for the presence of voltage, under-voltage, and over-voltage. Two bicolor LEDs are provided on the AIC-I faceplate for visual indication of either normal (green) or out-of-range (red) power levels. These LEDs are marked as PWR A and PWR B, and are located on the upper portion of the faceplate between the FAIL and ACT LEDs. The TCC2 and TCC2P controller cards also monitor the A and B power supplies for the chassis, and will override this feature of the AIC-I if installed in the same shelf. The TCC2/TCC2P force the power monitor LEDs on the AIC-I faceplate to match the state of their power-monitor LEDs. Because the older TCC+ controller cards do not include the power-monitoring feature, this feature of the AIC-I is more useful when installed with them.

## User Data Channels

Four point-to-point data communications channels are provided for possible network operator use by the AIC-I, with two user data channels (UDC-A and UDC-B) and two data communications channels (DCC-A and DCC-B). These channels enable networking between MSPP locations over embedded overhead channels that are otherwise typically unused. The two UDCs are accessed using a pair of RJ-11 faceplate connectors; the two DCCs use a pair of RJ-45 connectors.

The UDC-A and UDC-B channels use the F1 Section overhead byte to form a pair of 64-kbps data links, each of which can be routed to an individual optical interface for connection to another node site. The DCC-A and DCC-B use the D4-D12 line-overhead bytes to form a pair of 576-kbps data links, which are also individually routed to an optical interface.

## SONET/SDH Optical Interface Cards

All current industry-standard SONET/SDH interface types are available for the ONS 15454 platform, including OC-3/STM-1, OC-12/STM-4, OC-48/STM-16, and OC-192/STM-64. These interface cards are typically distinguished by bandwidth, wavelength, and number of ports; however, with the newer interfaces based on Small Form Factor Pluggable (SFP/XFP) technology, these parameters can vary from port to port on the same interface card.

Therefore, we briefly discuss the available card types in terms of two categories: fixed optics interfaces and modular optics interfaces.

Fixed optics interfaces are those for which the bandwidth (for example, OC-12/STM-4), the wavelength (for example, 1310 nm), and the number of equipped ports (for example, a four-port OC-12/STM-4 interface card) are predetermined parameters that cannot be field-modified. Table 6-4 gives a listing of these interfaces, including card name, SONET/SDH bandwidth for each port, transmitter wavelength, the number of ports included on the interface card, and the quantity and type of optical fiber connectors on the card's faceplate.

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**NOTE** Each port has two associated connectors, one for the transmitter and one for the receiver.

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**Table 6-4** *ONS 15454 Fixed Optics Interfaces*

<b>Card Name</b>	<b>Per-Port Bandwidth (Mbps)</b>	<b>Wavelength (nm)</b>	<b>Number of Ports</b>	<b>Connectors</b>
OC3 IR 4/STM1 SH 1310	155.52	1310	4	8 SC
OC3 IR/STM1 SH 1310-8	155.52	1310	8	16 LC
OC12 IR/STM4 SH 1310	622.08	1310	1	2 SC
OC12 LR/STM4 LH 1310	622.08	1310	1	2 SC
OC12 LR/STM4 LH 1550	622.08	1550	1	2 SC
OC12 IR/STM4 SH 1310-4	622.08	1310	4	8 SC
OC48 IR/STM16 SH AS 1310	2488.32	1310	1	2 SC
OC48 LR/STM16 LH AS 1550	2488.32	1550	1	2 SC
OC48 ELR/STM16 EH 100 GHz	2488.32	Various*	1	2 SC
OC192 SR/STM64 IO 1310	9953.28	1310	1	2 SC
OC192 IR/STM64 SH 1550	9953.28	1550	1	2 SC
OC192 LR/STM64 LH 1550	9953.28	1550	1	2 SC
OC192 LR/STM64 LH ITU 15xx.xx	9953.28	Various*	1	2 SC

\*Multiple different cards are included in this "family" of cards, with wavelengths corresponding to the ITU DWDM frequency grid.

A card name that includes the IR (and SH) designations indicates a card designed for intermediate-reach (short-haul) applications. A card with the LR/LH designations indicates a long-reach/long-haul card. Similarly, ELR/EH (extended long reach/extended haul) and SR (short reach) are indicative of the card's transmission distance specifications.

Modular optics interfaces are those for which the bandwidth, the wavelength, and possibly even the number of equipped ports are parameters that are made flexible through the use of SFPs or XFPs. SFPs and XFPs are essentially electrical-to-optical signal converters that provide a modular interface between a port on an interface card and the external fiber-optic cabling. SFPs and XFPs are similar in design; the primary difference is the module size (XFPs are larger). Modular optics are available for various wavelengths, optical reaches, and technologies, such as SONET/SDH and Gigabit Ethernet (GigE). An SFP or XFP is inserted into the required card port faceplate receptacle and provides a transmit/receive pair of LC fiber connectors. Figure 6-10 shows a group of SFPs, as well as an enlarged view of an SFP connector end.

**Figure 6-10** *SFP Interface Modules*



Currently, two SONET/SDH interfaces take advantage of SFP/XFP technology to offer user flexibility and maintenance spare savings:

- OC-192/STM-64 Any Reach**—This is a 10G interface card with a single XFP port capable of housing an SR, IR, or LR XFP module. Having a single card to stock (while maintaining a maintenance inventory of 10G XFPs) allows a carrier customer to realize efficiencies in maintenance sparing.
- MRC-12**—The 12-port multirate card (MRC) contains 12 modular SFP receptacles, with the various ports capable of being equipped for OC-3/STM-1, OC-12/STM-4, or OC-48/STM-16 operation. In addition to savings related to maintenance sparing, this card enables the network operator to equip ports for SONET/SDH services on demand. This flexibility also allows for a much more efficient use of chassis slots. For example, a single MRC-12 card can be equipped with one or more OC-48/STM-16 ports,

one or more OC-12/STM-4 ports, and one or more OC-3/STM-1 ports, and to use only a single card slot in the chassis instead of a minimum of three slots if fixed interface card types were used. Combinations of each port type can be used, up to the maximum available slot bandwidth, which varies based on the equipped cross-connect card type.

## Ethernet Interface Cards

Ethernet interface cards are used in the ONS 15454 platform to enable a service provider or network operator to integrate Ethernet into the SONET/SDH bandwidth. This allows data traffic to share the same transport platform as time-division multiplexing (TDM) links. Ethernet interface cards can be used for 10-Mbps, 100-Mbps, and 1000-Mbps (or GigE) signals, as well as subrate signals for each of these interface types. Some Ethernet interface cards, such as the G-Series and CE-Series, provide transport (or Layer 1) services; other card types enable switching (Layer 2) as well as routing (Layer 3) functionality.

## Transport (Layer 1) Ethernet Service Interfaces

Layer 1 Ethernet transport services, which are enabled using point-to-point ONS 15454 circuits, are provided using either the G-Series or CE-Series Ethernet interface cards. This type of service can also be provided using the E-Series cards when operated in what Cisco calls Port-Mapped mode. Table 6-5 provides a summary of these cards.

**Table 6-5** ONS 15454 Transport (Layer 1) Ethernet Service Interface Summary

Card Name	Per-Port Maximum Bandwidth	Number of Ports	Connectors
G1000-4	1000 Mbps	4	4 GBIC (SC) receptacles
G1K-4	1000 Mbps	4	4 GBIC (SC) receptacles
E1000-2	1000 Mbps	2	2 GBIC (SC) receptacles
E1000-2-G	1000 Mbps	2	2 GBIC (SC) receptacles
E100T-12	100 Mbps	12	12 RJ-45 jacks
E100T-G	100 Mbps	12	12 RJ-45 jacks
CE-100T-8	100 Mbps	8	8 RJ-45 jacks

## G-Series Ethernet Interface Cards

The G-Series interface cards are used to provide transport bandwidth for Ethernet frame forwarding between two locations in an MSPP network for point-to-point services. The bandwidth that can be allocated for linking G-Series ports is user-selectable, from a minimum of a single STS-1 up to full line-rate GigE. The G1000-4 and G1K-4 are hardware equivalents; the only difference between the two versions is XC card compatibility. The G1000-4 card is always limited to use with the XC10G cross-connect card and cannot be used in a chassis equipped with XCVT cross-connect cards. The G1K-4 card is a later version with additional flexibility. When ONS 15454 Software Release 4.0 or higher is used, the G1K-4 can be used with XCVT cross-connect cards; its use is limited to the high-speed slots (Slots 5, 6, 12, and 13).

G-Series cards have four Gigabit Interface Converter (GBIC) ports on the card faceplate. GBICs are similar in concept to SFPs, but in a larger physical package and with SC fiber connectors instead of an LC pair. Figure 6-11 shows a group of GBIC modules.

**Figure 6-11** *GBIC Modules*



Each G-Series card GBIC receptacle can be independently equipped with SX (short reach 850 nm), LX (long reach 1300 nm), ZX (extended reach 1550 nm), Coarse DWDM, or DWDM GBICs. Each card has an LED labeled ACT, which indicates the card's status, and an LED labeled FAIL, which remains illuminated if the card's processor is not ready or if a failure has occurred. Additionally, each of the four ports has a status LED, labeled ACT/LINK. A solid green ACT/LINK lamp indicates that a link is not carrying traffic; a flashing ACT/LINK lamp means that the link is active and carrying traffic. A solid amber ACT/LINK lamp indicates that there is link but that traffic is inhibited, such as when a circuit has not been built to the port or when the port has not been enabled.

Circuits for carrying Ethernet frames are built from a single port on a G-Series card in one MSPP node to another single port on a G-Series card in another MSPP node. The G-Series cards permit contiguously concatenated circuits of certain sizes. The allowable sizes that can be accommodated in the SONET platform are STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, and STS-48c. The maximum bandwidth that can be provisioned to a single G-Series card is 48 STS-1 equivalents.

One restriction exists for the circuit sizes that can be used with the G-Series cards, which could preclude the network operator from using the full 48 STS-1 bandwidth. This restriction is applicable to instances in which a single line-rate circuit (STS-24c) and one or more subrate circuits are used on the same card. In this case, the total bandwidth of the subrate circuits is limited to a maximum of 12 STS-1s. To realize the full bandwidth capability (48 STS-1s) of the G-Series card, the possible combinations are either two line-rate circuits or a combination of up to four subrate circuits with total bandwidth of 48 STS-1s.

Besides Ethernet transport between two sites, there is one additional application for the G-Series Ethernet interface cards. These interfaces can also be configured for use as transponders. This would enable a conventional SX, LX, or ZX Gigabit interface to be converted to a dense wavelength-division multiplexing (DWDM) or coarse wavelength-division multiplexing (CWDM)-compatible wavelength signal, and to be directly connected to a DWDM/CWDM filter system. In this mode, the traffic passing through the G-Series card does not access the cross-connect fabric; this simply provides a method for conditioning Ethernet signals for transport across an xWDM network.

## CE-Series Ethernet Interface Cards

Much like the G-Series, the CE-100T-8 interface card is used to provide transport bandwidth for Ethernet frame forwarding between two locations in an MSPP network for point-to-point services. The bandwidth that can be allocated for linking CE-Series ports is user-selectable, from a minimum of a single VT1.5, up to full line-rate 100Base-T Ethernet. The CE-100T-8 requires ONS 15454 software version 5.0.2 or higher and can be used in any of the 12 system traffic slots.

CE-100T-8 cards have eight 10/100 RJ-45 Ethernet ports on the card faceplate. Each card has an LED labeled ACT, which indicates the card's status, and an LED labeled FAIL, which remains illuminated if the card's processor is not ready or if a failure has occurred. Additionally, each of the eight ports has an ACT LED (amber) and a LINK LED (green). A solid green LINK lamp indicates that a link exists. A blinking amber ACT lamp indicates that traffic is being transmitted and received over the link.

Circuits built to connect ports on CE-100T-8 cards can be either contiguously concatenated or virtually concatenated, and either low order (VT1.5) or high order (STS-1 or STS-3c).

Combinations of the various circuit types and sizes are allowed. Some example circuits include these:

- **Line rate 100BASE-T**—To carry a full 100-Mbps signal, an STS-3c or an STS-1-3v can be provisioned.
- **Line rate 10BASE-T**—To carry a full 10-Mbps signal, an STS-1 (inefficient) can be used. A better option is a VT1.5-7v.
- **Subrate 100BASE-T**—An STS-1 can carry approximately 49 Mbps, or a VT1.5-14v can be used to provide 20-Mbps service.

Additional information on circuit sizing and CE-Series applications is provided in Chapter 7, “ONS 15454 Ethernet Applications and Provisioning.”

## E-Series Ethernet Interface Cards

The E-Series Ethernet cards can be used to provide Layer 1 transport or Layer 2 switched Ethernet services. Layer 1 services are provided when the cards on either end of a circuit (or circuits) are set up in what is known as port-mapped or linear-mapper mode. In this mode, Layer 2 features are disabled. The E-Series card works in a similar manner to the CE-100T-8.

Two types of E-Series cards exist, and there are two versions for each type, making a total of four cards in the set. The 10/100Base-T versions are the E100T-12 and the E100T-G. The difference between the two cards is that the E100T-12 can operate only with the XCVT cross-connect cards; the newer E100T-G does not have this restriction. The 1000-Mbps versions are the E1000-2 and the E1000-2-G. Like the 10/100 cards, the difference between these two cards is that the E1000-2 is supported only in systems equipped with the XCVTs; while the newer E1000-2-G is not limited to XCVT systems.

The E100T cards have 12 10/100 RJ-45 Ethernet ports on their faceplates; the E1000 cards have two GBIC receptacles. The E1000 cards can be equipped with either SX or LX GBICs. All E-Series cards have an LED called ACT, which indicates the card's status, and an LED labeled FAIL, which remains illuminated if the card's processor is not ready or if a failure has occurred. Additionally, each card has a port LED, which is green to indicate a link and amber to indicate that the port is active.

The E-Series cards are hardware-limited to a maximum circuit-termination size of STS-12c. Therefore, although a line-rate 100-Mbps Ethernet circuit can be provisioned to a port on the E100T cards, a GigE circuit provisioned to a port on the E1000 cards is bandwidth-limited to a maximum of 600 Mbps. The available circuit sizes for the E-Series cards in port-mapped mode are STS-1, STS-3c, STS-6c, and STS-12c. The E-Series cards do not support high-order or low-order virtual concatenation (VCAT) circuits.

## Switching (Layer 2) and Routing (Layer 3) Ethernet Service Interfaces

Layer 2 and Layer 3 Ethernet services can be provisioned on an ONS 15454 network using the E-Series (Layer 2 only) and ML-Series (Layer 2/Layer 3) interface cards. These cards can be used to build multipoint, switched services over the SONET network, such as shared packet rings or resilient packet rings (RPR). Chapter 7 covers these services in detail. Table 6-6 provides a summary of these cards.

**Table 6-6**    *ONS 15454 Switching/Routing Ethernet Service Interface Summary*

Card Name	Per-Port Maximum Bandwidth	Number of Ports	Connectors
ML100T-12	100 Mbps	12	12 RJ-45 jacks
ML1000-2	1000 Mbps	2	2 SFP (LC) receptacles
ML100-FX	100 Mbps	8	8 SFP (LC) receptacles
E1000-2	1000 Mbps	2	2 GBIC (SC) receptacles
E1000-2-G	1000 Mbps	2	2 GBIC (SC) receptacles
E100T-12	100 Mbps	12	12 RJ-45 jacks
E100T-G	100 Mbps	12	12 RJ-45 jacks

### E-Series Ethernet Interface Cards

The E-Series Ethernet interface cards, previously discussed within this chapter, can be used to provide Layer 2 services, such as virtual local-area network (VLAN) connectivity when provisioned in single-card EtherSwitch or multcard EtherSwitch mode. Chapter 7 covers these applications in detail.

### ML-Series Ethernet Interface Cards

The ML-Series cards are Layer 2/Layer 3 switching cards that are integrated into the ONS 15454 MSPP system. The ML cards use a combination of the Cisco IOS command-line interface (CLI) and CTC for operational provisioning. ML-Series cards can support the RPR topology for bridging multiple LANs across a metro optical network. See Chapter 7 for a detailed explanation of RPR.

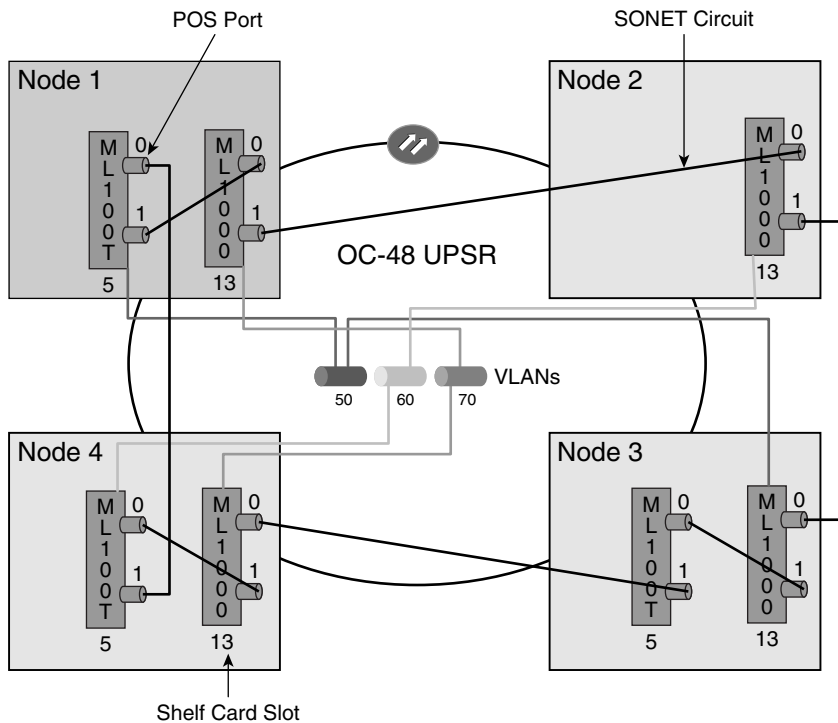
The ML-Series family consists of three different cards:

- **ML100T-12**—Provides 12 switched, autosensing, 10/100Base-T Ethernet ports for connecting to client equipment using RJ-45 faceplate connectors

- **ML100-FX**—Provides eight faceplate SFP receptacles supporting 10/100 SX and LX interfaces for connecting to client equipment
- **ML1000-2**—Provides two faceplate SFP receptacles supporting Gigabit SX and LX interfaces for connecting to client equipment

Each ML-Series card has two virtual Packet over SONET/SDH (POS) ports used to interconnect it to other Ethernet services interface cards (in the same or different ONS 15454 node), such as in a ring/RPR topology. These ports function similarly to OC-N card ports, and CTC is used to provision SONET/SDH circuits to these ports. The ML-Series cards can support contiguously concatenated (STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c) and virtually concatenated (STS-1-2v, STS-3c-2v, STS-12c-2v) circuits. The ML-Series cards also support a software-based Link Capacity Adjustment Scheme (LCAS), which allows VCAT circuit group members to be added or removed from the circuit bandwidth in case of a failure or recovery from failure. Figure 6-12 shows an example of a four-node ONS 15454 MSPP ring equipped with seven total ML-Series cards being linked by SONET circuits over an OC-48 UPSR in an RPR configuration.

**Figure 6-12** RPR Application over ONS 15454 MSPP Using ML-Series Cards Example



All ML-Series cards have an LED called ACT, which indicates the card’s status, and an LED labeled FAIL, which remains illuminated if the card’s processor is not ready or if a failure has occurred. Additionally, each card has a port LED, which is green to indicate a link and amber to indicate that the port is active.

## Electrical Interface Cards

Electrical interface cards are used in the ONS 15454 to provide DS1, DS3, EC1, and DS3 transmux services. Table 6-7 provides a summary of the available electrical interface cards for the ONS 15454 MSPP, including the EIA types that can be used on a shelf side with each type of interface card.

**Table 6-7** ONS 15454 Electrical Interface Card Summary

Card	Interface Type	Number of Ports	Bandwidth per Port	EIA Types Allowed
DS1-14/DS1N-14	DS1	14	1.544 Mbps	AMP Champ SMB UBIC-V UBIC-H
DS1-56	DS1	56	1.544 Mbps	UBIC-V UBIC-H
DS3-12/DS3N-12 DS3-12E/DS3N-12E	DS3	12	44.736 Mbps	BNC HD BNC HD Mini-BNC SMB UBIC-V UBIC-H
EC1-12	EC1	12	51.84 Mbps	BNC HD BNC HD Mini-BNC SMB UBIC-V UBIC-H
DS3/EC1-48	DS3/EC1	48	44.736 Mbps or 51.84 Mbps	HD Mini-BNC UBIC-V UBIC-H

**Table 6-7** ONS 15454 Electrical Interface Card Summary (Continued)

Card	Interface Type	Number of Ports	Bandwidth per Port	EIA Types Allowed
DS3XM-6	DS3 transmux	6	44.736 Mbps	BNC HD BNC HD Mini-BNC SMB UBIC-V UBIC-H
DS3XM-12	DS3 transmux	12	44.736 Mbps	BNC HD BNC HD Mini-BNC SMB UBIC-V UBIC-H

All of the electrical interface cards are identical in appearance from their faceplate, with the exception of the card name marking. Each of the cards has three LEDs. The FAIL LED is an indication that the card is not yet ready, or that a card failure has occurred if it remains illuminated. The ACT/STBY LED is green for an active card and amber for a card in the standby state (protect card in a protection group). The SF lamp is illuminated to indicate a signal failure or a condition such as a loss of signal (LOS), a loss of frame (LOF), or a high bit error rate (BER) on one or more of the card's ports.

The sections that follow discuss each of the available electrical interface cards.

## DS1-14 and DS1N-14 Interface Cards

DS1-14 and DS1N-14 cards each provide 14 DS1 ports, which operate at 1.544 Mbps. The difference between these two cards is that the DS1N-14 card contains additional circuitry, which allows it to act as the protection card in a 1:*N* (where *N* is less than or equal to 5) protection group (when installed in Slot 3 for Side A, or Slot 15 for Side B). The interface to these cards is through the shelf backplane EIA connectors. These cards can operate in any of the 12 traffic slots in the ONS 15454 chassis. A maximum of 12 DS1-14 or DS1N-14 cards can be active and providing service in a shelf. A typical shelf that is participating in a ring can have 112 working DS1 circuits using DS1-14 and DS1N-14 cards. This configuration would consist of ring OC-N cards in two slots, DS1N-14 standby cards in Slots 3 and 15, and working/active DS1-14 or DS1N-14 cards in the remaining eight slots, or 8 active cards × 14 ports per card = 112 working service ports.

## DS1-56 Interface Card

The DS1-56 interface card provides 56 DS1 ports operating at 1.544 Mbps. This card can function as a working card in shelf Slots 1, 2, 16, or 17, or as a protection card in Slot 3 (protecting working cards in Slots 1 and 2) and Slot 15 (protecting working cards in Slots 16 and 17). The interface to these cards is through the shelf backplane EIA connectors. A maximum of four DS1-56 cards can be active and providing service in a shelf. A typical shelf that is participating in a ring can have 224 working DS1 circuits using active DS1-56 cards in Slots 1, 2, 16, and 17, with optional protection/standby cards in Slot 3 (protecting Slots 1 and 2) and Slot 15 (protecting Slots 16 and 17), or  $4 \text{ active cards} \times 56 \text{ ports per card} = 224 \text{ working service ports}$ .

## DS3-12, DS3N-12, DS3-12E, and DS3N-12E Interface Cards

DS3-12, DS3N-12, DS3-12E, and DS3N-12E cards each provide 12 DS3 ports, which operate at 44.736 Mbps. The distinction between the E versions (DS3-12E, DS3N-12E) and the non-E versions (DS3-12 and DS3N-12) is that the E versions have enhanced performance-monitoring capabilities that are not included in the non-E versions. This allows for earlier detection of transmission problems. In addition, each version has both regular (for example, DS3-12E) and N (for example, DS3N-12E) card types. The difference between these two cards is that the DS3N-12 and DS3N-12E cards contain additional circuitry, which allows them to act as the protection card in a 1: $N$  (where  $N$  is less than or equal to 5) protection group (when installed in Slot 3 for Side A, or Slot 15 for Side B). The interface to these cards is through the shelf backplane EIA connectors. These cards can operate in any of the 12 traffic slots in the ONS 15454 chassis. A maximum of 12 DS3-12/DS3-12E and/or DS3N-12/DS3N-12E cards can be active and providing service in a shelf. A typical shelf that is participating in a ring can have 96 working DS3 circuits using DS3-12/DS3-12E and DS3N-12/DS3N-12E cards. This configuration would consist of ring OC-N cards in two slots, DS3N-12/DS3N-12E standby cards in Slots 3 and 15, and working/active DS3-12/DS3-12E or DS3N-12/DS3N-12E cards in the remaining 8 slots, or  $8 \text{ active cards} \times 12 \text{ ports per card} = 96 \text{ working service ports}$ .

## EC1-12 Interface Cards

EC1-12 cards each provide 12 EC-1 ports, which operate at 51.84 Mbps. The interface to these cards is through the shelf backplane EIA connectors. These cards can operate in any of the 12 traffic slots in the ONS 15454 chassis. A maximum of 12 EC1-12 cards can be active and providing service in a shelf. EC1-12 cards support 1:1 card protection only (1: $N$  protection is not an available option with the EC1-12 cards; there is no N version of the card). For 1:1 protection, the working/active EC1-12 cards are installed in even-numbered slots (2, 4, 6, 12, 14, and 16), while the protection/standby EC1-12 cards are installed in the corresponding odd-numbered slots. For example, an active EC1-12 card in Slot 2 can be

1:1 protected by a standby EC1-12 card in Slot 1. Another example is an active EC1-12 card installed in Slot 14, protected by a standby EC1-12 card installed in Slot 15. One possible shelf configuration using 1:1 protection groups with the EC1-12 cards would provide for 60 protected EC-1 ports. One example of this type of configuration would consist of ring OC-N cards installed in Slots 5 and 6; working/active EC1-12 cards installed in Slots 2, 4, 12, 14, and 16; and protection/standby EC1-12 cards installed in Slots 1, 3, 13, 15, and 17, or  $5 \text{ active cards} \times 12 \text{ ports per card} = 60 \text{ working service ports}$ .

## DS3/EC1-48 Interface Cards

The DS3/EC1-48 interface card provides 48 DS3 (44.736 Mbps) or EC-1 (51.84 Mbps). With software releases 6 and higher, each port on the card can be user defined to operate as either a DS3 or an EC-1. This card can function as a working card in shelf Slots 1, 2, 16, or 17, or as a protection card in Slot 3 (protecting working cards in Slots 1 and 2) and Slot 15 (protecting working cards in Slots 16 and 17). The interface to these cards is through the shelf backplane EIA connectors. A maximum of four DS3/EC1-48 cards can be active and providing service in a shelf. A typical shelf that is participating in a ring can have 192 working DS3 and EC-1 circuits using active DS3/EC1-48 cards in Slots 1, 2, 16, and 17, with optional protection/standby cards in Slot 3 (protecting Slots 1 and 2) and Slot 15 (protecting Slots 16 and 17), or  $4 \text{ active cards} \times 48 \text{ ports per card} = 192 \text{ working service ports}$ .

## DS3XM-6 and DS3XM-12 Interface Card

The DS3XM-6 interface card provides six M13 multiplexing ports, each of which converts a framed DS3 into 28 VT1.5s for grooming and cross-connection. This card can function as a working card in any slot, or as a protection card in a 1:1 protection group (in an even-numbered slot, with a working card in the adjacent odd slot). The DS3XM-6 card does not support the 1:N protection scheme. The interface to these cards is through the shelf backplane EIA connectors.

The DS3XM-12 interface card provides 12 M13 multiplexing ports, each of which converts a framed DS3 into 28 VT1.5s for grooming and cross-connection. This card can function as a working card in any slot, as a protection card in a 1:1 protection group (with a working card in an adjacent slot), or as a protection card in a 1:N protection group if located in Slot 3 or Slot 15. The DS3XM-12 interface cards can operate in one of two modes: ported or portless. In ported mode, the interface to each of the 12 card ports is through the shelf backplane EIA connectors. In portless mode, the M13 DS3 is groomed to an OC-N port on an optical card in the ONS 15454 for optical connection to an external switch. A variety of configurations can be supported using this interface card, with engineering rules based on the type of cross-connect card as well as the mode of operation. Consult the Cisco ONS 15454 Reference Manual for detailed usage information.

## Storage Networking Cards

The SL-Series Fibre Channel(FC)/FICON (Fiber Connection) interface card for the ONS 15454 MSPP, also referred to as the FC\_MR-4 card, is a four-port card used to provide storage-area networking (SAN) extension services over a SONET/SDH ring. This card can be installed in Slots 5, 6, 12, or 13 in a shelf equipped with XCVT cross-connect cards, or in any slot in a shelf equipped with XC10G or XC-VXC-10G cross-connect cards. Each of the four client ports can be independently equipped with 1-Gbps single-rate or 1-Gbps/2-Gbps dual-rate GBICs. Each port can support 1.0625 Gbps or 2.125 Gbps of FC/FICON connections. A maximum bandwidth of STS-48 is supported per card.

The SL-Series card supports both contiguously concatenated (CCAT) and virtually concatenated (VCAT) SONET/SDH circuits, as follows:

1 Gbps FC/FICON can be mapped into this:

- STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-18c, STS-24c, and STS-48c (minimum SONET CCAT size for line-rate service is STS-24c)
- VC4-1c, VC4-2c, VC4-3c, VC4-4c, VC4-6c, VC4-8c, and VC4-16c (minimum SDH CCAT size for line-rate service is VC4-8c)
- STS-1-nv, where  $n=1$  to 24 ( $n = 19$  for line-rate service)
- STS-3c-nv, where  $n=1$  to 8 ( $n = 6$  for line-rate service)
- VC4-nv, where  $n=1$  to 8 ( $n = 6$  for line-rate service)

2-Gbps FC/FICON can be mapped into:

- STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-18c, STS-24c, and STS-48c (minimum SONET CCAT size for line-rate service is STS-48c)
- VC4-1c, VC4-2c, VC4-3c, VC4-4c, VC4-6c, VC4-8c, VC4-12c, and VC4-16c (minimum SDH CCAT size for line-rate service is VC4-16c)
- STS-1-nv, where  $n = 1$  to 48 ( $n = 37$  for line-rate service)
- STS-3c-nv, where  $n = 1$  to 16 ( $n = 12$  for line-rate service)
- VC4-nv, where  $n = 1$  to 16 ( $n = 12$  for line-rate service)

The SL-Series cards also support advanced SAN distance extension features, including the use of buffer-to-buffer (B2B) credits, which are supported by the connected FC switching devices, to overcome distance limitations in 1-Gbps and 2-Gbps line-rate SAN extension applications. Additionally, distance extensions functions enabled by Receiver Ready (R\_RDY) spoofing enables the SL Series to serve as an integrated FC extension device, reducing the need for external equipment.

## MSPP Network Design Case Study

A major healthcare services provider in a large metropolitan area is currently preparing to implement a major upgrade to its data and telecommunications networks. Backbone connectivity for University Healthcare System, Inc. (UHCS), in Brounsville is currently provided using multiple T1, DS3, and OC-3 links provided by a local exchange carrier, BrounTel. These leased lines are used for connectivity among various company locations, such as the corporate headquarters campus and various hospital locations throughout the metro area. These services are provisioned through a combination of BrounTel copper T1 span lines, legacy point-to-point asynchronous optical multiplexers, and first-generation SONET OC-3 and OC-12 systems. The company is seeking to upgrade its current network services for several reasons:

- **Network survivability**—To ensure business continuity, the UHCS IT staff wants to improve the reliability of its leased network services. In the past, the nonredundant portions of the network serving some of its locations have failed, causing unacceptable service outage times.
- **Flexibility**—A major driver in the upgrade decision is the capability to add bandwidth and services with the simple addition or upgrade of existing components, versus the delay associated with conditioning new T1 span lines or adding fiber facilities.
- **Scalability**—UHCS seeks to future-proof its infrastructure so that the network can grow as the business continues to expand.
- **Advanced network services**—Line-rate and sub-rate GigE connections are among the current network requirements, and storage networking, 10 GigE, and wavelength services could become requirements in the long term. These services cannot be provided using the existing BrounTel network facilities that serve the UHCS locations.
- **Cost reduction**—By reducing their network to a simpler, more advanced technology platform, the company plans to reduce recurring costs paid to BrounTel.

After discussing service requirements and contract terms with BrounTel, the IT managers have elected to contract with BrounTel to provide a leased dedicated SONET ring (DSR) service for connectivity between company sites, and for access to the public switched telephone network (PSTN). BrounTel will deploy a Cisco ONS 15454 MSPP solution for the DSR.

### MSPP Ring Network Design

A total of seven sites in various parts of the metro area will need connectivity to the new network. BrounTel has existing standard single-mode fiber (SMF) optic cables serving some of the locations; it will use existing cable or build new optical cable facilities as required for diverse routing between the company locations and multiple BrounTel central

offices. Three central office locations will have MSPP nodes on the SONET ring; the others will serve as fiber patch (or pass-through) locations. Table 6-8 gives a list of location names, addresses, and site types.

**Table 6-8** *University Healthcare System DSR Locations and Requirements*

Node Number	Site Name	Site Address	Site Type
0	University Hospital North (UHCS)	4303 Thach Avenue	MSPP Node
-	Foy Central Office (BrounTel)	307 Duncan Drive	Fiber Patch
1	Magnolia Central Office (BrounTel)	41 Magnolia Avenue	MSPP Node
2	University Healthcare HQ (UHCS)	130 Donahue Drive	MSPP Node
-	Poplar Street Central Office (BrounTel)	8016 Poplar Street	Fiber Patch
3	Brounsville Main Central Office (BrounTel)	2004 Elm Street	MSPP Node
4	University Medical Center (UHCS)	34 South College Street	MSPP Node
-	Beech Street Central Office (BrounTel)	2311 Beech Street	Fiber Patch
5	University Hospital East (UHCS)	1442 Wire Road	MSPP Node
-	Roosevelt Drive Central Office (BrounTel)	1717 Roosevelt Drive	Fiber Patch
6	Samford Avenue Central Office (BrounTel and IXC POP)	940 Samford Avenue	MSPP Node
-	Mell Street Central Office (BrounTel)	1183 Mell Street	Fiber Patch
7	University Hospital South (UHCS)	9440 Parker Circle	MSPP Node
-	Haley Central Office (BrounTel)	1957 Concourse Way	Fiber Patch
-	Ross Central Office (BrounTel)	60 Wilmore Road	Fiber Patch
8	UHCS Data Center (UHCS)	1983 Draughton Trace	MSPP Node
-	Ramsay Central Office (BrounTel)	2322 Hemlock Drive	Fiber Patch
9	Jordan Memorial Hospital (UHCS)	1969 Goodwin Lane	MSPP Node
-	Morrison Central Office (BrounTel)	141 Morrison Drive	Fiber Patch

Table 6-9 shows the measured (for existing facilities) or calculated (for proposed facilities) fiber cable loss figures for the ring facilities. All loss figures include losses because of splices, connectors and patch panels, as well as the cable loss.

**Table 6-9** *Fiber Cable Losses for UHCS Ring Network*

<b>Fiber Span Number</b>	<b>From Location</b>	<b>To Location</b>	<b>Distance (km)</b>	<b>Loss at 1310 nm (dB)</b>	<b>Loss at 1550 nm (dB)</b>
1	University Hospital North (UHCS)	Foy Central Office (BrounTel)	12.3	7.42	5.38
2	Foy Central Office (BrounTel)	Magnolia Central Office (BrounTel)	13.8	8.12	5.79
3	Magnolia Central Office (BrounTel)	University Healthcare HQ (UHCS)	17.1	9.53	6.73
4	University Healthcare HQ (UHCS)	Poplar Street Central Office (BrounTel)	6.2	3.73	2.76
5	Poplar Street Central Office (BrounTel)	Brounville Main Central Office (BrounTel)	7.1	4.15	3.08
6	Brounville Main Central Office (BrounTel)	University Medical Center (UHCS)	18.9	11.16	6.98
7	University Medical Center (UHCS)	Beech Street Central Office (BrounTel)	9.4	5.92	3.70
8	Beech Street Central Office (BrounTel)	University Hospital East (UHCS)	8.7	5.48	3.43
9	University Hospital East (UHCS)	Roosevelt Drive Central Office (BrounTel)	13.2	8.58	5.37
10	Roosevelt Drive Central Office (BrounTel)	Samford Avenue Central Office (BrounTel and IXC POP)	7.0	4.73	3.25
11	Samford Avenue Central Office (BrounTel and IXC POP)	Mell Street Central Office (BrounTel)	12.3	7.06	4.97

*continues*

**Table 6-9** *Fiber Cable Losses for UHCS Ring Network (Continued)*

<b>Fiber Span Number</b>	<b>From Location</b>	<b>To Location</b>	<b>Distance (km)</b>	<b>Loss at 1310 nm (dB)</b>	<b>Loss at 1550 nm (dB)</b>
12	Mell Street Central Office (BrounTel)	University Hospital South (UHCS)	21.0	11.38	7.11
13	University Hospital South (UHCS)	Haley Central Office (BrounTel)	8.3	4.32	2.70
14	Haley Central Office (BrounTel)	Ross Central Office (BrounTel)	12.4	8.10	5.65
15	Ross Central Office (BrounTel)	UHCS Data Center (UHCS)	13.8	8.99	6.07
16	UHCS Data Center (UHCS)	Ramsay Central Office (BrounTel)	6.7	4.25	2.66
17	Ramsay Central Office (BrounTel)	Jordan Memorial Hospital (UHCS)	8.3	4.17	3.13
18	Jordan Memorial Hospital (UHCS)	Morrison Central Office (BrounTel)	10.3	7.72	5.33
19	Morrison Central Office (BrounTel)	University Hospital North (UHCS)	8.4	4.6	3.55

Because of the relatively short distances between MSPP node locations, polarization mode dispersion (PMD) will not be an issue in this deployment.

To determine the bandwidth requirements for the ring, the UHCS service demands must be considered. These services will be provided using the DSR:

- **Multipoint Switched Ethernet** will be used to connect the LANs at all the UHCS sites together using a resilient packet ring (RPR) with GigE links.
- **Private line Ethernet** connections, which are point-to-point Ethernet transport “pipes,” will be used between a subset of the UHCS sites.
- **TDM services**, including DS1 and DS3 links, will be required for transport of voice traffic between UHCS Private Branch eXchange (PBX) systems, and between UHCS sites and BrounTel central offices.

Listing the requirements individually, take a look at Table 6-10, which shows the planned circuits for the ring.

**Table 6-10** *DSR Circuit Requirements*

<b>Circuit Type</b>	<b>Circuit Size</b>	<b>Quantity</b>	<b>Protection?</b>	<b>Locations</b>	<b>Purpose</b>
GigE	STS-24c	1	None	Node 0 to Node 2	RPR for production data
GigE	STS-24c	1	None	Node 2 to Node 4	RPR for production data
GigE	STS-24c	1	None	Node 4 to Node 5	RPR for production data
GigE	STS-24c	1	None	Node 5 to Node 7	RPR for production data
GigE	STS-24c	1	None	Node 7 to Node 8	RPR for production data
GigE	STS-24c	1	None	Node 8 to Node 9	RPR for production data
GigE	STS-24c	1	None	Node 9 to Node 0	RPR for production data
GigE	STS-24c	1	UPSR	Node 0 to Node 2	Private line video and data application
GigE (Sub-Rate)	STS-12c	1	UPSR	Node 0 to Node 5	Private line video and data application
GigE (Sub-Rate)	STS-12c	1	UPSR	Node 0 to Node 7	Private line video and data application
DS3	STS-1	2	UPSR	Node 1 to Node 8	Data access
DS3	STS-1	3	UPSR	Node 2 to Node 6	Data access
DS3	STS-1	1	UPSR	Node 2 to Node 3	Data access
DS1	VT1.5	3	UPSR	Node 0 to Node 9	PBX voice trunks
DS1	VT1.5	4	UPSR	Node 0 to Node 2	PBX voice trunks
DS1	VT1.5	5	UPSR	Node 1 to Node 8	Voice access

*continues*

**Table 6-10** *DSR Circuit Requirements (Continued)*

<b>Circuit Type</b>	<b>Circuit Size</b>	<b>Quantity</b>	<b>Protection?</b>	<b>Locations</b>	<b>Purpose</b>
DS1	VT1.5	2	UPSR	Node 2 to Node 9	PBX voice trunks
DS1	VT1.5	4	UPSR	Node 2 to Node 8	PBX voice trunks
DS1	VT1.5	3	UPSR	Node 2 to Node 7	PBX voice trunks
DS1	VT1.5	22	UPSR	Node 2 to Node 6	Voice access
DS1	VT1.5	3	UPSR	Node 2 to Node 5	PBX voice trunks
DS1	VT1.5	4	UPSR	Node 2 to Node 4	PBX voice trunks
DS1	VT1.5	2	UPSR	Node 2 to Node 3	Voice access
DS1	VT1.5	3	UPSR	Node 4 to Node 8	PBX voice trunks
DS1	VT1.5	2	UPSR	Node 5 to Node 7	PBX voice trunks
DS1	VT1.5	2	UPSR	Node 7 to Node 9	PBX voice trunks
DS1	VT1.5	2	UPSR	Node 7 to Node 8	PBX Voice Trunks

To calculate the bandwidth requirements for the ring, simply add each of the individual requirements to arrive at the total number of STS-1s needed. This calculation is shown in Table 6-11.

**Table 6-11** *Ring Bandwidth Requirements*

<b>Circuit(s)</b>	<b>Number of Ring STS-1s Required</b>
(7) Unprotected GigE RPR links	24
(1) UPSR-Protected Line-Rate GigE	24
(2) UPSR-Protected Sub-Rate GigE (12 STS-1)	24
(6) UPSR-Protected DS3s	6
(61) UPSR-Protected DS1s	3
<b>Total STS-1s Required</b>	<b>81</b>

**NOTE**

The GigE links that form the RPR reuse the same bandwidth throughout the ring because they are built without SONET protection.

Because the initial requirements are 81 STS-1s, an OC-192 ring will be used. This allows sufficient capacity for the existing service requirements, as well as for future growth to the network.

## OC-192 Ring Transmission Design

Having defined the network bandwidth requirements to be OC-192, you can now select the appropriate OC-192 interfaces to equip at each ONS 15454 MSPP node to link the ring sites. ONS 15454 OC-192 IR interfaces transmit at a nominal wavelength of 1550 nm and have an allowable link loss budget of about 13 dB. OC-192 LR interfaces also transmit at the 1550 nm wavelength and have an allowable link loss budget of 26 dB. There is also an available SR OC-192 interface, but the small allowable link loss budget is not suitable for the distances involved in the UHCS application. Therefore, either the IR or LR optics will be used, with 10 dB being the “breakpoint” between the two. This allows 3 dB of margin for future loss increases due to fiber cable degradation, future repair splicing, and component aging.

Based on the specifications of the various ONS 15454 OC-192 interfaces and the loss characteristics of each fiber section (outlined in Table 6-9), the node-to-node interface types can be determined for the ring. OC-192/10G operation is allowed in chassis Slots 5, 6, 12, and 13. You use a pair of these slots at each location for the East- and West-facing ring interfaces. Although any combination of two of the four available slots is acceptable, uniformly select Slots 5 and 6 at each of the nodes for operational simplicity. Table 6-12 shows the selection of OC-192 optics for each ring span.

**Table 6-12** *OC-192 Ring Optics for UHCS DSR*

From East Node/Slot	To West Node/Slot	Loss at 1550 nm (dB)	OC-192 Interface Type
Node 0 Slot 6	Node 1 Slot 5	11.17	OC-192 1550 LR
Node 1 Slot 6	Node 2 Slot 5	6.73	OC-192 1550 IR
Node 2 Slot 6	Node 3 Slot 5	5.84	OC-192 1550 IR
Node 3 Slot 6	Node 4 Slot 5	6.98	OC-192 1550 IR
Node 4 Slot 6	Node 5 Slot 5	7.13	OC-192 1550 IR
Node 5 Slot 6	Node 6 Slot 5	8.62	OC-192 1550 IR
Node 6 Slot 6	Node 7 Slot 5	12.08	OC-192 1550 LR
Node 7 Slot 6	Node 8 Slot 5	14.42	OC-192 1550 LR
Node 8 Slot 6	Node 9 Slot 5	5.79	OC-192 1550 IR
Node 9 Slot 6	Node 0 Slot 5	8.88	OC-192 1550 IR

In addition to the optical trunk interface card selection, one of the BrounTel central office nodes will be designated as the Gateway Network Element (GNE) and will connect to BrounTel's Network Operations Center (NOC) using its IP-based interoffice management network. The Magnolia central office MSPP node will be chosen as the GNE.

For the purposes of network synchronization, each MSPP node located in a BrounTel central office will be connected to the office BITS and will be configured as externally timed. Line timing will be configured on the ONS 15454 systems located in the UHCS customer premises sites, with the OC-192 optical interface ports on the cards installed in Slots 5 and 6 serving as the primary and secondary reference sources.

With all the necessary parameters now defined, you can prepare all necessary engineering documentation, such as the network map, shelf card slot assignments, chassis EIA equipage, tributary protection group configuration, and cabling termination assignments.

## Network Map

The network map or ring map is a key piece of documentation that assists in bringing an MSPP network online, as well as a future as-built reference for planning, troubleshooting, and performing upgrades or additions. Figure 6-13 shows the network map for the UHCS DSR. The following information has been included:

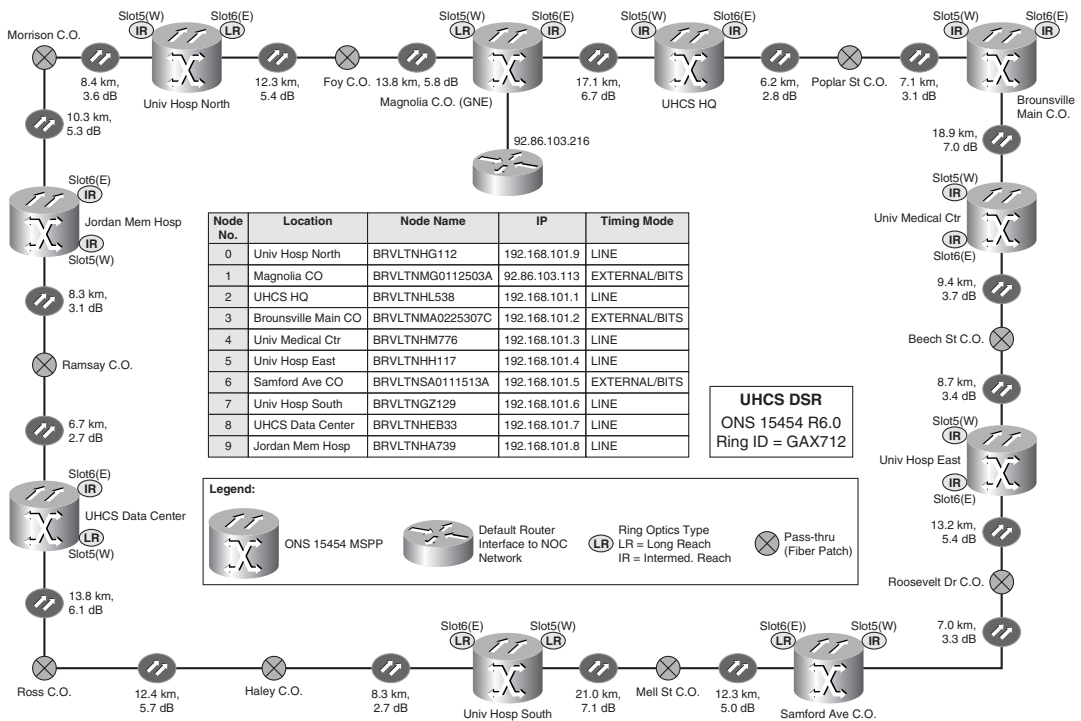
- Graphical representation of the network topology
- Location of all MSPP nodes and fiber pass-through offices (no equipment—just interconnection of outside plant fiber cables)
- Distance and loss/attenuation figures for each fiber link
- Slot assignments and card types for the interconnecting OC-192 interface cards
- Node names, IP addresses, and timing configurations
- GNE assignment and IP address of the default router
- Software version

The node numbers and Ring ID have also been provided as reference information; however, because this is not a BLSR network, this information is not required to provision the ring nodes.

## Shelf Card Slot Assignments, EIA Equipage, and Tributary Protection Group Configuration

The versatility of the ONS 15454 MSPP gives the BrounTel engineers multiple options when selecting the chassis card slot assignments. Some assignments will be common for all ring nodes; others might vary to allow for maximum flexibility to add future services to the network.

Figure 6-13 UCHS DSR Ring Map



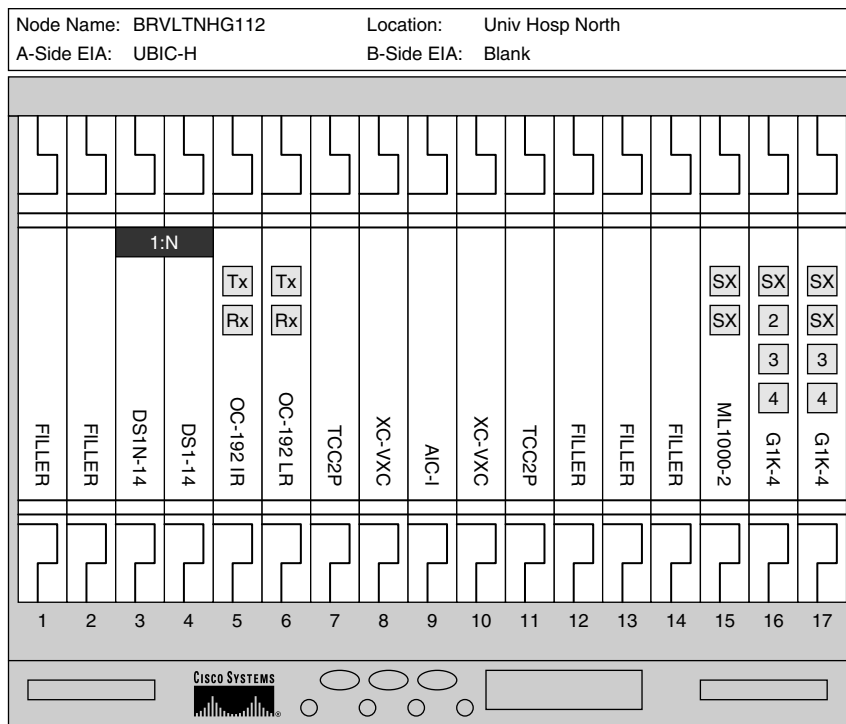
An important factor in the determination of card slot assignments for electrical interface cards, such as the DS1 and DS3 cards in the UHCS ring, is the type of tributary card protection required. Additionally, these interface types and their locations will help to determine the type of EIA that must be ordered for the ONS 15454 chassis.

All 10 of the ring nodes have the TCCP2 cards in Slots 7 and 11. Recall that two TCC cards are required in every ONS 15454 MSPP node. Likewise, two XC-VXC-10G cross-connect cards will be placed in Slots 8 and 10 for each node. Finally, for standardization and operational simplicity, the OC-192 ring interface cards will be placed in Slots 5 (West) and 6 (East) in each of the ring nodes. For the other interface cards required in the ring nodes, customized slot assignments will be specified. According to the conditions of the DSR service contract, BrounTel will design all TDM service interfaces to be card-protected in either 1:1 or 1:N protection groups. Of course, the Ethernet service interfaces will be unprotected.

At the University Hospital–North node (Node 0), the initial service-termination requirements include seven DS1 circuits, three private-line GigE links (one line rate and two substrate), and the GigE RPR circuit connections. Figure 6-14 shows the shelf diagram with card locations for this node. The DS1s require a single working DS1-14 card. This card

will be placed in Slot 4, with a DS1N-14 card installed in Slot 3 for protection. A 1:N protection group will be established for these cards, as indicated in the diagram. The use of Slots 3 and 4 will allow for future growth in DS1s; Slots 1 and 2 are left vacant for potential future DS3 requirements. Two G1K-4 cards are required because of the necessity of a line-rate (STS-24c) circuit, and two sub-rate circuits (STS-12c each), whose combined bandwidth exceeds 12 STS-1s. Slots 16 and 17 will be used for these cards. Note that the GBIC types for the ports to be equipped are indicated on the shelf diagram. The “SX” designation indicates that these ports will be equipped with 1000Base-SX (850-nm) GBICs. A single ML-Series card is required to connect this node to the RPR overlay. Because UHCS requires redundant GigE links from this interface, an ML1000-2 card with dual 1000Base-SX SFPs is specified, and this card will be installed in Slot 15. Also, an AIC-I card will be installed in Slot 9 so that, through the SONET overhead, the BrounTel network operations center can monitor the contact closure alarms from the associated direct current (DC) power plant. Card Slots 1, 2, 12, 13, and 14 will not be used for service interfaces initially and will be equipped with blanks.

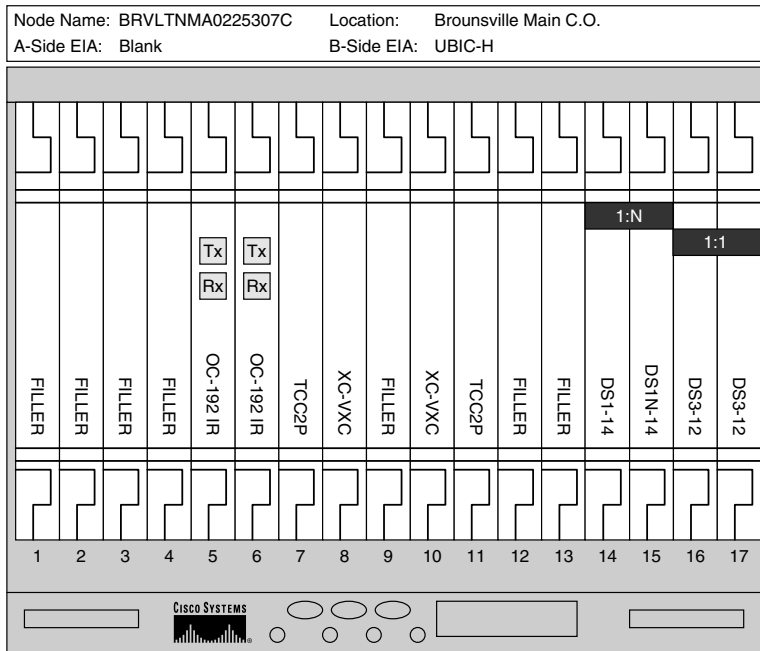
**Figure 6-14** *University Hospital North Node—Shelf Diagram*



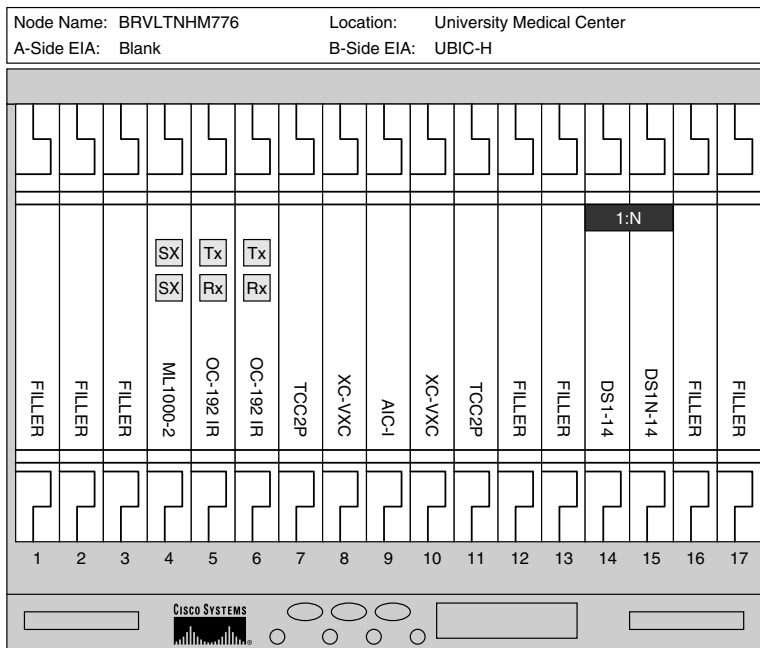




**Figure 6-17** *Brounsville Main Central Office Node—Shelf Diagram*

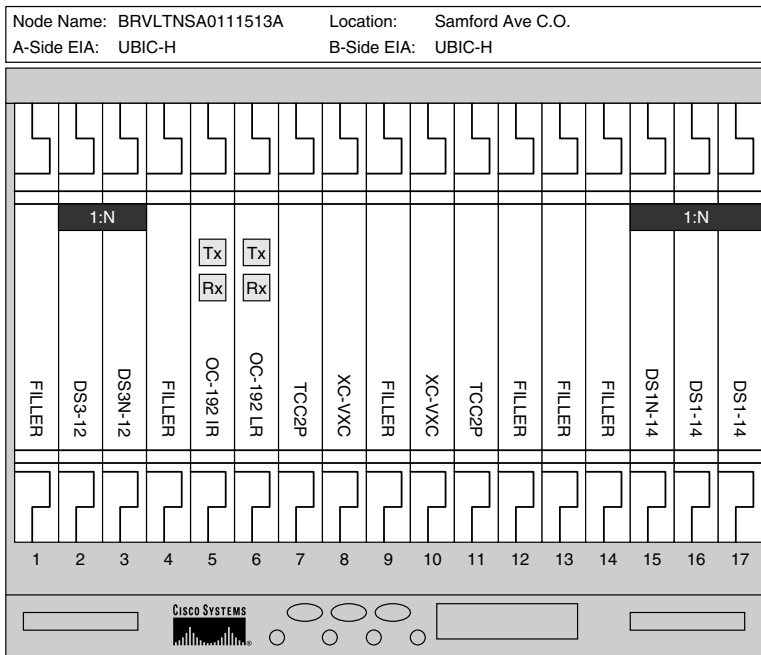


**Figure 6-18** *University Medical Center Node—Shelf Diagram*





**Figure 6-20** *Samford Avenue Central Office Node—Shelf Diagram*



**Figure 6-21** *University Hospital—South Node—Shelf Diagram*

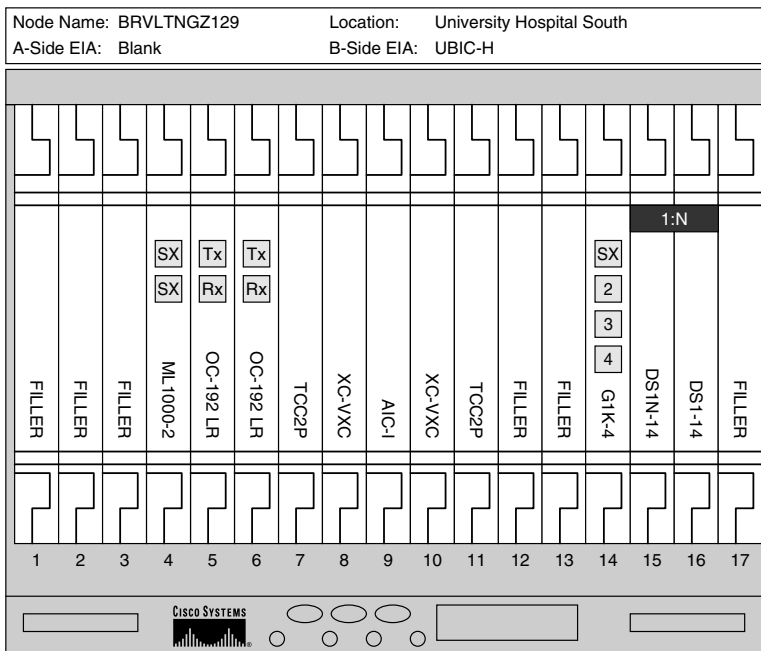




diagram with typical interface cabling for an ONS 15454 node location on the UHCS ring: the UHCS Headquarters node. The OC-192 ring optics will be cabled to the outside plant (OSP) fiber-termination panel using single-mode optical fibers from the SC faceplate connectors. DS1 and DS3 interface cards will be cabled to digital signal cross-connect (DSX) panels via the backplane UBIC EIA connectors. Ethernet interface cards, including the G1K-4 and ML1000-2, will be cabled to an optical splitter module panel using multimode fibers from the GBIC SC faceplate connectors (G1K-4) or the SFP LC faceplate connectors (ML1000-2).

**Figure 6-23** *Jordan Memorial Hospital Node—Shelf Diagram*

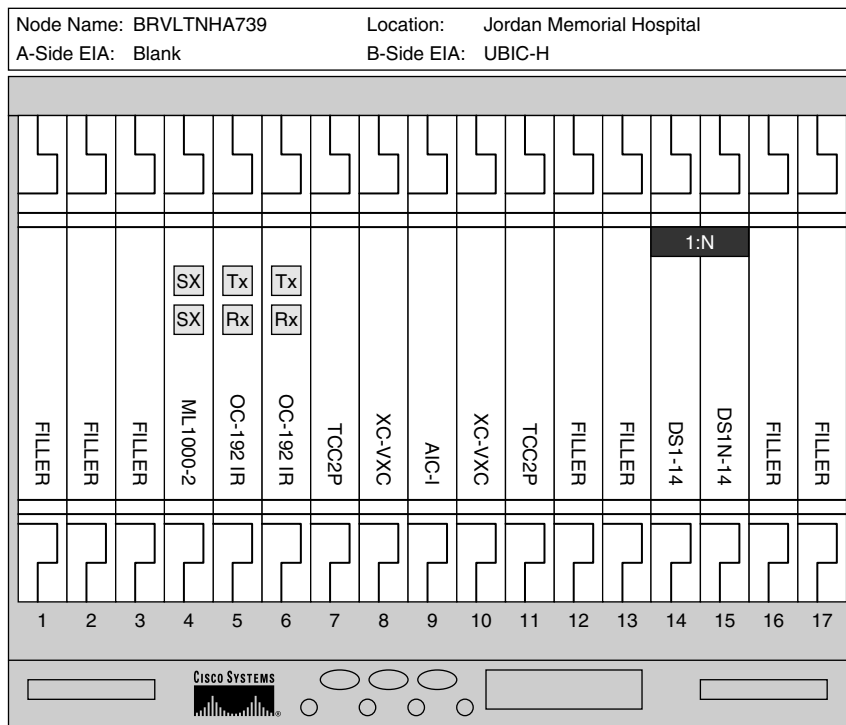


Table 6-13 shows an example cabling termination assignment chart for the UHCS Headquarters location.

Figure 6-24 Cabling Termination Diagram, UCHS Headquarters Node

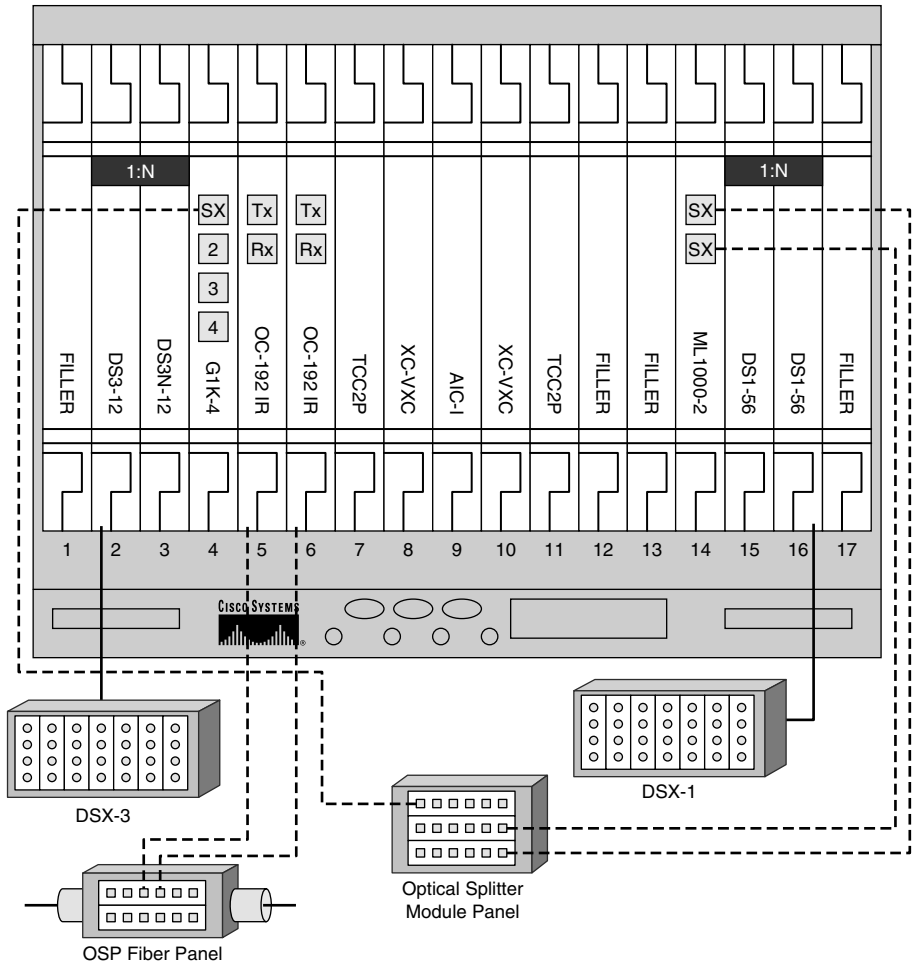


Table 6-13 Customer Drop Cabling Terminations for UHCS HQ Node

Panel Type	Panel Location	Connector/Jack	To Equipment	To Slot/Port
Optical	RR 101 PNL 4	1	ONS RR 101A	Slot 5 Tx
		2	ONS RR 101A	Slot 5 Rx
		3	ONS RR 101A	Slot 6 Tx
		4	ONS RR 101A	Slot 6 Rx
		5-24	FUTURE	FUTURE

**Table 6-13** *Customer Drop Cabling Terminations for UHCS HQ Node (Continued)*

Panel Type	Panel Location	Connector/Jack	To Equipment	To Slot/Port
Optical/ Splitter	RR 101 PNL 3	Mod 1 SRC Tx	ONS RR 101A	Slot 4/1 Tx
		Mod 1 SRC Rx	ONS RR 101A	Slot 4/1 Rx
		Mod 1 Cus Tx	ONS RR 101A	CPE Tx
		Mod 1 Cus Rx	ONS RR 101A	CPE Rx
		Mod 2 SRC Tx	ONS RR 101A	Slot 14/1 Tx
		Mod 2 SRC Rx	ONS RR 101A	Slot 14/1 Rx
		Mod 2 Cus Tx	ONS RR 101A	CPE Tx
		Mod 2 Cus Rx	ONS RR 101A	CPE Rx
		Mod 3 SRC Tx	ONS RR 101A	Slot 14/2 Tx
		Mod 3 SRC Rx	ONS RR 101A	Slot 14/2 Rx
		Mod 3 Cus Tx	ONS RR 101A	CPE Tx
		Mod 3 Cus Rx	ONS RR 101A	CPE Rx
DSX-1	RR 101 PNL 2	1-56	ONS RR 101A	Slot 16/1-56
		57-84	FUTURE	FUTURE
DSX-3	RR 101 PNL 1	1-12	ONS RR101A	Slot 2/1-12

## Summary

This chapter looked at the Cisco ONS 15454 MSPP, which is one of the most widely deployed MSPP systems worldwide. The system components, both hardware (shelf assembly, backplane interfaces, and EIAs) and interface modules (common/control, optical cards, Ethernet services cards, and electrical interface cards) were briefly described to provide an understanding of the basic functionality of the ONS 15454 MSPP.

After exploring the system, a network design example was presented. After identifying the requirements for the end customer, the entire network was designed, including network map, ring optics transmission design, interface slotting, EIA selection, protection group assignment, and interface cabling plan.

## Numerics

1000BaseT, 112  
 1000BaseX, 112  
 10G multirate transponders, 357–358  
 2.5 multirate transponders, 356–357  
 2.5G multiservice aggregation cards, 358–360  
 2-fiber BLSR operations, 201–205  
 32 DMX demultiplexer cards, 347  
 32 DMX-O demultiplexer cards, 346  
 32 MUX-O multiplexer cards, 343  
 32 WSS multiplexer cards, 344–345  
 32-channel demultiplexer cards, 345–347  
 32-channel multiplexer cards, 342–345  
 4-fiber BLSR operations, 206–209  
 4x2.5G enhanced muxponders, 358  
 64-kbps circuit-switched connections, 51

## A

AC (alternating current), 182  
 acceptance of light onto fiber, 102  
 acceptance testing, 433–435  
 access  
   PCA, 205, 291  
   remote, 150  
   rings, 146, 160–166  
   TAPs, 458  
 access identifier (AID), 475–476  
 ACO (alarm cutoff), 222  
   backplane interfaces, 330  
 ACT LED (AIC-I), 231  
 activating software, 440  
 active, DWDM, 104  
 add/drop multiplexers (ADMs), 9, 167, 209  
 adding, 426  
 addresses, 151, 415–416, 455  
 ADMs (add/drop multiplexers), 9, 167, 209  
 Advanced Timing Communications and Control (TCC2) card, 410–411  
 AEP (Alarm Expansion Panel), 234, 339  
 aggregation  
   2.5G multiservice cards, 358–360  
   links, 278

AIC (Alarm Interface Card), 222, 410  
 AIC-I (Alarm Interface Controller-International) cards, 230–231, 335–341, 412  
   environmental alarms, 231, 234  
   orderwires, 234–235  
   power supply voltage monitoring, 235  
   user data channels, 235  
 AID (access identifier), 475–476  
 AINS (Automatic In-Service), 477  
 air gaps, 459  
 alarm cutoff (ACO), 222  
   backplane interfaces, 330  
 Alarm Expansion Panel (AEP), 234, 339  
 Alarm Interface Card (AIC), 222, 410  
 Alarm Interface Controller-International cards.  
   *See* AIC-I cards  
 alarms, 41  
   correlation, 496  
   CTM, 503  
   environmental, 222  
     AIC-I, 231, 234, 337–339  
     backplane interfaces, 330  
   local, 222, 331  
   monitoring, 425–426  
   nonalarmed events, 462  
   profiles, 500  
   reports, 332  
   SNMP traps, 472  
   suppression, 496  
   troubleshooting, 432  
 Alarms tab (CTC), 448  
 alerts  
   SNMP traps, 472  
   TCA, 487  
 alternating current (AC), 182  
 AMP Champ EIA, 223  
 amplifiers, EDFAs, 107  
 applications  
   BLSR, 209  
   ONS 15454  
     CE-Series Ethernet, 283–284  
     E-Series Ethernet, 273–274  
     G-Series Ethernet, 276  
   UPSR, 199–200  
   voice/video (bandwidth), 18–19

**APS (automatic protection switching), 158, 322, 393  
architecture, 511**

CORBA, 398

CTM, 500–501

MSPP, 135, 152

*access rings, 160–166**customer network, 174–178**Frame Relay/ATM, 138–141, 150**IOF rings, 153–155**IP, 143, 151**legacy components, 148–149**MPLS, 143, 151**MSPPs, 171–174**NGOSS, 166–171**private, 155–159**PSTN, 135–138**SONET, 141–142, 150**transport, 144–148*

ONS 15454 ML-Series Ethernet, 287–288

point-to-point transport, 288

RPR transport, 288

SNA, 150

**arrayed waveguide grating (AWG), 343****asynchronous data replication, 313–314****ATM (Asynchronous Transfer Mode), 138–141,  
150, 199****A-to-Z circuit provisioning, 499****attaching telephones, 340****attenuation, manual DWDM design, 379–380****audit trails, 480, 499****automatic daily memory backups, 500****Automatic In-Service (AINS), 477****automatic protection switching (APS), 158,  
322, 393****automatic routed circuits, 429–430****availability**

bandwidth, 513

HA, 496

**AWG (arrayed waveguide grating), 343**

---

**B****backplane interfaces, 220–222**

AIC-I cards, 339

environmental alarm connections, 234

ONS 15454 Shelf Assembly, 329–330

**backups**

databases, 438–439, 452–453

memory, 500

**bandwidth**

available, 513

CIR, 513

circuits, 278

concatenation, 61–63

default best-effort, 513

high-bandwidth services, 11–19

LANs, 9–11

Layer 2 topologies, 512

ONS 15454, 219

service-provider

management, 513

sharing, 123

waste of, 121

XC cards, 229

**BDFB (battery distribution****fuse bay), 408****benefits**

of DWDM, 107

of Frame Relay, 140

**BER (bit error rate), 462****bidirectional line switch ring (BLSR),  
26, 197, 390****B-ISDN (Broadband Integrated Services Digital  
Network), 135****bit error rate (BER), 462****BITS (Building Integrated Timing Supply),  
75–76, 184, 221, 330****BLANK/FILLER, 231****BLSR (bidirectional line switch ring), 26,  
197, 390****BML (Business Management Layer), 498****BNC (Bayonet Neill-Concelman), 222****bridges, 292–294****Broadband Integrated Services Digital Network  
(B-ISDN), 135****Building Integrated Timing Supply.***See* BITS**Business Management Layer  
(BML), 498****bytes**

interleaving, 61

line overhead, 68

path overhead, 70

section overhead, 67

# C

## cabling, 109

troubleshooting, 454

## calculations, ROADM ring power, 385

## CAM (content addressable memory), 293

## capacity

2-fiber BLSR operations, 203

4-fiber BLSR operations, 209

LCAS, 243, 320

## capital expense reduction, 41–43

## cards

data service, 37

electrical service, 33–35

LEDs, 453

optical service, 36

SAN, 37–38

sparing, 439

## carrier loss, G1K ports, 476–477

## CCAT (contiguous concatenated) rates, 158, 320

## CE (customer edge), 143

## central office (CO), 137

## CE-Series Ethernet interface cards, 240, 279–284

## CEV (controlled-environment vault), 146, 231

## channels, 66–71

DCCs, 418

four-channel cards, 348–349

LDCC, 419

OADM cards, 353–354

overhead (SONET), 66

PCA, 205

SDCC, 418

substrate, 57–60

user data, 235, 340–341

## checklists, data gathering, 455–456

## chromatic dispersion, 381

## CIR (Committed Information Rate), 513–514

## circuits, 462

AIC-I, 230–231

*environmental alarms, 231, 234*

*orderwires, 234–235*

*power supply voltage monitoring, 235*

*user data channels, 235*

A-to-Z provisioning, 499

automatic routed, 429–430

bandwidth, 278

CE-Series, 281–283

creating, 428–432

EVC, 117

fixed, 121

manually routed, 431–432

monitoring, 458

ONS 15454 E-Series, 273

PCA, 291

troubleshooting, 458

## Cisco ONS 15454, 271–272

32-channel demultiplexer cards, 345–347

32-channel multiplexer cards, 342–345

AIC-I cards, 230–231, 335–341

*environmental alarms, 231, 234*

*orderwires, 234–235*

*power supply voltage monitoring, 235*

*user data channels, 235*

CE-Series Ethernet interface cards, 279–284

channel OADM cards, 353–354

CTC

*data gathering checklists, 455–456*

*locating problems, 447–455*

*tools, 456–457*

EIAs, 222–224

electrical interface cards, 244–247

E-Series Ethernet interface cards, 272–274

Ethernets

*interface cards, 238–244*

*troubleshooting, 462–463*

four-band OADM filters, 350

four-channel cards, 348–349

G-Series Ethernet interface cards, 275–278

logging on, 460–461

ML-Series Ethernet interface cards, 285–298, 300–307

MSTP

*analysis, 385–386*

*configurations, 365–368*

*design, 371*

*dispersion compensation units, 364–365*

*DWDM design, 371–377*

*DWDM ITU-T channel plans, 341–342*

- manual DWDM design*, 377–382
- MetroPlanner*, 382–386
- optical amplifiers*, 360–363
- ROADM*, 355
- transponder/muxponder interfaces*, 356–360
- one-band OADM filters, 351–352
- provisioning, 408
  - configuring*, 410–418, 420–423
  - connecting optical cards*, 424
  - documenting*, 424
  - installing shelf*, 408–410
- resources
  - CTC Online Help*, 444–446
  - documentation*, 443–444
  - TAC*, 446
  - troubleshooting*, 443
- rings, 462
- SAN, 309
  - data storage mirroring*, 311–314
  - extension solutions*, 314–315
  - overview of*, 309–310
  - protection*, 321–322
  - protocols*, 310–311
  - SONET*, 318–321
  - wavelength*, 315–318
- Shelf Assembly, 219–222, 327–330
- signals, 462
- SONET/SDH optical interface cards, 235–238
- storage networking cards, 248
- TCCs, 225–228, 331–333
- troubleshooting, 458–460
- XC cards, 228–229
- Cisco Transport Controller (CTC)**, 161, 319, 400
  - data gathering checklists*, 455–456
  - locating problems*, 447–455
  - Online Help*, 444–446
  - tools*, 456–457
- Cisco Transport Manager**. *See* CTM
- CISCO15 ID (Superuser)**, 416
- Class of service (CoS)**, 513
- CLEC (competitive local exchange carrier)**, 5
- CLEI (Common Language Equipment Identification)**, 171
- clients**, 503–509
  - architecture*, 500–501
  - management*, 502
  - protection*, 109
- CLIs (command-line interfaces)**, 39
- clocks**, 73, 185. *See also* timing
  - external/line-timed configuration*, 186
  - internal/line-timed configuration*, 188
- CNM (customer network management)**, 496
- CO (central office)**, 137
- command-line interfaces (CLIs)**, 39
- commands**
  - copy-run-start*, 303
  - get*, 480
  - getNext*, 480
  - show cdp neighbors*, 307
  - show running-config*, 304
  - TL1*, 483
- Committed Information Rate (CIR)**, 513–514
- common equipment cards**, installing, 410–412
- Common Language Equipment Identification (CLEI)**, 171
- Common Object Request Broker Architecture (CORBA)**, 398
- community names**, provisioning, 481
- competition**, SANs, 87
- competitive local exchange carrier (CLEC)**, 5
- components**, SONET/SDH, 64–65
- concatenation**
  - SONET/SDH, 61–63
  - VCAT, 158
- concrete huts**, 231
- conditions**
  - monitoring*, 426
  - SNMP traps*, 472
  - troubleshooting*, 432
- Conditions tab (CTC)**, 449
- configuration**
  - circuits*, 428–432
  - external/line-timed*, 186
  - file management*, 302
  - internal/line-timed*, 188
  - ONS 15454
    - connecting optical cards*, 424
    - documenting*, 424
    - provisioning*, 410–413, 415–423
  - SNMP, 481
- connections**
  - AIC-I cards, 339

backplane environmental alarms, 234  
 BITS, 184  
 craft-management, 331  
 CTM, 501  
 ESCON, 91–93, 310–311  
 FICON, 91, 311  
 incorrect fibers, troubleshooting, 459  
 LANs, 139–140  
 ONS 15454, 408  
 optical cards, 424  
 POP, 144  
 troubleshooting, 455  
**constant gain mode (OPT-PRE), 361**  
**constant power mode**  
   OPT-BST, 363  
   OPT-PRE, 361  
**content addressable memory (CAM), 293**  
**contiguous concatenated (CCAT) rates, 320**  
**control bandwidth, avoiding, 513**  
**control flow, 277**  
**controlled-environment vault (CEV), 146, 231**  
**copy-run-start command, 303**  
**CORBA (Common Object Request Broker Architecture), 398**  
**correlation, alarms, 496**  
**CoS (Class of service), 513**  
**cost, SANs, 86**  
**course wavelength-division multiplexing (CWDM), 15, 61, 102–103**  
**CPE (customer premises equipment), 14, 151**  
**craft management systems, 167**  
   connections, 222  
   backplane interfaces, 331  
**cross-connect (XC) cards, 183, 228–229, 411**  
**cross-connect loopbacks, 457**  
**Cross-Connect Virtual Tributary (XCVT), 229**  
**cross-connecting, 22**  
**CTC (Cisco Transport Controller), 161, 319, 400**  
   data gathering checklists, 455–456  
   locating problems, 447–455  
   Online Help, 444–446  
   tools, 456–457  
**CTM (Cisco Transport Manager), 398**  
   architecture, 500–501  
   HA architecture, 511  
   management, 502  
     configuration, 504  
     fault, 503

  HA, 509  
   performance, 505–506  
   security, 507–508

**customer edge (CE), 143**

**customer network architecture, 174–178**

**customer network management (CNM), 496**

**customer premises equipment (CPE), 14, 151**

**customizing security profiles, 508**

**CWDM (course wavelength-division multiplexing), 15, 61, 102–103**

## D

**daily memory backups, 500**

**DAS (Direct Attached Storage), 84**

**data communication channels (DCCs), 167, 192, 418, 472**

**data discovery, 496**

**data gathering checklists, 455–456**

**data service cards, 37**

**databases**

  backups, 438–439, 452–453

  restoration, 439

  TCCs, 331

**DC (direct current), 182, 409**

**DCCs (data communication channels), 167, 192, 418, 472**

**DCN (data communication network), 167**

**DCSs (digital cross-connect system), 9, 209**

**default best-effort bandwidth, 513**

**delay, round-trip, 319**

**demultiplexer cards, 345–347**

  32 DMX, 347

  32 DMX-O, 346

  four-channel, 348–349

**Dense Wavelength Division Multiplexing.**

*See* DWDM

**density, IOF, 155**

**design, 371–374, 376–386. *See also* configuration**  
   MSPP, 181

*case study, 249–267*

*methodology, 181*

*network management, 191–192*

*production, 182–186*

*timing, 186–191*

  MSTP, 371

  ONS 15454, 219–222

**diagnostics**

- files, 452
- TCCs, 332

**diagrams (faceplates)**

- ACI-I, 231
- TCC2/TCC2P, 226

**digital cross-connect (DSX) panels, 209****digital cross-connect systems (DCSs), 9, 209****digital loop carrier (DLC), 146, 199****digital multiplexing, SONET/SDH, 50–54****digital subscriber line (DSL), 137****digital subscriber line access multiplexer (DSLAM), 199****Direct Attached Storage (DAS), 84****direct current (DC), 182, 409****dirty fiber connectors, 459****discovery, data, 496****dispersion, 381****DLC (digital loop carrier), 146, 199****documentation, ONS 15454****configuration, 424****downloads, software, 41****DRI (Dual Ring Interconnect), 212****drivers (market)**

- capital expense reduction, 41–43
- high-bandwidth services, 11–19
- increased demand for LAN
  - bandwidth, 9–11
- MSPPs, 8
- OAM&P, 39–41
- TCO, 20–24, 27–38

**drops**

- cards off MSPPs, 32
- service, 21
- shelf, 23

**DS1 hierarchy (North American digital hierarchy), 50–52****DS1-14 interface cards, 245****DS1-56 interface cards, 246****DS1N-14 interface cards, 245****DS3 ports, 480****DS3/EC1-48 interface cards, 247****DS3-12 interface cards, 246****DS3-12E interface cards, 246****DS3N-12 interface cards, 246****DS3N-12E interface cards, 246****DS3XM-12 interface cards, 247****DS3XM-6 interface cards, 247****DSL (digital subscriber line), 137****DSLAM (digital subscriber line access multiplexer), 199****DSX (digital cross-connect) panels, 209****Dual Ring Interconnect (DRI), 212****DWDM (Dense Wavelength Division****Multiplexing), 315–318, 341–342, 392–395**

- access rings, 162
- fiber optic, 101–102
- history of, 98–101
- integration, 103–110
- OSC-CSM, 335
- OSCM, 334
- overview of, 98
- SAN, 311
- services, 15–16
- transport networks, 154
- WDM, 102–103

---

**E**

---

**EC1-12 interface cards, 246****EDFAs (erbium-doped fiber amplifiers), 107****EIAs (Electrical Interface Assemblies), 221–224, 329****electrical interface cards, 244–247****electrical service cards, 33–35****electromagnetic interference (EMI), 231****electrostatic discharge (ESD), 231****Element Management Layer (EML), 498****element-management System (EMS), 495, 499–509****elements, installing NEs, 412–415****EMI (electromagnetic interference), 231****EML (Element Management Layer), 498****EMS (element-management System), 495, 499–509****end-to-end provisioning, 39****ENEs (external network elements), 192****Enterprise Systems Connection (ESCON), 5, 91–93, 310–311****environmental alarms, 222, 231, 234**

- AIC-I, 231, 234
- AIC-I cards, 337–339
- backplane interfaces, 330

**EOW (Express Orderwire), 235**

**EPL (Ethernet Private Line), 13, 156, 275**  
**equipment, SONET/SDH, 64–65**  
**erbium-doped fiber amplifiers (EDFAs), 107**  
**ERS (Ethernet Relay Service), 156**  
**ESCON (Enterprise Systems Connection), 5,**  
**91–93, 310–311**  
**ESD (electrostatic discharge), 231**  
**E-Series Ethernet interface cards, 241–242,**  
**272–274**  
**ESF (Extended Superframe), 422**  
**Ethernet, 510–517**  
     emergence of, 112–113  
     FE, 111  
     GigE, 112  
     history of, 110–111  
     interface cards, 238–244  
     Layer 2 Ethernet Wizard, 514  
     management, 509  
     ONS 15454, 462–463  
     over MSPP, 113–115  
         *metro services, 116–120*  
         *point-to-point, 120–122*  
         *RPR, 122–129*  
     overview of, 110  
     performance, 488–492  
     private MSPPs, 156  
     services, 12–14  
     TL1, 484  
**Ethernet Private Line (EPL), 13, 156, 275**  
**Ethernet Relay Service (ERS), 156**  
**EVC (Ethernet virtual circuit), 117**  
**events**  
     logs, 41  
     nonalarmed, 462  
**EWS (Ethernet Wire Service), 13, 156**  
**Express Orderwire (EOW), 235**  
**Extended Superframe (ESF), 422**  
**extension solutions, SAN, 314–315**  
**external network elements (ENEs), 192**  
**external timing, 77**  
**external/line-timed configuration, 186**

## F

### faceplates

4MD-xx.x, 349  
 AD-1C-xx.x, 354

AD2C-xx.x, 354  
 AD-4C-xx.x, 354  
 AIC-I, 231, 336, 340  
 OSC-CSM, 335  
 OSCM, 334  
 TCC2/TCC2P, 226, 332

**Facility (FAC), 475**  
**facility loopbacks, 457**  
**FAIL LED (AIC-I), 231**  
**failures, RPR, 297–298**  
**Fast Ethernet (FE), 111**  
**fault management, 399**  
**FC (Fibre Channel), 5, 90–91, 309–310**  
**FCIP (Fibre Channel over IP), 94, 311**  
**FC-MR-4 (Fibre Channel Multirate 4-Port)**  
     **card, 318**  
**FE (Fast Ethernet), 111**  
**Fiber Connection (FICON), 5, 91, 311**  
**fiber optics, 45–49, 101–102**  
**Fibre Channel (FC), 5, 90–91, 309–310**  
**Fibre Channel Multirate 4-Port (Fc-MR-4)**  
     **card, 318**  
**Fibre Channel over IP (FCIP), 94, 311**  
**FICON (Fiber Connection), 5, 91, 311**  
**files**  
     configuration, 302  
     diagnostics, 452  
**filters**  
     four-band OADM, 350  
     one-band OADM, 351–352  
**fixed circuits, 121**  
**fixed-channel optical add/drop, 396–397**  
**flexibility, IOF, 155**  
**flow, control, 277**  
**flow-through provisioning, 495**  
**formats, AIDs, 476**  
**four-band OADM filters, 350**  
**four-channel multiplexer/demultiplexer**  
     **cards, 348–349**  
**four-wave mixing (FWM), 373**  
**Frame mode (GFP), 128**  
**Frame Relay, 138–141, 150**  
**frames, 277**  
     concatenation, 62  
     GFP, 128  
     ground terminals, 221, 330, 408  
     SONET/SDH, 50–54  
**FWM (four-wave mixing), 373**

## G

**G1K ports, carrier loss on**, 476–477  
**gateway network elements (GNEs)**, 192, 400, 496  
**gathering data (checklists)**, 455–456  
**GBICs (gigabit interface converters)**, 28, 239, 275, 319, 462  
**GEC (Gigabit EtherChannel)**, 278  
**Generic Framing Procedure (GFP)**, 128, 318  
**get command**, 480  
**getNext command**, 480  
**GFP (Generic Framing Procedure)**, 128, 318  
**Gigabit EtherChannel (GEC)**, 278  
**Gigabit Ethernet (GigE)**, 112, 183  
**gigabit interface converters**. *See* GBICs  
**GigE (Gigabit Ethernet)**, 112, 183  
**Global Positioning System (GPS)**, 184  
**GNEs (gateway network elements)**, 192, 400, 496  
**GPS (Global Positioning System)**, 184  
**graphical user interface (GUI)**, 26, 39  
**grounding frames**, ONS 15454, 408  
**groups, bridges**, 292  
**G-Series**

- Ethernet interface cards, 275–278
- interface cards, 239

**GUI (graphical user interface)**, 26, 39

## H

**HA (high availability)**, 496, 511  
**HD (High-Density BNC EIA)**, 222  
**HD mini-BNC EIA**, 223  
**HDSL (high-bit digital subscriber line)**, 21  
**high availability (HA)**, 496, 511  
**high-bandwidth services**, 11–19  
**high-bit digital subscriber line (HDSL)**, 21  
**High-Density (HD) BNC EIA**, 222  
**higher-rate signals**, 60  
**high-speed optical cards**, 28–32  
**History tab (CTC)**, 450  
**hubbed rings**, 367

## I

**I/O (input/output)**

- ports, 197
- performance, 90

**IBM InterSystem Channel (ISC)**

- interfaces, 316

**ILECs (incumbent local exchange carriers)**, 5, 470  
**incorrect fibers, troubleshooting**, 459  
**increased demand for LAN bandwidth**, 9–11  
**incumbent local exchange carriers**.  
*See* ILECs  
**indexes of refraction (Snell's Law)**, 47–48  
**initializing TCCs**, 331  
**input/output**. *See* I/O  
**installing**

- common equipment cards, 410–412
- cross-connect cards, 411
- MetroPlanner, 385
- Nes, 412–415
- online Help, 444–446
- ONS 15454shelf, 408–410

**integration**

- DRI, 212
- DWDM/MSPPs, 103–110
- OSS, 499
- storage cards, 96–98

**integrity, links**, 278  
**interexchange carrier (IXC)**, 138  
**interfaces**, 231–235, 272–288, 290–298, 300–307

- AIC-I, 230–341, 412
- AICs, 410
- backplane
  - AIC-I cards, 339
  - environmental alarm connections, 234
  - ONS 15454 Shelf Assembly, 329–330
- CCAT, 158
- CLI, 39
- EIAs, 221–224, 329
- electrical cards, 244–247
- Ethernet cards, 238–244
- GBICs, 275, 319, 462
- G-Series interface cards, 239
- GUI, 26, 39

ISC, 316  
 modules  
     *adding/removing, 426*  
     *installing, 410–412*  
 muxponder, 356–360  
 NBI, 468  
 OC-N, 183  
 OSCM, 334  
 SCSI, 310  
 SL-Series FC/FICON, 248  
 SONET/SDH optical cards, 235–238  
 TDM, 183  
 transponder, 356–360  
 UNI, 514

**internal clocks, 185**

**internal/line-timed configuration, 188**

**International Telecommunications Union (ITU), 497**

**Internet Protocol. *See* IP**

**Internet Protocol Television (IPTV), 146**

**Internet service provider (ISP), 200**

**Internetwork Packet eXchange (IPX), 150**

**interoffice facilities. *See* IOFs**

**IOFs (interoffice facilities), 144, 153–155, 497**

**IP (Internet Protocol), 143, 151**

addresses  
     *configuring, 415–416*  
     *TCCs, 331*  
     *troubleshooting, 455*  
 FCIP, 94

**IPT (IP-based telephony), 18**

**IPTV (Internet Protocol Television), 146**

**IPX (Internetwork Packet eXchange), 150**

**ISC (IBM InterSystem Channel) interfaces, 316**

**ISP (Internet service provider), 200**

**ITU (International Telecommunications Union), 497**

**IXC (interexchange carrier), 138**

## J–K

**JRE (Java Runtime Environment), 444**

**kinked fibers, 459**

## L

**L2 Service Wizard, 512**

**labels, MPLS, 143**

**LANs (local-area network interfaces), 139**

backplane interfaces, 330  
 bandwidth, 9–11  
 connecting, 139–140  
 SANs, 83  
 terminations, 222

**large-scale network management, 495–496**

EMS, 499–509  
 Ethernet, 509  
     *Layer 1 provisioning, 510–511*  
     *Layer 2 provisioning, 512–514, 517*  
 layers, 497, 499  
 NBI, 517–518

**LATA (local access and transport area), 138**

**Layer 1, Ethernet service interfaces, 238–241**

**Layer 2**

Ethernet service interfaces, 242–244  
 Ethernet Wizard, 514

**Layer 3, Ethernet service interfaces, 242–244**

**layers**

management, 497–499  
 RPR, 124

**LBO (Line Build-Out) settings, 454**

**LCAS (Link Capacity Adjustment Scheme), 127, 243, 320**

**LDCC (Line DCC), 419**

**LEDs (light emitting diodes), 102, 453**

**legacy components, 148–149**

**legacy optical platforms, 20**

OC-12, 21–22  
 OC-48, 23

**levels, FC, 92**

**LGX (Light Guide Cross-connect) panels, 424**

**light emitting diodes (LEDs), 102, 453**

**Light Guide Cross-connect (LGX) panels, 424**

**Line Build-Out (LBO) settings, 454**

**Line DCC (LDCC), 419**

**linear topologies, MSTP, 365**

**lines**

SONET/SDH transmission segments, 68–69  
 timing, 77

**line-terminating equipment (LTE), 189**

- Link Capacity Adjustment Scheme (LCAS), 127, 243, 320
- links, 278, 459–460
- LLQ (low-latency queue), 513
- loading MIBs, 482
- local access and transport area (LATA), 138
- local alarms, 222, 331
- Local Orderwire (LOW), 235
- local-area networks. *See* LANs
- LOF (loss of frame), 395
- logging on (to ONS 15454), 460–461
- logs, 41
- loopbacks, 456–457
- LoS (loss of service), 156
- LOS (loss of signal), 478
- loss of frame (LOF), 395
- loss of service (LoS), 156
- loss of signal (LOS), 478
- LOW (Local Orderwire), 235
- low light levels, 460
- low-latency queue (LLQ), 513
- LTE (line-terminating equipment), 189

## M

- maintenance, 435, 437–439
- MAN (metropolitan-area network), 9
- management, 302, 470–478, 480–486
  - CNM, 496
  - craft management systems, 167
  - CTM, 502
    - configuration*, 504
    - fault*, 503
    - HA*, 509
    - performance*, 505–506
    - security*, 507–508
  - EMS, 495
  - large-scale network, 495–496
    - EMS*, 499–509
    - Ethernets*, 509–514, 517
    - layers*, 497, 499
    - NBI*, 517–518
  - MSPPs, 155, 468–470, 486–492
  - policies, 496
  - TMN, 497
- Management Interface Blocks (MIBs), 170, 482
- MANs (metropolitan-area networks), 9, 163

- manually routed circuits, 431–432
- mapping, 55–63
- market drivers
  - MSPP-based DWDM, 110
  - MSPPs, 8
    - capital expense reduction*, 41–43
    - demand for LAN bandwidth*, 9–11
    - high-bandwidth services*, 11–19
    - OAM&P*, 39, 41
    - TCO*, 20–24, 27–38
- mean-time-to-repair (MTTR), 496
- memory
  - backups, 500
  - CAM, 293
- mesh topologies, private MSPPs, 165
- meshed rings, 368
- meshing, waste of bandwidth, 121
- messages, status, 189–191
- metro Ethernet services, 116–120
- metropolitan-area networks (MANs), 9, 163
- MIBs (Management Interface Blocks), 170, 482
- mirroring, 311–314
- ML-Series Ethernet interface cards, 242, 285–294, 296–307
- MMF (multimode fiber), 48–49
- mobile telephone switching office (MTSO), 200
- modems
  - backplane interfaces, 331
  - terminations, 222
- modes
  - GFP, 128
  - ONS 15454 E-Series Ethernet interface cards, 273
  - optical fiber, 48–49
- modules, 410–412
  - interfaces, 426
  - STM, 57
- monitoring, 340
  - alarms, 425–426
  - circuits, 458
  - conditions, 426
  - MSPPs, 467
    - CTC*, 484–486
    - fault management*, 468–470
    - local craft interfaces*, 492
    - performance*, 486–492
    - SNMP MIBs*, 470–478, 480–482
    - TL1*, 482–484

NMS, 495  
 performance, 435, 437  
 power supply voltage (AIC-I), 235  
 RMON, 398  
 thresholds, 487  
 voltage, 332

### **MPLS (Multiprotocol Label Switching), 143, 151**

### **MSPPs (Multiservice Provisioning Platforms), 5, 8, 229**

acceptance testing, 433–435  
 AIC-I cards, 230–235  
 alarms, 425–426  
 architecture, 135, 152  
     *access rings, 160–166*  
     *customer network, 174–178*  
     *Frame Relay/ATM, 138–141, 150*  
     *IOF rings, 153–155*  
     *IP, 143, 151*  
     *legacy components, 148–149*  
     *MPLS, 143, 151*  
     *MSPPs, 171–174*  
     *NGOSS, 166–171*  
     *private, 155–159*  
     *PSTN, 135–138*  
     *SONET, 141–142, 150*  
     *transport, 144–148*  
 conditions, 426  
 design, 181  
     *case study, 249–267*  
     *methodology, 181*  
     *network management, 191–192*  
     *production, 182–186*  
     *timing, 186–191*

### **DWDM**

*fiber optic cables, 101–102*  
*integration, 103–110*  
*WDM, 102–103*

### **EIAs, 222–224**

### **Ethernet over, 113–115**

*metro services, 116–120*  
*point-to-point, 120–122*  
*RPR, 122–129*

### **fault management, 468–470**

*CTC, 484–486*  
*SNMP MIBs, 470–482*  
*TL1, 482–484*

### **fiber optics, 45–49**

### **local craft interfaces, 492**

### **maintenance, 435–439**

### **market drivers, 8**

*capital expenses reduction, 41–43*  
*demand for LAN bandwidth, 9–11*  
*high-bandwidth services, 11–19*  
*OAM&P, 39, 41*  
*TCO, 20–29, 32–38*

### **monitoring, 467**

### **ONS 15454, 335–341, 355–368**

*32-channel demultiplexer cards, 345–347*  
*32-channel multiplexer cards, 342–345*  
*channel OADM cards, 353–354*  
*four-band OADM filters, 350*  
*four-channel cards, 348–349*  
*MSTP DWM ITU-T, 341–342*  
*one-band OADM filters, 351–352*  
*Shelf Assembly, 327–328*  
*TCCs, 331–333*

### **ONS 15454, 271–272**

*E-Series Ethernet interface cards, 272–274*  
*G-Series Ethernet interface cards, 275–284*  
*ML-Series Ethernet interface cards, 285–294, 296–307*  
*Shelf Assembly, 219*

### **overview of, 45**

### **performance, 486–492**

### **SAN over, 95–98**

### **services, 427–432**

### **software upgrades, 439–441**

### **TCCS, 225–228**

### **topologies, 193**

*BLSR, 200–209*  
*linear, 193–195*  
*mesh networks, 214–216*  
*ring-to-ring interconnect, 212–213*  
*subtending rings, 209–211*  
*subtending shelves, 211*  
*UPSR, 195–200*

### **XC cards, 228–229**

### **MS-SPR (multiplex section shared protection rings), 390**

### **MSTP (Multiservice Transport Platform), 16**

### **design, 371**

*analysis, 385–386*  
*DWDM, 371–377*  
*manual DWDM, 377–382*  
*MetroPlanner, 382–386*

DWDM protection, 392–395  
 wavelength services, 389  
     *configuring*, 401  
     *Ethernet*, 391  
     *implementing*, 395–397  
     *managing*, 398–399  
     *performance*, 402  
     *SAN*, 390–391  
     *security*, 403  
     *SONET/SDH*, 390  
     *variable bit-rate*, 391

**MTSO (mobile telephone switching office)**, 200

**MTTR (mean-time-to-repair)**, 496

**Multi Service Transport Platform (MSTP)**, 16

**Multicard EtherSwitch mode**, 273

**multicast traffic**, 121

**multihubbed rings**, 367

**multimode fiber (MMF)**, 48–49

**multiplex section shared protection rings (MS-SPR)**, 390

**multiplexer cards**, 342–345

32 MUX-O, 343

32 WSS, 344–345

four-channel, 348–349

**multipoint Ethernet monitoring**, 491–492

**Multiprotocol Label Switching (MPLS)**, 143, 151

**Multiservice Provisioning Platforms**. *See* MSPPs

**Multiservice Transport Platform**. *See* MSTP

**muxponder cards**, 322

## N

**names, provisioning**, 481

**NAS (Network Attached Storage)**, 85, 310

**NAT (network address translation)**, 151

**NBI (Northbound Interface)**, 468

integration, 517–518

**NEBS (Network Equipment Building Standards)**, 231

**NEs (network elements)**, 412–415, 483, 496  
 audit trails, 499

**network address translation (NAT)**, 151

**Network Attached Storage (NAS)**, 85, 310

**network elements**. *See* NEs

**Network Equipment Building Standards (NEBS)**, 231

**Network Management Layer (NML)**, 498

**Network Monitoring and Analysis (NMA)**, 148

**Network Operations Center (NOC)**, 167, 192

**network-management system (NMS)**, 495

**networks**, 191–203, 205–216, 219, 311

MSPP. *See also* MSPPs

*fiber optics*, 45

*optical fiber*, 46–49

*overview of*, 45

ONS 15454, 220–222

OSS synchronization, 497

SAN

*data storage mirroring*, 311–314

*extension solutions*, 314–315

*overview of*, 309–310

*protection*, 321–322

*protocols*, 310–311

*SONET*, 318–321

*wavelength*, 315–318

synchronization, 420–423

topologies, 193

**NGOSS (next-generation operational support systems)**, 166–171

**NMA (Network Monitoring and Analysis)**, 148

**NML (Network Management Layer)**, 498

**NMS (network-management system)**, 495

**NOC (Network Operations Center)**, 167, 192

**nodes**, 334

**nonalarmed events**, 462

**nonzero, dispersion-shifted fiber (NZDF)**, 372

**North American digital hierarchy**, 50–52

**Northbound Interface (NBI)**, 468

integration, 517–518

**NZDF (nonzero, dispersion-shifted fiber)**, 372

## O

**OADM (optical add/drop multiplexers)**, 155

channel cards, 353–354

four-band filters, 350

one-band filters, 351–352

**OAM&P (operations, administration, maintenance, and provisioning)**, 39, 41, 166

**OC (Optical Carrier)**, 56, 146

**OC-12 optical cards**, 21–22

**OC-192 interfaces**, 255

**OC-48 optical cards**, 23

**OC-N (Optical) interfaces**, 183

## one-band OADM filters, 351–352

## Online Help, 444–446

## ONS 15454, 271–272

- 32-channel demultiplexer cards, 345–347
- 32-channel multiplexer cards, 342–345
- AIC-I, 335–341
- AIC-I cards, 230–235
- CE-Series Ethernet interface cards, 279–284
- channel OADM cards, 353–354
- CTC
  - data gathering checklists, 455–456*
  - locating problems, 447–455*
  - tools, 456–457*
- EIAs, 222–224
- electrical interface cards, 244–247
- E-Series Ethernet interface cards, 272–274
- Ethernets
  - interface cards, 238–244*
  - troubleshooting, 462–463*
- four-band OADM filters, 350
- four-channel cards, 348–349
- G-Series Ethernet interface cards, 275–278
- logging on, 460–461
- ML-Series Ethernet interface cards, 285–294, 296–307
- MSTP
  - configurations, 365–368*
  - dispersion compensation units, 364–365*
  - DWDM, 392–395*
  - Ethernet services, 391*
  - optical amplifiers, 360–363*
  - ROADM, 355*
  - SAN services, 390–391*
  - SONET/SDH services, 390*
  - transponder/multiplexer interfaces, 356–360*
  - variable bit-rate services, 391*
  - wavelength services, 389, 395–403*
- MSTP DWDM ITU-T channel plans, 341–342
- one-band OADM filters, 351–352
- provisioning, 408
  - configuring, 410–418, 420–423*
  - connecting optical cards, 424*
  - documenting, 424*
  - installing shelf, 408–410*
- resources
  - CTC Online Help, 444–446*

*documentation, 443–444*

*TAC, 446*

*troubleshooting, 443*

rings, 462

Shelf Assembly, 219–222, 327–330

signals, 462

SONET/SDH optical interface cards, 235–238

storage networking cards, 248

TCCs, 225–228, 331–333

troubleshooting, 458–460

XC cards, 228–229

## OOS (Out-of-service), 321

## OOS-AINS (Out of Service-Automatic in Service) state, 424

## Open Systems Interconnection (OSI), 14 operational support system. *See* OSS

## Operations Systems Modifications for the Integration of Network Elements (OSMINE), 148

## operations, administration, maintenance, and provisioning. *See* OAM&P

## OPT-BST (optical booster amplifier), 360, 362–363

## Optical (OC-N) interfaces, 183

## optical add/drop multiplexers. *See* OADMs

## optical booster amplifier (OPT-BST), 360–363

## optical cards

connecting, 424

high-speed, 28–29, 32

## Optical Carrier (OC), 56, 146

## optical links, troubleshooting, 459–460

## optical preamplifier (OPT-PRE), 360–361

## optical service cards, 36

## optical service channel module (OSCM), 334

## optimization

MetroPlanner, 385

ONS 15454, 408

## OPT-PRE (optical preamplifier), 360–361

## orderwires, 234–235, 340

## OSC-CSM, 335

## OSCM (optical service channel module), 334

## OSI (Open Systems Interconnection), 14

## OSMINE (Operations Systems Modifications for the Integration of Network Elements), 148

## OSS (operating support systems), 8, 497, 517–518

management, 499–509

**Out of Service-Automatic in Service (OOS-AINS), 424**

**Out-of-service (OOS), 321**

**overhead channels, 66–71**

## P

**PABX (private automatic branch exchange), 137**

**panels, DSX, 209**

**passive DWDM, 104**

**pass-through, 294**

**Path Protected Mesh Networks (PPMN), 27, 152, 215**

**paths, SONET/SDH transmission segments, 69–71**

**PBX (private branch exchange) switches, 183**

**PCA (Protection Channel Access), 205, 291**

**PCM (pulse code modulation), 67**

**PDH (plesiochronous digital hierarchy), 138**

**Peak Information Rate (PIR), 514**

**performance**

ATM, 150

Frame Relay, 150

IO, 90

monitoring, 435, 437

**Performance tab (CTC), 451**

**phases, evolution of SANs, 88–90**

**pigtailing, 102**

**PIR (Peak Information Rate), 514**

**plain old telephone service (POTS), 146, 199**

**platforms**

legacy optical, 20

*OC-12, 21–22*

*OC-48, 23*

MSPPs, 5, 8

*capital expense reduction, 41–43*

*demand for LAN bandwidth, 9–11*

*high-bandwidth services, 11–19*

*market drivers, 8*

*OAM&P, 39, 41*

*TCO, 20–24, 27–38*

**plesiochronous digital hierarchy (PDH), 138**

**PLSs (Private Line Services), 116**

**point of presence (POP), 144, 192**

**point-to-point Ethernet over MSPP, 120–122**

**Point-to-Point Protocol (PPP), 141**

**point-to-point transport architecture, 288**

**policies, management, 496**

**POP (point of presence), 144, 192**

**Port-mapped mode, 273**

**ports**

DS3, 480

G1K, 476–477

I/O, 197

**POTS (plain old telephone service), 146, 199**

**power supply**

connections, 409

MSPPs, 155

supply voltage monitoring, AIC-I, 235

troubleshooting, 454

voltage monitoring, 235, 332, 340

**PPMN (Path Protected Mesh Networks), 27, 152, 215**

**PPP (Point-to-Point Protocol), 141**

**PRI (primary rate ISDN), 200**

**primary reference source (PRS), 420**

**prioritization, timing, 189**

**private architecture, 155–159**

**private automatic branch exchange (PABX), 137**

**private branch exchange (PBX) switches, 183**

**Private Line Services (PLSs), 116**

**private rings, 146–148**

**production design, 182–186**

**profiles**

alarms, 500

security, 508

**propagation, light (in fiber), 46–48**

**protection, 321–322**

APS, 322

bandwidth, 121

DWDM, 109

mechanisms, 182–186

switches, 478–479

**Protection Channel Access (PCA), 205, 291**

**PROTNA (Protection Unit Not Available), 225**

**protocols, 310–311**

Frame Relay, 150

IP, 94

IPTV, 146

PPP, 141

SNMP, 398

STP, 514

**provisioning, 278–283, 408–410, 424**

A-to-Z circuit, 499

community names, 481

end-to-end, 39  
 E-Series Ethernet interface cards, 273–274  
 flow-through, 495  
 MSPPs, 155  
 ONS 15454, 408–418, 420–423  
 RPR, 300–307  
 services, 427–432

**PRS (primary reference source), 420**

**PSTN (public switched telephone network), 135–138, 199**

**pulse code modulation (PCM), 67**

## Q

**Q-in-Q, 126**

**QoS (quality of service), 14**

**queues, 279–280**

## R

**rates, SONET/SDH, 55–63**

**RBOC (Regional Bell Operating Company), 148**

**reconfigurable optical add/drop. *See* ROADM**

**reconfigurable rings, 368**

**reduction, capital expense, 41–43**

**redundancy**

MSPPs, 181

*cable route diversity, 185*

*common control redundancy, 182–183*

*multiple shelves, 185*

*redundant power feeds, 182*

*rings, 186*

*synchronization, 184–185*

*tributary interface protection, 183–184*

RPR, 146

**references, timing, 188–189**

**reflection, 46–48**

**refraction, 46–48**

**Regional Bell Operating Company (RBOC), 148**

**regulations, SANs, 86**

**reliability, 181**

cable route diversity, 185

common control redundancy, 182–183

multiple shelves, 185

redundant power feeds, 182

rings, 186

synchronization, 184–185

tributary interface protection, 183–184

**remote access, 150**

**remote-monitoring. *See* RMON**

**replication**

asynchronous data, 313–314

synchronous data, 312–313

**reports, alarms, 332**

**resiliency, 123**

**resilient packet ring. *See* RPR**

**resources, 443–446**

**restoring databases, 439**

**RET1/BAT1 terminals, 221**

**retrieving, 480**

**return on investment (ROI), 150**

**reversion, software, 441**

**rings**

ONS 15454, 462

topologies, 366–368

**RMON (remote-monitoring), 398, 488**

Ethernets, 490

thresholds, 489–490

**ROADM (reconfigurable optical add/drop), 368**

DWDM, 397–398

ring power calculations, 385

**ROI (return on investment), 150**

**round-trip delay, SAN, 319**

**Route Processor Redundancy (RPR), 146**

**routes, 205**

**routing circuits**

automatically, 429–430

manually, 431–432

**Routing Layer, 242–244**

**RPR (resilient packet ring), 14, 122–129**

ONS 15454 ML-Series Ethernet, 288–298

provisioning, 300–307

transport architecture, 288

**RPR (Route Processor Redundancy), 146**

## S

**SANs (storage-area networks), 5, 309**

data storage mirroring, 311–314

demand for, 86–88

ESCON, 91–93

evolution of, 88–90

- extension solutions, 314–315
- FC, 90–91
- FCIP, 94
- FICON, 91
- history of, 83–84
- over MSPPs, 95–98
- networking cards, 248
- overview of, 82–83, 86, 309–310
- private MSPPs, 158
- protection, 321–322
- protocols, 310–311
- service cards, 37–38
- services, 17–18
- SONET, 318–321
- wavelength, 315–318
- scalability**
  - IOF, 155
  - MPLS VPNs, 151
- scratched connectors, 459**
- SCSI (Small Computer System Interface), 310**
- SD (signal degrade), 109, 395, 462**
- SDCC (Section Data Communications Channel), 418**
- SDH (Synchronous Digital Hierarchy), 77, 184**
  - digital multiplexing/framing, 50–54
  - equipment, 64–65
  - ONS 15454 CE-Series Ethernet interface cards, 281–283
  - optical interface cards, 235–238
  - overview of, 49–50
  - rates/tributary mapping, 55–63
  - synchronization, 72
  - timing, 73–75
  - wavelength services, 390
- Section Data Communications Channel (SDCC), 418**
- sections, SONET/SDH transmissions, 66–67**
- security**
  - MPLS VPNs, 151
  - ONS 15454, 416
- selecting timing references, 188–189**
- serial numbers, retrieving, 480**
- servers, 500–502**
- Service Management Layer (SML), 498**
- service-level agreements (SLAs), 205, 398**
- service-provider management, 513**
- services, 116, 389**
  - drops, 21
  - DWDM, 15–16
  - Ethernet, 12–14
  - high-bandwidth, 11–19
  - MPLS VPNs, 151
  - provisioning, 427–432
  - SAN, 17–18
- SF (Signal Fail) LEDs, 454**
- SF (single failure), 395**
- SF (Superframe), 422**
- SFP (small form factor pluggable), 28, 316**
- shared packet ring (SPR), 273**
- sharing bandwidth, 123**
- Shelf Assembly (ONS 15454), 219–222, 327–330**
  - drops, 23
  - installing, 408–410
- show cdp neighbors command, 307**
- show running-config command, 304**
- signal degrade (SD), 109, 395, 462**
- Signal Fail (SF) LEDs, 454**
- signals, 50–54**
  - EDFAs, 107
  - higher-rate, 60
  - ONS 15454, 462
  - troubleshooting, 458–460
- Simple Network Management Protocol (SNMP), 398**
- single failure (SF), 395**
- Single-card EtherSwitch mode, 273**
- single-mode fiber (SMF), 48–49**
- SLAs (service-level agreements), 205, 398**
- SL-Series FC/FICON interface cards, 248**
- Small Computer System Interface (SCSI), 310**
- small form factor pluggable (SFP), 28, 316**
- SMB (Sub-Miniature B) EIA, 223**
- SMF (single-mode fiber), 48–49**
- SML (Service Management Layer), 498**
- SNA (Systems Network Architecture), 150**
- SNCP (subnetwork connection protection), 390**
- Snell's Law (index of refraction), 47–48**
- SNMP (Simple Network Management Protocol), 398**

**software**

- activation, 440
- downloads, 41
- reversion, 441
- TCCs, 331
- upgrading, 439–441, 499

**SONET (Synchronous Optical Network), 9, 72, 141–142, 150, 318–321**

- digital multiplexing/framing, 50–54
- equipment, 64–65
- ONS 15454 CE-Series Ethernet, 281–283
- optical interface cards, 235–238
- overhead channels, 66–71
- overview of, 49–50
- rates/tributary mapping, 55–63
- SAN, 311
- synchronization, 72
- timing, 73–77
- transport networks, 155
- wavelength services, 390

**Spanning Tree Protocol (STP), 514****sparing (card), 439****spatial reuse, RPR, 298****SPE (Synchronous Payload Envelope), 54****splitting wavelengths, 109****SPR (shared packet ring), 273****SSM (synchronization status messaging), 422****standby (STBY) state, 231****status, messaging, 189–191****STBY (standby) state, 231****STM (Synchronous Transport Module), 57****storage, 331****storage-area networks. *See* SANs****STP (Spanning Tree Protocol), 514****stripping wavelength, 294****STS-1 frames, 53****STSs (Synchronous Transfer Signals), 320, 457****Sub-Miniature B (Sub-Miniature) EIA, 223****subnetwork connection protection (SNCP), 390****subrate channels, transporting, 57–60****Superframe (SF), 422****suppressing alarms, 496****switches**

- ESCON, 310–311
- FC, 309–310
- PBX, 183
- protection, 478–479

**SANs, 86****switching, APS, 393****Switching Layer, 242–244****synchronization**

- networks, 420–423, 497
- SONET/SDH, 72
- status messaging, 189–191

**synchronization status messaging (SSM), 422****synchronous data replication, 312–313****Synchronous Digital Hierarchy. *See* SDH****Synchronous Envelope Payload (SPE), 54****Synchronous Optical Network. *See* SONET****Synchronous Transfer Signals (STSs), 320, 457****Synchronous Transport Module (STM), 57****Systems Network Architecture (SNA), 150****T****tables, alarms, 503****TAC (Technical Assistance Center), 150****TAPs (test access points), 458****TCA (Threshold Crossing Alert), 472, 487****TCC2 (Advanced Timing Communications and Control) card, 410–411, 484****TCCs (Timing, Communications, and Control) cards, 183, 225–228, 331–333, 403****TCO (total cost of ownership), 20–29, 32–38****TDM (time-division multiplexing), 5**

- private MSPPs, 159

- interfaces, 183

**Technical Assistance Center (TAC), 150****telecommunications management network (TMN), 497****TEMS (Transport Element Activation Manager), 148****terminals**

- frame ground, 221, 330
- loopbacks, 457
- RET1/BAT1, 221

**termination, DCCs, 419****test access points (TAPs), 458****testing, acceptance, 433–435****Threshold Crossing Alert (TCA), 472, 487****thresholds**

- monitoring, 487
- RMON, 489–490

**through timing, 78**

**time-division frames, 50**

**time-division multiplexing. *See* TDM**

**timing**

GPS, 75–77

SONET/SDH, 72–75

**Timing Communications and Control 2 (TCC2), 410–411, 484**

**timing design, 186, 188–191**

**Timing, Communications, and Control. *See* TCCs**

**TIRKS (Trunk Integrated Record Keeping System), 148**

**TL1 (Transaction Language 1), 482–484**

**TMN (telecommunications management network), 497**

**tolerance, OSNR, 381–382**

**too-high light levels, 460**

**tools, troubleshooting, 456–457**

**topologies**

BLSR, 197

Layer 2 bandwidth, 512

linear, 365

MSPP, 193

*BLSR, 200–209*

*linear, 193–195*

*mesh networks, 214–216*

*ring-to-ring interconnect, 212–213*

*subtending rings, 209, 211*

*subtending shelves, 211*

*UPSR, 195–200*

ring, 366–368

**ToS (Type of Service), 9**

**total cost of ownership. *See* TCO**

**traditional DRI, 212**

**traditional Ethernet services, 12–14**

**traffic**

fiber optics, 45

multicast, 121

routes, 205

**Transaction Language 1 (TL1), 482–484**

**Transparent mode (GFP), 128**

**Transport Element Activation Manager (TEMS), 148**

**Transport Layer, 238–241**

**transport networks, 144–148**

DWDM, 154

ONS 15454 ML-Series, 287–288

SONET, 155

**transporting subrate channels, 57–60**

**traps, SNMP, 472–474**

**tributary mapping, 55–63**

**troubleshooting, 447–457, 460–463**

alarms, 432

cabling, 454

card LEDs, 453

circuits, 458

conditions, 432

connections, 455

maintenance, 435, 437–439

ONS 15454, 458–460

optical links, 459–460

power, 454

round-trip delay, 319

signals, 458–460

**Trunk Integrated Record Keeping System (TIRKS), 148**

**trunks, 399**

**Type of Service (ToS), 9**

**types of optical fiber, 48–49**

---

## U

**UBIC (Universal Backplane Interface Connector), 223**

**UDCs (user data channels), 235, 340–341**

**UNI (User-to-Network Interface) ports, 514**

**unidirectional path switched ring. *See* UPSR**

**Universal Backplane Interface Connector (UBIC), 223**

**Universal Time Coordinated (UTC), 420**

**upgrading software, 439–441, 499**

**UPSR (unidirectional path switched ring), 26, 152, 185, 274, 390**

**user data channels (UDCs), 235, 340–341**

**users, security, 416**

**User-to-Network Interface (UNI) ports, 514**

**UTC (Universal Time Coordinated), 420**

---

## V

**Variable Bindings, 474**

**variable optical attenuators. *See* VOAs**

**VCAT (virtual concatenation), 158**

rates, 320

RPR, 126–127

**VCG (VCAT Group), 320**

**VCI (virtual channel identifier)**, 166  
**verification, RPR**, 303–307  
**video bandwidth**, 18–19  
**virtual channel identifier (VCI)**, 166  
**virtual concatenated**. *See* VCAT  
**virtual LAN (VLAN)**, 13  
**virtual path identifier (VPI)**, 166  
**Virtual Private Network (VPN)**, 143  
**Virtual Tributary (VT)**, 57, 475  
**virtual tributary group (VTG)**, 57–60  
**virtual wire operation**, 339  
**VLAN (virtual LAN)**, 13  
**VOAs (variable optical attenuators)**, 343, 385, 397  
**voice, bandwidth**, 18–19  
**VoIP (Voice over IP)**, 19, 137  
**voltage**

- AIC-I cards, 340
- monitoring, 332

**VPI (virtual path identifier)**, 166  
**VPN (Virtual Private Network)**, 143  
**VT (Virtual Tributary)**, 57, 475  
**VTG (virtual tributary group)**, 57–60

**wavelength, 389–399, 401–403**

- DWDM. *See* DWDM
- private MSPPs, 159
- splitting, 109
- storage over, 315–318

**WDM (wavelength-division multiplexing)**, 102–103

**wizards**

- L2 Service Wizard, 512
- Layer 2 Ethernet Wizard, 514

**WKSWPR (Working Switched to Protection)**, 478

**XC (cross-connect) cards**, 183, 228–229, 411  
**XCVT (Cross-Connect Virtual Tributary)**, 229

**Y-cable protection**, 109, 322

## W–X–Y

---

**WANs (wide-area networks)**, 9, 139  
**waste of bandwidth**, 121