



## Applications and Configurations

---



### Note

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

This chapter provides examples of common ONS 15454 Multi-Service Provisioning Platform (MSPP) network applications and shelf configurations. All SONET examples are shown as either ring or 1+1 protected. All DS-1, DS-3, and EC-1 examples are shown either as 1:N (N<5) or 1:1 protected. Ethernet cards are shown unprotected.

The examples shown in this chapter are designed to provide general guidance for creating ONS 15454 node configurations to meet your service needs.

The following topics are covered in this chapter:

- [Overview, page 9-2](#)
- [Interoffice \(IOF\) Transport, page 9-2](#)
- [Metro Transport, page 9-5](#)
- [Access Transport, page 9-7](#)
- [Regenerator Site, page 9-30](#)
- [Passive DWDM Applications, page 9-31](#)
- [MSTP DWDM Applications, page 9-33](#)
- [Ethernet Applications, page 9-33](#)
- [Wireless Networking, page 9-47](#)
- [Video Transport, page 9-48](#)
- [SAN Extension Options, page 9-54](#)

# Overview

The Cisco ONS 15454 Multi-Service Provisioning Platform (MSPP) combines the best of a traditional SONET TDM (time division multiplexing) system along with statistical multiplexing in a single platform. It is a flexible SONET add/drop multiplexer that offers service aggregation and high-bandwidth transport of voice, data, and digital video traffic on a single platform.

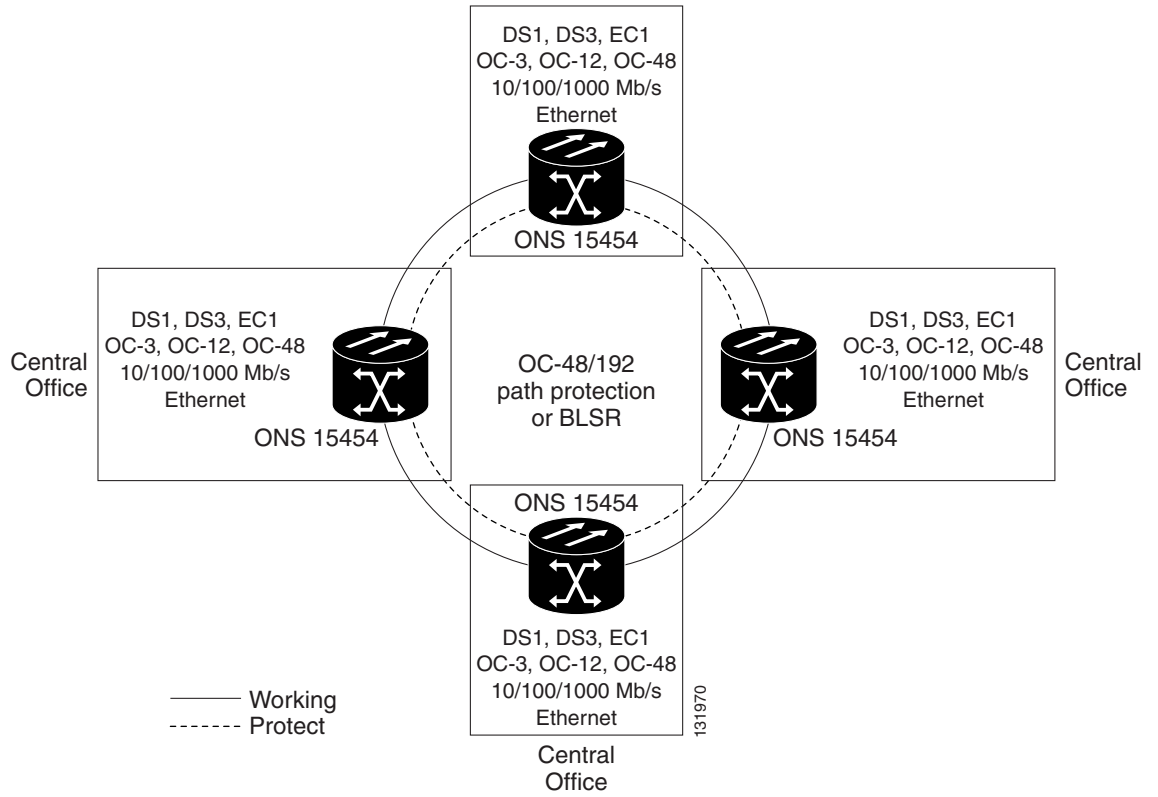
Integrating Dense Wavelength Division Multiplexing (DWDM) transport and wavelength services into the ONS 15454 re-configures the MSPP into a Multi-Service Transport Platform (MSTP). Leveraging on the MSPP and MSTP features and functionalities, customers can use a single ONS 15454 solution to meet cost-effective provisioning and transport requirements ranging from access, interoffice (IOF), and long-haul applications.

The ONS 15454 allows you to easily manage services and quickly increase capacity without disrupting service. NOC workstations or technician laptops can connect to the ONS 15454 using either direct PC, LAN, or firewall-compliant Ethernet connections, as well as through DCC connections for OAM&P. The Cisco Transport Controller (CTC) and TL1 interfaces makes provisioning and troubleshooting ONS 15454 applications fast, simple, and easy.

## Interoffice (IOF) Transport

The ONS 15454 can be easily configured to carry TDM, ATM, data, and digital video services with path protection or BLSR protection. Its full range of interfaces provide incremental bandwidth increases as needed and supports DS-1, DS-3, DS-3 transmux, EC-1, OC-3, OC-12, OC-48, OC-192, 10/100 Mb/s, and Gigabit Ethernet line rates. The short reach (SR), intermediate reach (IR), and long reach (LR) optical interface cards along with the ability to support any network topology makes the ONS 15454 ideal for IOF transport applications. [Figure 9-1](#) shows an example of an IOF transport in either a path protection or BLSR configuration.

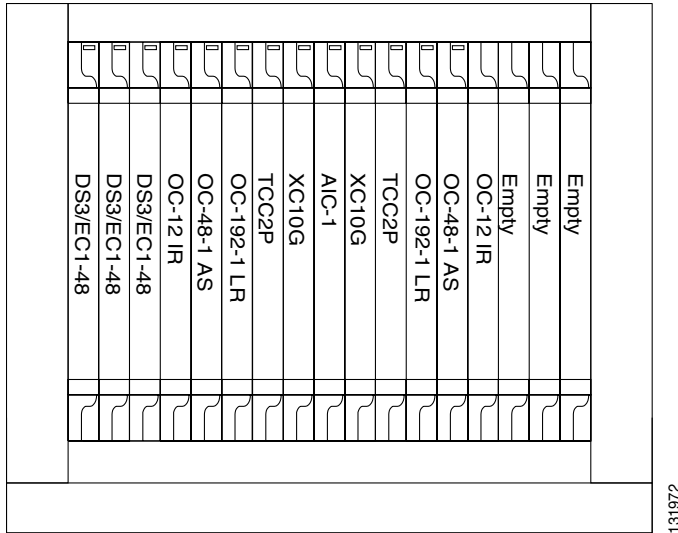
Figure 9-1 Interoffice Transport



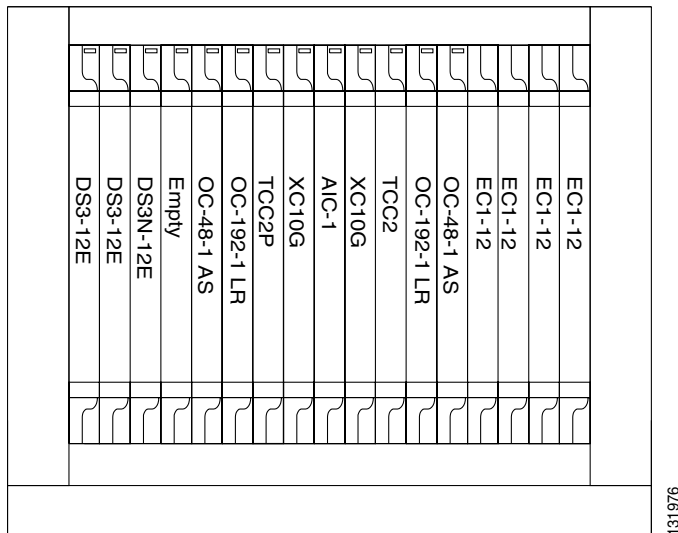
## Typical IOF Node Configurations

Figure 9-2, Figure 9-3, and Figure 9-4 show the shelf layouts for typical OC-192 IOF nodes. Note the empty card slots available to increase the capacity of the shelf.

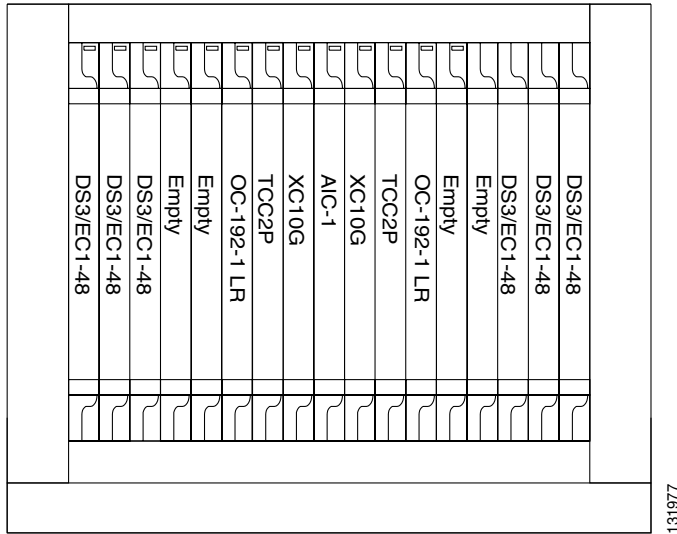
**Figure 9-2** OC-192 IOF Node Configured for 96 DS-3s Using High-Density Cards



**Figure 9-3** OC-192 IOF Node Configured for 24 DS-3s and 24 EC-1s Using Low-Density Cards



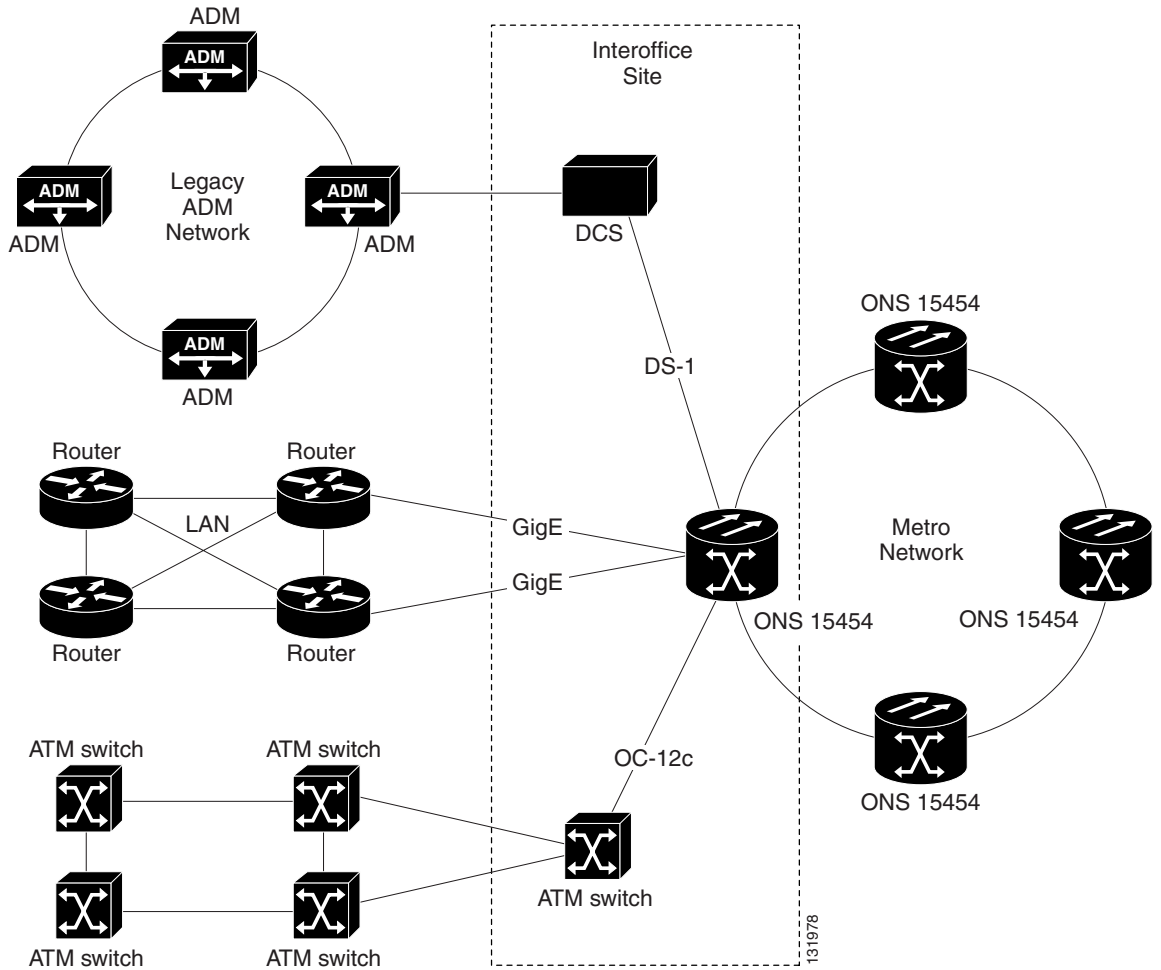
**Figure 9-4** OC-192 IOF Node Configured for 192 DS-3/EC-1s or 96 DS-3s and 96 EC-1s Using High-Density Cards



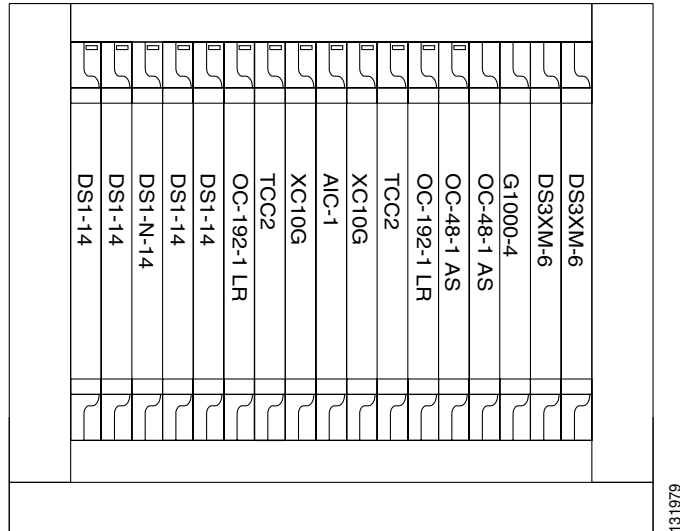
# Metro Transport

The ONS 15454 can groom services at the edge of the Metro transport network shown in [Figure 9-5](#), packing the network with information and eliminating the need for multiple cross-connects and routers. [Figure 9-6](#) shows the shelf layout of the ONS 15454 node located at the Interoffice Site.

Figure 9-5 Multi-Service Grooming at the Edge of the Metro Transport Network



**Figure 9-6 Shelf Layout of a Multi-Service Grooming Node**



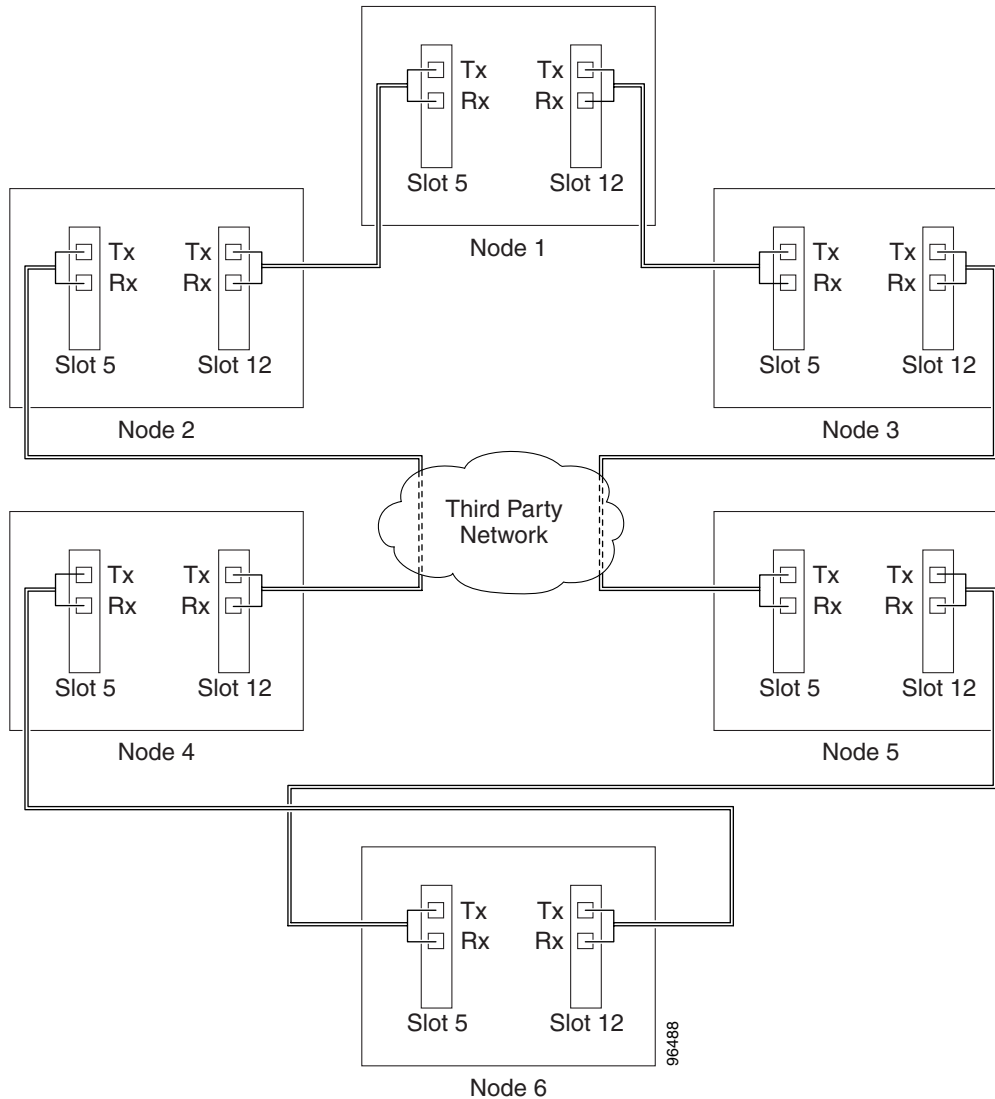
## Access Transport

The ONS 15454 provides the flexibility required to link remote sites to a serving central office (CO) and to aggregate a wide range of services at the edge of the network and transport them to the core of the network.

### Open-Ended Path Protection Circuit

An open-ended path protection circuit allows you to route a circuit from one ONS 15454 network to another ONS 15454 network through a third party's network. [Figure 9-7](#) shows an example of this topology. Node 1 is connected to ONS 15454 Nodes 2 and 3 through Slots 12 and 5. Trunk cards at Nodes 2 and 3 are connected to the third party's equipment.

Figure 9-7 Open-Ended Path Protection Example



The third party time slots must match the ONS 15454 card time slots to which they are connected. For example, if your trunk card is an OC-48, the third party's card must have STSs 1-48 available. You provision SONET DCC terminations for the ONS 15454 cards/ports that are connected to another ONS 15454. Do not create a DCC termination for the card/port that connects to the third-party's equipment. For example in Figure 9-10, DCC terminations are created at the following cards/ports:

- Nodes 1 and 6 - Slot 5 and Slot 12
- Node 2 and 5 - Slot 12
- Node 3 and 4 - Slot 5

To create an open-ended path protection circuit, you create three circuits. One circuit is created on the source ONS 15454 network. This circuit has one source and two destinations, one at each ONS 15454 that is connected to the third-party network. The second circuit is created on the third-party network so that the circuit travels across the network on two paths to the ONS 15454s. That circuit routes the two circuit signals across the network to ONS 15454 nodes that are connected to the network on other side.



At the destination node network, the third circuit is created with two sources, one at each node connected to the third-party network. A selector at the destination node chooses between the two signals that arrive at the node, similar to a regular path protection circuit.

## BLSR DRI



### Note

---

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

---

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

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

Figure 9-8 Traditional BLSR DRI (Same Side Routing)

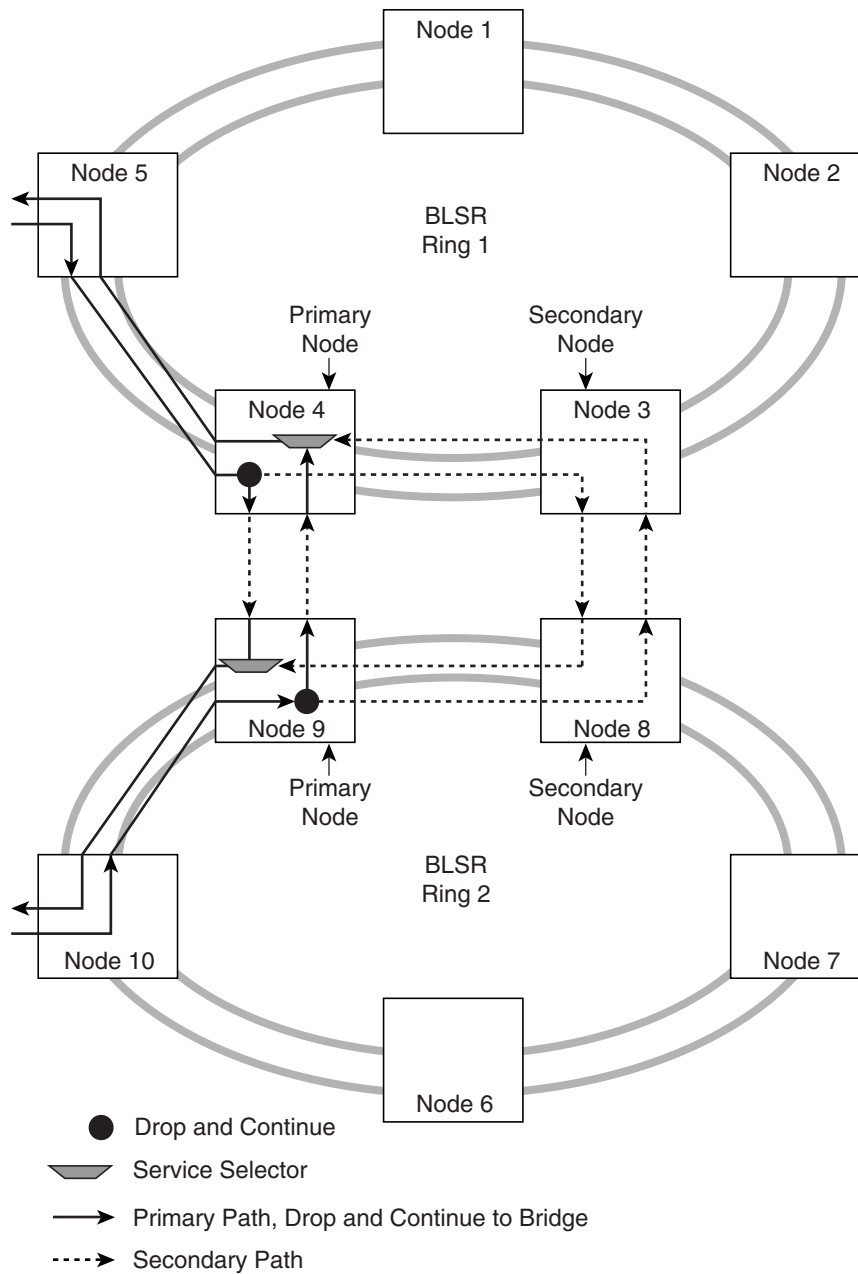


Figure 9-9 shows ONS 15454 nodes in a traditional BLSR-DRI topology with opposite-side routing. In Ring 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 8 and 9 are the interconnect nodes. Duplicate signals are sent from Node 4 (Ring 1) to Node 8 (Ring 2), and between Node 3 (Ring 1)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

Figure 9-9 ONS 15454 Traditional BLSR DRI (Opposite-Side Routing)

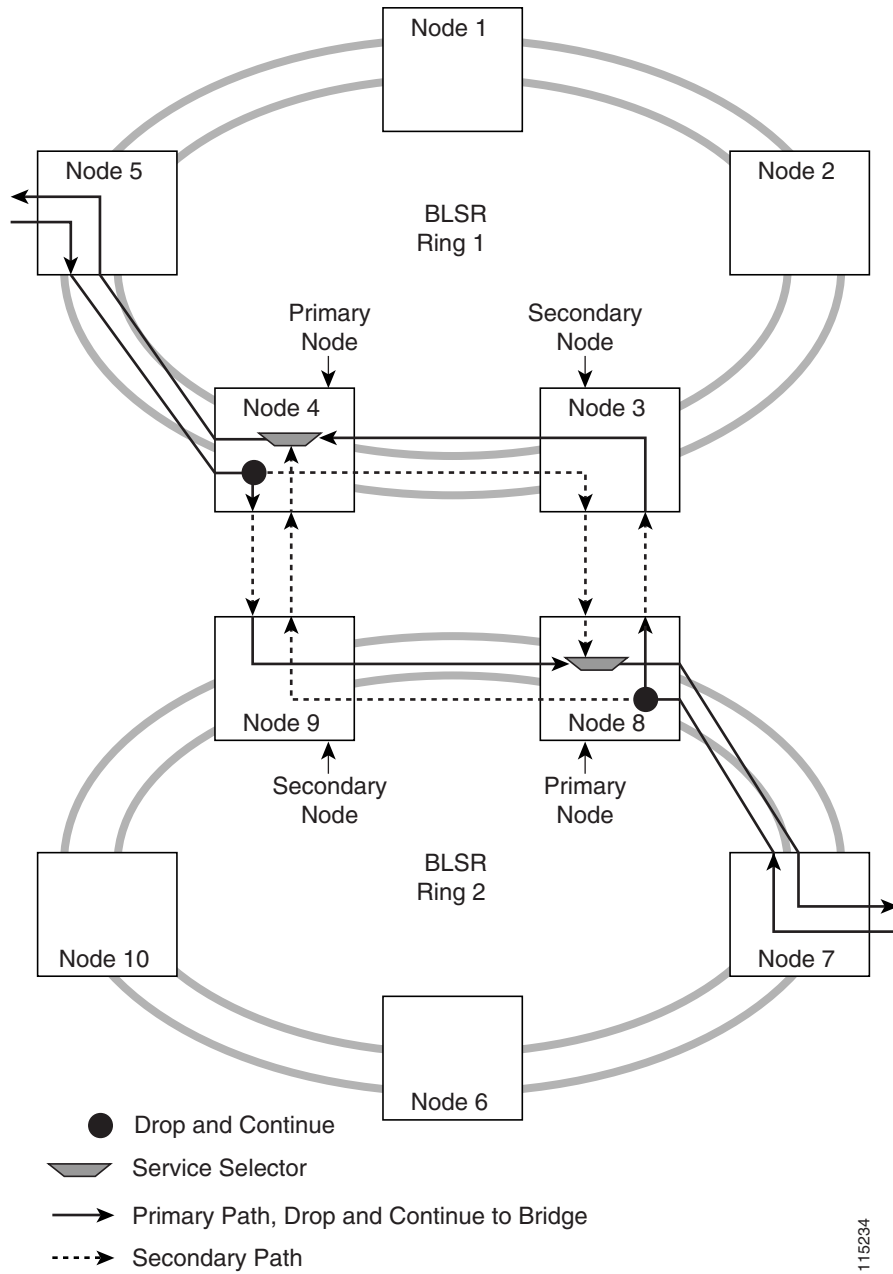
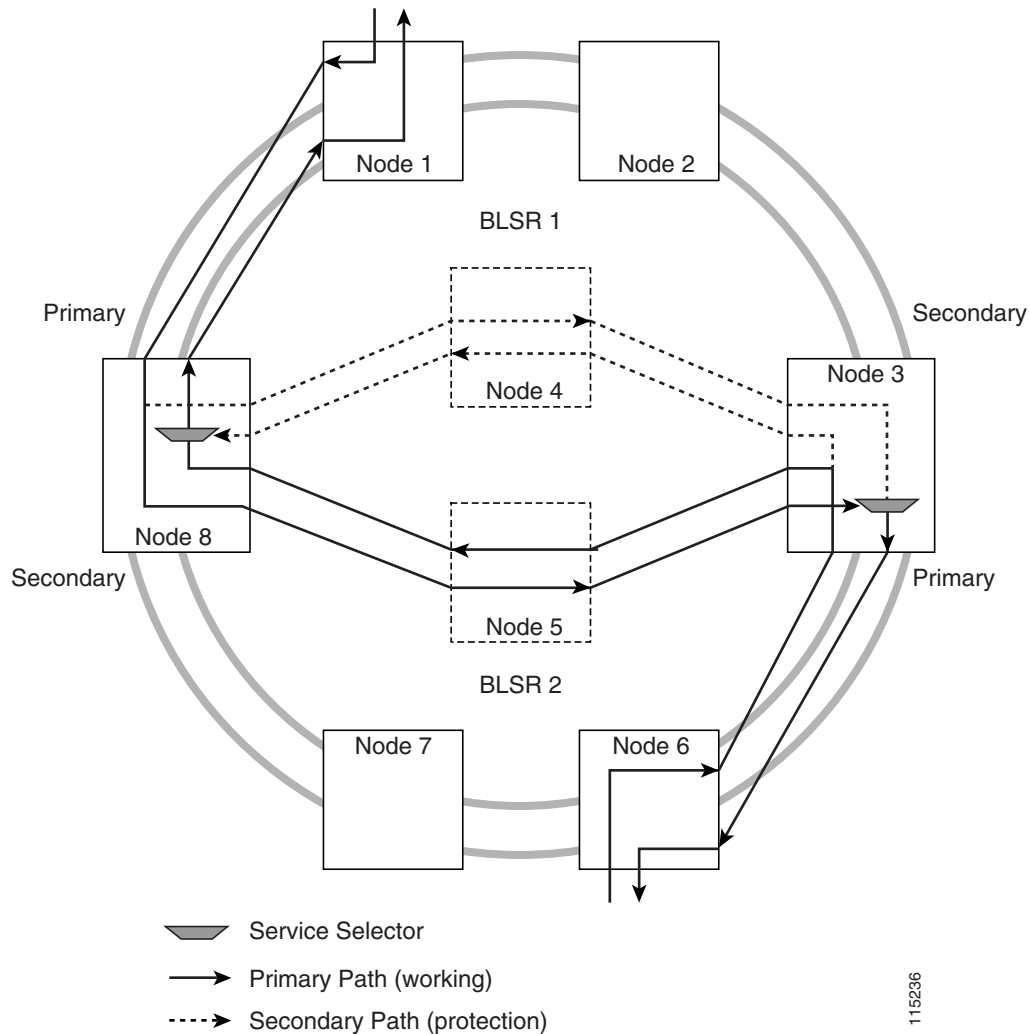


Figure 9-10 shows ONS 15454 nodes in an integrated BLSR-DRI topology. The same drop-and-continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an additional OC-N trunk at the two interconnect nodes. Nodes 3 and 8 are the interconnect nodes.

Figure 9-10 ONS 15454 Integrated BLSR DRI



## Path Protection DRI

Figure 9-11 shows ONS 15454 nodes in a traditional drop-and-continue path protection DRI topology. In Ring 1, Nodes 4 and 5 are the interconnect nodes, and in Ring 2, Nodes 6 and 7 are the interconnect nodes. Duplicate signals are sent between Node 4 (Ring 1) and Node 6 (Ring 2), and between Node 5 (Ring 1) and Node 7 (Ring 2). In Ring 1, traffic at Node 4 is dropped (to Node 6) and continued (to Node 5). Similarly, at Node 5, traffic is dropped (to Node 7) and continued (to Node 4).

Figure 9-11 ONS 15454 Traditional Path Protection DRI

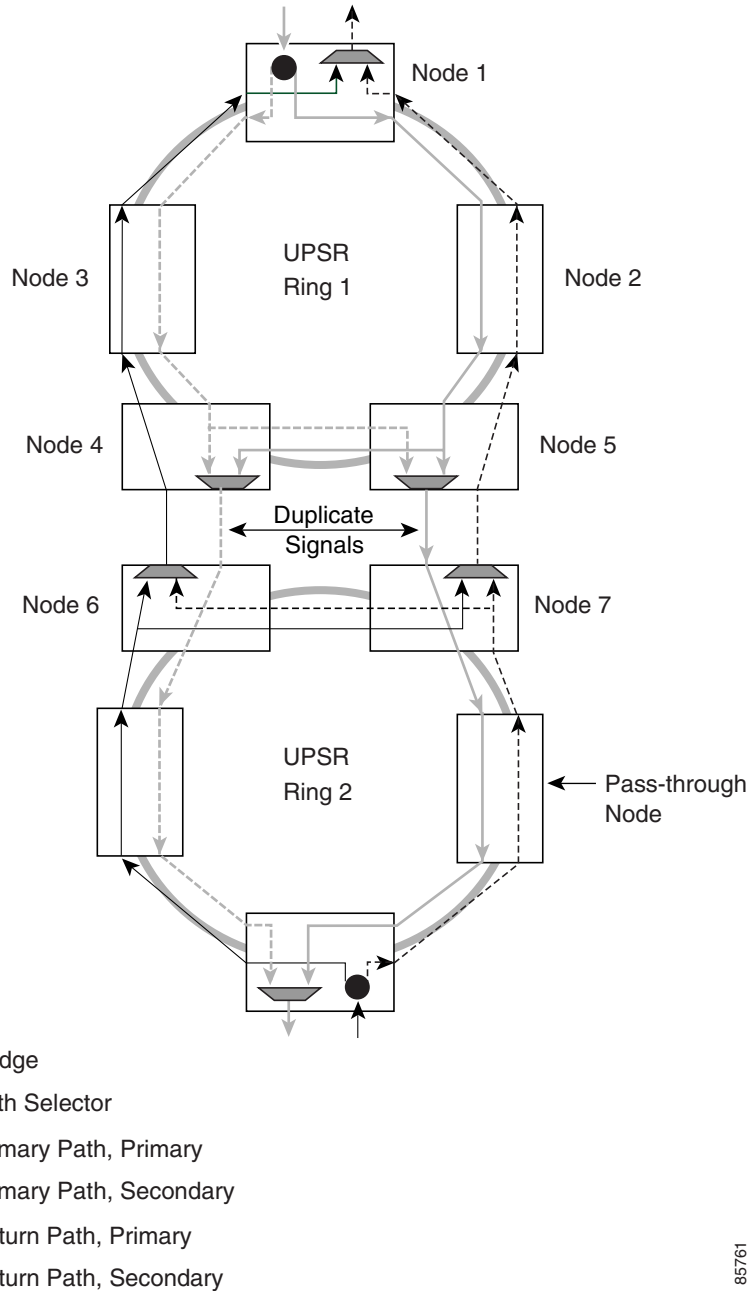
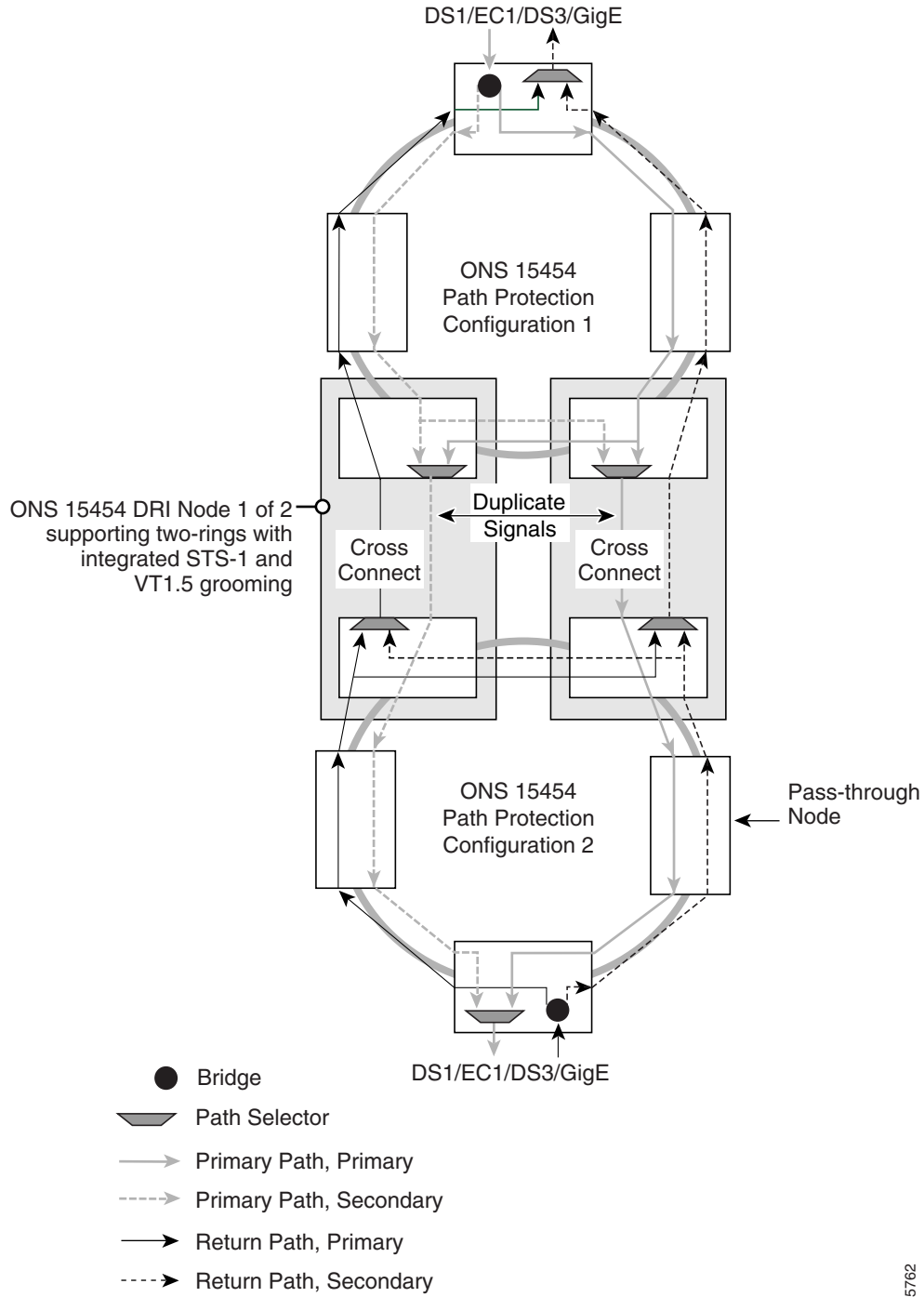


Figure 9-12 shows ONS 15454s in an integrated DRI topology. The same drop-and-continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an additional OC-N trunk at the two interconnect nodes.

Figure 9-12 ONS 15454 Integrated Path Protection DRI



85762

## Path Protection/BLSR DRI Handoff Configurations

Path protection configurations and BLSRs can also be interconnected. In BLSR/path protection DRI handoff configurations, primary and secondary nodes can be the circuit source or destination, which is useful when non-DCC optical interconnecting links are present. Figure 9-13 shows an example of a path protection to BLSR traditional DRI handoff.

Figure 9-13 ONS 15454 Path Protection to BLSR Traditional DRI Handoff

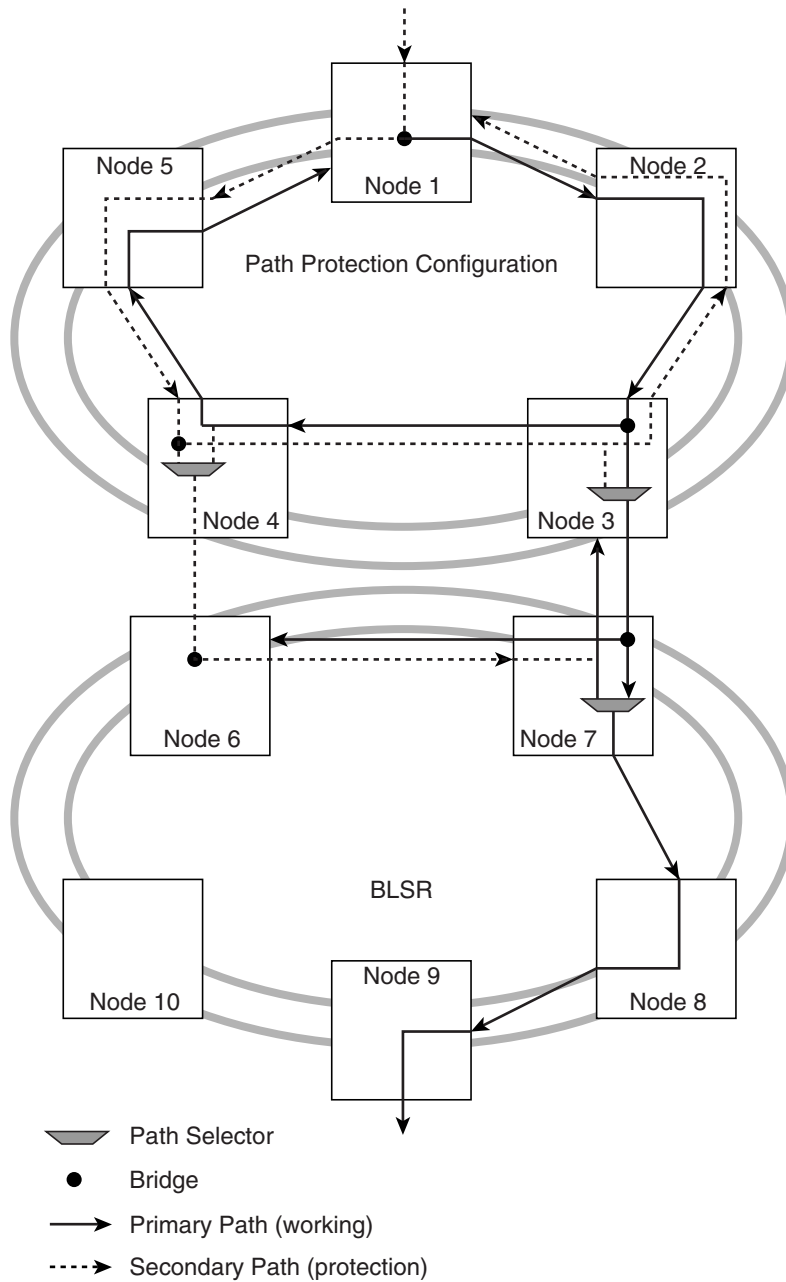
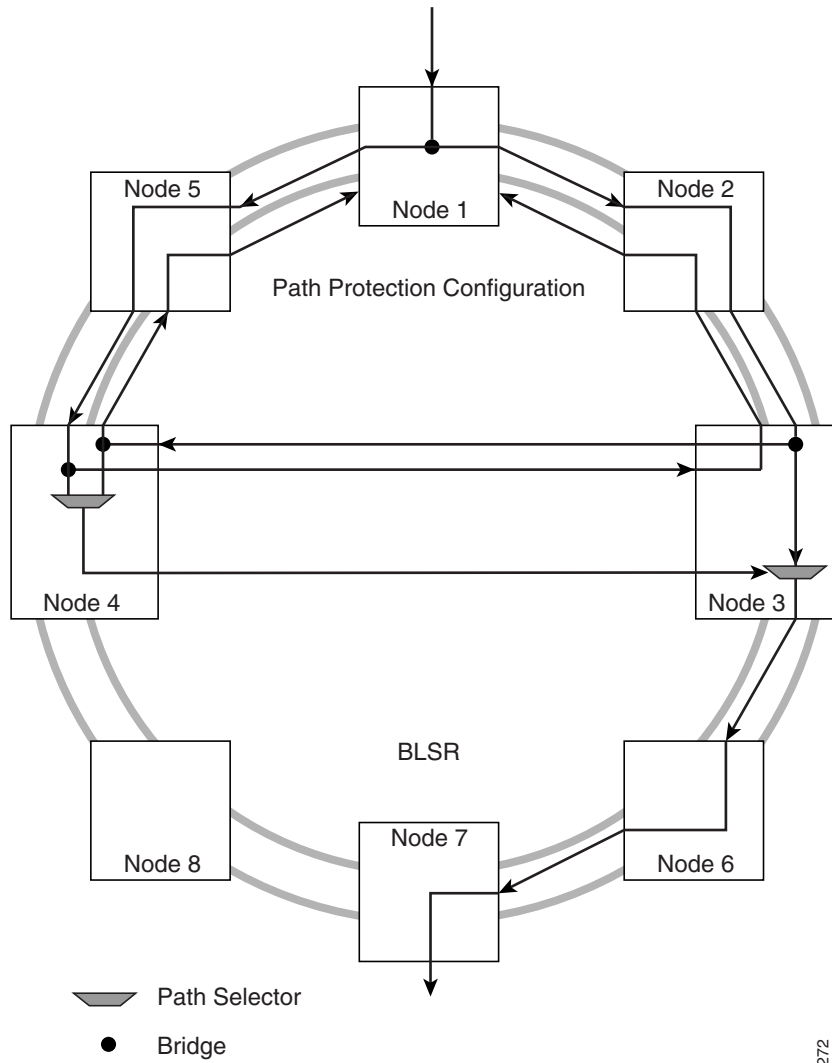


Figure 9-14 shows an example of a path protection to BLSR integrated DRI handoff.

Figure 9-14 ONS 15454 Path Protection to BLSR Integrated DRI Handoff



## Linear ADM Configurations

You can configure ONS 15454s as a line of add/drop multiplexers (ADM) by configuring one set of OC-N cards as the working path and a second set as the protect path. Unlike rings, linear (point-to-point) ADMs require that the OC-N cards at each node be in 1+1 protection to ensure that a break to the working line is automatically routed to the protect line.

A common linear application is a configuration with a backbone route requiring traffic to be dropped and inserted at each site. Figure 9-15 shows an OC-192 linear application with 10 DS-1s and 2 DS-3s dropped at nodes 2 and 3. Four OC-192 modules are required at these nodes to handle traffic in both directions.



**Figure 9-15 OC-192 Linear ADM 1+1 Protected**

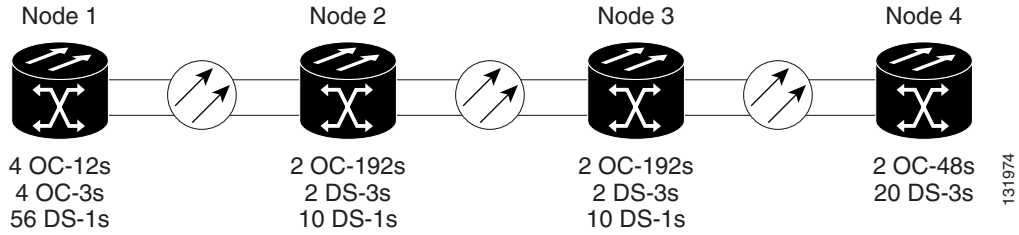
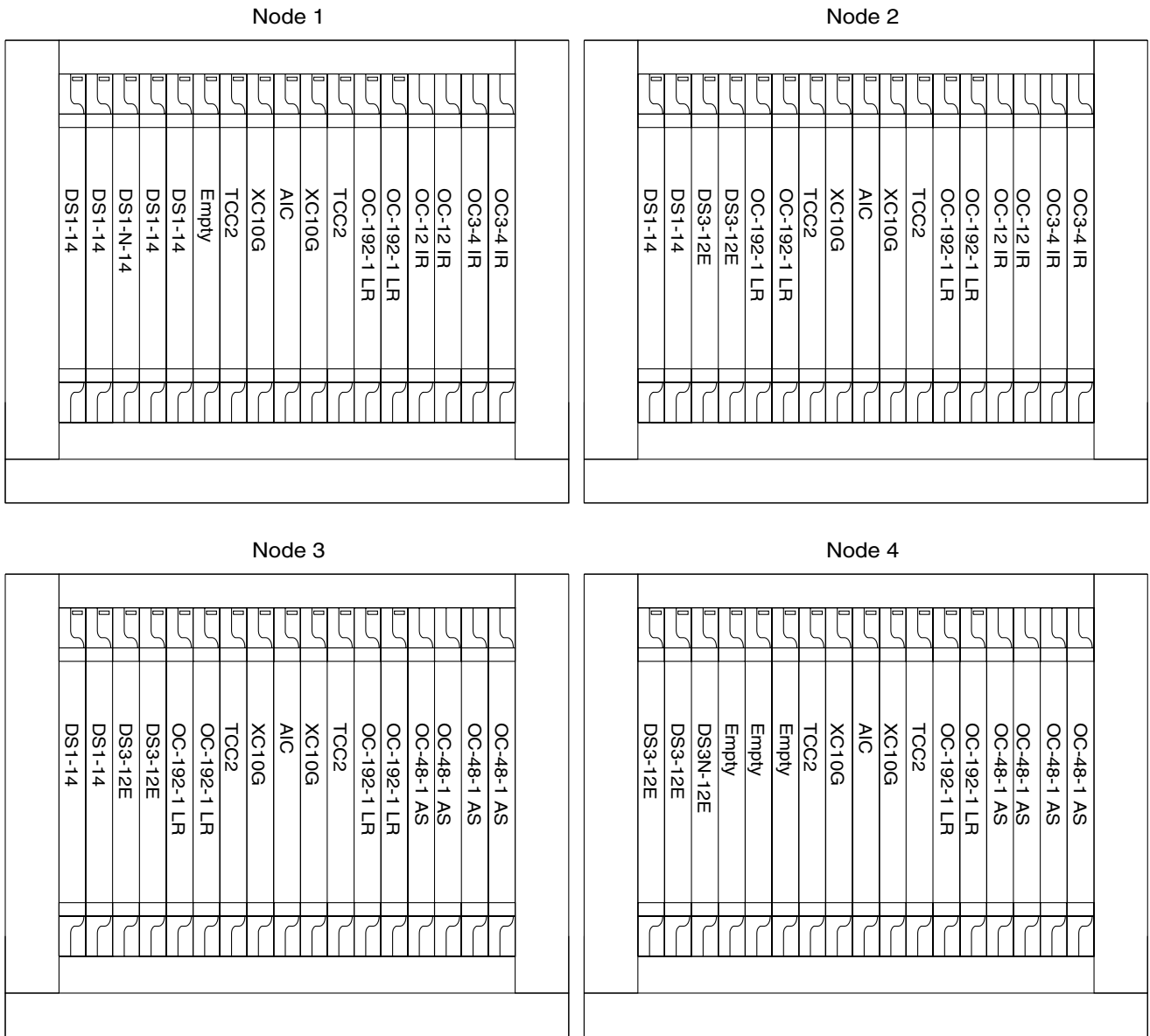


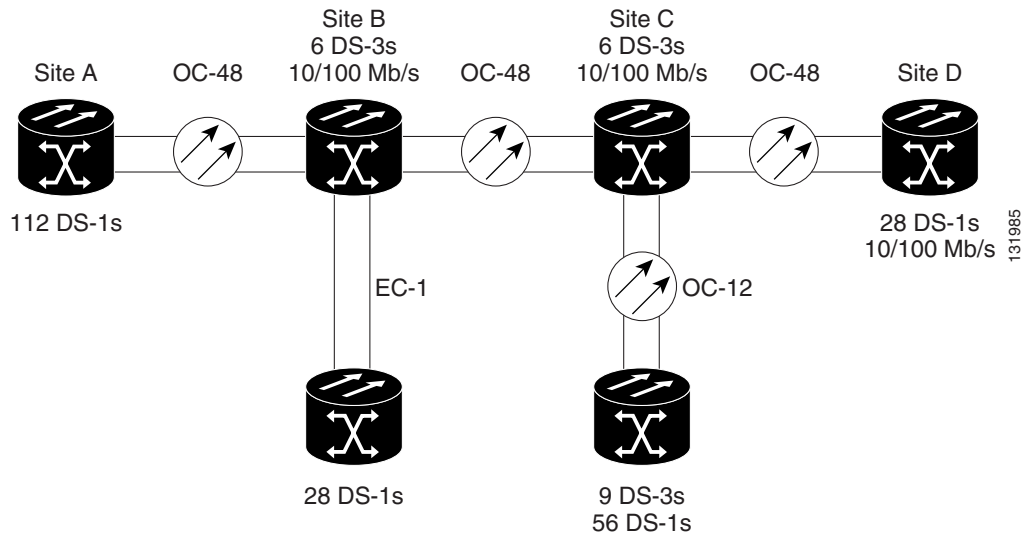
Figure 9-16 shows the shelf layouts for Nodes 1 to 4 in the above example.

**Figure 9-16 OC-192 Linear ADM 1+1 Protected Shelf Layouts**

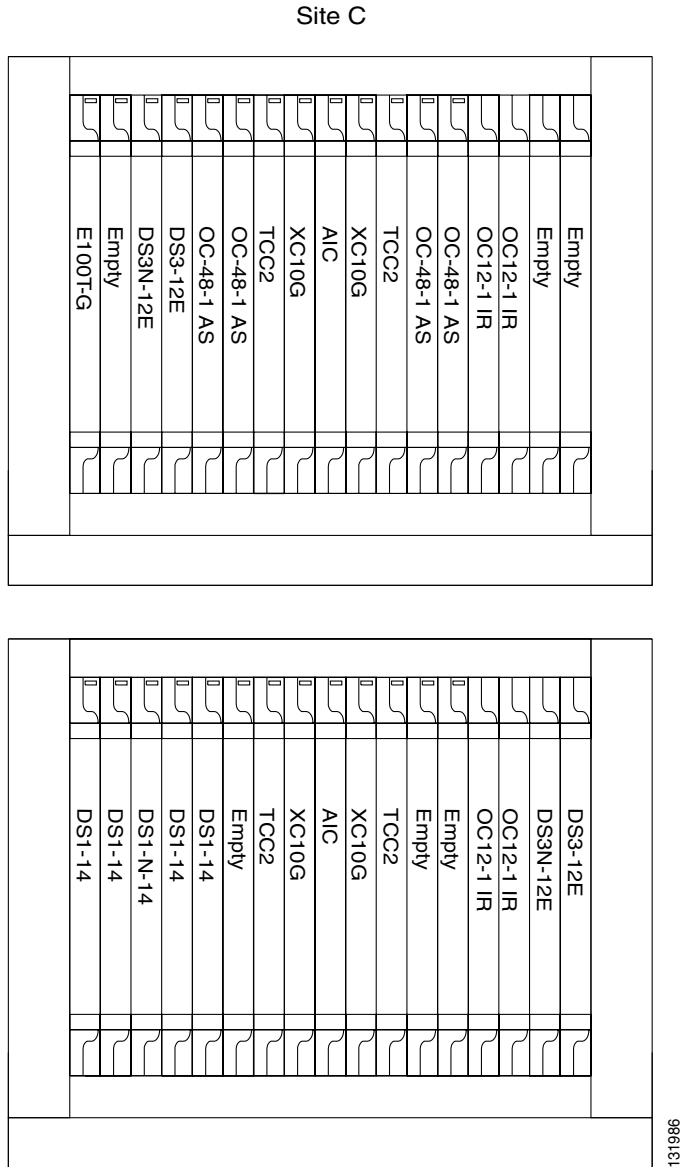


The ONS 15454 also supports distributed linear networks. [Figure 9-17](#) shows a distributed OC-48 backbone with OC-12 and EC-1 uplinks. Site A collects DS-1 traffic from the remote sites, while, Sites B, C, and D are configured in an Ethernet Virtual Private Network (VPN). Note that at Site C, an OC-12 can be dropped from the same shelf that contains an OC-48 (see [Figure 9-18](#)).

**Figure 9-17** Distributed Linear Network



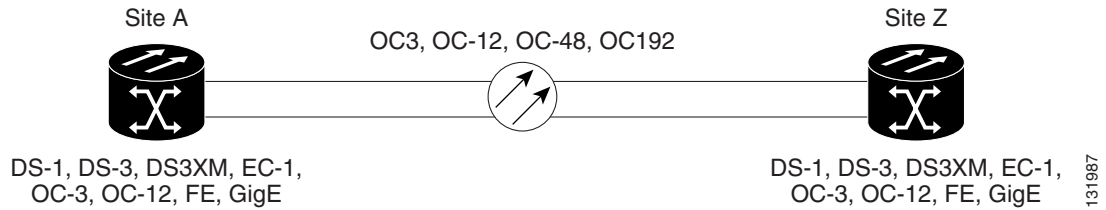
**Figure 9-18 Multi-homed Linear ADM Shelf Layout**



## Terminal Mode

In a Terminal Mode (TM) configuration, the ONS 15454 node terminates the entire SONET payload at each end of the fiber span. TM systems are generally employed in a basic transport application calling for a single system/single route solution.

The ONS 15454 is designed to meet a wide range of capacity demands and can support TM configurations using OC-3, OC-12, OC-48 and OC-192 line rates. The ONS 15454 also supports an extensive range of mixed voice and data interfaces within the same shelf that hosts the SONET spans, making it extremely cost-effective for TM point-to-point applications shown in [Figure 9-19](#).

**Figure 9-19** *Distributed Linear Network*

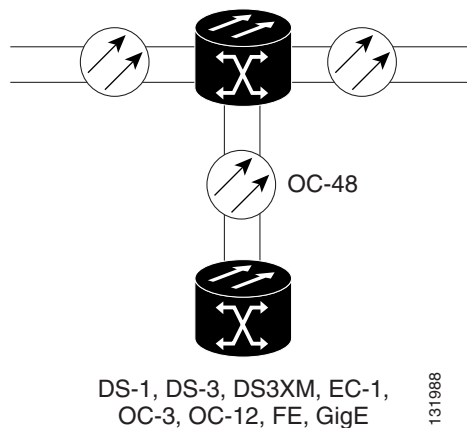
Depending on the ONS 15454 port card used for the SONET span, protection spans can be added by installing another port card, such as OC-192, or by using additional ports on a multi-port card, such as OC-3 or OC-12. [Table 9-1](#) lists the available TM protection schemes for electrical and optical interface cards.

**Table 9-1** *Terminal Mode Protection Schemes*

Protection Scheme Supported	Electrical Cards	Optical Cards
Unprotected	X	X
1:1	X	
1:N	X	
1+1		X
Path protection		X
BLSR		X
PPMN		X

## Traffic Aggregation

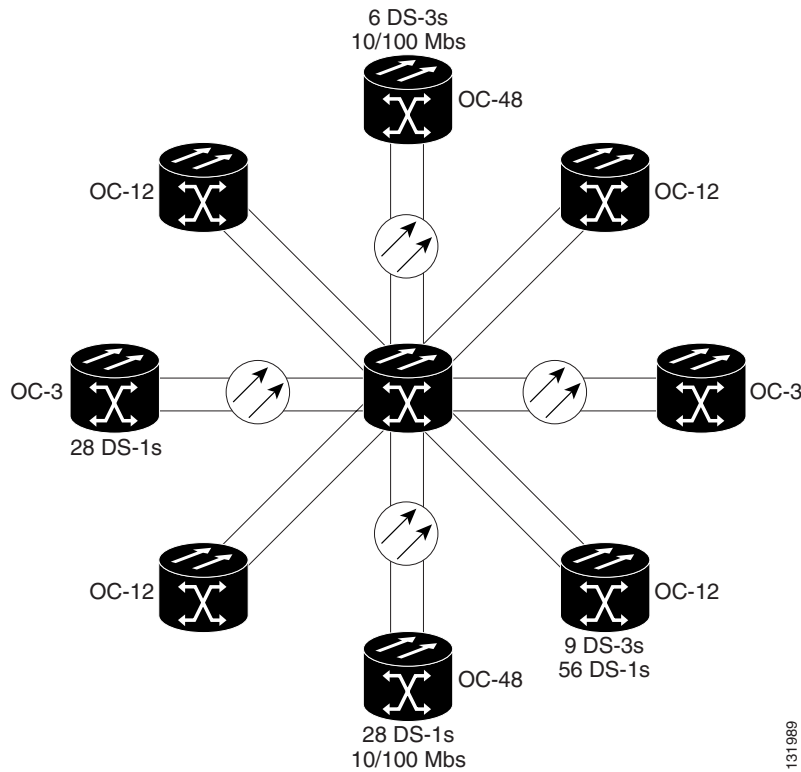
As an aggregator, the ONS 15454 combines the traffic from several low-speed sources for transmission across a high-speed link to another ONS 15454 node as illustrated in [Figure 9-20](#).

**Figure 9-20** *Traffic Aggregation Application*

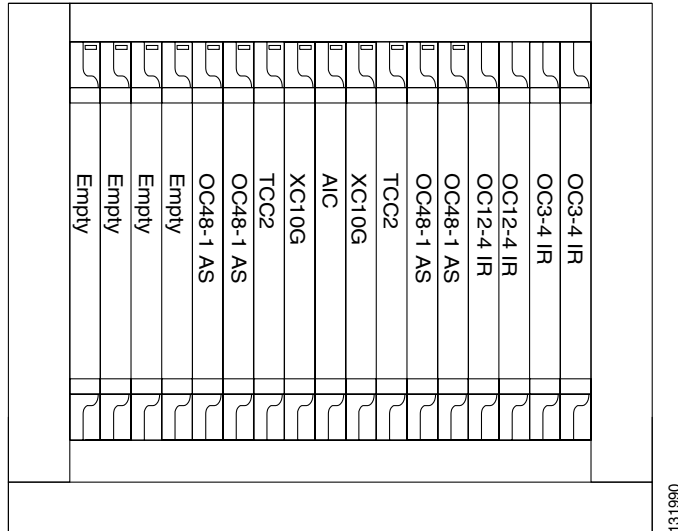
# Optical Hub

The multi-service flexibility and shelf capacity of the ONS 15454 enables a single shelf to act as an optical hub. As an optical hub, a single ONS 15454 can support multiple linear or ring systems. Traffic can be groomed and routed through an optical hub. [Figure 9-21](#) shows an optical hub supporting two OC-48, four OC-12, and three OC-3 terminations.

**Figure 9-21 Optical Hub Application**



[Figure 9-22](#) shows the shelf layout for the optical hub node in [Figure 9-21](#).

**Figure 9-22 Optical Hub Shelf Layout**

## Digital Cross-Connect Applications

The ONS 15454 digital cross-connect system (DCS) capabilities provide full STS and VT1.5 matrices to facilitate traffic grooming and consolidation. This allows the ONS 15454 to act as a 3/1 and/or 3/3 DCS. The DCS functionality is key to traffic grooming where you take a series of partially filled STSs and consolidate them into a few tightly packed STSs.

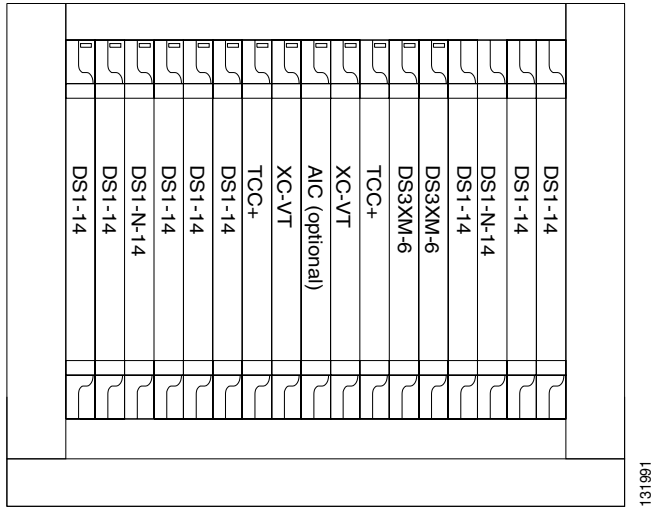
### 3/1 DCS

The VT Cross-connect (XCVT) and DS3XM (transmux) cards enable 3/1 DCS functionality. DS-1s, DS-3s and VT1.5 signals are mapped into STS circuits. The ONS 15454 can take several partially filled DS-3s and combine them into one DS-3. This ensures that the SONET ring is full of used channels, not idle channels.

The ONS 15454 also performs Time Slot Interchange (TSI) and in addition to cross-connecting. This allows signals to be groomed at the edge of the network, which can reduce or eliminate the need for expensive DCSs and fan out ports to the DCSs at a central office.

[Figure 9-23](#), [Figure 9-24](#), [Figure 9-25](#), and [Figure 9-26](#) show rack and shelf layouts for 3/1 DCS applications:

**Figure 9-23 Single Shelf 3/1 DCS 112 DS1 Ports and 6 DS3 Transmux Ports**



**Figure 9-24 Two Shelf 3/1 DCS with 140 DS1 Ports and 18 DS3 Transmux Ports**

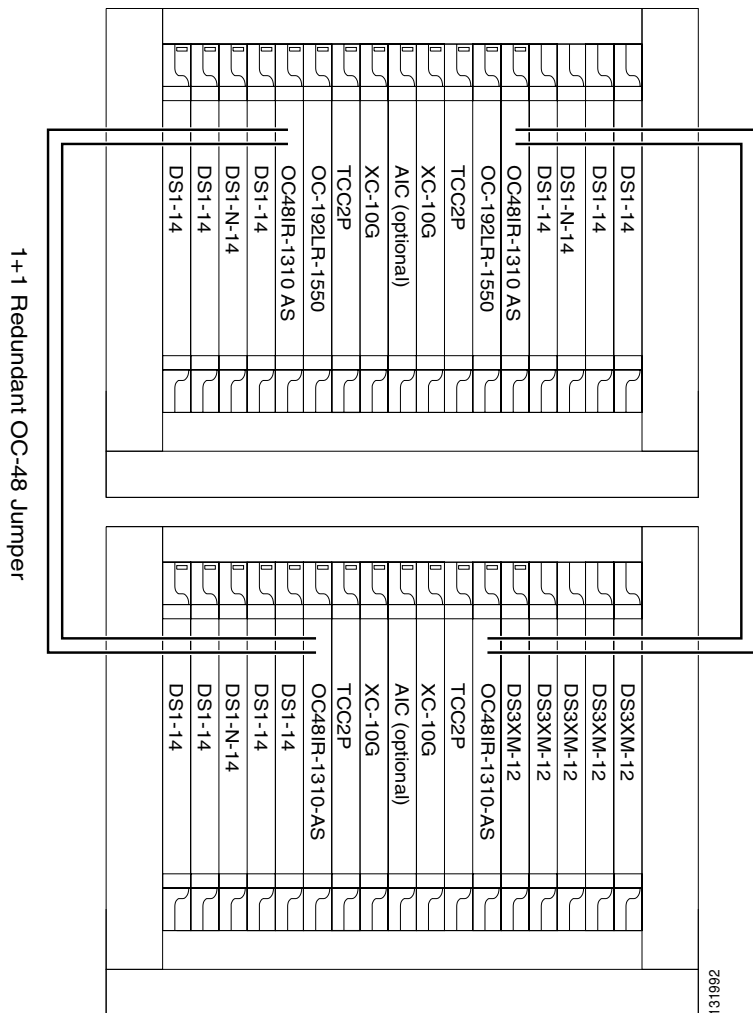
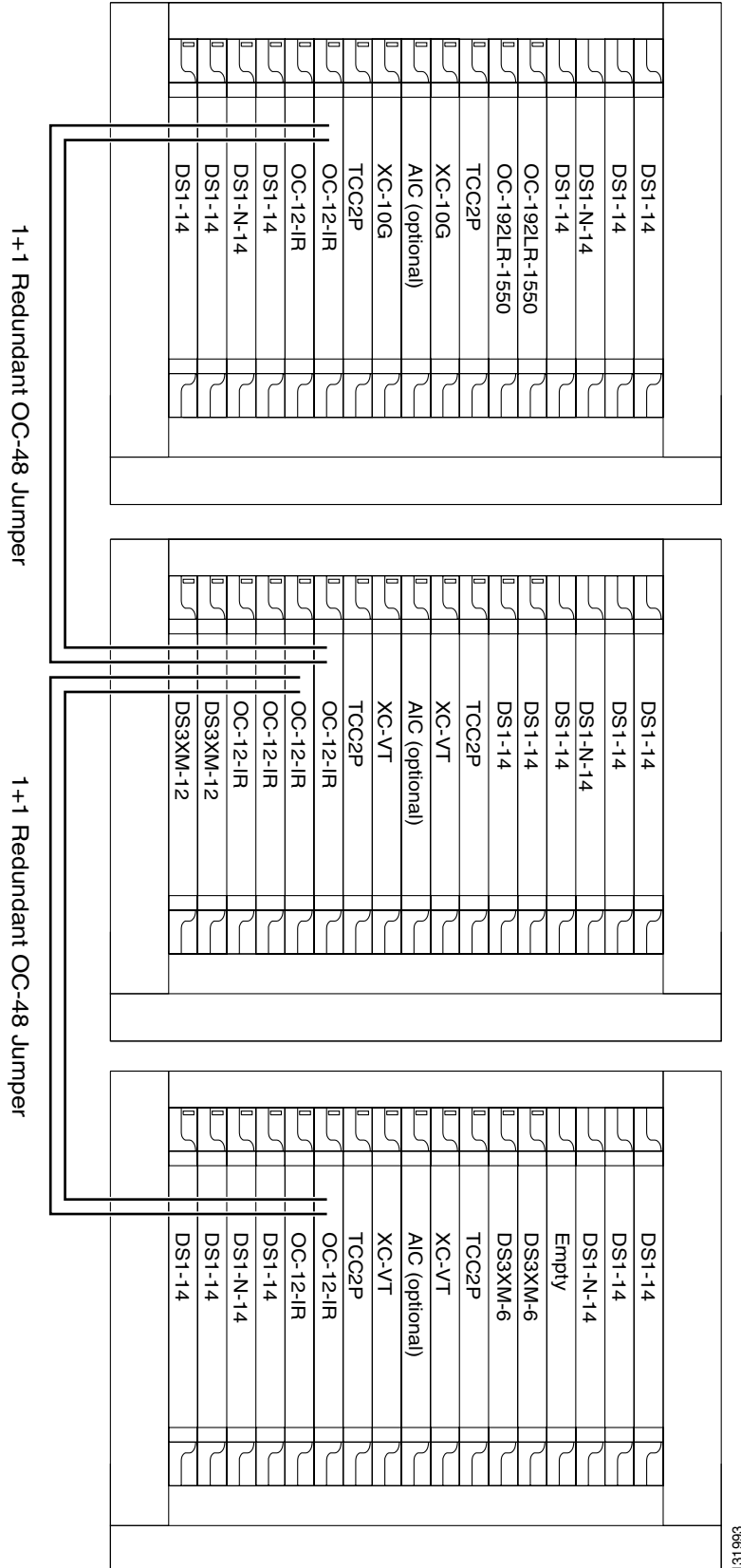


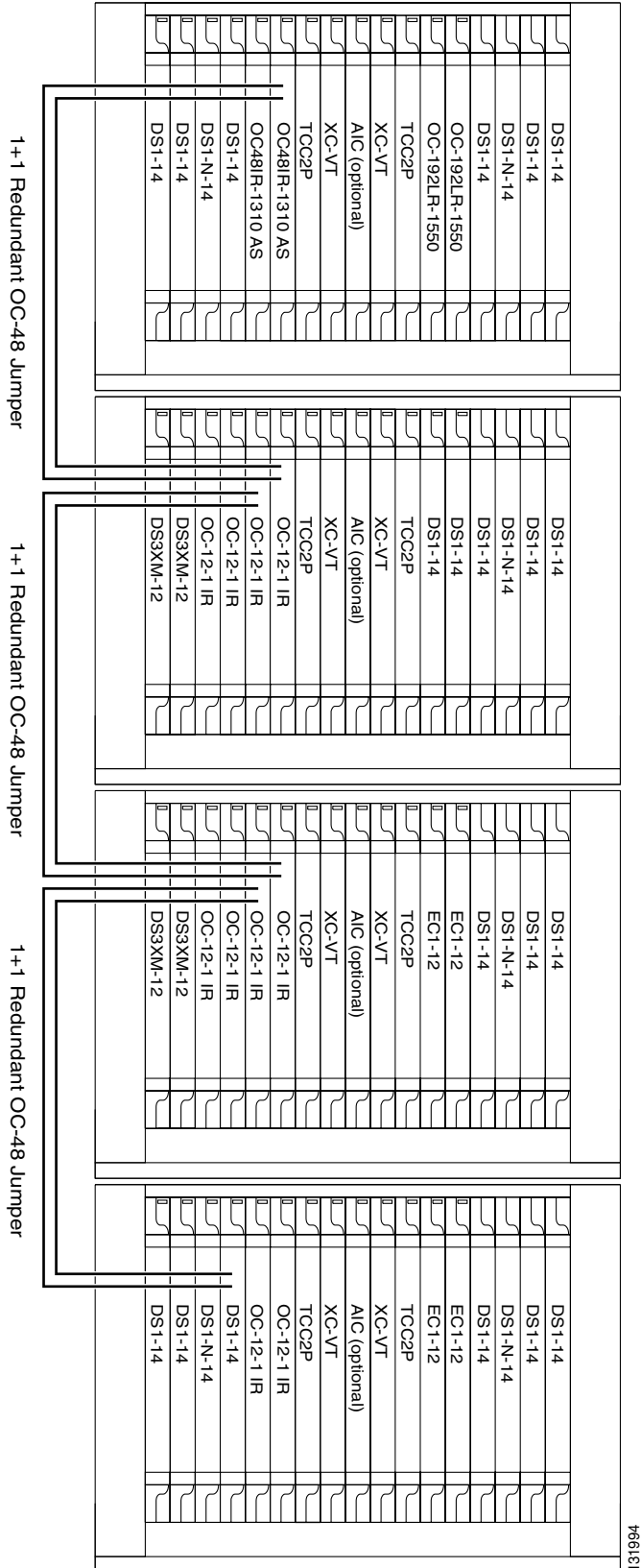
Figure 9-25 Three-shelf 3/1 DCS with 224 DS1 ports, 18 DS3 Transmux ports, and 12 STS1 ports



998131



Figure 9-26 Four Shelf 3/1 DCS with 280 DS1 ports, 24 DS3 Transmux Ports, and 24 STS1 Ports



466181

## 3/3 DCS

The ONS 15454 also has an integrated 3/3 cross-connect, which is ideal for grooming DS-3s and STSs prior to passing them into a core network. A typical 3/3 DCS application for the ONS 15454 is at IOF sites where local loops converge.

Table 9-2 lists the 3/3 DCS configurations supported by the ONS 15454.


**Note**

The DS-3 capacity will be reduced if you assign OC-N modules to card slots optimized for DS-3 traffic.

**Table 9-2** 3/3 DCS Configurations and Capacities

Configuration	Tributaries
192 DS3/EC1 Ports	DS-3s or STS-1s
384 DS3/EC1 Ports	DS-3s or STS-1s
576 DS3/EC1 Ports	DS-3s or STS-1s
768 DS3/EC1 Ports	DS-3s or STS-1s

Figure 9-27, Figure 9-28, Figure 9-29, and Figure 9-30 show the rack and shelf layouts for the 3/3 DCS applications:

**Figure 9-27** 3/3 DCS Application with 192 DS-3/STS-1 Ports

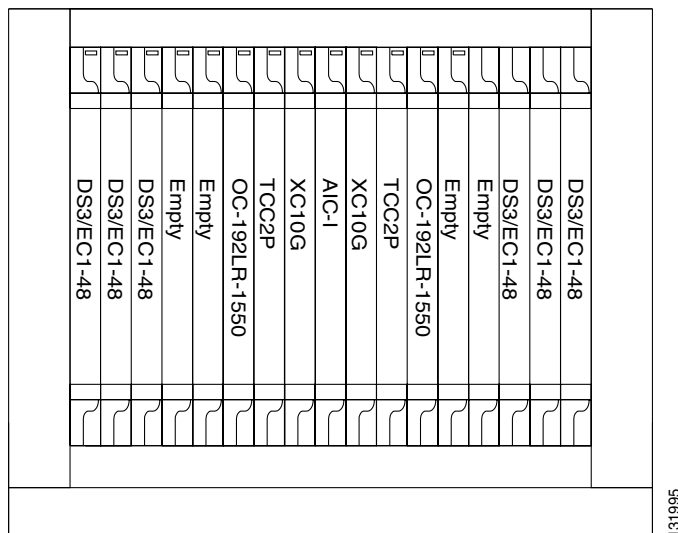


Figure 9-28 3/3 DCS Application with 264 DS-3 Ports

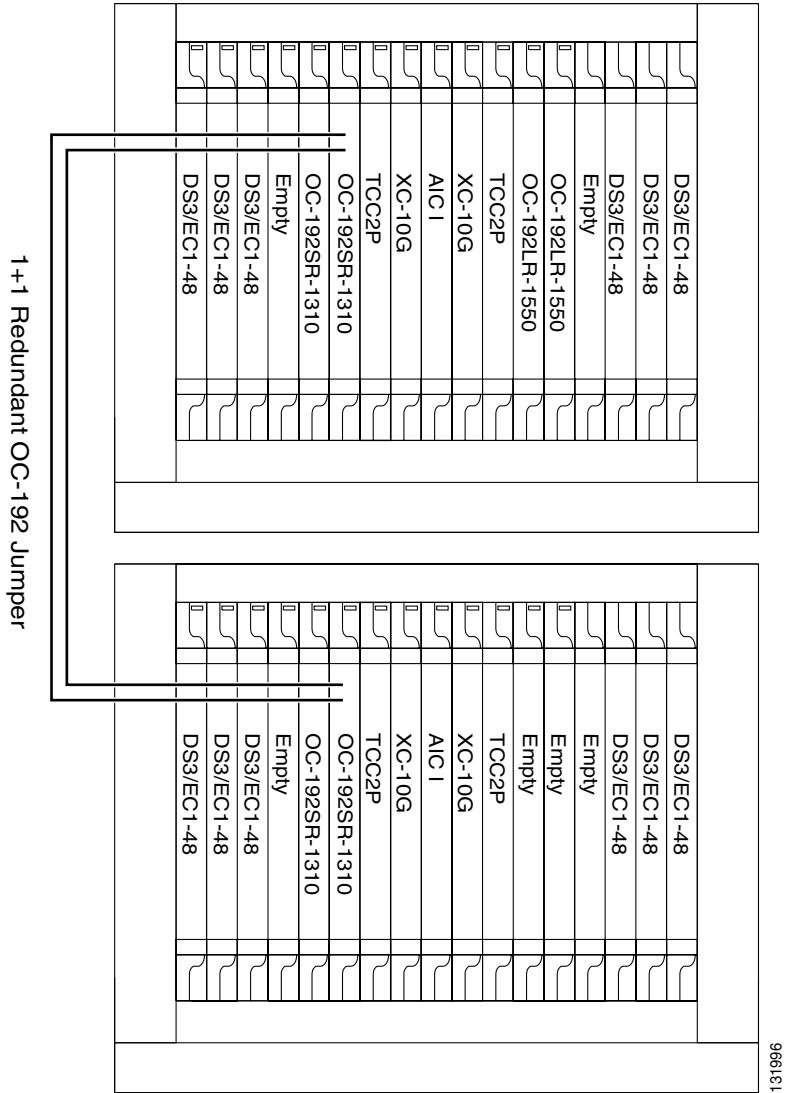


Figure 9-29 3/3 DCS Application with 336 DS-3 Ports

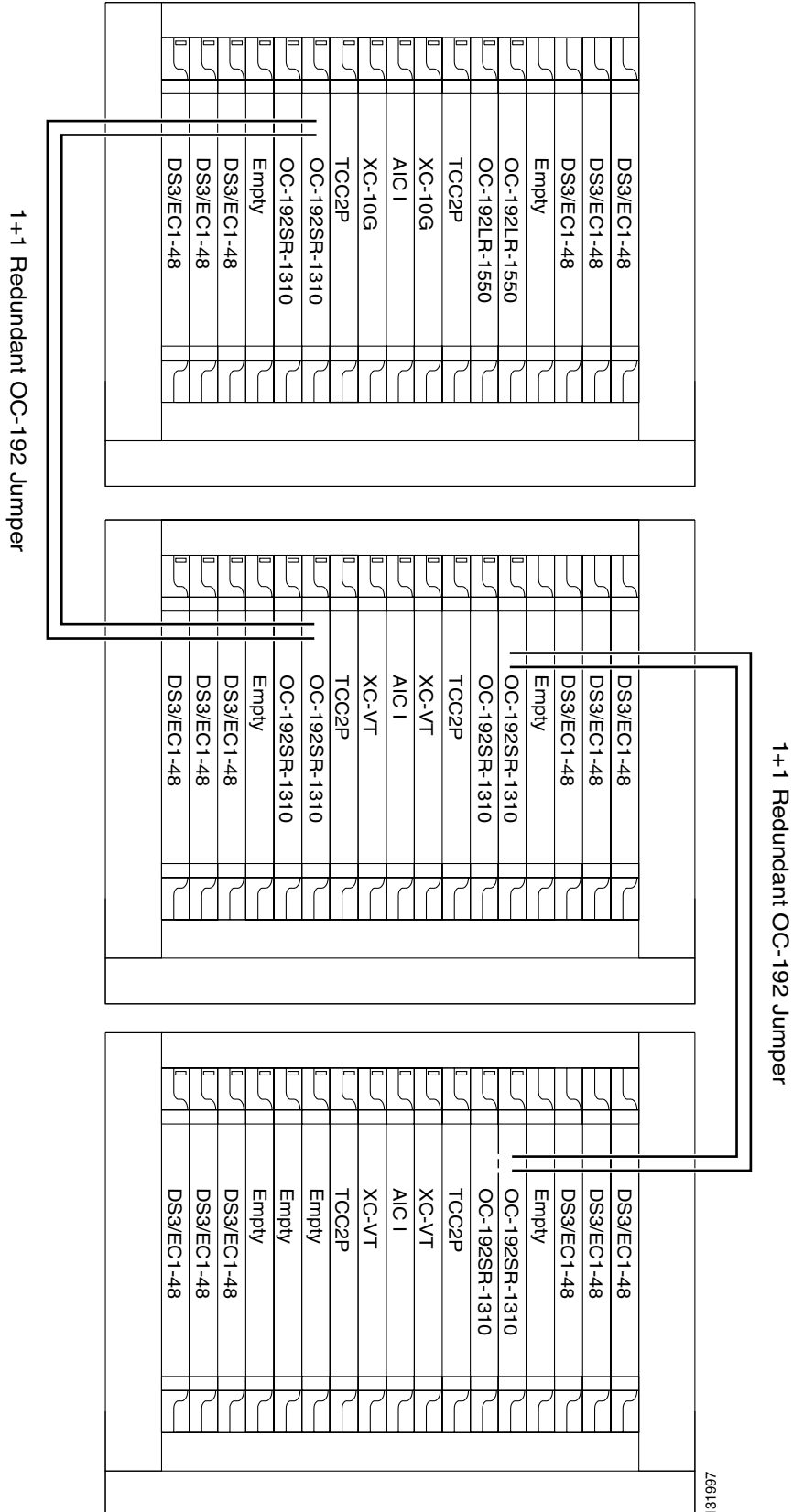
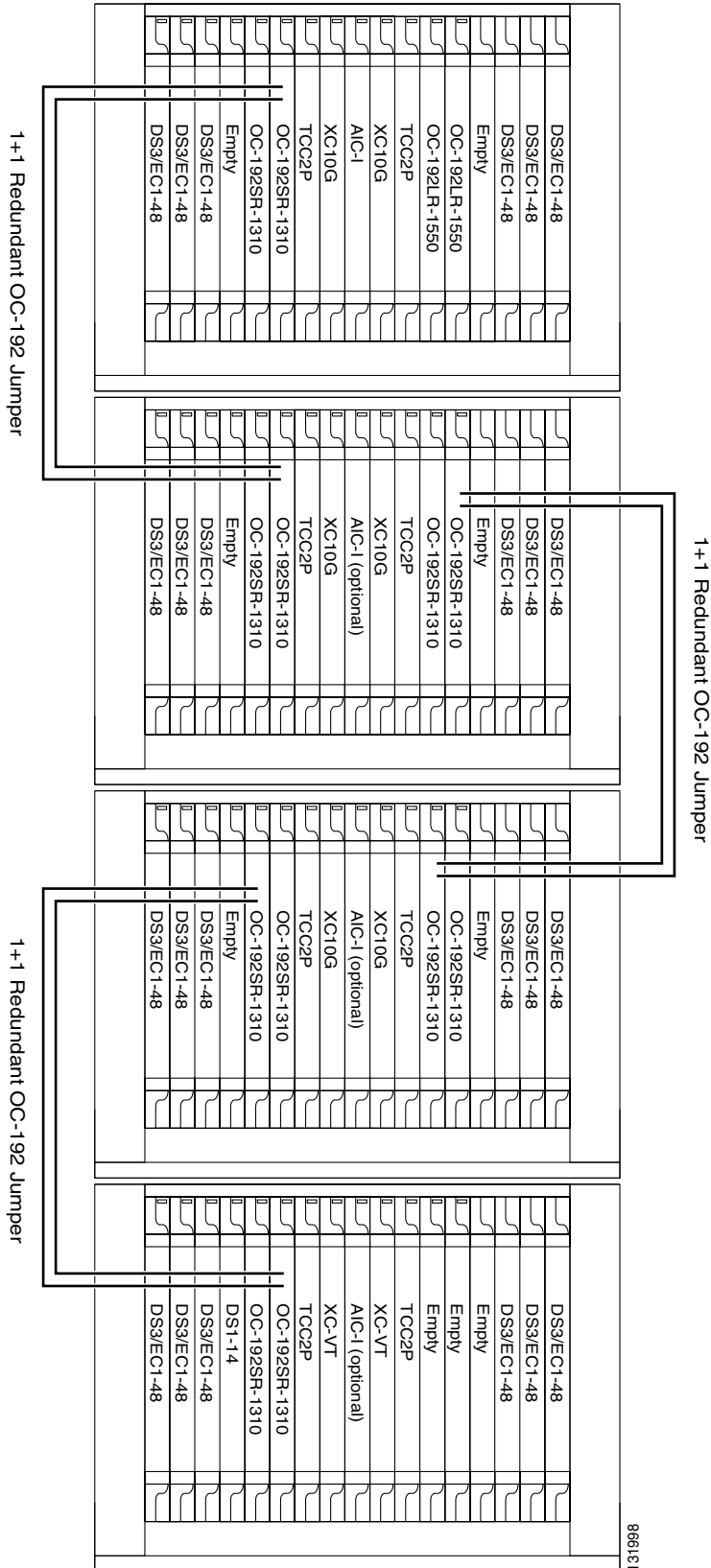


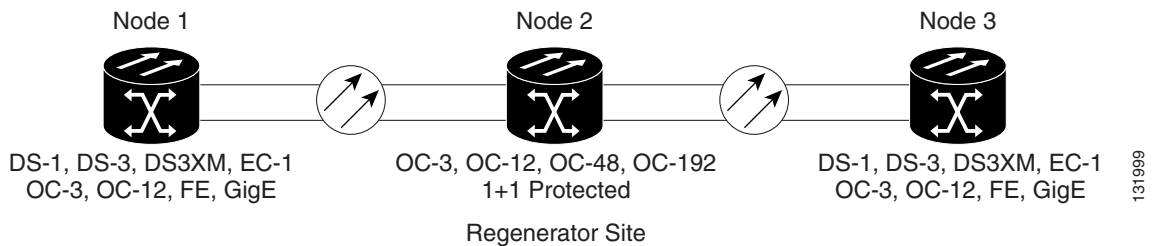
Figure 9-30 3/3 DCS Application with 768 DS-3/STS-1 Ports



# Regenerator Site

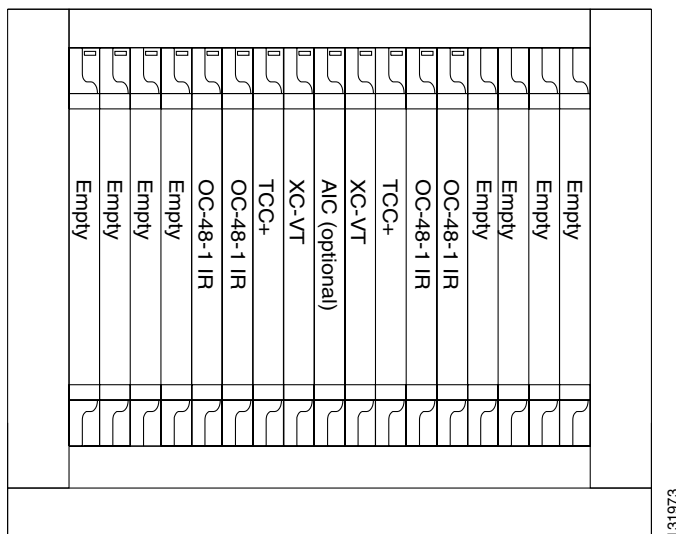
The ONS 15454 can be configured as an effective regenerator. An added benefit of this configuration is that when new services are needed at the regenerator, you simply add an interface card to the ONS 15454 to support the services. This does not require any new software or network engineering, just plug in the interface card and turn up the service. [Figure 9-31](#) shows the ONS 15454 supporting a regenerator configuration for a linear ADM network. The ONS 15454 can also act as a regenerator for other SONET topologies including path protection, BLSR, and virtual rings, and PPMN meshes. Adding new interface cards and activating new services is non-service affecting.

**Figure 9-31 Regenerator Application for a Linear Network**



Regenerators are popular for long-haul systems where signal regeneration and future access to traffic is required. Another popular configuration is the extension of digitized video traffic to other sites to eliminate the costs of building a new headend site. However, the most exciting application is the pre-positioning of SONET terminals as future service nodes. The continuing reduction in SONET costs has made this a feasible deployment option. The ONS 15454 supports this application since an ONS 15454 can be configured to support terminal mode, ADM, ring, hub, and regenerator applications. [Figure 9-32](#) shows the shelf layout for the ONS 15454 OC-48 regenerator node shown in [Figure 9-31](#).

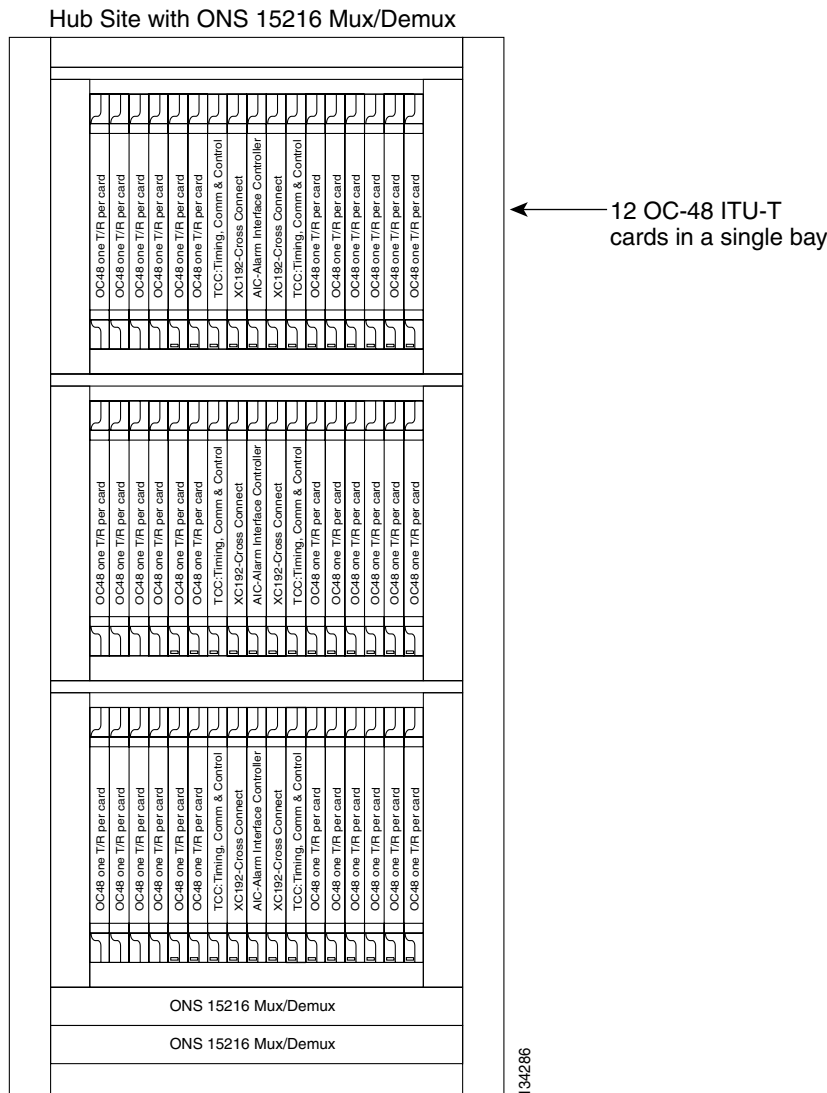
**Figure 9-32 OC-48 Regenerator Node Shelf Layout**



# Passive DWDM Applications

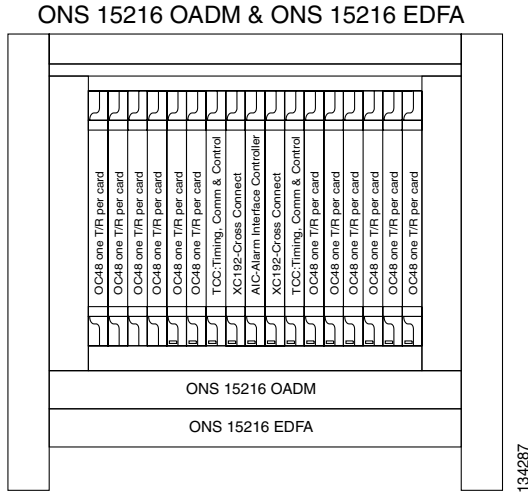
The ONS 15454 supports 18 different OC48 ELR ITU-T 200 GHz, 37 OC48 ELR ITU-T 100 GHz cards, or OC192 LR ITU-T 1000Hz to provide you with up to 320 Gb/s of bandwidth over a single fiber. Deployed where fiber routes are constrained, this fiber bandwidth leverages the installed fiber resources and reduces the need to install new fiber. Matching the ONS 15454 ITU-T cards with the ONS 15216 passive DWDM filters greatly expands the capabilities of the ONS 15454. [Figure 9-33](#) shows a typical 7ft. x 19in. rack layout for a DWDM hub site using ONS 15454 OC48 ELR ITU-T cards and multiplexers and demultiplexers.

**Figure 9-33 DWDM Hub Site Layout**



[Figure 9-34](#) is an example of an optical add/drop multiplexer (OADM) site where multiple channels can be dropped an inserted. The 7ft. x 19in. rack is equipped with a single ONS 15454 shelf containing the ONS 15454 OC48 ELR ITU-T optics cards, OADM unit, and EDFA.

**Figure 9-34 OADM Site Shelf Layout**



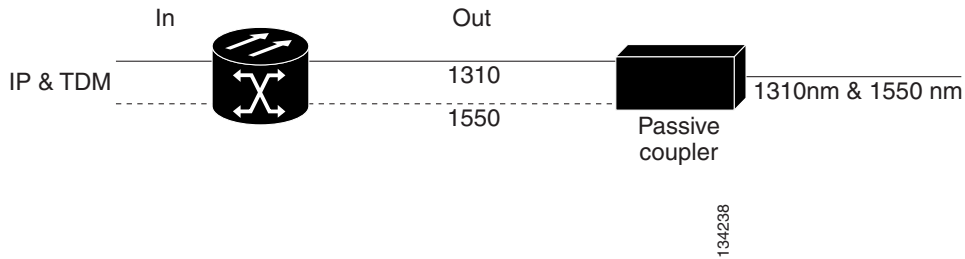
## Wavelength Multiplexer

The multi-wavelength capabilities of the ONS 15454 allow it to easily interface with passive WDM filters.

Since the WDM/DWDM systems are transparent to the ONS 15454, all of the topologies described in this document can be run over WDM/DWDM networks. This includes linear networks, rings, data meshes, PPMN and Virtual rings.

1310 nm and 1550 nm OC-48 and OC-12 cards can be passed through inexpensive passive couplers to be multiplexed over a single fiber. See [Figure 9-35](#).

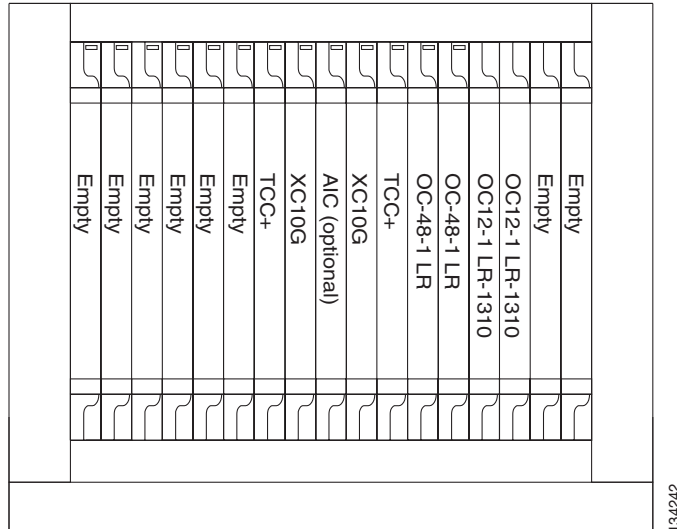
**Figure 9-35 Passive DWDM Interface**



[Figure 9-36](#) shows the shelf layout for an ONS 15454 Passive Wavelength Multiplexing node.



**Figure 9-36** *Passive Wavelength Multiplexing Node*



## MSTP DWDM Applications

Cisco ONS 15454 MSTP nodes can be provisioned for metro access and metro core DWDM network applications. Metro access networks are 60 km or less in size. Channels are not equalized and dispersion compensation is not applied. Metro access networks have few spans and very low span loss, so the signal link budget is the limiting factor for performance. Metro core networks can be up to 400 km in size. The channel power is equalized and dispersion compensation is applied. Metro core networks often include multiple spans and amplifiers, so the optical signal-to-noise ratio (OSNR) is the limiting factor for channel performance in metro core networks.

Within DWDM networks, the ONS 15454 uses a communications protocol, called node services protocol (NSP), to communicate with other nodes. NSP automatically updates nodes whenever a change in the network occurs. Each ONS 15454 DWDM node can:

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

For ONS 15454 MSTP DWDM node configurations, refer to Chapter 4 in this document.

## Ethernet Applications

The Cisco ONS 15454 integrates Ethernet into a SONET time-division multiplexing (TDM) platform. The ONS 15454 supports CE-, E-, G-, and ML-Series Ethernet cards.

The CE-Series card is the CE-100T-8, which is a Layer 1 mapper card with eight 10/100 Ethernet ports. It maps each port to a unique SONET circuit in a point-to-point configuration. The CE-100T-8 card allows you to provision and manage an Ethernet private line service like a traditional SONET line. CE-100T-8 card applications include providing carrier-grade Ethernet private line services and high-availability 10/100 Mb/s data transport.

The CE-100T-8 has eight POS ports, numbered one through eight. Each POS port is statically mapped to a matching Ethernet port. Each POS port terminates an independent contiguous SONET concatenation (CCAT) or virtual SONET concatenation (VCAT). The CE-100T-8 supports circuit sizes from VT1.5-nV (n= 1 to 64) to STS-3c.

The ONS 15454 E-Series cards include the E100T-12, E100T-G, E1000-2, and E1000-2-G. An ONS 15454 supports a maximum of ten E-Series cards, however Cisco recommends that you place no more than four 12-port Ethernet cards in a single shelf. You can insert these cards in slots 1 - 6 and 12 - 17. Use the E-Series cards if your application requires Layer 2 switching. These cards support point-to-point, hub and spoke, and shared packet ring topologies with a maximum circuit size of STS-12c.

The G-Series cards include the G1000-4 and G1K-4. These cards map up to four Gigabit Ethernet interfaces onto a SONET transport network. G-Series cards provide scalable and provisionable transport bandwidth at signal levels up to STS-48c per card. The G-Series cards provide line rate forwarding for all Ethernet frames (unicast, multicast, and broadcast) and can be configured to support Jumbo frames (defined as a maximum of 10,000 bytes). Use the G-Series cards if your application is for an Ethernet private line service providing transparent LAN services (TLS), line rate GigE, and high-availability transport for applications such as storage over MAN/WANs. You can independently map the four ports on the G-Series card to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, and STS-48c circuit sizes, provided the sum of the circuit sizes that terminate on a card do not exceed STS-48c.

The ML-Series cards consist of the ML100T-12 and ML-1000-2. These cards integrate high-performance Ethernet transport, switching, and routing into a single card. Use the ML-Series cards if your application calls for Layer 2 bridging and/or Layer 3 routing, switching, or forwarding of data packets. ML-Series cards can be installed in any of the multipurpose slots. For a description of ML-Series software features and configuration files, see the *Cisco ONS 15454 Ethernet Card Software Feature and Configuration Guide*.

The ONS 15454 is designed to be located at the edge and core of the network to provide Ethernet transport between Enterprise locations, data centers, remote sites, and Internet service providers (ISPs). Use [Table 9-3](#) to select the Ethernet card and features for your application. For more information about Cisco ONS 15454 Ethernet cards and software configurations, refer to the *Cisco Ethernet Card Software Feature and Configuration Guide*.

**Table 9-3 Supported Ethernet Features**

Card Type	10/100 Interfaces	GE Interfaces	Shelf Assembly	Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q in Q VLAN Tagging	GFP Support
CE-100T-8	8	—	15454-SA-A NSI 15454-SA-H D	> R5.0.2	Transparent	Transparent	Transparent	Yes
E100T-12	12	—	All	> R2.0	509	Configurable	Linear Mode	—
E100T-12G	12	—	All	> R2.0	509	Configurable	Linear Mode	—
E1000-2	—	2	All	> R2.0	509	Configurable	Linear Mode	—
E1000-2-G	—	2	All	> R2.0	509	Configurable	Linear Mode	—

Table 9-3 Supported Ethernet Features (continued)

Card Type	10/100 Interfaces	GE Interfaces	Shelf Assembly	Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q in Q VLAN Tagging	GFP Support
G1000-4	—	4	15454-SA-A NSI 15454-SA-H D	> R3.2	Transparent	Transparent	Transparent	—
G1K-4	—	4	15454-SA-A NSI 15454-SA-H D	> R3.2	Transparent	Transparent	Transparent	—
ML100T-12	12	—	15454-SA-A NSI 15454-SA-H D	> R4.0	255 Logical VLANs, 900 VLAN Subinterface s	Configurabl e	Yes	Yes
ML1000-2	—	2	15454-SA-A NSI 15454-SA-H D	> R4.0	255 Logical VLANs, 900 VLAN Subinterface s	Configurabl e	Yes	Yes <sup>1</sup>
Card Type	VCAT Support	LCAS Support	Maximum Frame Size	Broadcast and Multicast Support	Spanning Tree Support	Resilient Packet Ring (RPR)	Rate Limiting	Maximum Circuit Size
CE-100T-8	HO, LO	Yes	1548 bytes	Point-to-P oint <sup>1</sup>	Transparent	—	VT1.5-nV (n= 1 to 64) to STS-1-2v	STS-3C (100 Mb/s)
E100T-12	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
E100T-12G	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
E1000-2	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
E1000-2-G	—	—	1522 bytes	Limited to 9-12 kb/s	Yes, 8 instances	—	STS-1 to STS-12C	STS-12C
G1000-4	—	—	10,000 bytes	Point-to-P oint <sup>1</sup>	Transparent	—	STS-1 to STS-24C	STS-48C
G1K-4	—	—	10,000 bytes	Point-to-P oint <sup>1</sup>	Transparent	—	STS-1 to STS-24C	STS-48C

**Table 9-3 Supported Ethernet Features (continued)**

Card Type	10/100 Interfaces	GE Interfaces	Shelf Assembly	Software Release	802.1Q VLAN Support	802.1Q VLAN Filtering	Q in Q VLAN Tagging	GFP Support
ML100T-12	HO <sup>2</sup>	SW-LCAS <sub>3</sub>	10,000 bytes	Yes <sup>4</sup>	Yes, 255 STP and RSTP instances	Yes	1 Mb/s increments at port level	STS-24C
ML1000-2	HO <sup>2</sup>	SW-LCAS <sub>3</sub>	10,000 bytes	Yes <sup>4</sup>	Yes, 255 STP and RSTP instances	Yes	1 Mb/s increments at port level	STS-24C

1. Multicast support limited to port-to-port circuits.
2. Requires Software Release 5.0 or higher.
3. Cisco's proprietary software link capacity adjustment scheme (SW-LCAS) is the software implementation of a LCAS-type feature. SW-LCAS differs from LCAS because it is not errorless and uses a different handshaking mechanism.
4. No IGMP snooping, which allows multicast to be treated as broadcast.

## Ethernet Private Line

The CE- and G-Series cards allow you to provision and manage an Ethernet private line service like a traditional SONET line. Ethernet private lines provide carrier-grade transparent LAN services (TLS) between two ONS 15454 nodes. No VLAN knowledge or layer 2 provisioning is required in this application. Only simple provisioning of STS cross-connects is required.

The Ethernet frame from the data network is transmitted on the Ethernet cable into the standard RJ-45 port on a CE-100T-8 card. The CE-100T-8 card transparently maps Ethernet frames into the SONET payload using packet-over-SONET (POS) encapsulation. The POS circuit with its encapsulated Ethernet inside is then multiplexed onto an OC-N card like any other SONET STS.

The G1000-4 and G1K4 cards map a single Ethernet port to a single STS circuit. You can independently map the four ports on a G-Series card to any combination of STS-1, STS-3c, STS-6c, STS-9c, STS-12c, STS-24c, and STS-48c circuit sizes, provided that the sum of the circuit sizes that terminate on a card do not exceed STS-48c.

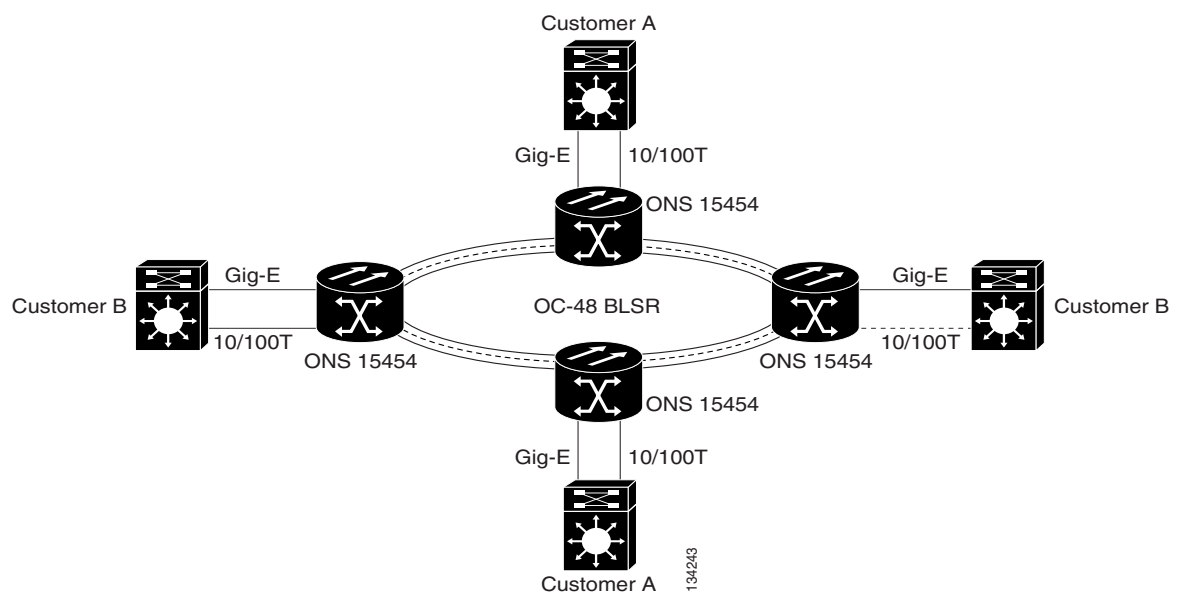
Standard SONET path protection configurations/BLSRs provide less than 50 milliseconds restoration of service for Ethernet private line transport. [Figure 9-37](#) illustrates an example of an Ethernet Private Line application. In this example, data traffic from the Fast Ethernet port of a switch travels across the point-to-point circuit to the Fast Ethernet port of another switch.

**Figure 9-37 Ethernet Private Line**

## Transparent LAN Service

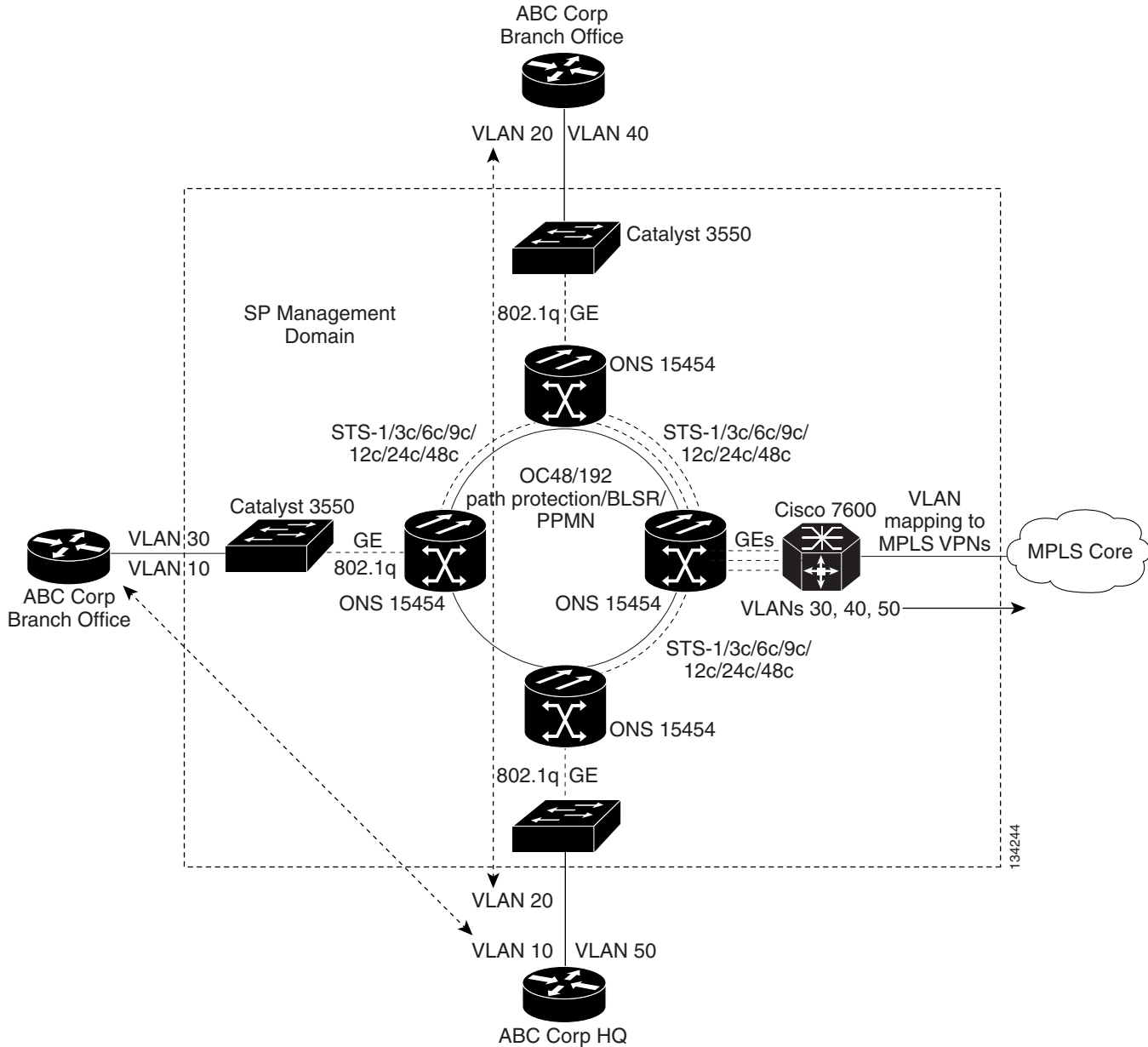
A transparent LAN service (TLS) is a Virtual Ethernet Connection (VEC) that appears to act as an Ethernet wire, where all Ethernet traffic is seen by all remote ends. The customer only sees its end devices and the traffic generated or going through these equipments. In other words, the Metro network devices do not send any Protocol Data Units (PDUs) to the customer network. The Layer 2 protocols such as STP, CDP, VTP and EtherChannel must be transported transparently across the TLS as they would be over "dark fiber". The Metro network appears as an Ethernet segment to the customer. In addition, this service must allow any number of customer VLANs to be tunneled together the Metro network run, so that the customer is not limited by number nor forced by the service provider to use specific assigned VLANs. This service is a multi-point to multi-point connection type of service illustrated in [Figure 9-38](#).

**Figure 9-38** Transparent LAN Service Architecture



As illustrated on the [Figure 9-39](#), several types of services can be delivered through the same client network interface with this architecture. The TLS between the corporate office and the branch offices (VLAN 10 and 20) and Access to MPLS VPNs are delivered over the same UNI and GE circuits. The Ethernet Virtual Circuit Service is locally switched and is indicated logically by the dashed arrows (VLANs 10, 20). Access to the corporate network is provided via mapping VLANs (30, 40, and 50) to MPLS VPNs in the SONET network. Both of these services can operate at the same time over the same UNI. Only three STSs or Virtual Circuits (VCs) are needed to provision these two services.

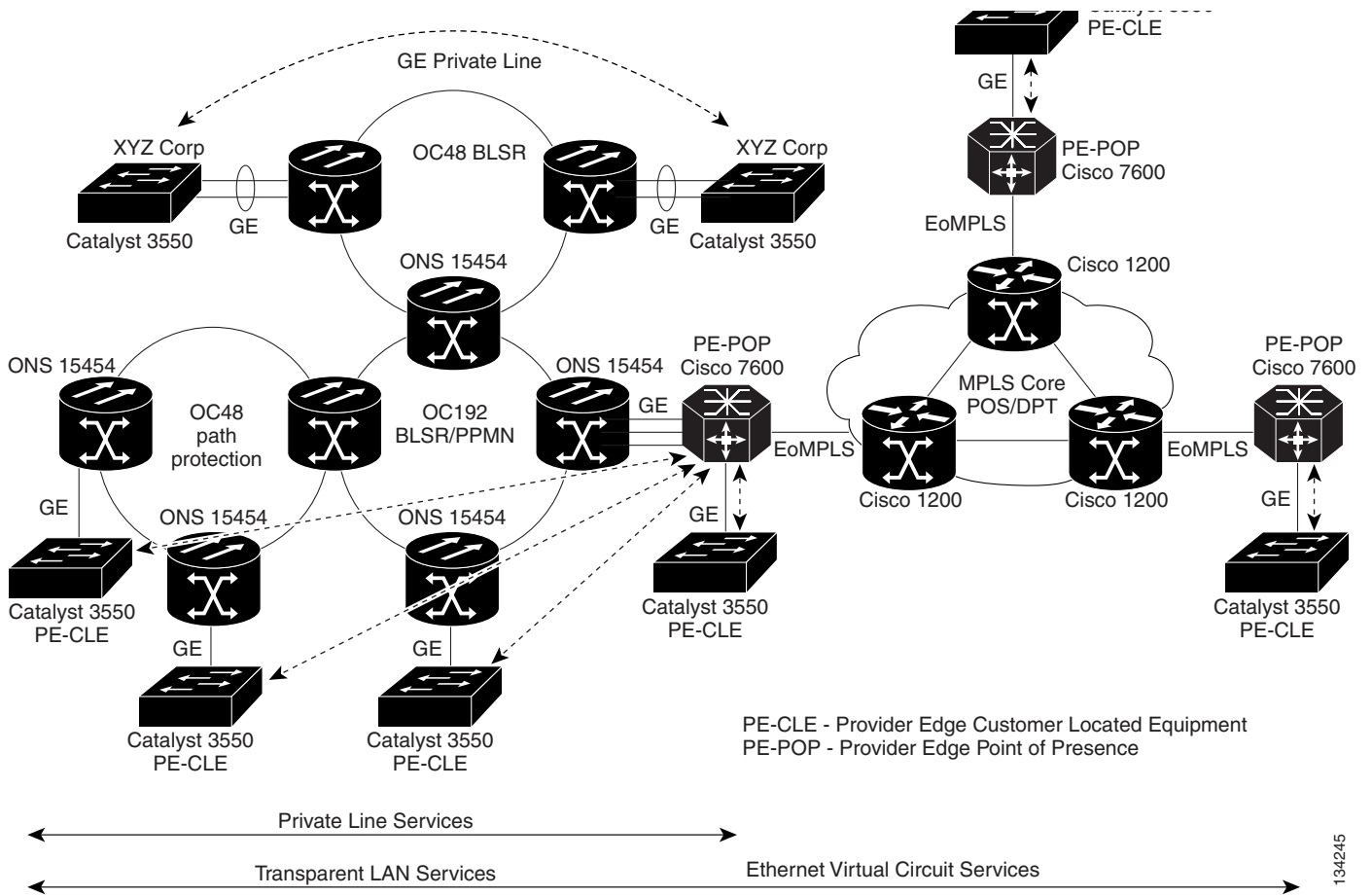
Figure 9-39 Transparent LAN Service Example



## Metro Ethernet Solution

A complete Metro Ethernet solution illustrating TLS and GE private line services or Ethernet Virtual Circuit services is shown in [Figure 9-40](#). The G-Series cards support frame forwarding for unicast, multicast, and broadcast traffic, so Multicast traffic can be transported transparently by this TLS Metro Ethernet solution over the optical Metro network.

Figure 9-40 Metro Ethernet Solution



## Resilient Packet Ring

Resilient Packet Ring (RPR) is an emerging network architecture designed for metro fiber ring networks. This new MAC protocol is designed to overcome the limitations of IEEE 802.1D Spanning Tree Protocol (STP), IEEE 802.1W Rapid Spanning Tree Protocol (RSTP), and SONET in packet-based networks. RPR operates at the Layer 2 level and is compatible with Ethernet and SONET.

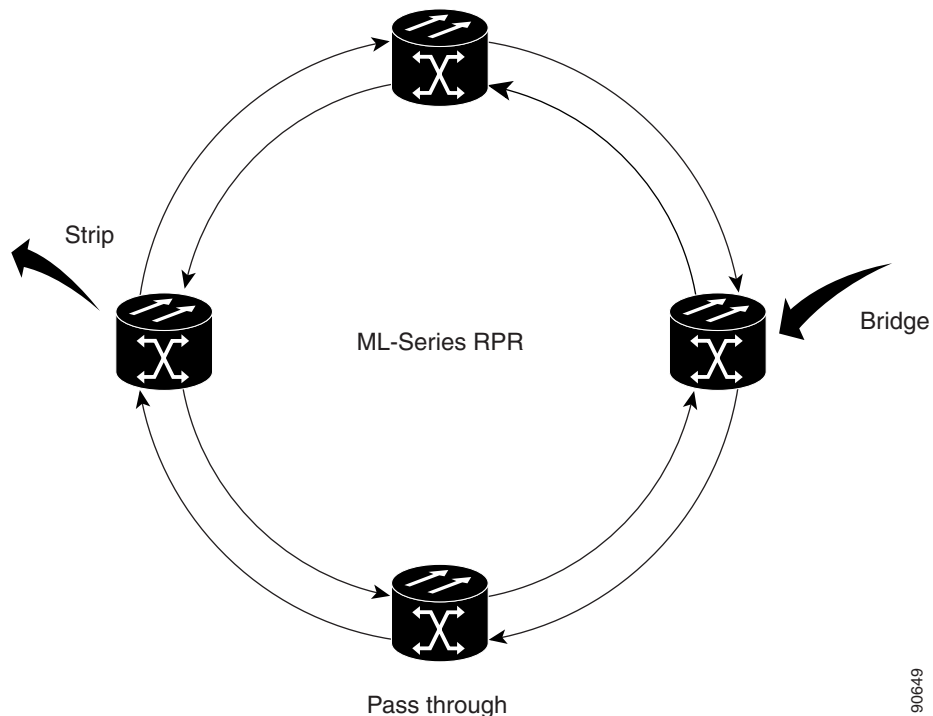
The ML-Series card's RPR relies on the quality of service (QoS) features of the ML-Series card for efficient bandwidth utilization with service level agreement (SLA) support. ML-Series card QoS mechanisms apply to all SONET traffic on the ML-Series card, whether passed-through, bridged, or stripped.

When a ML-Series card is configured with RPR and made part of a shared packet ring (SPR), the ML-Series card assumes it is part of a ring. If a packet is not destined for devices attached to the specific ML-Series, the ML-Series card simply continues to forward this transit traffic along the SONET circuit, relying on the circular path of the ring architecture to guarantee that the packet will eventually arrive at the destination. This eliminates the need to queue and forward the packet flowing through the nondestination ML-Series card. From a Layer 2 or Layer 3 perspective, the entire RPR looks like one shared network segment.

RPR supports operation over protected and unprotected SONET circuits. On unprotected SONET circuits, RPR provides SONET-like protection without the redundant SONET protection path. Eliminating the need for a redundant SONET path frees bandwidth for additional traffic. RPR also incorporates spatial reuse of bandwidth through a hash algorithm for east/west packet transmission. RPR utilizes the entire ring bandwidth and does not need to block ring segments like STP or RSTP.

Because STP or RSTP is not in effect between nodes when RPR is configured, the transmitting RPR port strips its own packets after they return from circling the ring. A hash algorithm is used to determine the direction of the packet around the RPR. [Figure 9-41](#) illustrates how RPR handles this operation.

**Figure 9-41 RPR Packet Handling Operations**



## Configuring ML-Series Cards for RPR

RPR on the Cisco ONS 15454 enables two or more ML-Series cards to become one functional network segment or SPR. The bridged ML-Series cards are connected to each other through point-to-point STS circuits, which use one of the first ML-Series card's POS ports as a source and one of the second ML-Series card's POS ports as a destination. All ML-Series cards in an SPR must be connected directly or indirectly by point-to-point circuits.

The point-to-point circuits use the ONS 15454 SONET network for transport and protection. Provision the point-to-point circuits using Cisco Transport Controller (CTC) or TL1 in the same manner as an ONS 15454 OC-N card STS circuits. The Cisco ONS 15454 Procedure Guide or the Cisco ONS 15454 Procedure Guide provides specific instructions about how to create an automatically routed optical circuit.

When configuring a point-to-point circuit on the ML-Series perform the following:



- Leave all CTC Circuit Creation Wizard options at default, except Fully Protected Path on the Circuit Routing Preferences dialog box, which provides SONET protection and should be unchecked. RPR provides Layer 2 protection for SPR circuits.
- Check Using Required Nodes and Spans to route automatically in the Circuit Routing Preferences dialog box. If the source and destination nodes are adjacent on the ring, exclude all nodes except the source and destination in the Circuit Routing Preferences dialog box. This forces the circuit to be routed directly between source and destination and preserves STS circuits, which would be consumed if the circuit routed through other nodes in the ring. If there is a node or nodes that do not contain an ML-Series card between the two nodes containing ML-Series card, include this node or nodes in the included nodes area in the Circuit Routing Preference dialog box, along with the source and destination nodes.
- Keep in mind that ML-Series card STS circuits do not support unrelated circuit creation options, such as unidirectional traffic, creating cross-connects only (TL1-like), interdomain (unified control plane [UCP]), protected drops, or path protection path selectors.

After the CTC circuit process is complete, begin a Cisco IOS session to configure RPR/SPR on the ML-Series card and interfaces.

**Note**

A best practice is to configure SONET circuits in an east-to-west or west-to-east configuration, from Port 0 (east) to Port 1 (west) or Port 1 (east) to Port 0 (west), around the SONET/SDH ring. Do not configure Port 0 to Port 0 or Port 1 to Port 1. The east-to-west or west-to-east setup is required for the Cisco Transport Manager (CTM) network management software to recognize the ML-Series configuration as an SPR.

## Configuring Cisco IOS on the ML-Series Cards for RPR/SPR

You configure RPR on the ML-Series cards by creating an SPR interface from the Cisco IOS CLI. The SPR is a virtual interface, similar to an EtherChannel interface. The POS interfaces are the physical interfaces associated with the RPR SPR interface. An ML-Series card supports a single SPR interface. The SPR interface has a single MAC address and provides all the normal attributes of a Cisco IOS interface, such as support for default routes. An SPR interface is considered a trunk port, and like all trunk ports, subinterfaces must be configured for the SPR interface to become part of a bridge group.

An SPR interface is configured similarly to a EtherChannel (port-channel) interface. The members of the SPR interface must be POS interfaces. Instead of using the channel-group command to define the members, you use the spr-intf-id command. And like port-channel, you configure the SPR interfaces instead of the POS interface.

**Caution**

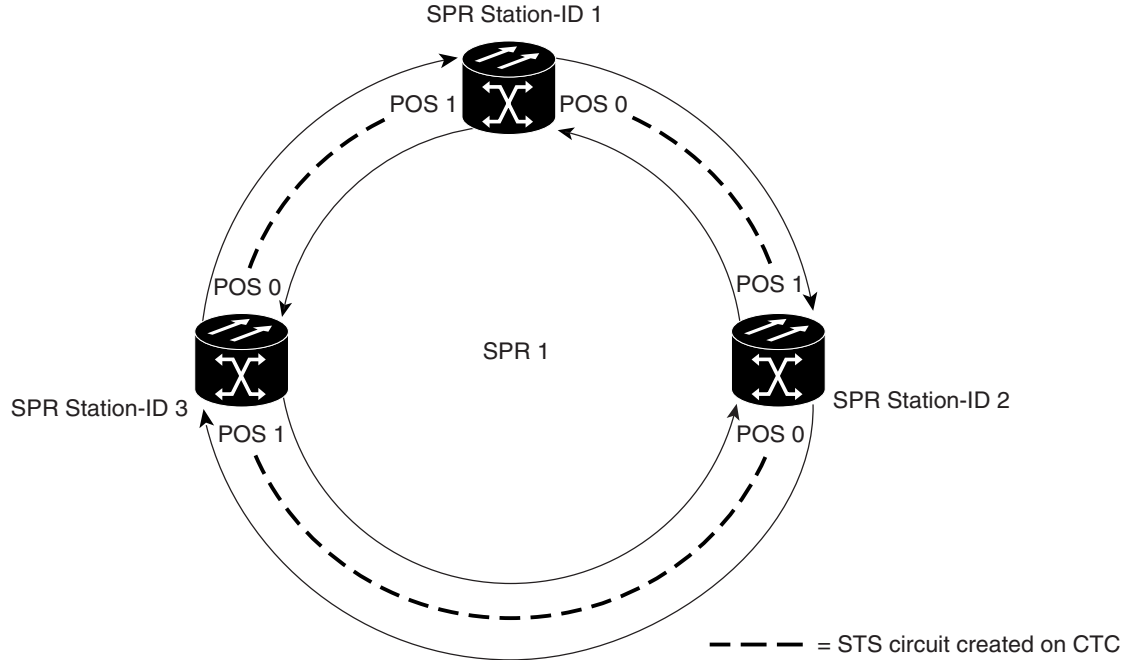
In configuring an SPR, if one ML-Series card is not configured with an SPR interface, but valid STS circuits connect this ML-Series card to the other ML-Series cards in the SPR, no traffic will flood between the properly configured ML-Series cards in the SPR, and no alarms will indicate this condition. Cisco recommends that you configure all of the ML-Series cards in an SPR before sending traffic.

**Caution**

Do not use native VLANs for carrying traffic with RPR.

To provision RPR and to assign a POS interface on the ML-Series to the SPR, follow the procedures listed in the Cisco Ethernet Card Software Feature and Configuration Guide. [Figure 9-42](#) shows an example of an RPR IOS configuration.

Figure 9-42 RPR Cisco IOS Configuration



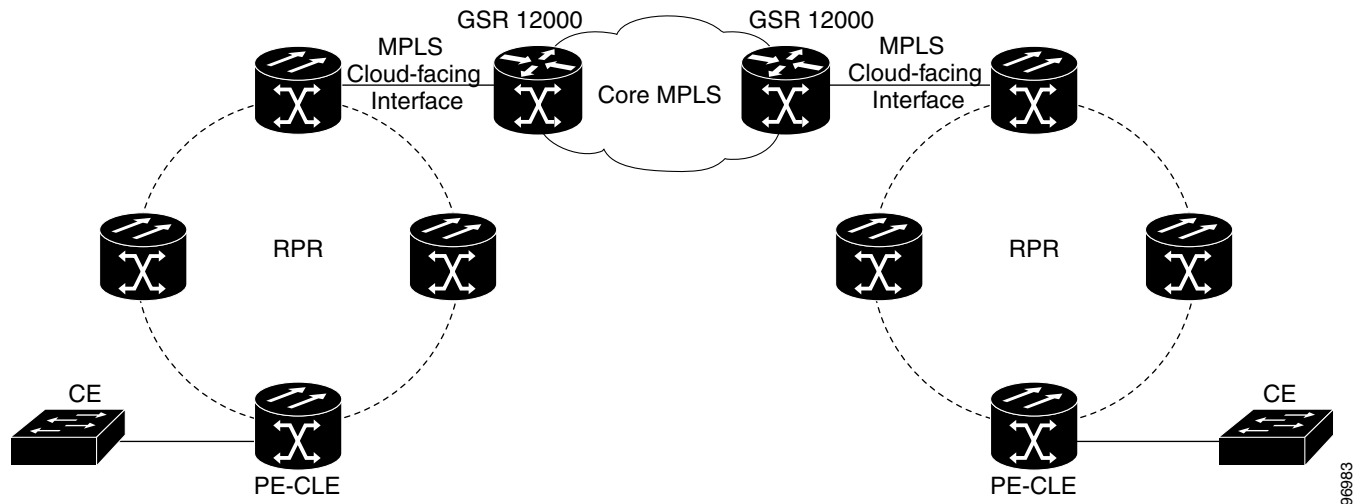
## Ethernet over MPLS

Ethernet over MPLS (EoMPLS) provides a tunneling mechanism for Ethernet traffic through an MPLS-enabled Layer 3 core. It encapsulates Ethernet protocol data units (PDUs) inside MPLS packets and using label stacking forwards them across the MPLS network. EoMPLS is an Internet Engineering Task Force (IETF) standard-track protocol based on the Martini draft, specifically the draft-martini-l2circuit-encap-mpls-01 and draft-martini-l2circuit-transport-mpls-05 sections.

EoMPLS allows you to offer customers a virtual Ethernet line service or VLAN service using the service provider's existing MPLS backbone. It also simplifies service provider provisioning, since the provider edge customer-leading edge (PE-CLE) equipment only needs to provide Layer 2 connectivity to the connected customer edge (CE) equipment.

Figure 9-43 shows an example of EoMPLS implemented on a service provider network. In the example, the ML-Series card acts as PE-CLE equipment connecting to the Cisco GSR 12000 Series through an RPR access ring. Point-to-point service is provided to CE equipment in different sites that connect through ML-Series cards to the ML-Series card RPR access ring.

Figure 9-43 EoMPLS Service Provider Network



Implementing EoMPLS on a network requires ML-Series card interfaces to play three major roles. The ML-Series card interface roles must be configured on both sides of the EoMPLS point-to-point service crossing the MPLS core as follows:

- ML-Series card interfaces connect the provider's network directly to the customer edge equipment and are known as the PE-CLE interfaces. This PE-CLE interface on the ML-Series card is FastEthernet or GigabitEthernet and is configured to be an endpoint on the EoMPLS point-to-point session.
- An ML-Series card interface bridges the PE-CLE interface and the RPR network of ML-Series cards. This RPR/SPR interface contains POS ports and is configured for MPLS IP.
- An ML-Series card interface connects to a core MPLS interface. This interface is GigabitEthernet or FastEthernet and connects to the port of a Cisco GSR 12000 Series or similar device that is on the MPLS network. This MPLS cloud-facing interface bridges the SPR interface and the MPLS cloud.

Implementing EoMPLS across a network requires setting up directed Label Distribution Protocol (LDP) sessions (LSPs) between the ingress and egress PE-CLE routers to exchange information for a virtual circuit (VC). Each VC consists of two LSPs, one in each direction, since an LSP is a directed path to carry Layer 2 frames in one direction only.

EoMPLS uses a two-level label stack to transport Layer 2 frames, where the bottom/inner label is the VC label and the top/outer label is the tunnel label. The VC label is provided to the ingress PE-CLE by the egress PE-CLE of a particular LSP to direct traffic to a particular egress interface on the egress PE-CLE. A VC label is assigned by the egress PE-CLE during the VC setup and represents the binding between the egress interface and a unique and configurative VC ID. During a VC setup, the ingress and egress PE-CLE exchange VC label bindings for the specified VC ID.

An EoMPLS VC on the ML-Series card can transport an Ethernet port or an IEEE 802.1Q VLAN over MPLS. A VC type 5 tunnels an Ethernet port and a VC type 4 transports a VLAN over MPLS. In a VC type 5 session, the user can expect any traffic that is received on an ML-Series card PE-CLE port with an `mpls Layer 2 transport route` command to be tunneled to the remote egress interface on the far-end ML-Series card PE-CLE port. With a VC type 4, a user can expect the tunnel to act as physical extension to that VLAN. The EoMPLS session commands are entered on a VLAN subinterface on the PE-CLE, and only VLAN-tagged traffic received on that port will be tunneled to the remote PE-CLE.

EoMPLS on the ML-Series card has the following characteristics:

- EoMPLS is only supported on FastEthernet and GigabitEthernet interfaces or subinterfaces.
- MPLS tag switching is only supported on SPR interfaces.
- Class of service (CoS) values are mapped to the experimental (EXP) bits in the MPLS label, either statically or by using the IEEE 802.1p bits (default).
- The ingress PE-CLE ML-Series card sets the time-to-live field to 2 and the tunnel label to a value of 255.
- Ingress PE-CLE ML-Series cards set the S bit of the VC label to 1 to indicate that the VC label is at the bottom of the stack.
- Since EoMPLS traffic is carried over the RPR, whatever load balancing is applicable for the traffic ingressing RPR is also applicable for the EoMPLS traffic.
- The Ethernet over MPLS feature is part of the Cisco Any Transport over MPLS (AToM) product set.
- The ML-Series card hosting the EoMPLS endpoint ports must be running the MPLS microcode image to support EoMPLS. For more information on multiple microcode images, see the "Multiple Microcode Images" section in the Cisco Ethernet Card Software Feature and Configuration Guide. Other ML-Series cards in the RPR are not restricted to the MPLS microcode image.

EoMPLS on the ML-Series card has the following restrictions:

- Packet-based load balancing is not supported. Instead, circuit-ID based load balancing is used.
- Zero hop or hairpin VCs are not supported. A single ML-Series card cannot be both the source and destination for a VC.
- MPLS control word for sequencing of data transmission is not supported. Packets must be received and transmitted without control word.
- Sequence checking or resequencing of EoMPLS traffic is not supported. Both depend on the control word to function.
- Maximum transmission unit (MTU) fragmentation is not supported.
- Explicit-null label for back-to-back LDP sessions is not supported.



#### Caution

Since MTU fragmentation is not supported across the MPLS backbone, the network operator must make sure the MTU of all intermediate links between endpoints is sufficient to carry the largest Layer 2 PDU.

## Configuring EoMPLS

The ML-Series peer cards on both endpoints of the EoMPLS point-to-point service must be configured. Perform the following configuration tasks to enable EoMPLS:

- VC Type 4 Configuration on PE-CLE Port (Either VC type 4 or VC type 5 is required).
- VC Type 5 Configuration on PE-CLE Port (Either VC type 4 or VC type 5 is required).
- EoMPLS Configuration on PE-CLE SPR Interface.
- Bridge Group Configuration on MPLS Cloud-facing Port.
- Setting the Priority of Packets with the EXP,

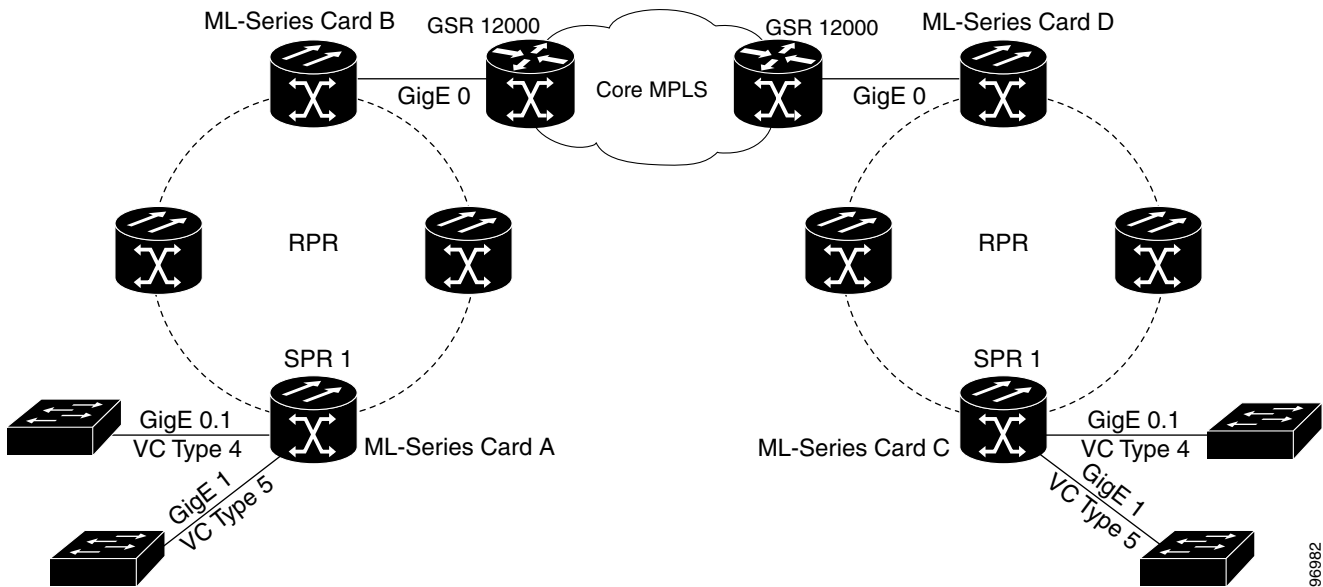
These are the guidelines for configuring EoMPLS:

- Loopback addresses are used to specify the peer ML-Series card's IP address.
- LDP configuration is required. The default Tag Distribution Protocol (TDP) will not work.

- EoMPLS uses LDP targeted session between the ML-Series cards to create the EoMPLS VCs.
- The MPLS backbone must use an Interior Gateway Protocol (IGP) routing protocol, for example, Intermediate System-to-Intermediate System (IS-IS) Protocol or Open Shortest Path First (OSPF).
- Tag switching of IP packets must be enabled on the SPR interface for the PE-CLE ML-Series card.

Figure 9-44 illustrates the sample network that the configuration commands reference.

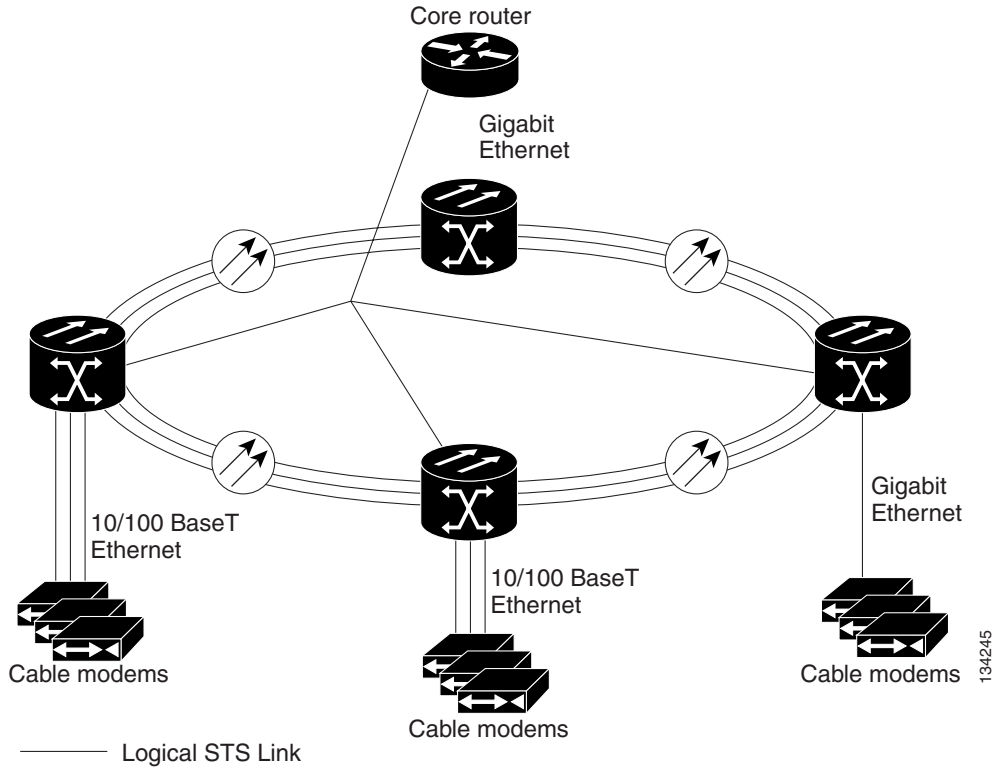
Figure 9-44 EoMPLS Configuration Example



## Cable Modem Aggregation

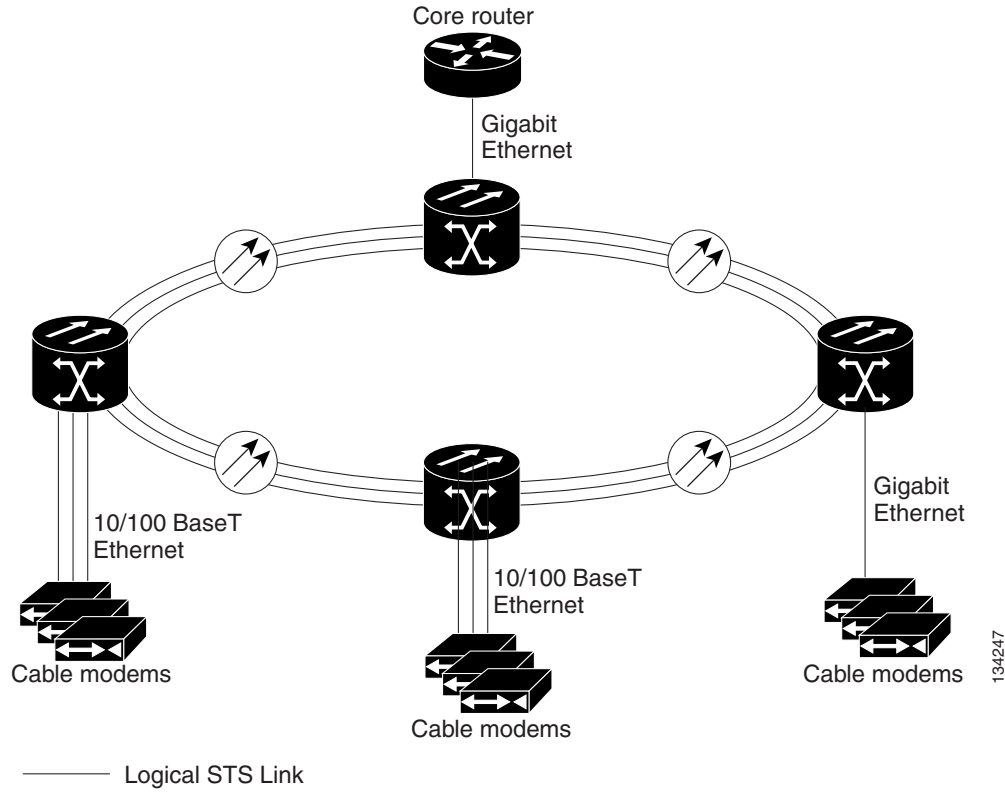
The ONS 15454 is ideal for providing Ethernet aggregation at remote sites and them back to one central site or headend location. Aggregation can be performed via point-to-point Transparent LAN Service (TLS) shown in Figure 9-45 or over a Shared Packet Ring shown in Figure 9-46.

Figure 9-45 Point-to-Point Cable Modem Aggregation



134245

**Figure 9-46 Shared Packet Ring Cable Modem Aggregation**

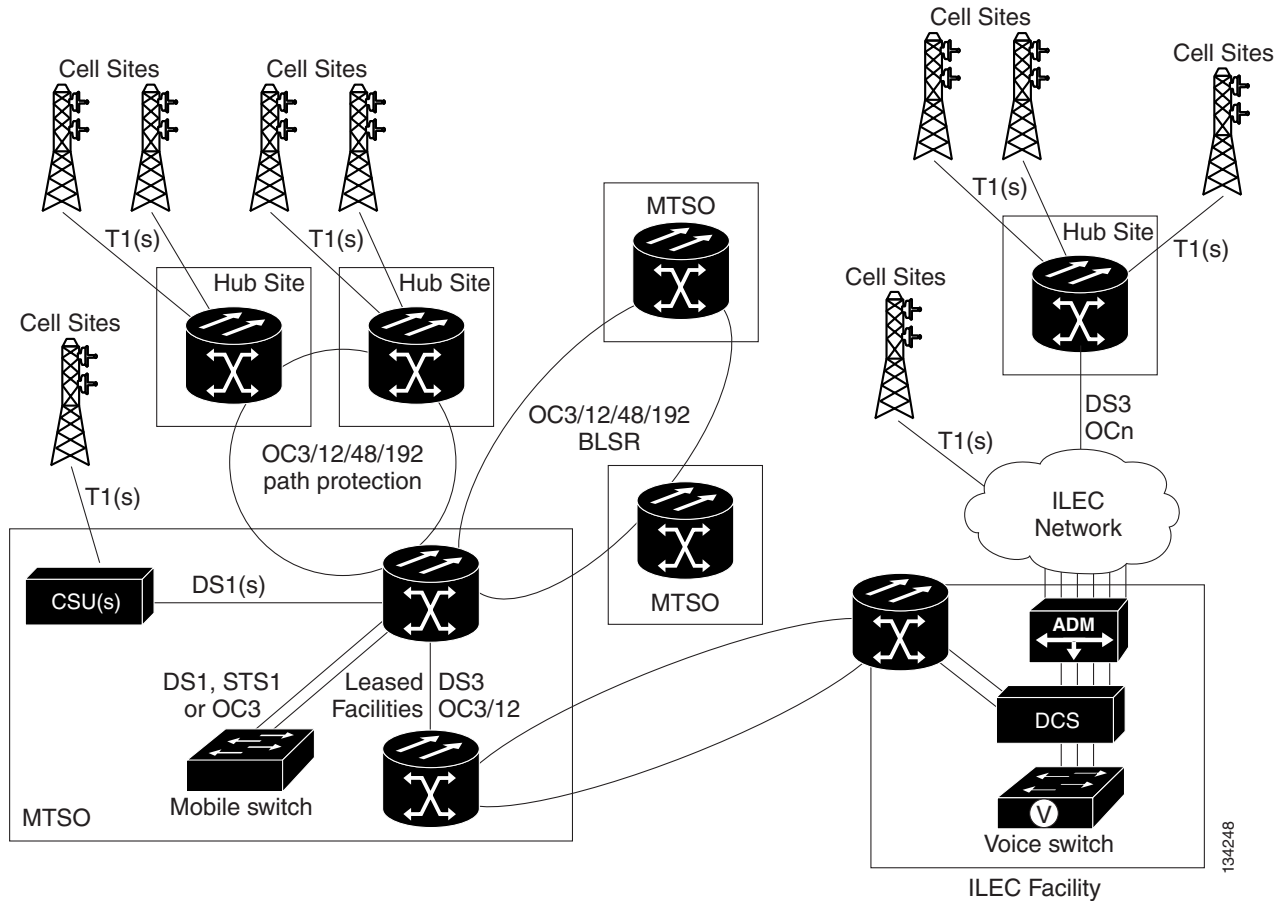


134247

## Wireless Networking

The ONS 15454 provides cost-effective transport of services between mobile telephone switch offices (MTSOs) and hub sites. In [Figure 9-47](#), the ONS 15454 provides T1 links from the cell sites to the hub sites and SONET transport between the MTSO sites and ILEC transport facilities. It also provides the optical bandwidth management between each MTSO site.

Figure 9-47 Wireless Networking Optical Bandwidth Management



## Video Transport

The ONS 15454 provides the flexibility required to support the next generation hybrid fiber coax (HFC) and IP video networks.

## HFC Networks

Next generation HFC networks are based on the regional hub concept and includes the following attributes:

- A master headend offering the ability to combine voice, data, and video into ATM cells for transmission on a SONET network to secondary headends and regional hubs.
- Centralized regional hubs which allow sharing of common equipment among multiple system operators (MSOs) within the region.
- Fiber rings interconnecting hubs and headends extend their reach and offers routing capabilities.
- No amplifiers needed for fiber rings.
- Maximum distance between furthest end user node and fiber hub of 80 km.

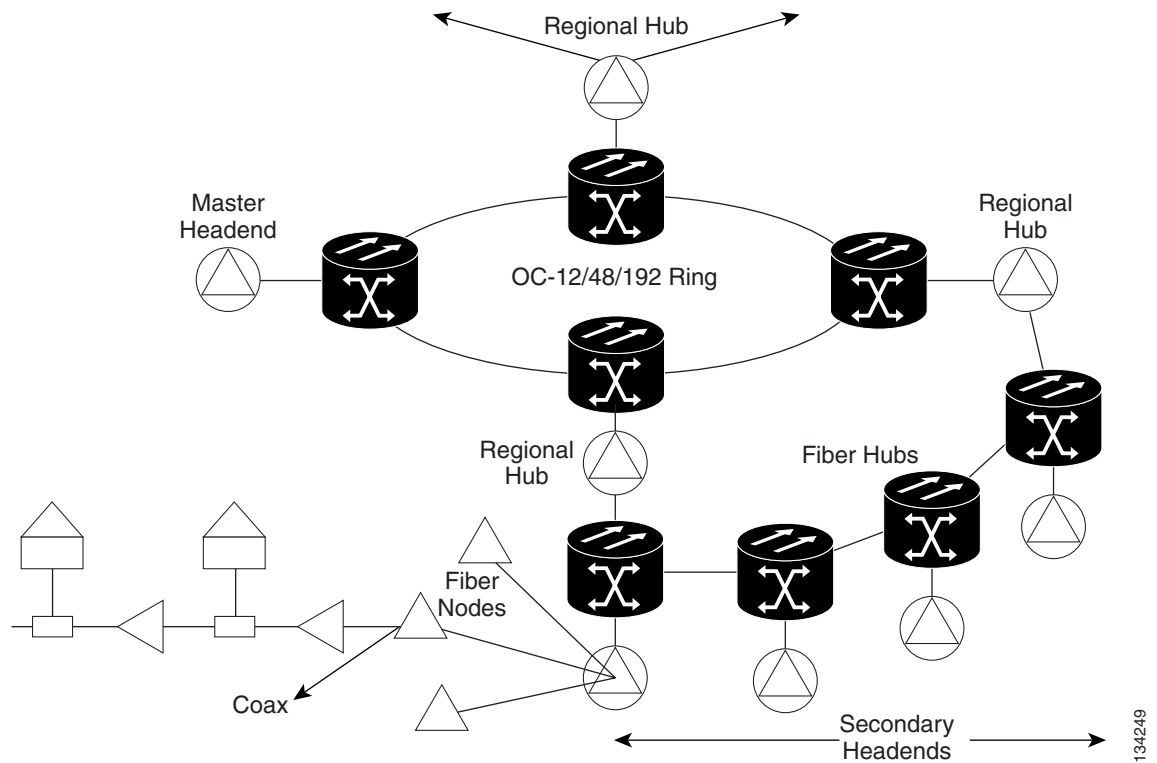


- The ring topology may interconnect a single operator's headends or the headends of any number of MSOs operating in adjacent serving areas.

Centralization of capital-intensive investments at the regional hub allows the cable operators to spread the investments across a wider base and provides a platform for offering a common set of services to subscribers and other cable operators.

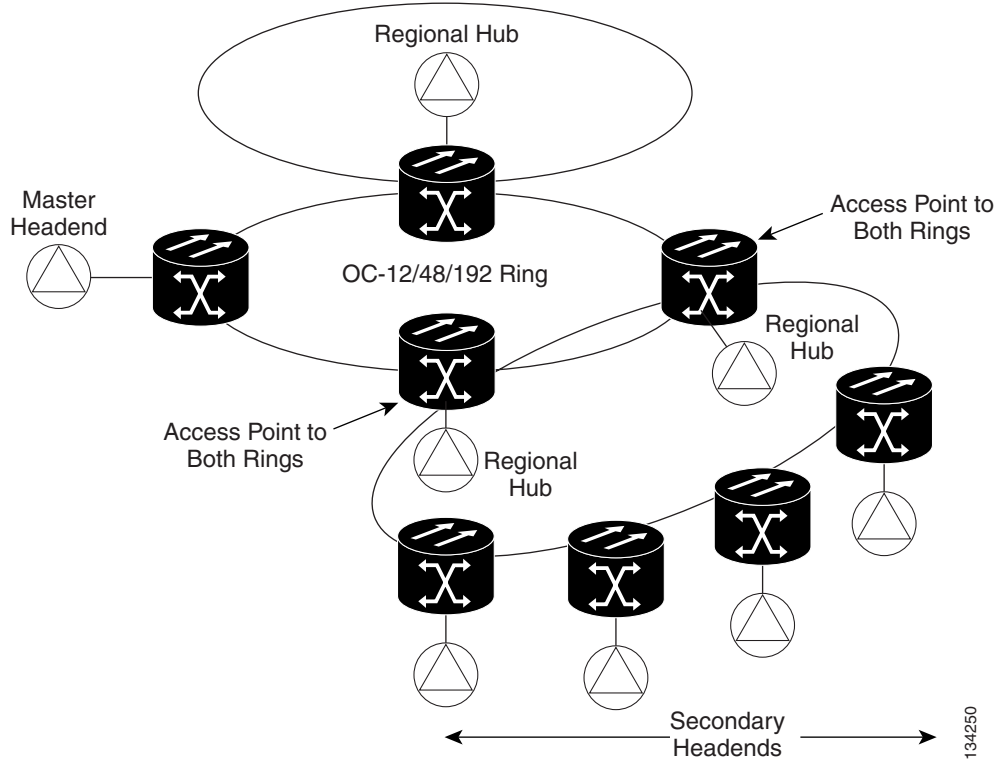
In [Figure 9-48](#), the ONS 15454 MSPP is used to transport voice over IP (VoIP), high-speed data access, and video signals from the Master Headend to all Regional Headends and Fiber Hubs using SONET point-to-point and drop and continue circuits.

**Figure 9-48** Next Generation HFC Network Architecture



Redundant systems can be installed to avoid single points of failure, as shown in [Figure 9-49](#).

Figure 9-49 Avoiding Single Points of Failure

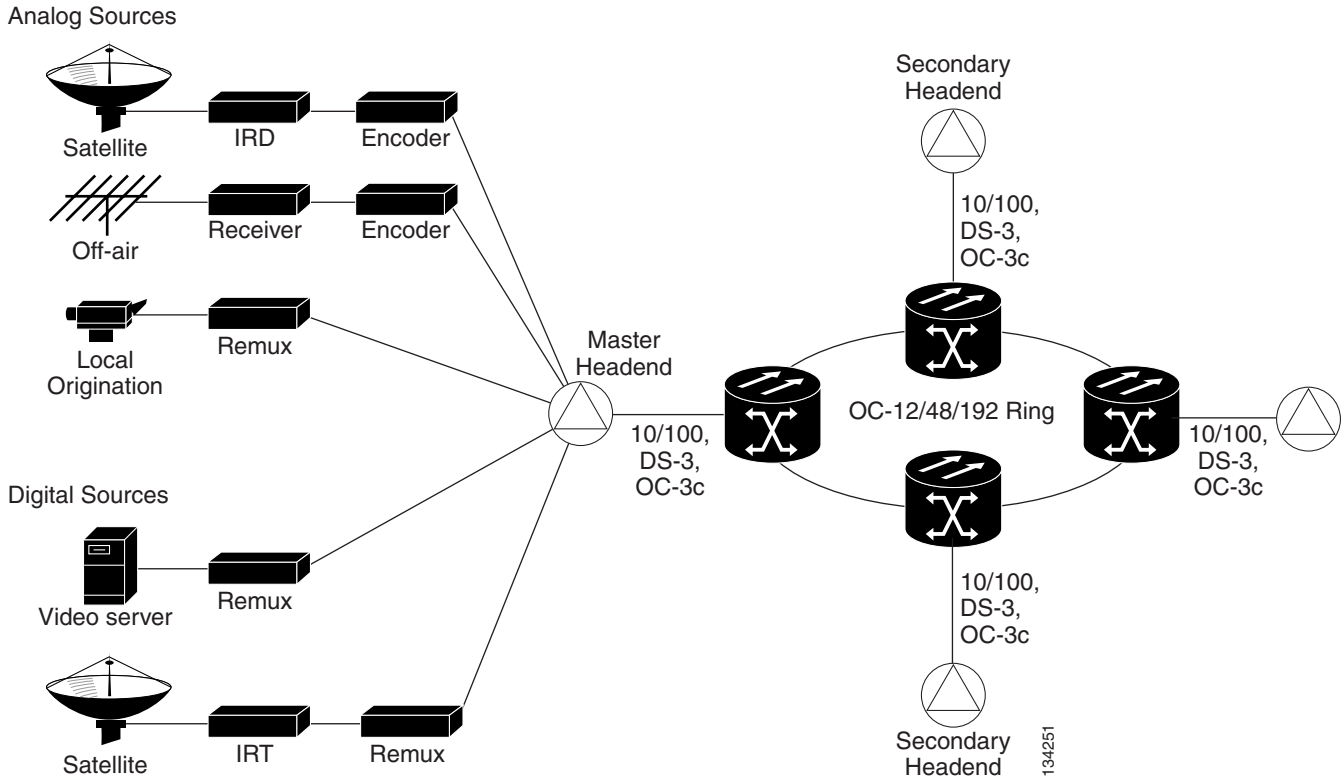


MSOs have been trading systems to create contiguous serving areas. These contiguous serving areas form a region. A region may have 10 to 20 different cable systems connected to a Regional Hub.

Contiguous serving areas allow MSOs to consolidate headends from various areas into a Master Headend. To consolidate headends, MSOs can transport their standard channel line up from the Master Headend to Secondary Headends. Localized broadcast services, advertising, and must-carry channels are added to the standard line up at the Secondary Headend.

In Figure 9-50, the ONS 15454 transports the standard channel line up over a SONET path protection to each Secondary Headend through its drop and continue capability.

Figure 9-50 Headend Consolidation

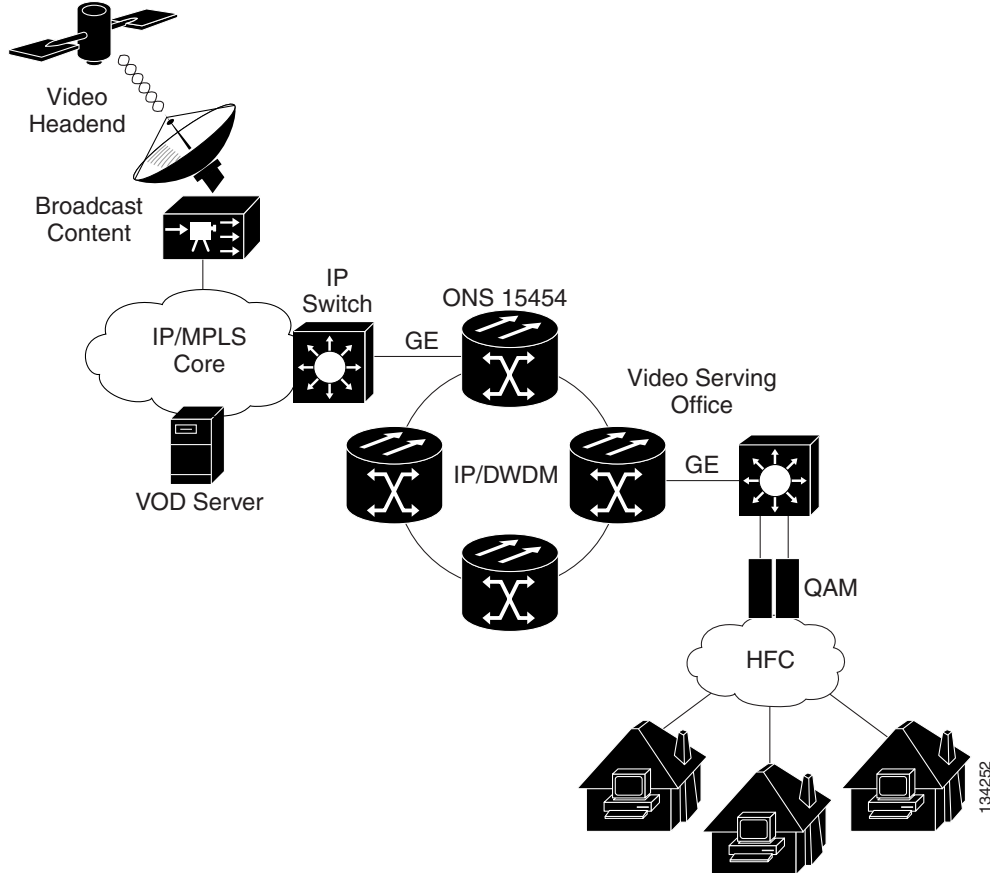


## Video Over IP

Cable MSOs have been deploying separate networks for delivering cable television services and IP-based services such as high-speed data and IP telephony. The Video over IP architecture enables video services to be distributed via the IP network, enabling network consolidation and functionality not possible with the traditional video transport solutions.

The Video over IP architecture leverages the current digital video systems being deployed today while exploiting the benefits of IP networks for distributing broadcast video and video-on-demand (VOD) from the video headend offices (VHOs) and video serving offices (VSOs) to the HFC access network. The inherent routing capability of the Video over IP architecture provides flexibility in the placement of video sources and improves network efficiency by enabling any video source to deliver content to any set-top box (STB). A reference architecture for Video over IP is depicted in [Figure 9-51](#).

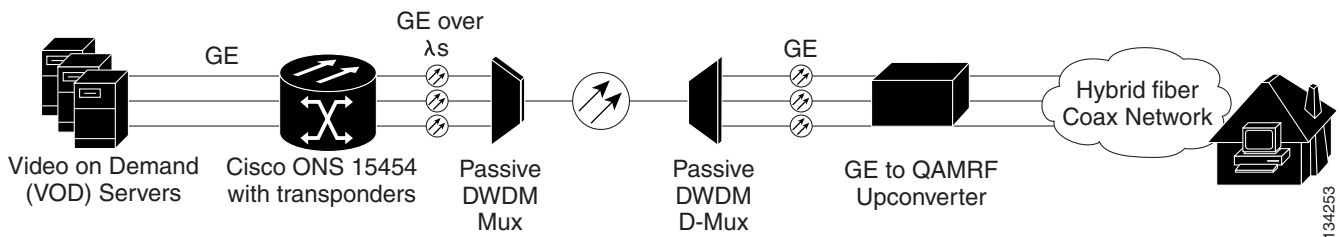
Figure 9-51 Video Over IP Reference Architecture



Many MSOs have a single unidirectional optical link between the headend and distribution hubs. DWDM (as opposed to CWDM) is typically chosen as the optical multiplexing technology, because the distance between the headend and distribution hubs often exceeds the CWDM range.

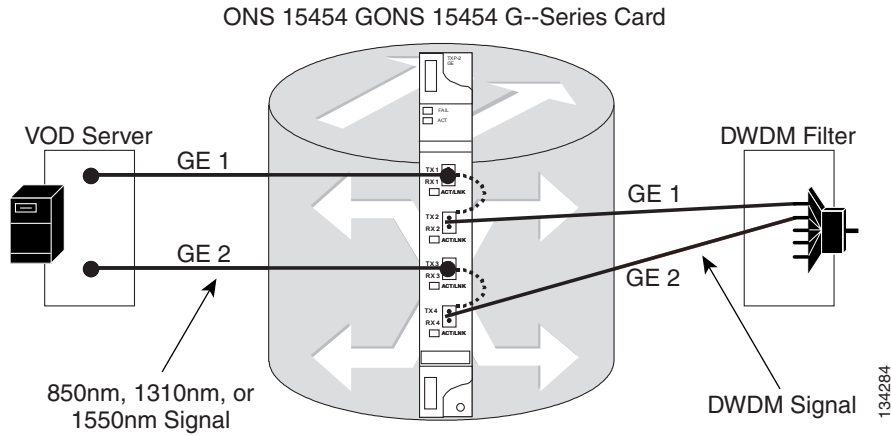
Gigabit Ethernet VOD can use DWDM optical components that are cost reduced to include DWDM lasers on ONS 15454 nodes that are used for transport. For example, the ONS 15454 nodes shown in [Figure 9-52](#) are configured with G-Series Ethernet cards provisioned in the Gigabit Ethernet transponder mode for efficient delivery VOD channels.

Figure 9-52 Efficient Distribution of VOD Channels



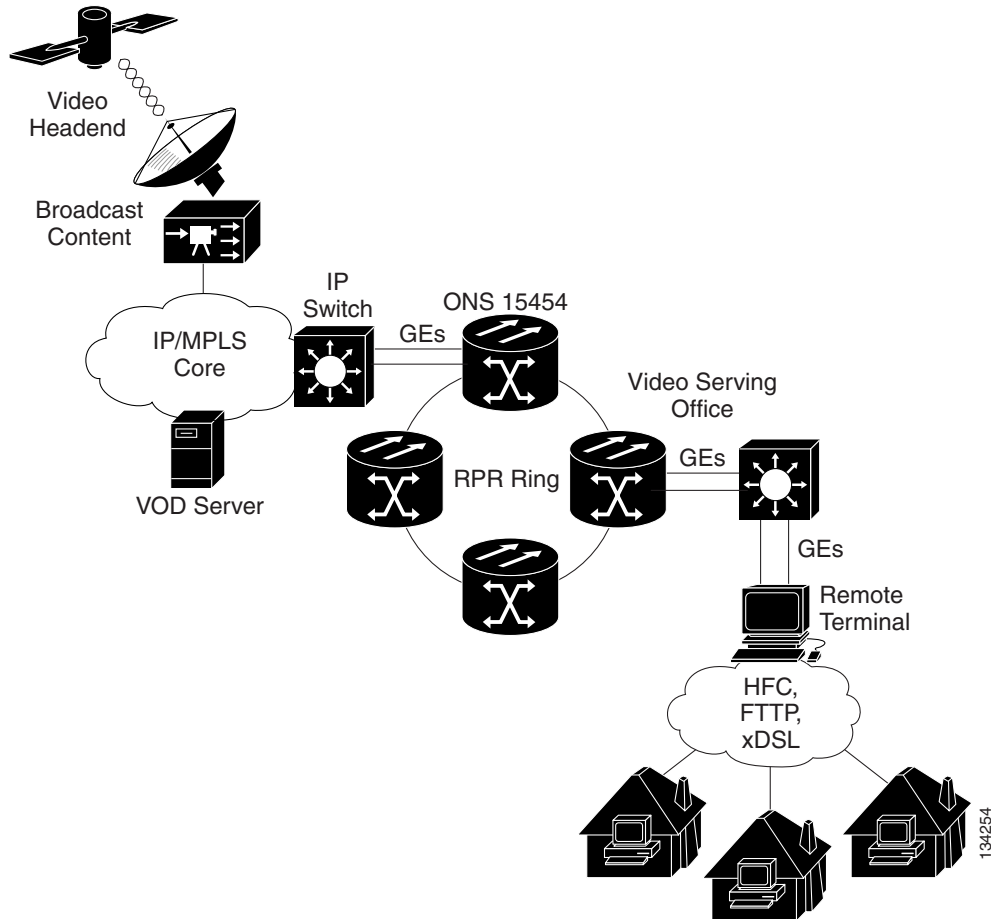
[Figure 9-53](#) shows the basic wiring between the VOD server, G-Series Ethernet card, and the passive DWDM multiplexer.

**Figure 9-53 Basic Gigabit Ethernet Transponder Wiring Diagram**



You can also use ONS 15454 separate GE channels on ML-Series cards configured for RPR to distribute multi-cast broadcast and uni-cast VOD traffic between the VHOs and SVOs as illustrated in [Figure 9-54](#). The access facilities between the VSO and remote terminals can either be HFC, FTTP, or xDSL.

**Figure 9-54 RPR Video Distribution Architecture**



# SAN Extension Options

Storage Area Networks (SANs) consolidate data storage needs, increase storage efficiency, and reduce capital and operational costs (CapEx and OpEx). SAN extension enables disaster recovery and business continuance applications by transporting SAN protocols over long distances and thereby interconnecting isolated storage islands.

The following options are available for extending SAN over metro or WAN distances:

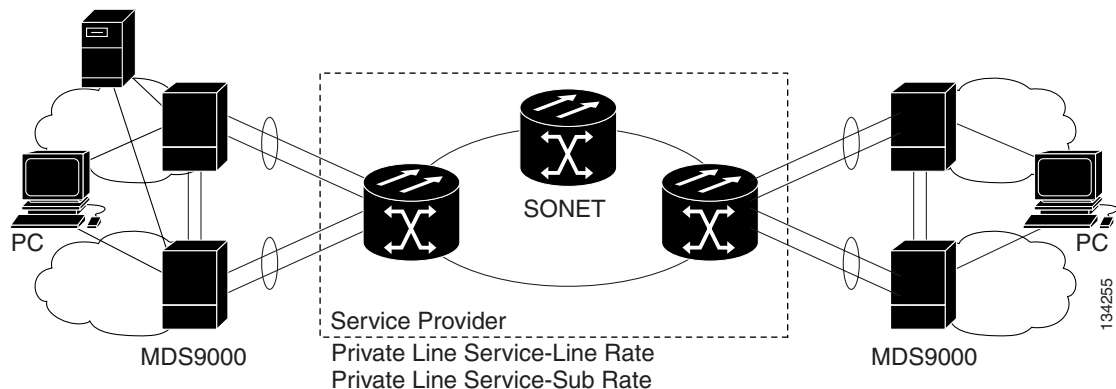
- Dark fiber - Distances are limited by the transmitter power, OSNR, and system receiver sensitivity.
- FC over DWDM - Delivers high bandwidth with low latency but at high cost. Deployed within metro rings with distances less than 200 kms. DWDM networks can be extended much further using amplifiers and dispersion compensation units, but the limitations of the FC protocol and business continuance applications may limit implementation to 100 kms or less.
- FC over IP - IP networks can extend SAN protocols over large areas, but applications with stringent requirements may not function efficiently due to the unpredictable nature of large TCP/IP networks. In well engineered IP networks, asynchronous applications perform extremely well.
- FC over SONET - SONET networks provide the primary optical backbone for most service providers. FC traffic can be integrated seamlessly with TDM and Ethernet traffic over a SONET/SDH network, with bandwidth assigned based on application requirements. A SONET/SDH network provides low latency and may extend FC over a large area.

SAN Extension services can be further classified as private line services and wire line services.

## Private Line Services

SONET-based storage services can extend the SAN extension solutions to distances over 2000 Km by using spoofing techniques and are not subject to the buffer credit limitations imposed by storage switches and directors. SONET sub-rate support and 50 msec recovery time is ideal for supporting SLA's for a large number of enterprise applications. [Figure 9-55](#) shows a typical SONET-based network providing both line rate and sub-rate services.

**Figure 9-55** SONET-Based Private Line Service



## Wire Line Services (FCIP Over SONET)

Wire Line Services over SONET is another viable low-cost way to extend SAN traffic. FCIP can be implemented using Layer 3 components of the ML-Series card on the ONS 15454. ONS 15454 networks can offer the multiplexing capability of IP and the protection of SONET. The ONS 15454 is also ideal for both asynchronous and synchronous applications. A typical service architecture is shown in Figure 9-56.

**Figure 9-56 FCIP Over SONET—Point to Point**

