NT0H65AM **323-1701-110**

Nortel

Optical Metro 5100/5200

Network Planning and Link Engineering, Part 1 of 3

Standard Release 8.0 Issue 1 April 2005

What's inside...

See Part 2 for the following:

See Part 3 for the following:

NORTEL

Printed in Canada and the United Kingdom

Contents

About this document

> **ATTENTION**
> This document is presented in three parts: Part 1, Part 2, and Part 3. Each part has its own table of contents. The table of contents in Part 1 contains topics found in Part 1 only. The table of contents in Part 2 contains topics found in Part 2 only. The table of contents in Part 3 contains topics found in Part 3 only.

You are reading Part 1 of *Network Planning and Link Engineering,* 323-1701-110.

This document provides the information needed to understand and plan a Nortel Optical Metro 5100/5200 network (identified prior to Release 7 as Nortel Networks OPTera Metro 5000-series Multiservice Platform).

Part 1 of *Network Planning and Link Engineering* includes:

- system description
- building blocks
- supported configurations
- network interoperability

Part 2 of *Network Planning and Link Engineering* includes:

- link engineering prerequisites
- link engineering components
- link engineering rules
- basic fixed value link engineering
- remodeling a network plan for optimal link budgets
- data communications in the Optical Metro 5100/5200 network
- network security planning

Part 3 of *Network Planning and Link Engineering* includes:

- site requirements and equipping rules
- ordering information
- fiber characterization
- custom link engineering design output

Audience for this document

This document is intended for the following audience:

- strategic and current planners
- provisioners
- installers
- transmission standards engineers
- field maintenance engineers
- system lineup and testing (SLAT) personnel
- maintenance technicians
- network administrators

Documentation library for the Optical Metro 5100/5200

The documentation library consists of the *Nortel Optical Metro 5100/5200 Technical Publications*, NT0H65AM.

Technical Publications

The *Optical Metro 5100/5200 Technical Publications* (NTP) consist of descriptive information and procedures.

Descriptive information

These documents provide detailed descriptive information about the Optical Metro 5100/5200, including:

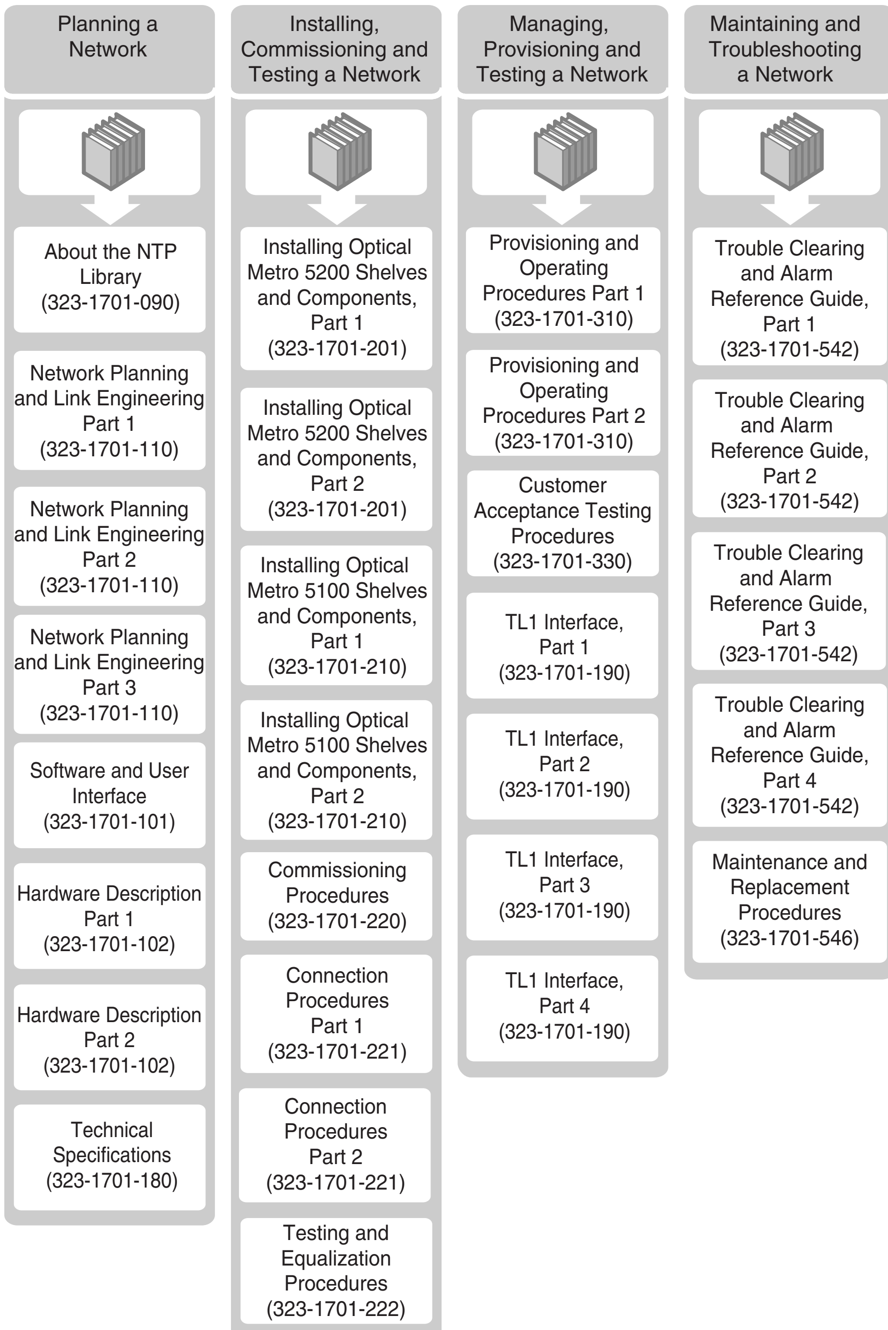
- system description
- software descriptions
- hardware descriptions
- technical specifications
- ordering information
- TL1 user information

Procedures

These documents contain all procedures required to install, provision, and maintain the Optical Metro 5100/5200 system.

The following roadmap lists the documents in the Optical Metro 5100/5200 library.

OM2805p



Technical assistance service telephone numbers

For technical support and information from Nortel Networks, refer to the following table.

Technical Assistance Service	
For service-affecting problems: For 24-hour emergency recovery or software upgrade support, that is, for: • restoration of service for equipment that has been carrying traffic and is out of service • issues that prevent traffic protection switching • issues that prevent completion of software upgrades	**North America:** 1-800-4NORTEL (1-800-466-7835) **International:** 001-919-992-8300
For non-service-affecting problems: For 24-hour support on issues requiring immediate support or for 14-hour support (8 a.m. to 10 p.m. EST) on upgrade notification and non-urgent issues.	**North America:** 1-800-4NORTEL (1-800-466-7835) ***Note:*** You require an express routing code (ERC). To determine the ERC, see our corporate Web site at www.nortel.com. Click on the Express Routing Codes link. **International:** Varies according to country. For a list of telephone numbers, see our corporate Web site at www.nortel.com. Click on the Contact Us link.
Global software upgrade support:	**North America:** 1-800-4NORTEL (1-800-466-7835) **International:** Varies according to country. For a list of telephone numbers, see our corporate Web site at www.nortel.com. Click on the Contact Us link.

System description

In this chapter

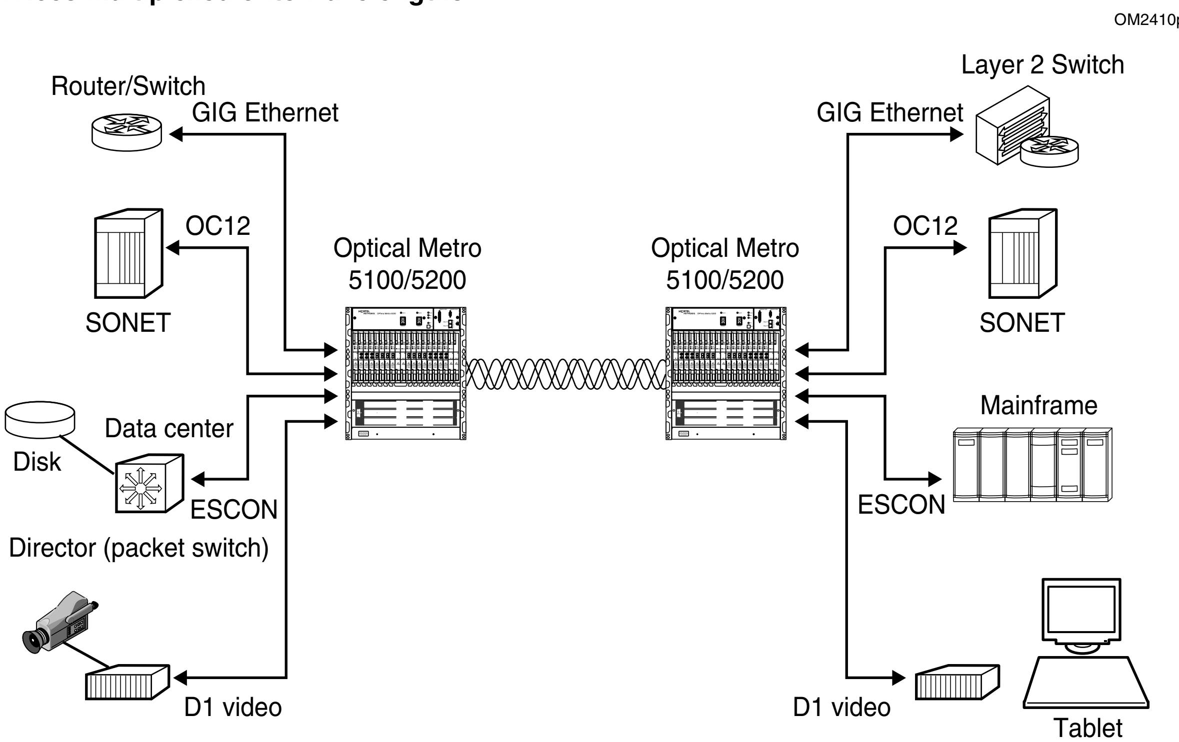
Understanding a metropolitan WDM optical network

In optical transport networks, a fiber pair traditionally carries a SONET/SDH or other native optical signal. Each fiber pair carries a signal over a single wavelength. Optical transport networks are typically made up of multiple overlay networks to support end-user services. As the demand for service grows, the demand for fiber grows as well. Service providers are faced with the challenge of getting the best use out of limited fiber to carry optical signals.

Wavelength division multiplexing (WDM) allows multiple services to be carried by the same fiber pair. Information is mapped onto one of several wavelengths that are multiplexed onto a single fiber pair. All wavelengths are transported simultaneously over the fiber. At destination points, specific wavelengths can be demultiplexed in order to extract the information and recover the original transmitted signal.

Figure 1-1 shows the concept of transmitting signals over fiber using WDM technology.

Figure 1-1
Services multiplexed onto wavelengths



It is convenient to describe a WDM network at two different levels: the optical layer and the service layer.

Optical layer

The optical layer consists of the components that define the flow of the wavelengths. This is independent of the signals that are being carried. Consider the optical layer as the network of streets that exist within a city. The streets are independent of the traffic that is travelling over them.

Optical components are the physical units that perform core optical functions, both active and passive, and include such devices as:

- optical amplifiers such as erbium-doped fiber amplifiers (EDFA)
- wavelength multiplexer/demultiplexer
- optical transmitters for generation of the signals
- optical receivers for termination of the signals
- optical attenuators (both manual and automated) for power level management

From the perspective of the optical transmitters and receivers facing the optical layer, the set of optical components with which they interact is often referred to as the **line side**.

Service layer

The service layer consists of the components in the system that carry end-user services over the optical layer. Consider the service layer as the bus routes or taxi routes that are implemented over a network of city streets (the optical layer).

The service layer typically consists of:

- client interface transmitters and receivers, where the client is the source or destination of the signal being carried
- cross-connect for mapping client signals to specific wavelengths
- client signal multiplexing to maximize the use of each wavelength
- protection mechanisms to implement reliable data transmission

From the perspective of the optical transmitters and receivers that are part of the service layer, the set of optical components with which they interact is often referred to as the **client side**.

The Optical Metro 5100/5200 solution

The Nortel Networks product offering in metropolitan optical networks is the Optical Metro 5100/5200. The Optical Metro 5100/5200 uses 32 wavelengths from the ITU wavelength grid to transport optical signals on DWDM systems, or eight wavelengths to transport optical signals on CWDM or ITU CWDM systems.

The Optical Metro 5100/5200 is a high-speed system that can carry up to 40 Gbit/s of protected capacity in less than two cubic feet of space. The Optical Metro 5100/5200 is European Telecommunications Standards Institute (ETSI) and Network Equipment Building System (NEBS) compliant. The Optical Metro 5100/5200 consists of the following main products:

- Optical Metro 5200 (supports DWDM, CWDM, and ITU CWDM applications)
- Optical Metro 5100 (supports DWDM, CWDM, and ITU CWDM applications)

The Optical Metro 5200 manages each wavelength and provides passive optical pass-through to deliver true optical networking and reduce the need for repeated electrical-to-optical conversions. This technology results in a system that is easy to manage and has high network availability.

The Optical Metro 5100 is a smaller version of the Optical Metro 5200. It supports all of the functionality of Optical Metro 5200, but is intended for smaller channel access applications.

Optical Metro 5100/5200 service layer

The traffic-carrying modules in Optical Metro 5100/5200 platform support a range of protocols and bit rates. This flexibility enables Optical Metro 5100/5200 networks to carry many different protocols, such as:

- Gigabit Ethernet
- SONET
- SDH
- ESCON
- Fiber Channel

You can connect native data interfaces, such as Gigabit Ethernet or ATM, directly to Optical Metro 5100/5200 without modifications. This flexibility enables operating companies to fill user requests for increased bandwidth or different protocols quickly without modifying the network infrastructure. You can change the bit rate on a specific channel without reprovisioning the entire system. For example, you can increase a channel from OC-3 to OC-12.

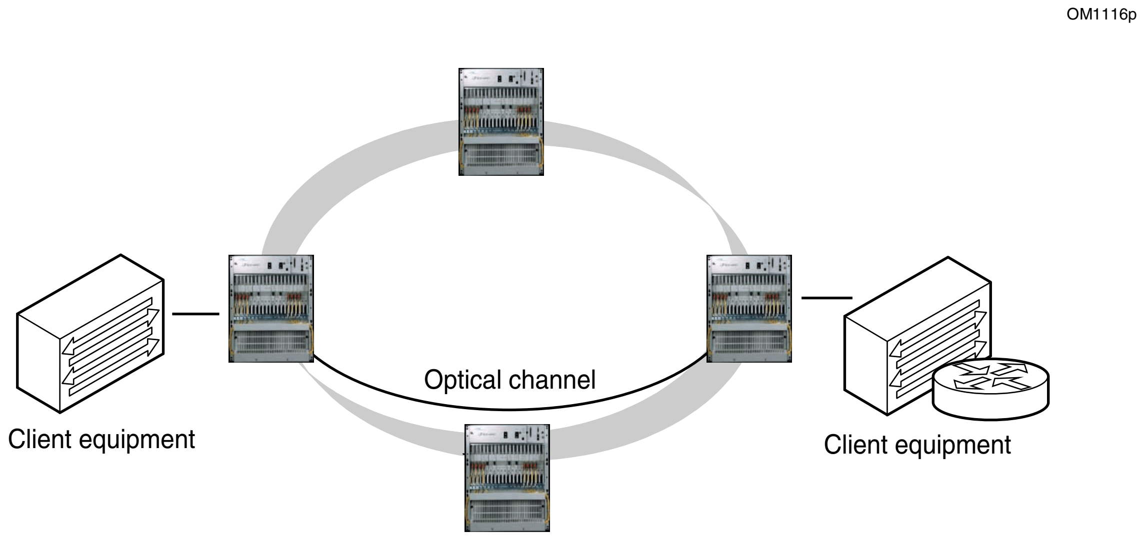
Optical channels

Client signals or protocols are mapped to a specific wavelength as they enter the Optical Metro 5100/5200 network. The signal is transported over the optical layer to its destination within the network, where it is extracted from a wavelength and transmitted to the terminating client equipment.

The complete path taken by a specific client signal, from the time it is received by the Optical Metro 5100/5200 client interface module to the time it is transmitted through another Optical Metro 5100/5200 client interface module— without having gone through any other non-Optical Metro 5100/5200 equipment— is called an **optical channel**.

Figure 1-2 shows an optical channel in an Optical Metro 5100/5200 network.

Figure 1-2
Optical channel in an Optical Metro 5100/5200 network



Protected optical channels

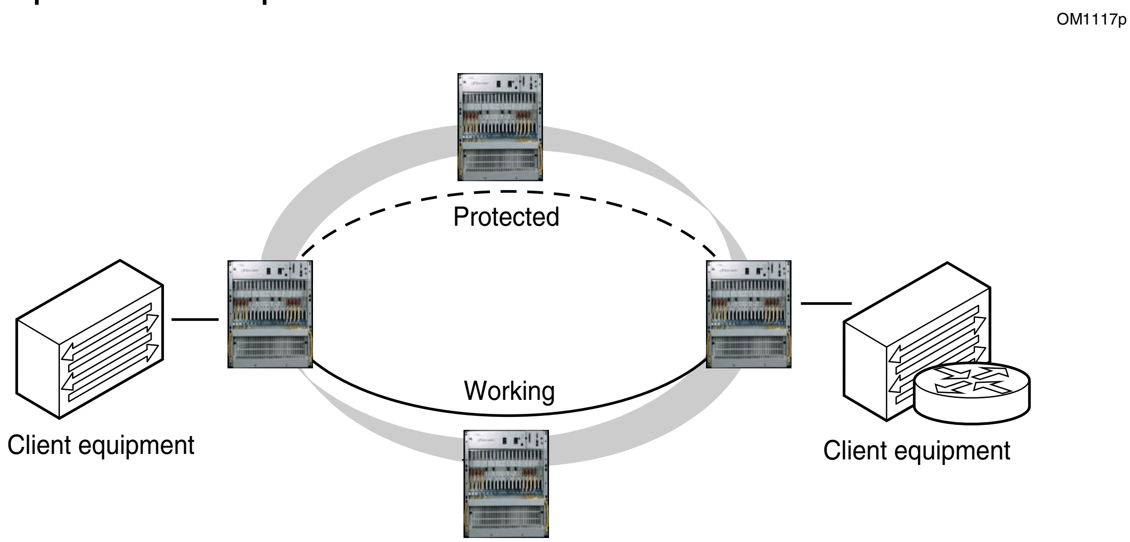
In order to provide more reliable transmission of client signals over optical channels during maintenance and upgrade activities or during failure conditions, an optical channel can be protected.

When a client signal that requires protection is received by the Optical Metro 5100/5200 client interface components, it is transmitted on two diversely routed optical paths. At the terminating point of each optical path, the two signals are received, and protection criteria are applied to determine which of the two signals will be transmitted through the client interface components.

Standard protection

An optical channel can be fully protected within a single Optical Metro 5100/5200 network. In this case, the signal is transmitted over two diverse routes that originate at a single network element, and terminate at a single network element. Only one instance of the client signal is received and transmitted. This is referred to as **standard protection**. Figure 1-3 on page 1-6 shows standard protection in an Optical Metro 5100/5200 network.

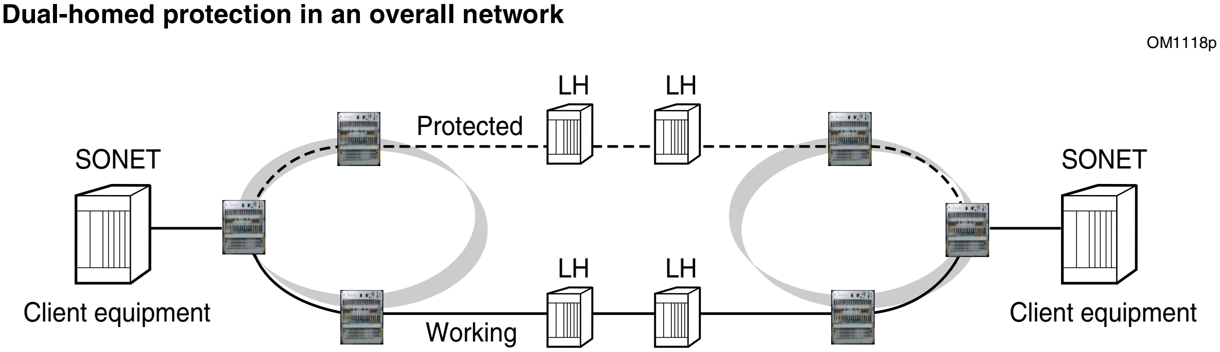
Figure 1-3
Standard protection in an Optical Metro 5100/5200 network



Dual-homed protection

A client signal can also be protected over a larger span within a customer's overall network. In this case, an Optical Metro 5100/5200 network may only be involved in duplicating the signal over two diversely routed optical channels and sending them out as two distinct client signals. Or conversely, the signal may arrive at the Optical Metro 5100/5200 network as two distinct client signals, which are routed over two diverse optical channels and mapped to a single client signal, using the protection criteria at the destination. This mechanism of protecting optical channels is referred to as **dual-homed protection**. Figure 1-4 shows a client signal that uses dual-homed protection.

Figure 1-4
Dual-homed protection in an overall network



Optical channel traffic patterns

As multiple services are mapped from client source to destination and optical channel routing requirements begin to be understood, traffic patterns may begin to emerge that allow you to identify client signals with similar requirements.

The types of patterns that may emerge are:

- all or most client signals originate and terminate at the same physical locations
- all client signals originate at the same physical location, but terminate at many different physical locations
- client signals originate and terminate at many different physical locations
- client signals are transported by unprotected optical channels
- client signals are transported by protected optical channels

These traffic patterns influence the way in which you design your optical layer.

The Optical Metro 5100/5200 network has been designed to accommodate specific traffic patterns. These influence the network topologies that can be implemented. For more information about traffic patterns and network topologies, refer to the chapter "Supported configurations" in this book.

Mapping services to the optical layer

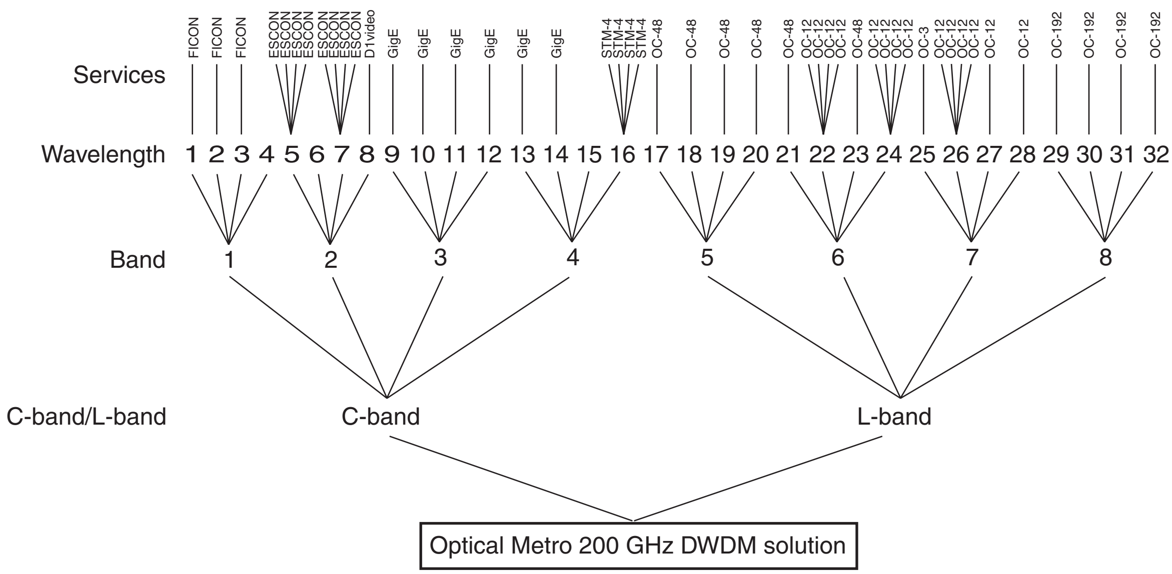
Mapping services to the optical layer consists of determining what optical components are required to effectively carry all client signals over the Optical Metro 5100/5200 network.

The hierarchies illustrated in Figures 1-5, 1-6, 1-7, and 1-8 show how client interface signals are logically combined in order to be carried over a single fiber pair. The layers in these hierarchy are associated with various components of the Optical Metro 5100/5200. This section steps through the hierarchies and provides a high-level overview of how to map services onto the Optical Metro 5100/5200 optical layer.

A DWDM 200 GHz hierarchy

Figure 1-5 on page 1-8 shows how client interface signals are mapped to the optical layer in a DWDM 200 GHz system.

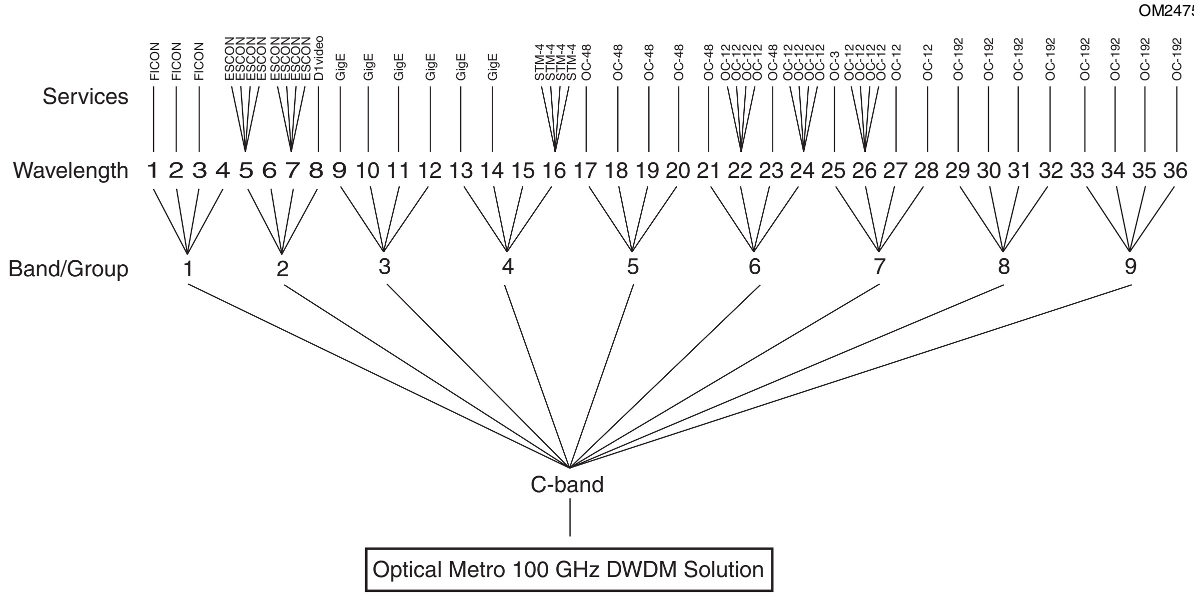
Figure 1-5
Mapping services onto the optical layer in a DWDM 200 GHz system



A DWDM 100 GHz hierarchy

Figure 1-6 shows how client interface signals are mapped to the optical layer in a DWDM 100 GHz system.

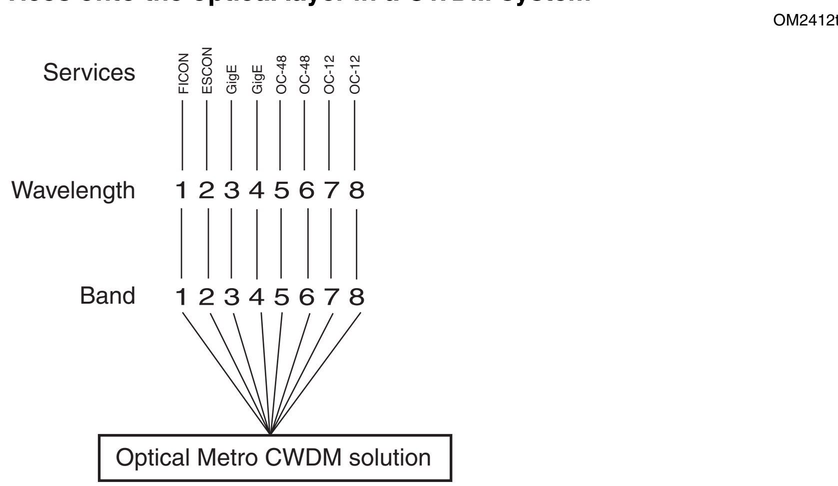
Figure 1-6
Mapping services onto the optical layer in a DWDM 100 GHz system



A CWDM hierarchy

Figure 1-7 shows how client interface signals are mapped to the optical layer in a CWDM system.

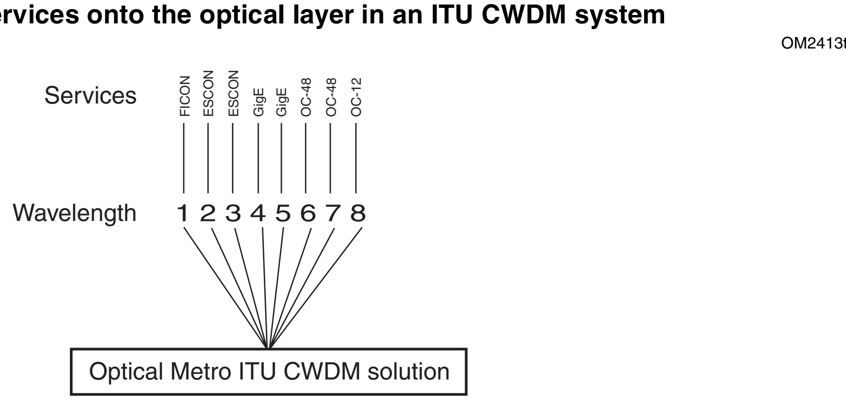
Figure 1-7
Mapping services onto the optical layer in a CWDM system



An ITU CWDM hierarchy

Figure 1-8 shows how client interface signals are mapped to the optical layer in an ITU CWDM system.

Figure 1-8
Mapping services onto the optical layer in an ITU CWDM system



Mapping client side interfaces to wavelengths

Mapping services to the optical layer starts with determining which wavelength will carry a specific service.

For some client signal types, Optical Metro 5100/5200 provides the ability to multiplex several independent signals onto a single wavelength. This is done through the sub-rate multiplexing (SRM) capabilities of the client interface circuit packs. For more information about SRM circuit packs, refer to “Client side interface circuit packs” in the “Building blocks” chapter in this book.

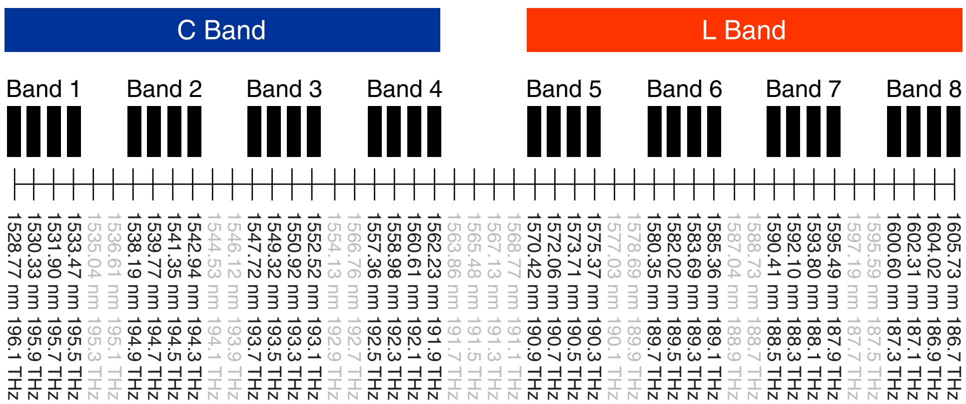
When planning your services, it is important to identify similar signals that are originating and terminating at the same locations. These signals may be candidates to multiplex through an SRM circuit pack.

DWDM wavelengths

Optical Metro 5100/5200 DWDM systems use 32 wavelengths from the international ITU-T 200 GHz wavelength grid, as shown in Figure 1-9.

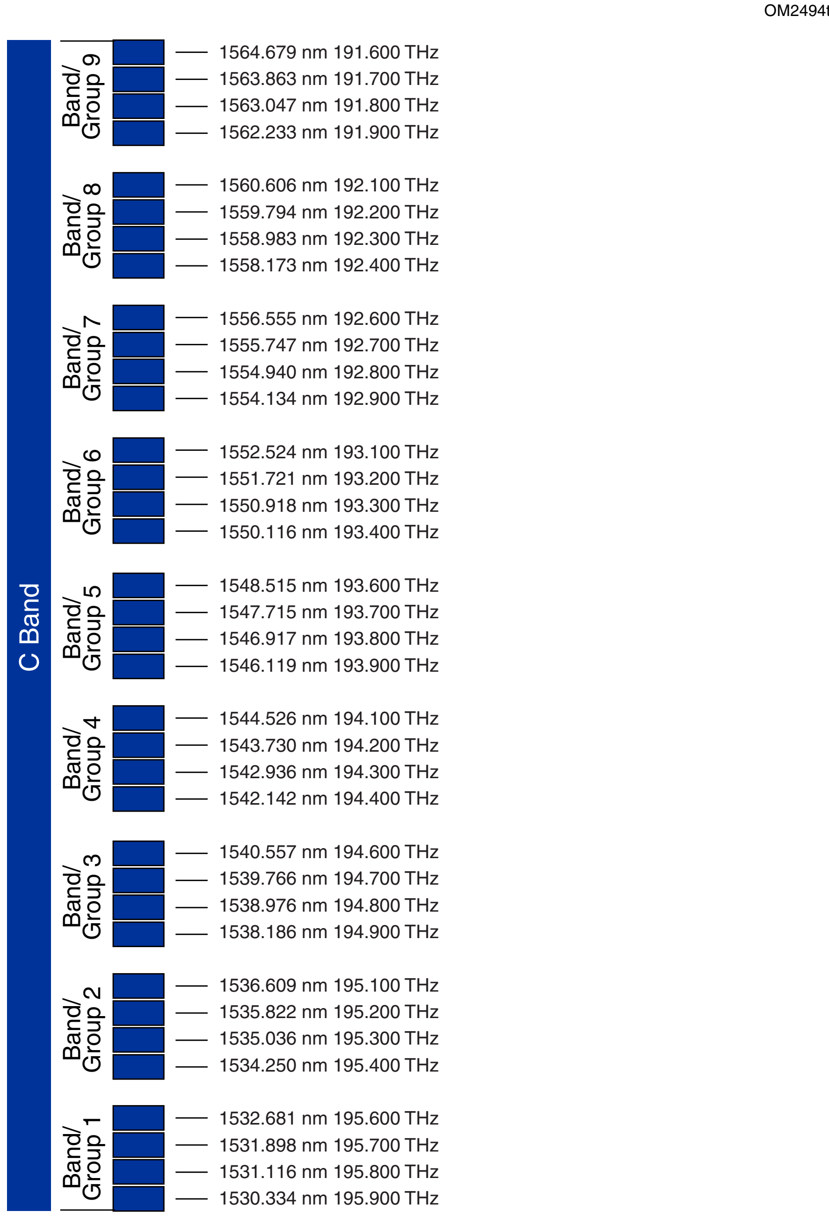
Figure 1-9
Optical Metro 5100/5200 DWDM 200 GHz wavelengths

OM1120t



Optical Metro 5100/5200 DWDM systems also support 36 wavelengths from the international ITU-T 100 GHz wavelength grid when used with the Nortel Networks Common Photonic Layer platform, as shown in Figure 1-10.

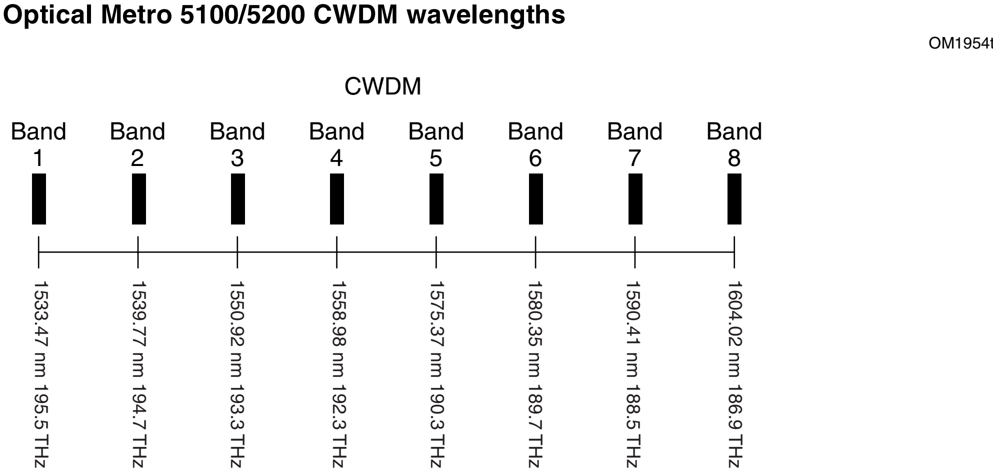
Figure 1-10
Optical Metro 5100/5200 DWDM 100 GHz wavelengths



CWDM wavelengths

Optical Metro 5100/5200 CWDM systems use eight wavelengths from the international ITU-T 200 GHz wavelength grid, as shown in Figure 1-11.

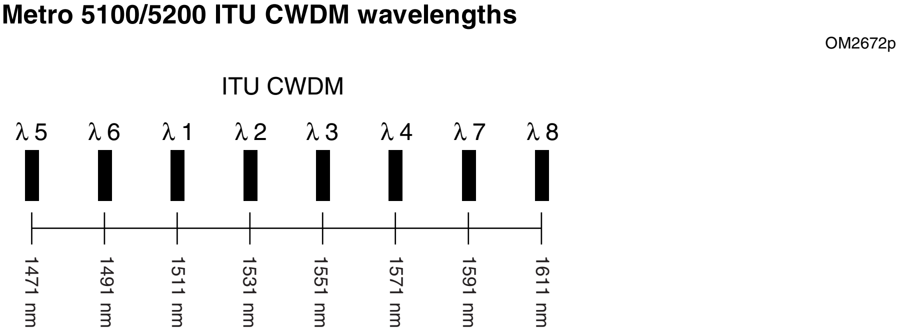
Figure 1-11
Optical Metro 5100/5200 CWDM wavelengths



ITU CWDM wavelengths

Optical Metro 5100/5200 ITU CWDM systems use eight wavelengths from the international ITU-T 20 nm spacing CWDM wavelength grid, as shown in Figure 1-12. Some Optical Metro 5100/5200 ITU CWDM hardware introduced before the ITU CWDM standard (G.695) was finalized will have labels with a center wavelength that differs by 1 nm with respect to the finalized ITU CWDM standard (G.695). For example, for the 1471 nm wavelength, the label will show 1470 nm. However, there is no wavelength incompatibility since the passbands are the same. For example, the pre-finalized ITU CWDM standard 1470 nm channel specified a range of–5.5 to +7.5 nm, that is, a passband of 1464.5 to 1477.5 nm. The finalized ITU CWDM standard 1471 nm channel specifies a range of ±6.5 nm, that is, the passband is still 1464.5 to 1477.5 nm. The only difference is one of labeling.

Figure 1-12
Optical Metro 5100/5200 ITU CWDM wavelengths



Grouping wavelengths into bands

Bands are important in the understanding of the optical network topology because they define the granularity of what may be added or dropped at a specific physical location. If any optical channel carried by a wavelength within a band originates or terminates at a physical location, the entire band must be dropped and each individual channel must be handled by the service layer components. The individual wavelengths within the band are said to either **terminate** if they are added or dropped to a client interface signal, or **electrically pass through** a network element if they are mapped directly back onto the optical layer. If no wavelength within a band is carrying an optical channel that terminates or originates at this physical location, then there is no need for this band to be dropped. In this case, the entire band is said to **optically pass through** this physical location.

> ***Note:*** ITU CWDM systems do not utilize bands. Each wavelength in an ITU CWDM system correlates to one channel.

DWDM bands

In order to manage the multiple wavelengths in the grid and to assist in optical network planning and link engineering, the 32 DWDM 200 GHz wavelengths used by the Optical Metro 5100/5200 are grouped into eight bands. These are referred to as **Band 1** to **Band 8**. Each band contains four consecutive wavelengths as defined in Table 1-1 on page 1-14. The 36 DWDM 100 GHz wavelengths used by the Optical Metro 5100/5200 with the Nortel Networks Common Photonic Layer platform are grouped into nine bands or groups. These are referred to as **Band 1/Group 1** to **Band 9/Group 9**. Each band/group contains four consecutive wavelengths as defined in Table 1-2 on page 1-15.

CWDM bands

For the CWDM wavelengths, there is a one-to-one correlation between the eight bands and the eight CWDM wavelengths. For this reason, the term “band” may sometimes be used to reference a CWDM wavelength. The CWDM bands are defined in Table 1-3 on page 1-15.

Grouping bands: the C-band and the L-band

The Optical Metro 5100/5200 further groups the 32 DWDM 200 GHz wavelengths within the bands into the **conventional band (C-band)** spectrum, which covers band 1 to band 4, and the **long band (L-band)** spectrum, which covers band 5 to band 8. The 36 DWDM 100 GHz wavelengths within the bands/groups are grouped into the **conventional band (C-band)** spectrum, which covers band 1/group 1 to band 9/group 9.

> ***Note:*** CWDM and ITU CWDM systems do not utilize the concept of C-band and L-band spectrums.

Table 1-1 lists the 200 GHz center wavelengths of each band and channel in an Optical Metro 5100/5200 DWDM system.

Table 1-1
200 GHz center wavelengths of each DWDM band and channel

	DWDM band	Center wavelengths (channels) (nm)			
		Channel 1	**Channel 2**	**Channel 3**	**Channel 4**
C-band	1	1528.77	1533.47	1530.33	1531.90
	2	1538.19	1542.94	1539.77	1541.35
	3	1547.72	1552.52	1549.32	1550.92
	4	1557.36	1562.23	1558.98	1560.61
L-band	5	1570.42	1575.37	1572.06	1573.71
	6	1580.35	1585.36	1582.02	1583.69
	7	1590.41	1595.49	1592.10	1593.80
	8	1600.60	1605.73	1602.31	1604.02

Table 1-2 lists the 100 GHz center wavelengths of each band and channel in an Optical Metro 5100/5200 DWDM system.

Table 1-2
100 GHz DWDM center wavelengths

Band/Group	Center wavelength			
	Channel 1	Channel 2	Channel 3	Channel 4
1	1530.33 nm	1531.12 nm	1531.90 nm	1532.68 nm
2	1534.25 nm	1535.04 nm	1535.82 nm	1536.61 nm
3	1538.19 nm	1538.98 nm	1539.77 nm	1540.56 nm
4	1542.14 nm	1542.94 nm	1543.73 nm	1544.53 nm
5	1546.12 nm	1546.92 nm	1547.72 nm	1548.52 nm
6	1550.12 nm	1550.92 nm	1551.72 nm	1552.52 nm
7	1554.13 nm	1554.94 nm	1555.75 nm	1556.56 nm
8	1558.17 nm	1558.98 nm	1559.79 nm	1560.61 nm
9	1562.23 nm	1563.05 nm	1563.86 nm	1564.68 nm

Table 1-3 lists the center wavelengths of each channel in an Optical Metro 5100/5200 CWDM system.

Table 1-3
Center wavelengths of each CWDM band

CWDM band	Center wavelengths (nm)
1	1533.47
2	1539.77
3	1550.92
4	1558.98
5	1575.37
6	1580.35
7	1590.41
8	1604.02

Table 1-4 lists the wavelengths in an Optical Metro 5100/5200 ITU CWDM system. Some Optical Metro 5100/5200 ITU CWDM hardware introduced before the ITU CWDM standard (G.695) was finalized will have labels with a center wavelength that differs by 1 nm with respect to the finalized ITU

CWDM standard (G.695). For example, for the 1471 nm wavelength, the label will show 1470 nm. However, there is no wavelength incompatibility since the passbands are the same. For example, the pre-finalized ITU CWDM standard 1470 nm channel specified a range of –5.5 to +7.5 nm, that is, a passband of 1464.5 to 1477.5 nm. The finalized ITU CWDM standard 1471 nm channel specifies a range of ±6.5 nm, that is, the passband is still 1464.5 to 1477.5 nm. The only difference is one of labeling.

Table 1-4
Wavelengths in an ITU CWDM system

Wavelength (nm)
1511.00
1531.00
1551.00
1571.00
1471.00
1491.00
1591.00
1611.00

Building blocks

This chapter describes the components that make up the Optical Metro 5100/5200 product. These are the components that are used to implement the optical layer and to interface to client equipment.

In this chapter

Site

A site is a physical location where a set of Optical Metro 5100/5200 optical components and shelves interact with the optical signal that flows through the fiber. These interactions include

- adding and dropping bands and channels from the aggregate signal flow
- amplifying the signal
- regenerating the signal
- bridging signals from one system to another

The set of shelves and components present at a site are grouped into one hubbing group. A hubbing group can be managed through the Optical Metro 5100/5200 operation, administration, maintenance, and provisioning (OAM&P) interfaces.

Client side interface circuit packs

A number of circuit packs are available to interface a client signal (for example, SONET, ATM, and Gigabit Ethernet) to the Optical Metro 5100/5200 network. One of these circuit packs is always found at each of the two endpoints of an optical channel.

The client side interface circuit packs are referred to as **Optical Channel Interface** (**OCI**) circuit packs. OCI circuit packs typically interface with one client signal. Some OCI circuit packs interface with up to eight client signals. These are referred to as **sub-rate multiplex OCI** (**OCI SRM**) circuit packs.

Alternately, the **Optical Transponder** (**OTR**) circuit pack provides a client side interface for one client signal and the **Muxponder** circuit packs interface with up to ten client signals.

The following client side interface circuit packs are available:

- OCI 622 Mbit/s 1310 nm
- OCI 1.25 Gbit/s 1310 nm
- OCI 1.25 Gbit/s 850 nm
- OCI ISC 1.25 Gbit/s 1310 nm
- OCI GbE 1.25 Gbit/s 1310 nm
- OCI GbE 1.25 Gbit/s 850 nm
- OCI OC-48/STM-16 2.5 Gbit/s 1310 nm
- OCI OC-3/12/48, STM-1/4/16 2.5 Gbit/s 1310nm
- OCI OC-3/12/48, STM-1/4/16 2.5 Gbit/s 1310nm (with IR on OC-48/STM-16)
- OCI SRM 1310 nm (up to 270 Mbit/s)

- OCI SRM 1310 nm LC (up to 270 Mbit/s)
- OCI SRM SONET/SDH 2.5 Gbit/s (OC-12/STM-4 only)
- OCI SRM SONET/SDH LTE 2.5 Gbit/s (OC-3/STM-1 and OC-12/STM-4)
- OCI SRM ESCON
- OCI SRM GbE/FC 1310 nm
- OCI SRM GbE/FC 850 nm
- OCI SRM GbE/FC Enhanced 1310 nm
- OCI SRM GbE/FC Enhanced 850 nm
- OCI SRM GbE 1310 nm
- OCI SRM GbE 850 nm
- OTR 10 Gbit/s
- OTR 10 Gbit/s Enhanced
- OTR 2.5 Gbit/s Flex 1310 nm
- OTR 2.5 Gbit/s Flex 850 nm
- OTR 2.5 Gbit/s Universal
- Muxponder 10 Gbit/s GbE/FC
- Muxponder 10 Gbit/s GbE/FC VCAT
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-add
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-drop

For more information about these circuit packs, refer to the “Circuit packs” chapter in *Hardware Description,* 323-1701-102.

Line side interface circuit packs

A number of circuit packs are available to interface to the line side of an Optical Metro 5100/5200 network. One of these circuit packs is always found at each of the two endpoints of an optical channel although more may be at intermediate points along the optical channel.

The line side interface circuit packs are referred to as **Optical Channel Laser and Detector** (**OCLD**) circuit packs. OCLD circuit packs always interface to a single wavelength on the line side.

In addition, the **Optical Transponder** (**OTR**) and **Muxponder** circuit packs also provide a line side interface for one wavelength.

The following line side interface circuit packs are available for DWDM 200 GHz systems:

- OCLD 1.25 Gbit/s normal reach (32 instances)

- OCLD 1.25 Gbit/s Extended Reach (32 instances)
- OCLD 2.5 Gbit/s normal reach (32 instances)
- OCLD 2.5 Gbit/s Extended Reach (32 instances)
- OCLD 2.5 Gbit/s Flex normal reach (32 instances)
- OCLD 2.5 Gbit/s, Flex Extended Reach (32 instances)
- OCLD 2.5 Gbit/s Flex Extended Metro (32 instances)
- OCLD 2.5 Gbit/s Universal (32 instances)
- OTR 2.5 Gbit/s Flex normal reach 1310 nm (32 instances)
- OTR 2.5 Gbit/s Flex Extended Reach 1310 nm (32 instances)
- OTR 2.5 Gbit/s Flex Extended Metro 1310 nm (32 instances)
- OTR 2.5 Gbit/s Flex normal reach 850 nm (32 instances)
- OTR 2.5 Gbit/s Flex Extended Reach 850 nm (32 instances)
- OTR 2.5 Gbit/s Flex Extended Metro 850 nm (32 instances)
- OTR 2.5 Gbit/s Universal (32 instances)
- OTR 2.5 Gbit/s Universal 1310 nm (32 instances)
- OTR 2.5 Gbit/s Universal 850 nm (32 instances)
- OTR 10 Gbit/s (16 instances, C-band only)
- OTR 10 Gbit/s Enhanced (32 instances)
- Muxponder 10 Gbit/s GbE/FC (32 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT (32 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-add (32 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-drop (32 instances)

The following line side interface circuit packs are available for DWDM 100 GHz systems when used with the Common Photonic Layer platform:

- OCLD 2.5 Gbit/s Flex 100 GHz (36 instances)
- OTR 2.5 Gbit/s Flex 100 GHz 1310 nm (36 instances)
- OTR 2.5 Gbit/s Flex 100 GHz 850 nm (36 instances)
- OTR 10 Gbit/s Enhanced 100 GHz (36 instances)
- Muxponder 10 Gbit/s GbE/FC 100 GHz (36 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT 100 GHz (36 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT 100 GHz Uni-add (36 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT 100 GHz Uni-drop (36 instances)

The following line side interface circuit packs are available for CWDM systems:

- OCLD 1.25 Gbit/s (8 instances)
- OCLD 2.5 Gbit/s (8 instances)
- OCLD 2.5 Gbit/s Flex (8 instances)
- OTR 2.5 Gbit/s Flex 1310 nm (8 instances)
- OTR 2.5 Gbit/s Flex 850 nm (8 instances)
- OTR 10 Gbit/s Enhanced (8 instances)
- Muxponder 10 Gbit/s GbE/FC (8 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT (8 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-add (8 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-drop(8 instances)

The following line side interface circuit packs are available for ITU CWDM systems:

- OCLD 2.5 Gbit/s Flex (8 instances)
- OTR 2.5 Gbit/s Flex 1310 nm (8 instances)
- OTR 2.5 Gbit/s Flex 850 nm (8 instances)
- OTR 10 Gbit/s Enhanced (5 instances)
- Muxponder 10 Gbit/s GbE/FC (5 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT (5 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-add (5 instances)
- Muxponder 10 Gbit/s GbE/FC VCAT Uni-drop (5 instances)

The OTR and Muxponder circuit packs appear both as a client side interface circuit pack and a line side interface circuit pack. This is because these circuit packs provide both these interfaces by mapping directly from the client interface onto a wavelength.

For more information about these circuit packs, refer to the “Circuit packs” chapter in *Hardware Description,* 323-1701-102.

Optical channel manager circuit pack

The **Optical Channel Manager** (**OCM**) circuit pack provides cross connect functionality to implement channel assignments between two circuit packs within a single network element. Channel assignments can be between an OCI (or OCI SRM) and OCLD or between two OCLDs.

The OCM is only applicable to the Optical Metro 5200 product. It is not required in the Optical Metro 5100 product.

The following OCM circuit packs are available:

- OCM 1.25 Gbit/s
- OCM 2.5 Gbit/s

For more information about OCM circuit packs, refer to the “Circuit packs” chapter in *Hardware Description,* 323-1701-102.

Shelf processor

The **Shelf Processor** (**SP)** circuit pack provides centralized processing and data communications capabilities for all functions associated with a single shelf. For a description about shelves, refer to “Optical Metro 5100/5200 shelf” on page 2-12.

For more information about SP circuit packs, refer to the “Circuit packs” chapter in *Hardware Description,* 323-1701-102.

WDM wavelength filters

Wavelength filters extract specific wavelengths from a multiplexed signal on a fiber in order to connect them to the OCLD, OTR or Muxponder for further processing. This is referred to as a wavelength being **dropped**. Conversely these filters are used to insert a signal from an OCLD, OTR or Muxponder onto the appropriate wavelength for multiplexing with the rest of the signals. This is referred to as a wavelength being **added**. Hence, these filters are often referred to as **add/drop filters**.

The add/drop filters that are used within an Optical Metro 5100/5200 network are **Optical Multiplexer** (**OMX)** filters. OMX filters (except for the OMX 16CH DWDM) are packaged in a **tray,** which in turn is placed in a **drawer**. There are different variants of drawers that can contain one or two filter trays, depending on the type. The OMX 16CH DWDM is packaged in a 2U high shelf.

There are OMX filters that interface with the DWDM, CWDM, and ITU CWDM wavelength grids of the optical layer.

The following OMX modules are available:

- **OMX (Standard) DWDM—**eight variants (Band 1 to 8): OMX tray only
- **OMX 4CH + Fiber Manager DWDM—**eight variants (Band 1 to 8): OMX tray and 1U high drawer (1 tray per drawer)
- **OMX 4CH DWDM Enhanced—**eight variants (Band 1 to 8): OMX tray and 1U high drawer (1 tray per drawer)
- **OMX 16CH DWDM—**two variants (C-Band and L-Band): 2U high shelf
- **OMX 4CH CWDM—**two variants, **(**Band 1 to 4 and Band 5 to 8): OMX tray and 1U high drawer (1 tray per drawer)

- **OMX 4CH CWDM with dual taps—**two variants, (Band 1 to 4 and Band 5 to 8): OMX tray and 1U high drawer (1 tray per drawer)
- **OMX 1CH CWDM—**eight variants (Band 1 to 8): OMX tray and 1U high drawer (2 trays per drawer)
- **OMX 4CH ITU CWDM—**one variant (1511, 1531, 1551, 1571 nm wavelengths): OMX tray and 1U high drawer (1 tray per drawer)

  Note: Some Optical Metro 5100/5200 ITU CWDM hardware introduced before the ITU CWDM standard (G.695) was finalized will have labels with a center wavelength that differs by 1 nm with respect to the finalized ITU CWDM standard (G.695). For example, for the 1471 nm wavelength, the label will show 1470 nm. However, there is no wavelength incompatibility since the passbands are the same. For example, the pre-finalized ITU CWDM standard 1470 nm channel specified a range of –5.5 to +7.5 nm, that is, a passband of 1464.5 to 1477.5 nm. The finalized ITU CWDM standard 1471 nm channel specifies a range of ±6.5 nm, that is the passband is still 1464.5 to 1477.5 nm. The only difference is one of labeling.

- **OMX 8CH ITU CWDM—**one variant (1471, 1491, 1511, 1531, 1551, 1571, 1591, 1611 nm wavelengths): OMX tray and 1U high drawer (1 tray per drawer)

  Note: Some Optical Metro 5100/5200 ITU CWDM hardware introduced before the ITU CWDM standard (G.695) was finalized will have labels with a center wavelength that differs by 1 nm with respect to the finalized ITU CWDM standard (G.695). For example, for the 1471 nm wavelength, the label will show 1470 nm. However, there is no wavelength incompatibility since the passbands are the same. For example, the pre-finalized ITU CWDM standard 1470 nm channel specified a range of –5.5 to +7.5 nm, that is a passband of 1464.5 to 1477.5 nm. The finalized ITU CWDM standard 1471 nm channel specifies a range of ±6.5 nm, that is the passband is still 1464.5 to 1477.5 nm. The only difference is one of labeling.

- **OMX 4CH OADM ITU CWDM—**two variants, (1471, 1491, 1511, 1531 nm wavelengths) and (1551, 1571, 1591, 1611 nm wavelengths): OMX tray and 1U high drawer (1 tray per drawer)
- **OMX 1CH OADM ITU CWDM—**eight variants (1471, 1491, 1511, 1531, 1551, 1571, 1591, 1611 nm wavelengths): OMX tray and 1U high drawer (2 trays per drawer)

For more information about OMXs, see the “OMX modules” chapter in *Hardware Description,* 323-1701-102.

C-band and L-band splitter and coupler

There is sometimes a need to separate the C-band wavelengths from L-band wavelengths prior to extracting specific bands and channels. This may be required for optimizing link budgets, for planning network growth, or for amplification.

To provide this capability, a filter is available that splits the C-band and L-band signals onto two separate fibers. Conversely, it combines the C-band signals from one fiber with the L-band signals from another fiber onto a single fiber. This is referred to as the **C&L splitter/coupler**.

The C&L splitter/coupler is available in a tray, which is inserted into the separately mountable 1U high dual filter drawer.

For more information about C&L splitter/coupler trays and drawers, see the “C&L splitter/coupler” chapter in *Hardware Description,* 323-1701-102.

1310 nm splitter and coupler

There may be a requirement to overlay a WDM network on an existing SONET/SDH network that uses a 1310 nm wavelength.

To provide this capability, a filter is available that combines the 1310 nm signal with the ITU CWDM wavelengths for transmission down the fiber. Conversely, it splits the 1310 nm wavelength from the ITU CWDM wavelengths at the destination site. This is referred to as the **1310 nm splitter/coupler**.

The 1310 nm splitter/coupler is available as a 1U high drawer with one or two splitter/coupler trays.

For more information about 1310 nm splitter/coupler trays and drawers, see the “1310 nm splitter/coupler” chapter in *Hardware Description,* 323-1701-102.

Optical protection equipment

Three types of protection equipment are available:

- OTR protection
- Trunk switch protection

OTR protection

To protect a signal that is received or transmitted using the OTR circuit pack, you must deploy a **transponder protection tray**. The following transponder protection tray kits are available:

- single-mode transponder protection tray kit (four splitter/couplers for up to eight OTR circuit packs)

- single-mode transponder protection tray kit (two splitter/couplers for up to four OTR circuit packs)
- multimode transponder protection tray kit (four splitter/couplers for up to eight OTR circuit packs)
- multimode transponder protection tray kit (two splitter/couplers for up to four OTR circuit packs)

For more information about transponder protection tray kits, see the "Transponder Protection Tray" chapter in *Hardware Description,* 323-1701-102.

For more information about OTR and Transponder Protection Tray protection switching, see the "Optical path protection switching" chapter in *Software and User Interface,* 323-1701-101.

Trunk switch protection

In some situations, it is desirable to simply provide protection at the level of the line side fiber. This provides a cost effective means of protecting the system against the most likely cause of failure, which is damaged fiber.

The fiber can be protected by a **trunk switch**, which is inserted on the fiber, following all other Optical Metro 5100/5200 optical components. It works with a mated trunk switch at the remote end, transmitting and receiving the signal on the primary fiber pair under normal operating conditions. Upon failure conditions, the signal is switched over to a standby fiber pair. For more information about trunk switch protection, refer to the chapter "Supported configurations" in this book.

Optical Metro 5100/5200 offers the following two types of trunk switches:

- optical trunk switch (OTS), with mounting brackets for rack installation
- Enhanced Trunk Switch (ETS), which consists of the following three components, as well as a shelf installation kit:
  - — ETS shelf
  - — ETS Switch module
  - — ETS Comms module

For more information about optical trunk switches, see the "Optical Trunk Switch" chapter and the "Enhanced Trunk Switch" chapter in *Hardware Description,* 323-1701-102.

For more information about trunk switch protection switching, see the "Optical path protection switching" chapter in *Software and User Interface,* 323-1701-101.

Amplification circuit packs

In some network designs, it may be necessary to amplify a signal to ensure that it is received at its destination with sufficient power.

Amplification in an Optical Metro 5100/5200 network must be applied to either the C-band or the L-band independently. All wavelengths within either the C-band or L-band are amplified as an aggregate signal, which results in an equal optical power gain on the individual channels.

Amplification is applied to the aggregate signal by the **Optical Fiber Amplifier** (**OFA)** circuit pack. The following OFA circuit packs are available:

- standard OFA
- high input power OFA
- variable gain OFA

The C-band and the L-band must be amplified independently and each type of OFA circuit pack has the following variants:

- OFA C-band
- OFA L-band

If your network carries C-band and L-band traffic on the same fiber, you must separate the C-band and L-band before the signal is sent to an OFA circuit pack. The C-band and L-band must then be recombined following amplification prior to transmitting on the fiber. This can be achieved by using the C&L splitter/coupler. See “C-band and L-band splitter and coupler” on page 2-8.

Alternatively, the C-band and L-band splitting and coupling functionality can be provided by the Equalizer Coupler Tray (ECT) components. For information about ECTs, see “Band power equalization components” on page 2-10.

For more information about OFA circuit packs, refer to the “Circuit packs” chapter *Hardware Description,* 323-1701-102.

Band power equalization components

To obtain optimum performance when amplifying the optical signals carried by either the C-band or the L-band, each individual band that makes up the C-band or L-band aggregate signal must enter the OFA with roughly the same power level. You must also ensure that the optical power of the signal sent to the OFA circuit pack falls within acceptable limits or you risk overloading the amplifier. Band power equalization can be achieved in one of two ways: distributed equalization or centralized equalization.

With distributed equalization, the individual bands are attenuated at various locations around the network. With centralized equalization, the individual bands are separated, attenuated, and recombined just prior to entering the amplifier.

Distributed equalization

Distributed equalization is achieved by using attenuator pads in the OMX, and at the input and output of the amplifier. The attenuator pads ensure that the signal power of each band is controlled so that all individual band power levels fall within acceptable variance limits going into the OFA circuit pack.

Various levels of attenuator pads are available that can be used for distributed equalization. The following kits are available:

- OCLD distributed equalization kit, which includes two attenuators each of: 2 dB, 4 dB, 6 dB, 8 dB, 10 dB, 12 dB, 14 dB, 16 dB
- OFA output attenuator kit, which includes two attenuators each of: 1 dB, 2 dB

Centralized equalization

Optical Metro 5200 offers four different components that can be used to equalize the individual band power levels prior to amplifying the aggregate C-band or L-band signal: **Equalizer Coupler Tray (ECT), Per Band Equalizer (PBE)**, **Active Per Band Equalizer (APBE)** and **Active Per Band Equalizer Enhanced (eAPBE)**. All four components allow you to attenuate signal power on a per-band basis. In addition to the previous list, the variable gain OFA provides amplifier-band power control; it, hence, increases the benefit in extended reach networks and gives the ability to add new wavelengths without affecting other wavelengths.

The ECT and the PBE are 1 U high, rack-mounted components that contain variable optical attenuators (VOAs) that you use to manually adjust the power of individual bands. The APBE and eAPBE are a two-slot wide circuit pack that contains electronic variable optical attenuators (eVOAs) that you use to adjust band power remotely, through the Optical Metro 5100/5200 graphical user interface or TL1.

To accommodate various network topologies and designs, many different packaging options exist that combine the functionality of splitting and coupling C-band and L-band signals, equalizing the bands within the C-band or L-band, and possibly attenuating the aggregate signal prior to entering the OFA. For guidelines on which packaging option to select, refer to Chapter 3,“Supported configurations” and Chapter 12, “Site requirements and equipping rules”.

The following components are available for implementing centralized equalization:

- ECT (C-band PBE and C&L Splitter/Coupler module)
- ECT (L-band PBE and C&L Splitter/Coupler module)
- ECT (C-band and L-band PBE and C&L Splitter/Coupler module)
- PBE (C-band, without C&L Splitter/Coupler)
- PBE (L-band, without C&L Splitter/Coupler)
- PBE (C-band and L-band, without C&L Splitter/Coupler)
- APBE circuit pack (C-band)
- APBE circuit pack (L-band)
- APBE Enhanced circuit pack (C-band)
- APBE Enhanced circuit pack (L-band)

For more information about all band power equalization components, refer to *Hardware Description,* 323-1701-102.

Attenuation components

In some network designs, it may be necessary to attenuate a signal into an OFA. Variable optical attenuators and fixed attenuator pads allow you to attenuate aggregate C-band or L-band signals.

The following attenuation components are available:

- ECT (C&L Splitter/Coupler with VOA)
- discrete VOA
- fixed attenuator pads

Optical Metro 5100/5200 shelf

The Optical Metro 5100/5200 shelf provides the infrastructure for the circuit packs to operate and interface with the client side and line side.

The main functions of the wavelength division multiplexing (WDM) shelf are:

- card cage, which houses the circuit packs and provides backplane communication between circuit packs.
- maintenance panel, which provides power switches and electrical interfaces required by the shelf.
- cooling unit, which houses fans to control the temperature of the shelf.
- fiber management trough, which provides a mechanism to manage the fibers that carry the optical interfaces into and out of the shelf.

The following shelves are available:

- Optical Metro 5200 shelf assembly (standard 12U high)
- Optical Metro 5200 shelf assembly (modified for OMX variants, 11U high)
- Optical Metro 5200 shelf assembly (modified for OMX variants, 11U high) Enhanced
- Optical Metro 5100 shelf assembly (standard 4U high)

Optical Metro 5200 shelf assembly (standard 12U high)

The Optical Metro 5200 shelf assembly contains a 20-slot card cage. This shelf can be equipped with either client and line side interface cards (OCI, OCLD, OTR, or Muxponder circuit packs) in which case it is a **WDM shelf** or with OFA or APBE circuit packs, in which case it is an **OFA shelf**.

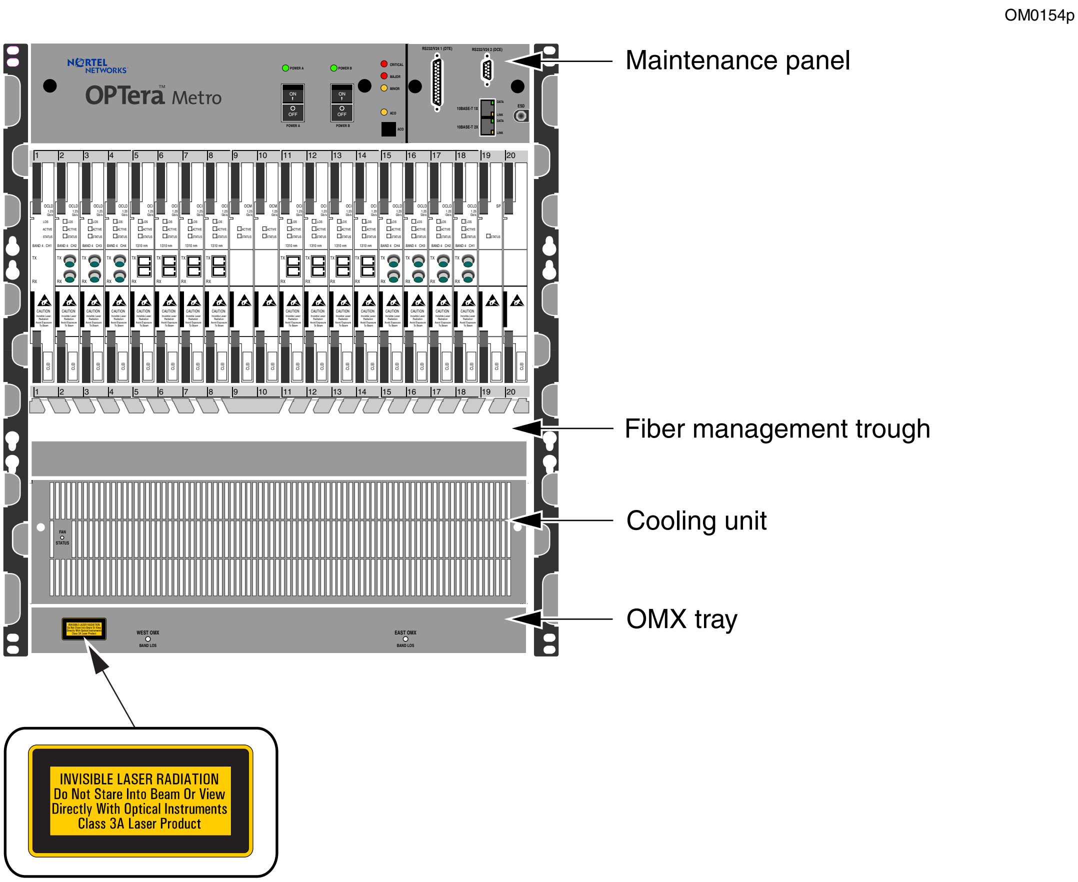
Within the Optical Metro 5200 shelf assembly, slots 1 to 8 are referred to as the **west plane** and slots 11 to 18 are referred to as the **east plane**. This distinction is important when discussing supported configurations (see the chapter "Supported configurations" in this book).

As a WDM shelf, the standard Optical Metro 5200 shelf contains a built-in drawer that holds two OMX trays: one for a single band carrying east-bound traffic and one for a single band carrying west-bound traffic.

When using ECT trays for band power equalization, use the Optical Metro 5200 shelf assembly (standard 12U high) for the OFA shelf. A 12 U high OFA shelf contains a built-in drawer that holds one ECT tray. If this tray is used for the east-bound traffic, to equalize west-bound traffic you must install a separate removable drawer below the east-bound ECT to handle west-bound traffic.

Figure 2-1 shows an example of an Optical Metro 5200 shelf assembly (standard 12U high).

Figure 2-1
Standard DWDM shelf



Optical Metro 5200 shelf assembly (modified for OMX variants, 11U high)

This variant of the Optical Metro 5200 shelf assembly is the same as the standard version in that it contains a 20-slot card cage. This shelf can be equipped with either client and line side interface cards (OCI, OCLD, OTR, or Muxponder circuit packs) in which case it is a **WDM shelf** or with OFA or APBE circuit packs, in which case it is a **OFA shelf**.

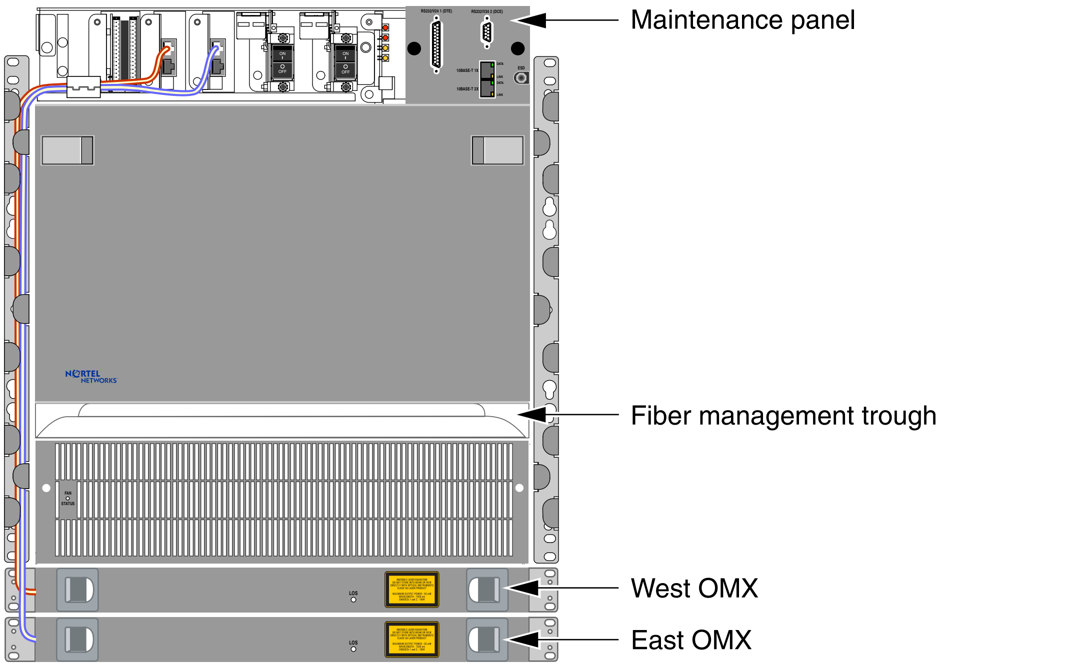
Within the Optical Metro 5200 shelf assembly, slots 1 to 8 are referred to as the **west plane** and slots 11 to 18 are referred to as the **east plane**. This distinction is important when discussing supported configurations (see the chapter “Supported configurations” in this book).

The difference with this modified version is that this shelf does not contain a built-in drawer to hold OMX trays or ECT trays. Any OMX trays associated with this shelf must be inserted in drawers that you can install separately.

With the 11U high shelf for an OFA shelf, you must install any non-circuit pack components, such as C&L splitter/couplers or PBEs, in a separate removable drawer.

Figure 2-2 shows an example of an Optical Metro 5200 shelf assembly (modified for OMX variants, 11U high).

Figure 2-2
Shelf assembly for OMX variants (11U high)



Optical Metro 5200 shelf assembly (modified for OMX variants, 11U high) Enhanced

This variant of the Optical Metro 5200 shelf assembly is the same as the Optical Metro 5200 shelf assembly (modified for OMX variants, 11U high) with the following changes:

- New offset hole plate in air plenum at the top of the shelf. With this change, the Optical Metro 5200 shelf assembly (modified for OMX variants, 11U high) Enhanced meets NEBS flame spread requirements without the use of the NEBS Extension Shelf.

  Note: The NEBS Extension Shelf uses up 1 U of rack space and is required when using the other Optical Metro 5200 shelf types in applications requiring that the shelf meet NEBS flame spread requirements.

- A change to the maintenance panel area to improve the extraction of the power card.
- An enlargement of the opening for cables in the maintenance panel.
- A new gasket type for the shelf door.
- The creation of a fiber extraction tool and the introduction of features on the shelf door to retain the tool.
- Changes to the physical design of the Cooling Unit (NT0H51AD).

Optical Metro 5100 shelf assembly (standard 4U high)

The Optical Metro 5100 shelf assembly contains a 6-slot card cage. This shelf can only be deployed as a WDM shelf.

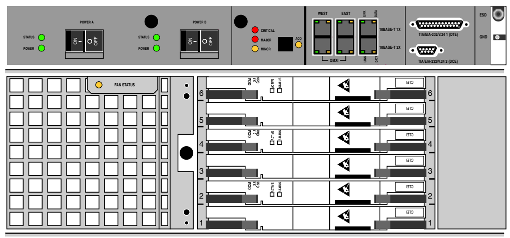
Within the Optical Metro 5100 shelf assembly, slots 1 and 2 are referred to as the **west plane** and slots 3 to 4 are referred to as the **east plane**. This distinction is important when discussing supported configurations (see the chapter "Supported configurations" in this book).

The standard Optical Metro 5100 shelf does not contain a built-in drawer to hold OMX trays. Any OMX trays associated with this shelf must be inserted in drawers that are installed separately.

Figure 2-3 shows an example of an Optical Metro 5100 shelf assembly (standard 4U high).

Figure 2-3
Shelf assembly for Optical Metro 5100

OM0972t



For more information about shelf assemblies, refer to the “Optical Metro 5100 shelves” and “Optical Metro 5200 shelves” chapters in *Hardware Description,* 323-1701-102.

OSC tray

For DWDM and CWDM networks, a dedicated wavelength that is outside of the range of the traffic carrying wavelength spectrum provides fault sectionalization and data communications. The wavelength dedicated for this purpose is referred to as the **Optical Supervisory Channel** (**OSC**). This wavelength is 1510 nm.

The OSC wavelength must be extracted from the aggregate signal prior to any further optical layer processing at a site. Similarly, the OSC wavelength must be added to the aggregate signal following all optical level processing at a site.

The following components are available for adding and dropping the OSC wavelength.

- OSC Splitter/Coupler tray
- OSC Splitter/Coupler tray, with optical tap
- OSC Splitter/Coupler tray, with dual taps

For more information about the OSC splitter/coupler, refer to the “OSC” chapter in *Hardware Description,* 323-1701-102.

OSC circuit pack

To process the information carried on the OSC wavelength, the signal is processed by the OSC circuit pack. The OSC circuit pack provides the interface from the dedicated OSC wavelength to the rest of the Optical Metro 5100/5200 data communications network.

The OSC circuit pack can be inserted into any Optical Metro 5100/5200 shelf.

For more information about the OSC circuit pack, refer to the “Circuit packs” chapter in *Hardware Description,* 323-1701-102.

Ethernet hub

If multiple shelves are colocated at a common physical location, communication between the shelves is achieved by creating a local Ethernet network between them. To create a local Ethernet network at locations where there are three or more shelves, the shelves must be interconnected through an Ethernet hub.

The following Ethernet hub is available:

- Ethernet hub (up to 12 connections)**—**NEBS compliant

For more information about Ethernet hubs, refer to the “Ethernet hub” chapter in *Hardware Description,* 323-1701-102.

Equipment inventory unit

The equipment inventory unit allows you to connect multiple passive optical devices to the maintenance panel of a single Optical Metro 5100/5200 shelf, which allows the network management software (System Manager) to inventory the devices.

DSCM

DSCMs (Dispersion Slope Compensating Module) are designed to compensate the chromatic dispersion slope and dispersion in Extended Metro applications that use OTR 10 Gbit/s Enhanced and Muxponder 10 Gbit/s GbE/FC circuit packs. The DSCM tray provides compensation on NDSF fiber type for a range of 10 km to 140 km for both C-band and L-band with 10 km increments. The DSCM trays are available in different lengths to compensate for different amounts of accumulated dispersion.

Network management

Several interfaces are available to provide operation, administration, maintenance, and provisioning (OAM&P) functionality.

System Manager

The Optical Metro 5100/5200 native graphical user interface for operation, administration, maintenance and provisioning (OAM&P) activities is the **System Manager.**

The Optical Metro 5100/5200 System Manager is a Web-based graphical user interface included with the software package for the Optical Metro 5100/5200 shelf.

System Manager operates on Windows 2000/NT/XP, as well as Solaris 8.0. Use System Manager to:

- view system-wide alarms—alarm summaries and a detailed active alarm list for all Optical Metro 5100/5200 shelves in the network
- view system-wide events—the system can retrieve up to 400 events from each shelf in the network for analysis, and asynchronously reports the 400 most recent network events
- view additional troubleshooting data from routing and interface statistics
- view system-wide inventory—equipment and facility inventory of all circuit packs in the network plus administrative and operation state information
- manage the software—download software from the System Manager to any Optical Metro 5100/5200 shelf in the network, activate and commit the new software
- manage end-to-end connections—set up protected, unprotected, and pass-through channel assignments across the network
- configure external management and surveillance

You can have a maximum of eight System Manager or equivalent SNMP Manager sessions. For more information about System Manager, refer to *Software and User Interface,* 323-1701-101.

TL1 for Optical Metro 5100/5200 shelves

The Optical Metro 5100/5200 shelves also support a transaction language (TL1) user interface for OAM&P. You can use the TL1 interface with operations support systems (OSS) to manage multiple network elements.

You can have a maximum of ten TL1 sessions. For more information about TL1, refer to *TL1 Interface,* 323-1701-190.

TL1 for Optical Trunk Switch and Enhanced Trunk Switch shelves

The Optical Trunk Switch (OTS) and Enhanced Truck Switch (ETS) shelves also support a TL1 user interface for OAM&P. You can use the TL1 interface with operations support systems (OSS) to manage multiple OTS or ETS shelves.

You can have a maximum of five TL1 sessions, four using port 3082 and one using port 23. For more information about TL1, refer to *TL1 Interface,* 323-1701-190.

SNMP for Optical Metro 5100/5200 shelves

The Optical Metro 5100/5200 shelves also support a Simple Network Management Protocol (SNMP) interface for OAM&P functionality. The Optical Metro 5100/5200 supports a management information base (MIB) model with SNMP-based network management systems.

Optical Metro 5100/5200 exports the following set of MIBs:

- SNMP Surveillance MIB

You can have a maximum of four SNMP trap registration sessions, plus four ring-wide sessions. For more information about SNMP, refer to *Software and User Interface,* 323-1701-101.

SNMP for Enhanced Trunk Switch shelves

The ETS shelves also support an SNMP interface for OAM&P functionality. The ETS supports a MIB model with SNMP-based network management systems.

You can have a maximum of four SNMP trap registration sessions. For more information about SNMP, refer to *Software and User Interface,* 323-1701-101.

Supported configurations

In this chapter

Service layer

Description

The service layer of the Optical Metro 5100/5200 defines the traffic that is carried over the optical layer.

The logical view of the service layer describes the traffic patterns. Traffic patterns are governed by channel assignments, protection schemes and protocol specifics.

The physical view of the service layer describes the relationships between traffic carrying circuit packs in a shelf. These relationships dictate the traffic flow.

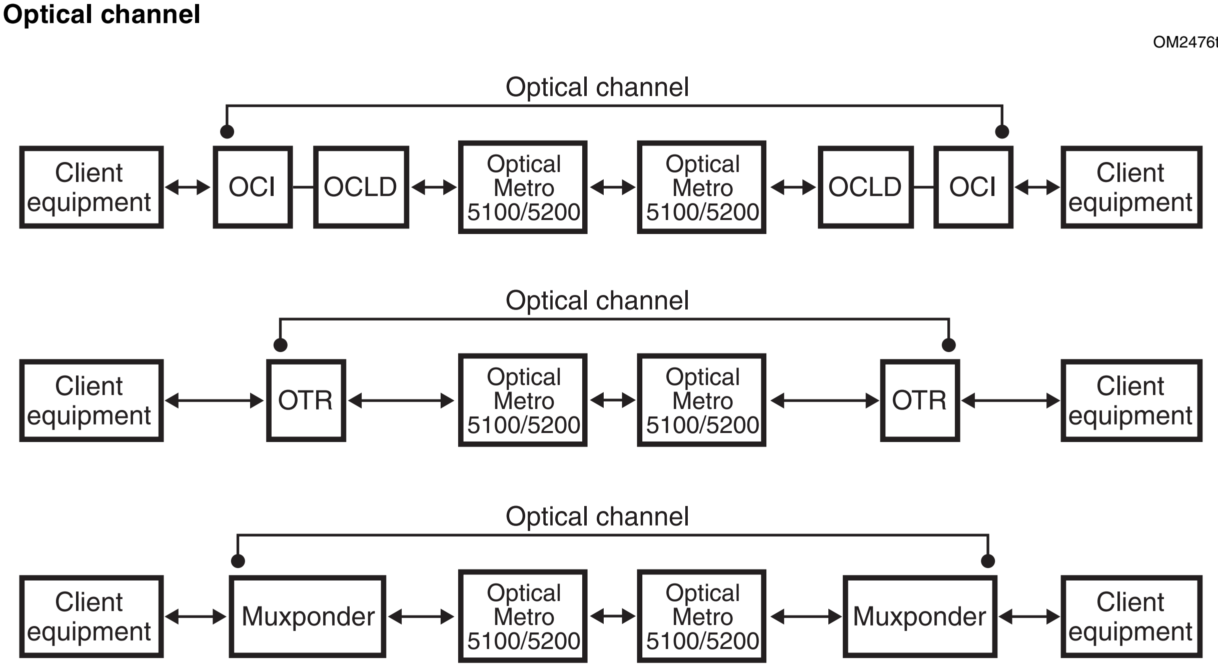
Optical channels

An optical channel is the complete path taken by a client signal from the point the signal is received by the Optical Metro 5100/5200 client interface to the point it is transmitted through another Optical Metro 5100/5200 client interface—without traveling through any other non-Optical Metro 5100/5200 equipment.

An optical channel typically starts where the client signal enters the network through an OCI, OTR or Muxponder circuit pack, and terminates where the client signal leaves the networks through another OCI, OTR or Muxponder circuit pack. Along the way, the optical channel is assigned to a wavelength and carried over the optical layer.

There may be several points along the path where the optical channel is subjected to an optical or electrical pass-through. These pass-throughs do not segment the optical channel; the client interfaces define the end points of the optical channel. Figure 3-1 shows an optical channel.

Figure 3-1
Optical channel



Although client interfaces usually define the end points of an optical channel, there are some exceptions:

- When signals that are carried by OTR 10 Gbit/s or OTR 10 Gbit/s Enhanced circuit packs undergo electrical pass-through, the signal flows out of the client interface on one OTR 10 Gbit/s or OTR 10 Gbit/s Enhanced circuit pack and back into the client interface on another OTR

10 Gbit/s or OTR 10 Gbit/s Enhanced circuit pack in the same shelf. Although client interfaces are involved in this process, the optical channel does not terminate or “leave” the network.

- When signals that are carried by Muxponder 10 Gbit/s GbE/FC or Muxponder 10 Gbit/s GbE/FC VCAT circuit packs undergo electrical pass-through, the signal flows out of the client interface on one OTR 10 Gbit/s Enhanced circuit pack and back into the client interface on another OTR 10 Gbit/s Enhanced circuit pack in the same shelf. Although client interfaces are involved in this process, the optical channel does not terminate or “leave” the network.

An optical channel carries a signal that consists of a protocol that runs at a specific bit rate. For OCI and OTR circuit packs, a single client signal is mapped onto a single wavelength. For OCI sub-rate multiplexer and Muxponder circuit packs, multiple client signals can be multiplexed onto a single wavelength. Depending on the bit rate of the protocol, it is possible to multiplex multiple client signals onto one of the following OCI sub-rate multiplexer circuit packs:

- OCI 4:1 SRM (up to 270 Mbit/s)
- OCI 4:1 SRM SONET/SDH (OC-12/STM-4 only)
- OCI 4:1 SRM SONET/SDH LTE 2.5 Gbit/s (OC-3/STM-1 and OC-12/STM-4)
- OCI 8:1 SRM ESCON
- OCI 2:1 SRM GbE/FC
- OCI 2:1 SRM GbE/FC Enhanced
- OCI 2:1 SRM GbE

Depending on the bit rate of the protocol, it is possible to multiplex multiple client signals onto one of the following Muxponder circuit packs:

- Muxponder 10 Gbit/s GbE/FC
- Muxponder 10 Gbit/s GbE/FC VCAT

In most cases, signals that are multiplexed onto a single wavelength at the originating point of an optical channel must be demultiplexed at the terminating point of an optical channel. If a wavelength enters as four individual client signals, it must leave as four individual client signals. The OCI SRM or Muxponder circuit packs in these cases are implemented in bookended configurations.

The exception to the above rule occurs when OCI SRM or Muxponder circuit packs are implemented in interoperable configurations. In interoperable configurations, multiple client signals are multiplexed onto a single wavelength at the originating point of an optical channel, but do not require demultiplexing at the terminating point of the optical channel.

For more information about bookended and interoperable configurations, see "Service layer topologies" on page 3-52.

In both bookended and interoperable configurations, you cannot drop individual client signals at different locations along the optical channel.

Channel assignments

Channel assignments are mappings between two signal carrying circuit packs within a single Optical Metro 5100/5200 shelf. These mappings establish the flow of the signal between these circuit packs.

Channel assignments between OCI and OCLD circuit packs establish the signal flow between the client side signal and the line side wavelength at the end points of an optical channel. These channel assignments map the client signal onto a specific wavelength.

Channel assignments between OCLD circuit packs at intermediate points along the optical channel are used if the signal carrying wavelength requires regeneration. Establishing a signal flow from one OCLD to another forces an electrical pass-through at a shelf. Both OCLDs have the same OSID (Optical System Identifier) value.

Channel assignments between OCLDs are also used to bridge a signal from one Optical Metro 5100/5200 system to another. In this case, the two OCLDs have different OSID (Optical System Identifier) values. For more information about bridged topologies, see "Bridged traffic" on page 3-20.

For OTR and Muxponder circuit packs, the association between the client side signal and the line side wavelength is implicit within the circuit pack. The association between the circuit packs at intermediate points along the optical channel for signal regeneration or for bridging networks is established via physical connection instead of mapping.

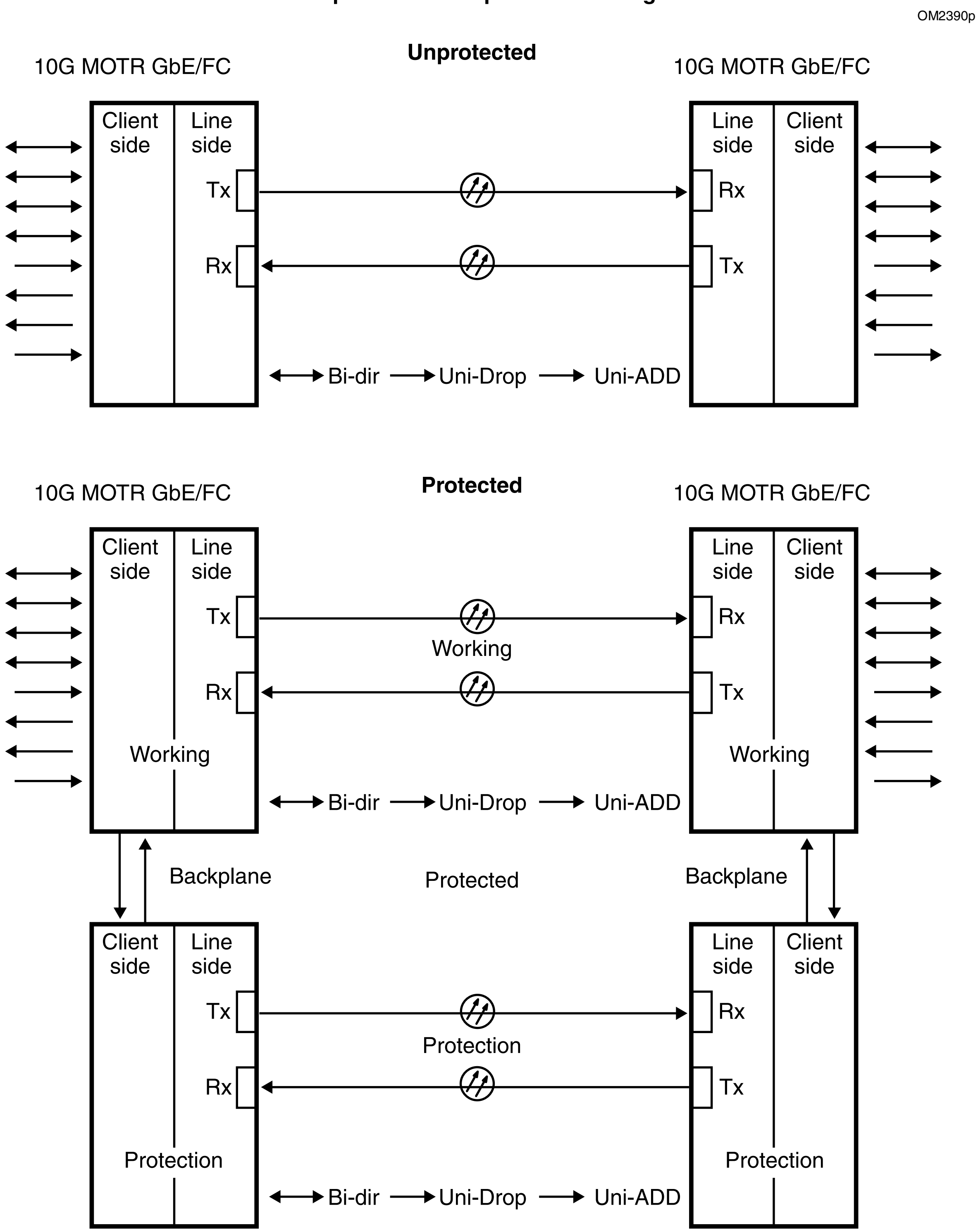
Gigabit Ethernet channel assignments

Unidirectional and bidirectional Gigabit Ethernet traffic support

Unidirectional and bidirectional Gigabit Ethernet traffic is supported on the eight client ports of the Muxponder 10 Gbit/s GbE/FC circuit pack and all ten ports on the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack. To configure unidirectional or bidirectional Gigabit Ethernet traffic on a client port, you must provision the client type to uni-add, uni-drop or bi-directional. You can mix unidirectional and bidirectional traffic on the same Muxponder circuit pack.See Figure 3-2 on page 3-5 for an illustration of both unidirectional and bidirectional protected and unprotected configurations.

> ***Note 1:*** Gigabit Ethernet is the only protocol to support unidirectional configurations. Bidirectional configurations are supported for both Gigabit Ethernet and Fibre Channel/FICON protocols.
>
> ***Note 2:*** The line signal of a Muxponder 10 Gbit/s GbE/FC link is always bidirectional. This is valid for unidirectional and bidirectional client traffic.

Figure 3-2
Unidirectional and bidirectional unprotected and protected configurations



In a unidirectional port assignment, an internal loopback on the corresponding path is automatically performed at the uni-drop site. This is done to suppress alarms in the unused direction. Because of this loopback at the uni-drop site, the Client Tx port at the uni-add site transmits the same Gigabit Ethernet traffic that is being received on the Client Rx port at that site.

When using the Muxponder 10 Gbit/s GbE/FC circuit pack or the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack and GFP-T encapsulation, if a link fault occurs in the unused direction, Gigabit Ethernet 8B10B error codes are sent out the uni-add Client Tx port. To ensure full traffic recovery upon fault restoration, a two-way optical splitter can be used at the local near-end node to split the client signal prior to connecting it to the SFP Client Rx uni-add port. One of the split signals can be connected to the SFP Client Rx uni-add port and the other back to the local subtending equipment.

> ***Note:*** If you do not have an optical splitter, you can use the multimode Transponder Protection Tray (NT0H59BA/BB) for 850 nm operation or the single mode Transponder Protection Tray (NT0H59AA/AB) for 1310 nm operation.

When using the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack and GFP-F encapsulation, if a link fault occurs in the unused direction, Gigabit Ethernet idle codes are sent out the uni-add Client Tx port. These idle codes do not bring down the Gigabit Ethernet link on the subtending equipment and therefore the subtending equipment's transmitter will continue to transmit frames. For this reason, a two-way optical splitter is not needed.

Alarms and PMs are masked on a Client Tx port when the port type is provisioned to uni-add. Alarms and PMs are also masked on the Client Rx port when the port type is provisioned to uni-drop.

Protecting an optical channel signal

Equipment protection

When Optical Metro 5200 shelves are configured with OCI and OCLD circuit packs, the Optical Channel Manager (OCM) circuit packs are used to protect the channel assignments on the shelf.

In all Optical Metro 5200 shelf configurations there are two OCMs. For shelves with OCIs and OCLDs, each OCM carries traffic. If one OCM fails or if you take an OCM out-of-service, a backplane signal is detected by the circuit packs in the shelf indicating that one OCM is not available. The other circuit packs in the shelf automatically switch to the redundant OCM. Equipment switching guarantees that a single failure cannot cause an outage.

> ***Note:*** On the Optical Metro 5200 shelf, a protected connection is established between the working and protection Muxponder 10 Gbit/s GbE/FC circuit pack through the OCM 2.5 Gbit/s circuit packs. Protection is not available if an OCM circuit pack fails or if an OCM circuit pack is removed from the shelf. On the Optical Metro 5100 shelf, a protection connection is established between the working and protection Muxponder 10 Gbit/s GbE/FC circuit pack through the backplane interface.

Path protection using OCIs and OCLDs

When Optical Metro 5100/5200 shelves are configured with OCI and OCLD circuit packs, you can implement path protection by provisioning a channel assignment between one OCI and two OCLDs. In this protection scheme, the same signal is transmitted over two diverse paths, one east and one west. If the fibers in the working (active) path are cut or are out of service, the protected path ensures that the signal reaches its destination.

In an Optical Metro 5200 protected network, the active receiving OCM circuit pack assesses which of the two signals to transmit to the OCI or OCLD circuit pack, based on the protection criteria. In an Optical Metro 5100 protected network, the receiving OCI assesses which signal to transmit. The OCM or OCI circuit packs select the signal to transmit based on which signal has the better quality.

Figure 3-3 on page 3-8 shows an example of path protection in an Optical Metro 5100 network. The same signal is transmitted from Site A (or Site B) to Site B (or Site A) on two separate paths.

Figure 3-3
Example of protected signal paths in Optical Metro 5100 network

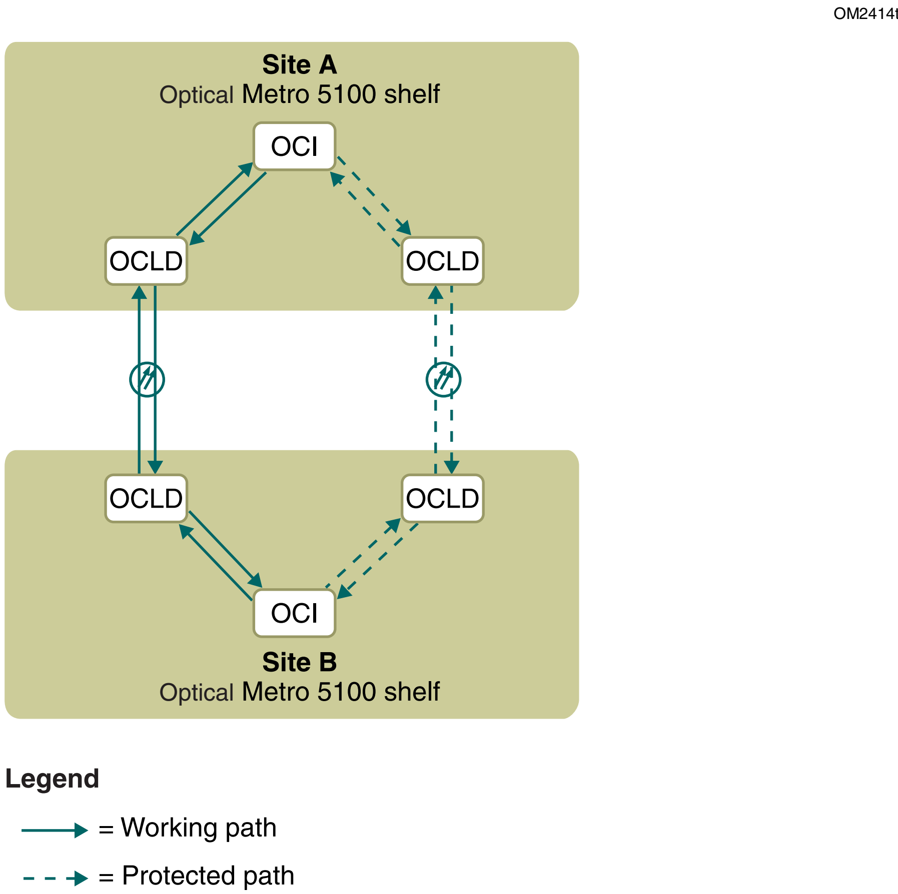
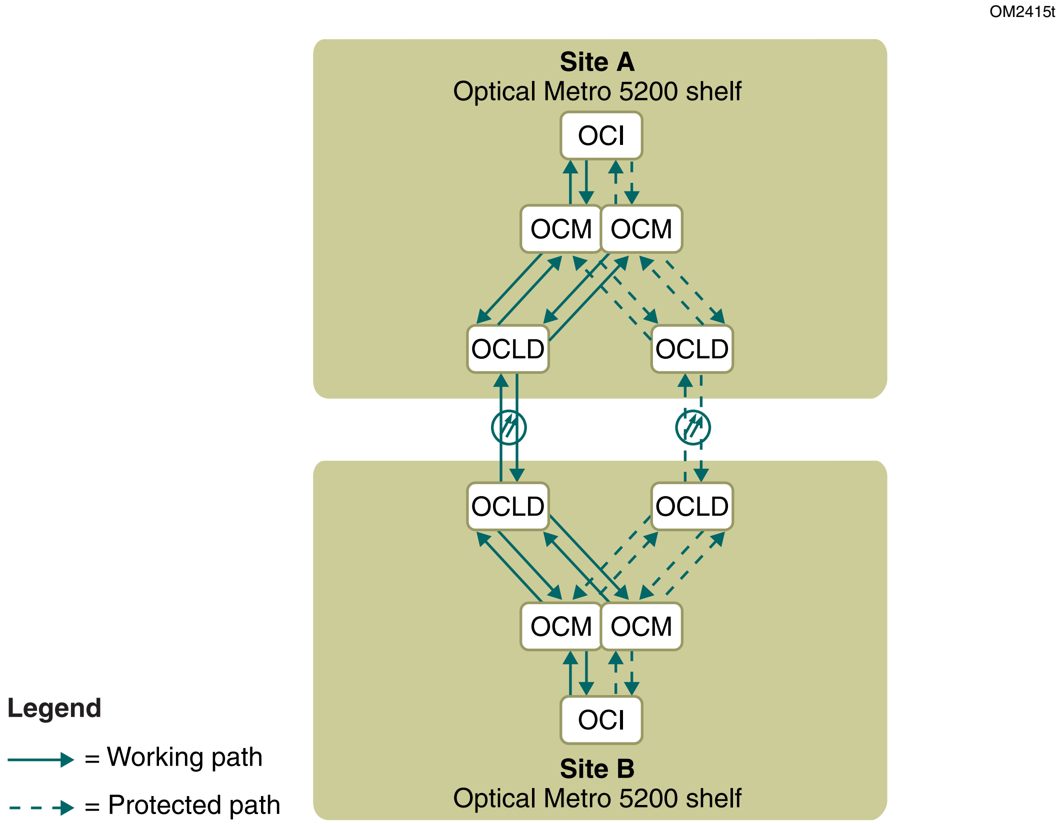


Figure 3-4 shows an example of path protection in an Optical Metro 5200 network. The same signal is transmitted from Site A (or Site B) to Site B (or Site A) on two separate paths.

Figure 3-4
Example of protected signal paths in Optical Metro 5200 network



Path protection using a Transponder Protection Tray

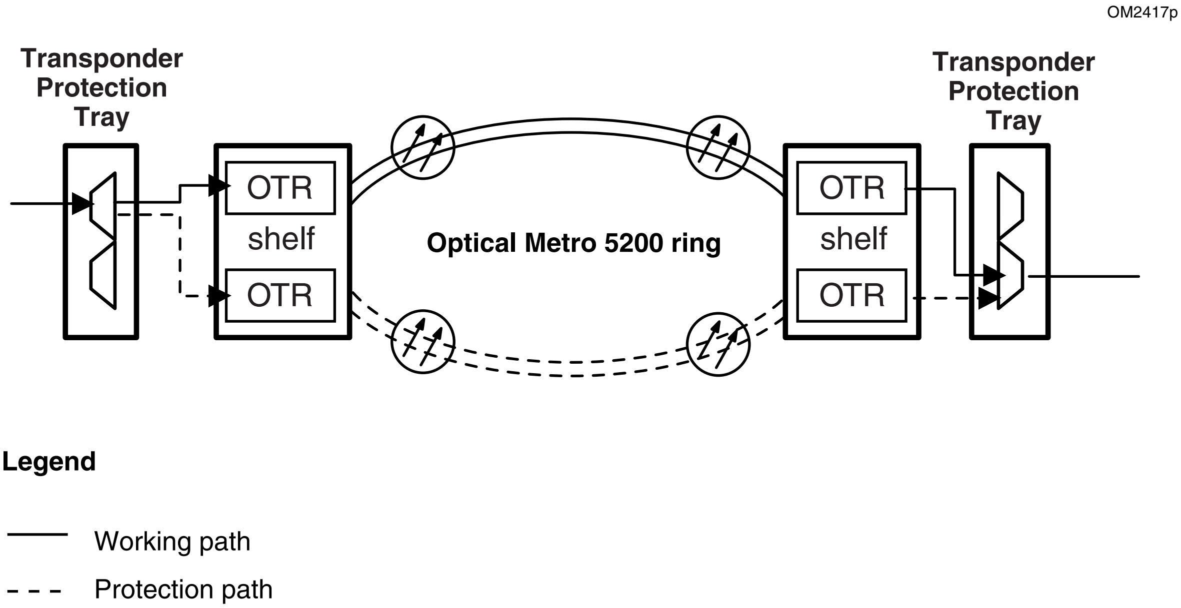
Optical transponder (OTR) circuit packs operate without OCLDs, and their signals do not pass through the OCMs. Instead, path protection for OTRs is implemented by pairing OTRs, and installing a Transponder Protection Tray. Two types of Transponder Protection Trays are available in both single-mode and multimode variations: one contains four optical splitter/couplers, and one contains two optical splitter/couplers. When Transponder Protection Trays are deployed, they are connected directly to the customer equipment and function as the entry and exit points to the Optical Metro 5100/5200 network.

As an entry point to the network, each splitter/coupler receives a signal from one client fiber. It splits the power of the signal and then transmits it over two diverse fibers, to two OTRs through a protected channel assignment. The receiving OTRs assesses, based on protection criteria, which signal is transmitted to the subtending equipment on the receiving end.

As an exit point from the network, each splitter/coupler can receive a signal from two OTRs. Only one OTR in the pair transmits at a time. When the splitter/coupler receives a signal, it transmits the signal to one client fiber.

Figure 3-5 on page 3-10 shows how the Transponder Protection Tray provides path protection for pairs of OTRs.

Figure 3-5
OTR path protection



Line protection using Muxponders

When Optical Metro 5100/5200 shelves are configured with Muxponder circuit packs, you can implement protection by provisioning a channel assignment between two Muxponders. In this protection scheme, the same signal is transmitted over two diverse paths, one east and one west. If the fibers in the working (active) path are cut or are out of service, the protected path ensures that the signal reaches its destination.

Client signals are connected to the working Muxponder only. The working Muxponder is bridged onto the line as well as across the shelf backplane to the mate protection Muxponder. The protection Muxponder does not have any client Small Form Factor Pluggable (SFP) modules populated, it provides line protection only. Failure of the working Muxponder or a client interface causes traffic loss (that is, no client or equipment protection).

Muxponder line side protection is implemented using the 1+1 APS (Automatic Protection Switch) protocol using the K1 and K2 bytes in the SONET line overhead or SDH Multiplex Section overhead. The K1 byte is used to indicate a request by a Muxponder for a switch action, through a request code, as well as an indication as to the channel number making the switch request. The K2 byte is used to indicate the bridging action, the provisioned architecture (1+1), and mode of operation (unidirectional or bidirectional).

The Muxponder 10 Gbit/s GbE/FC circuit packs support both bidirectional and unidirectional protection switching modes.

In unidirectional mode, a protection switch can take place at only one end of the protection switching circuit if there is a single fiber break. In bidirectional mode, on a single fiber break, both ends switch from the working path to the protection path. Bidirectional has the added advantage that the network operator always knows whether the working and protection path is active at any point in time. In unidirectional mode, the working path can be active at one end, and the protection path at the other end.

In both protection switching modes, the working and protection signals are always the same; they are permanently bridged.

In bidirectional protection switching mode, the receiver that detects the fault requests that both the near-end and far-end switch to protection. Requests to the far-end are transmitted by the APS channel (the K1 and K2 bytes protocol).

The default protection switching mode for 1+1 APS protection switching is unidirectional.

Figure 3-6 on page 3-12 illustrates line-side protection on a Muxponder circuit pack connection on an Optical Metro 5200 shelf. Figure 3-7 on page 3-13 illustrates line-side protection on a Muxponder circuit pack connection on an Optical Metro 5100 shelf.

Figure 3-6
Line-side protection on an Optical Metro 5200 shelf

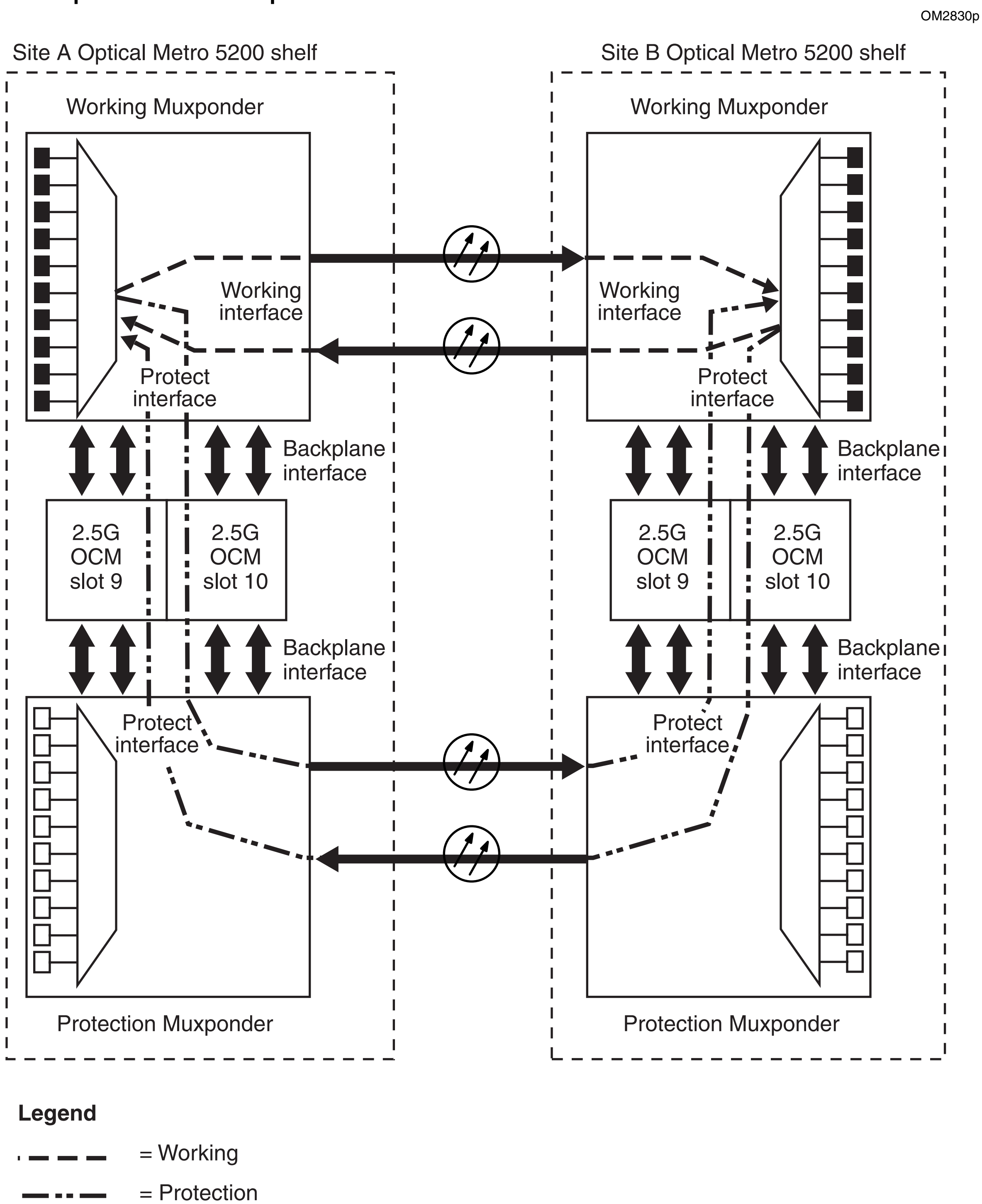
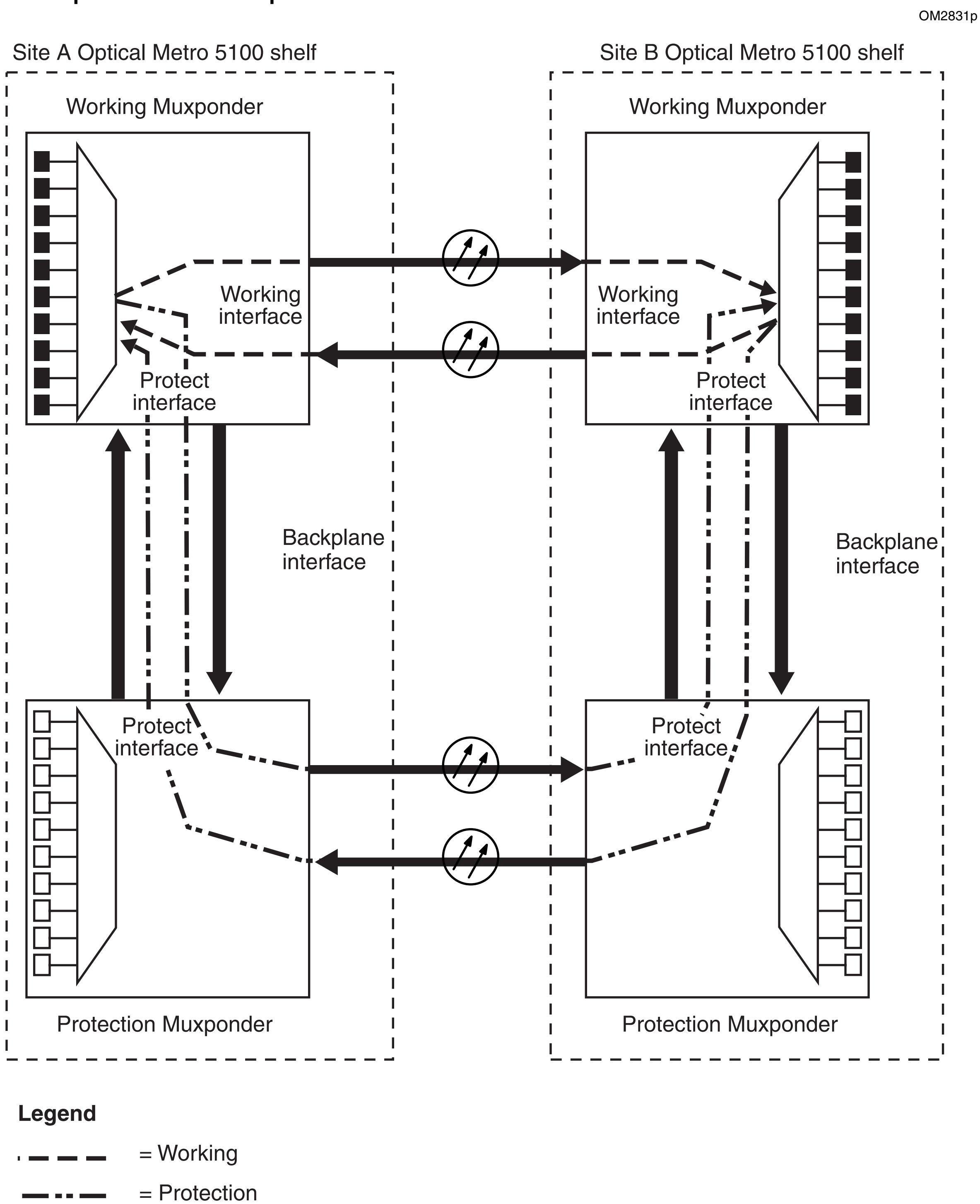


Figure 3-7
Line-side protection on an Optical Metro 5100 shelf



Line protection using an Optical Trunk Switch

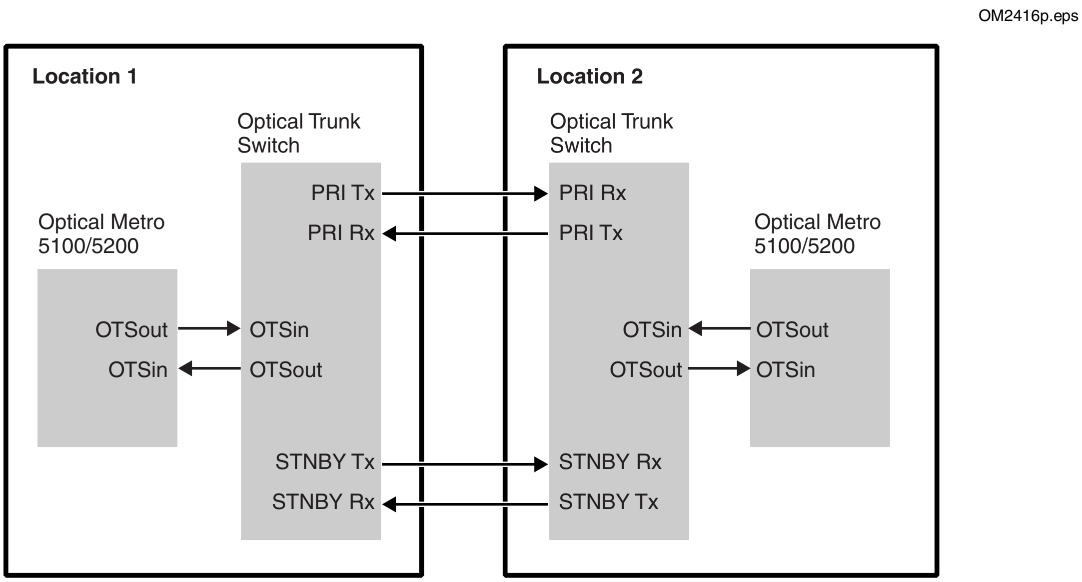
The Optical Trunk Switch (OTS) is a standalone component that provides optical line protection for Optical Metro 5100/5200 point-to-point configurations.

When the OTS is installed at each site in a point-to-point system, it provides protection to the fiber-optic cable between each site. If one fiber-optic cable is damaged, the OTS switches bi-directionally to a redundant optical fiber path.

Figure 3-8 on page 3-14 shows a typical application of the OTS in an Optical Metro 5100/5200 network.

For more information about OTS protection switching, refer to *Software and User Interface,* 323-1701-101.

Figure 3-8
OTS line protection



Line protection using an Enhanced Trunk Switch

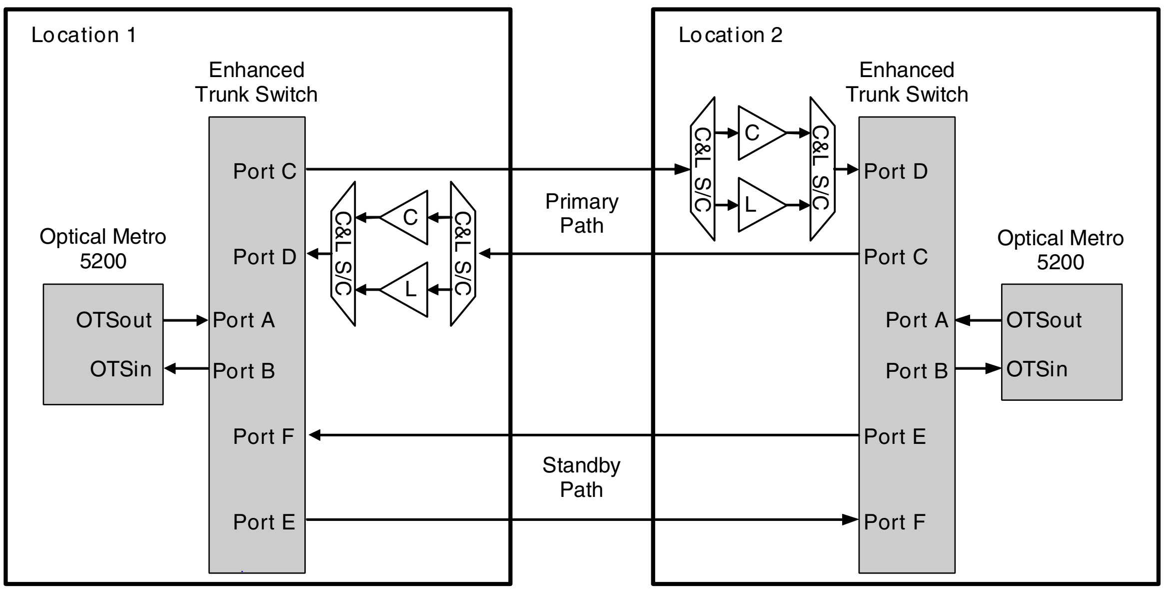
The ETS consists of three components: the ETS shelf, the ETS Switch module and the ETS Comms module. The ETS can be deployed in unamplified point-to-point configurations, and in amplified point-to-point configurations that contain a single pre-amplifier in the link.

> ***Note:*** The ETS does not replace the OTS, nor is it backward compatible with the OTS. You cannot deploy the ETS and the OTS modules in the same point-to-point link.

Figure 3-9 on page 3-15 shows a typical application of the ETS in an Optical Metro 5200 network. The pre-amplifiers are optional. Amplifiers cannot be used in an Optical Metro 5100 network.

For more information about ETS protection switching, refer to *Software and User Interface,* 323-1701-101.

Figure 3-9
ETS line protection



Dual homing protection

Dual homing protection refers to an optical channel that is routed over two diverse paths within an Optical Metro 5100/5200 network and is transmitted out of the network over two diverse client interfaces. On the second network, the two signals enter another Optical Metro 5100/5200 network as two independent client interfaces and are diversely routed around the ring where they then come together at a single shelf at the remote end. At the remote end, the two signals come into two line side interface circuit packs (for example, two 2.5 Gbit/s Flex OCLD circuit packs), and the standard protection criteria is used to select the best signal.

If the signal is a SONET/SDH signal, the signal between the two Optical Metro 5100/5200 rings may be sent through a SONET/SDH network in order to provide longer reach between the source and destination nodes. In this case, a form of protection, using line-AIS is available where if one span fails, the remote Optical Metro 5100/5200 network element can perform a protection switch.

Using Figure 3-10 on page 3-16 as an example, line-AIS based protection occurs as follows:

- a fiber break occurs between transmission nodes (see Figure 3-10)
- the SONET/SDH system transmits line AIS towards the Optical Metro 5100/5200 network
- the remote network element detects that there is line-AIS on one side, but not the other, and causes the OCLD that was active to become inactive, and vice versa
- the protection switch is complete

The circuit packs that support line-AIS protection are:

- OTR 2.5 Gbit/s Flex
- OTR 10 Gbit/s
- OTR 10 Gbit/s Enhanced (for SONET, SDH, and WAN PHY modes only)
- OCLD 2.5 Gbit/s Flex

> ***Note:*** If the SONET/SDH equipment is transmitting path-AIS instead of line-AIS, a protection switch cannot take place.

Figure 3-10
Dual ring configuration with line-AIS based protection

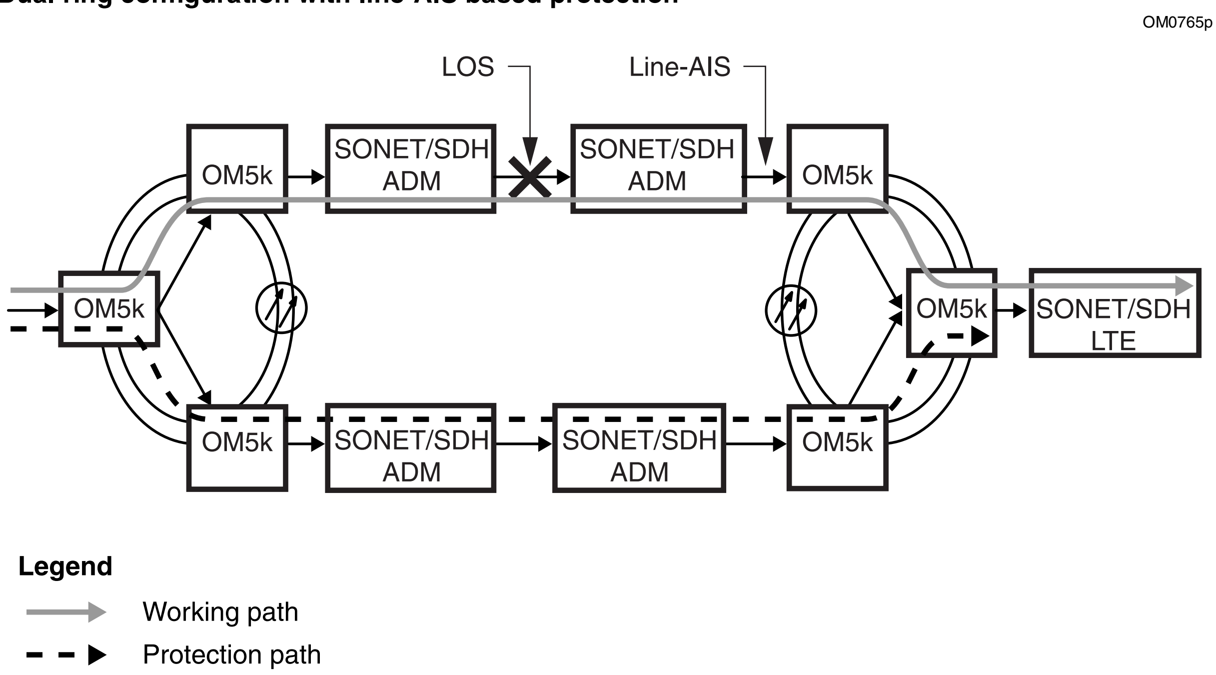
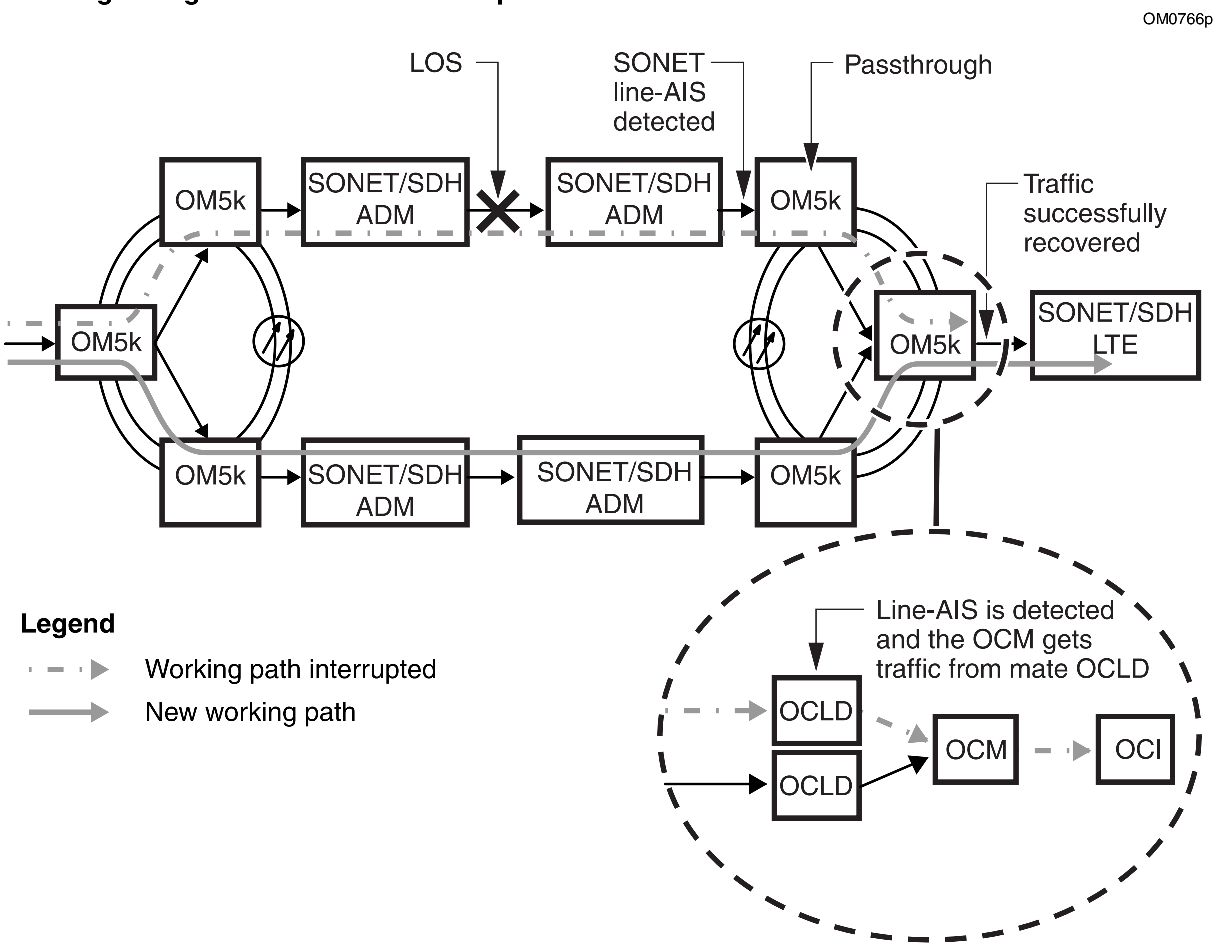


Figure 3-11 on page 3-17 shows how the protection switch takes place when a loss of signal occurs in the SONET system, and line-AIS is injected towards the Optical Metro 5100/5200 system.

Figure 3-11
Dual ring configuration with AIS-based protection



Dual homing protection for Muxponder circuit packs

For dual homing protection configurations using the Muxponder 10 Gbit/s GbE/FC circuit packs, see "Implementing interoperable topologies with Muxponder 10 Gbit/s GbE/FC circuit packs" on page 3-59.

Traffic patterns

Traffic pattern models define the logical flow of traffic between sites in a network. This section describes the traffic pattern models that are supported by the Optical Metro 5100/5200.

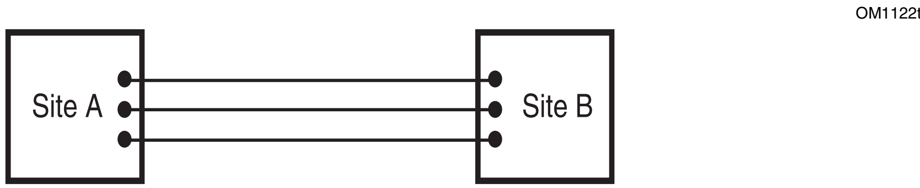
The set of components and shelves present at a site are grouped into one entity that can be managed through the Optical Metro 5100/5200 operation, administration, maintenance, and provisioning (OAM&P) interfaces.

In the following traffic pattern model diagrams, the lines between sites represent the logical view of the optical channel within the network. These lines do not necessarily represent the fiber spans.

Point-to-point traffic

The basic traffic pattern between sites in a network is point-to-point. The optical channel originates at one site and terminates at another. If all of the channels in the network originate and terminate at the same two sites, the network is a point-to-point network, as shown in Figure 3-12.

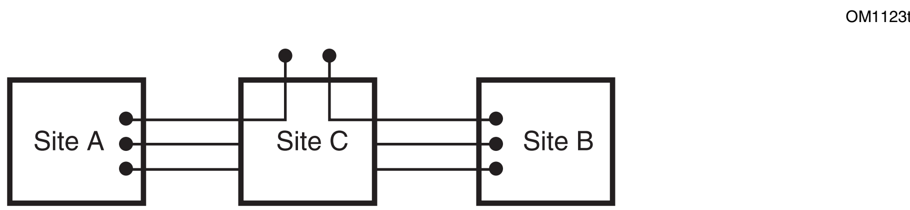
Figure 3-12
Point-to-point traffic



Linear OADM traffic

In a point-to-point network, if there are intermediate sites where some channels are dropped or added, the network is a linear OADM network, as shown in Figure 3-13.

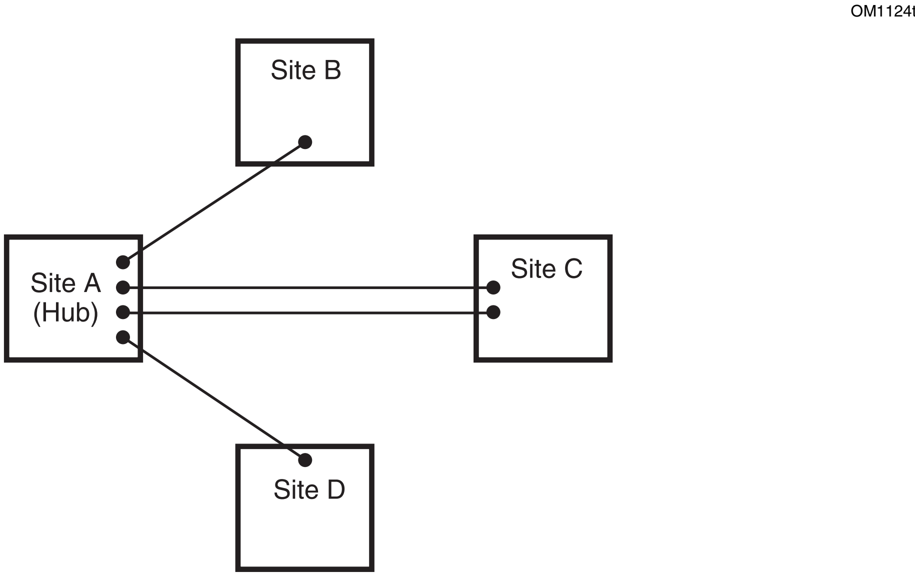
Figure 3-13
Linear OADM traffic



Hubbed traffic

If all of the traffic signals originate at the same site and terminate at multiple sites, the network is a hubbed network, as shown in Figure 3-14.

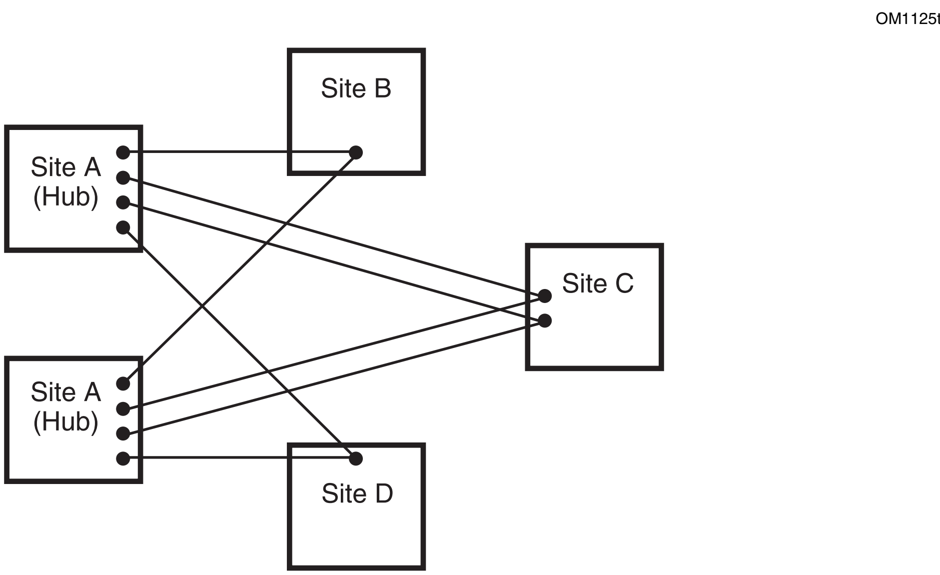
Figure 3-14
Hubbed traffic



Dual-hubbed traffic

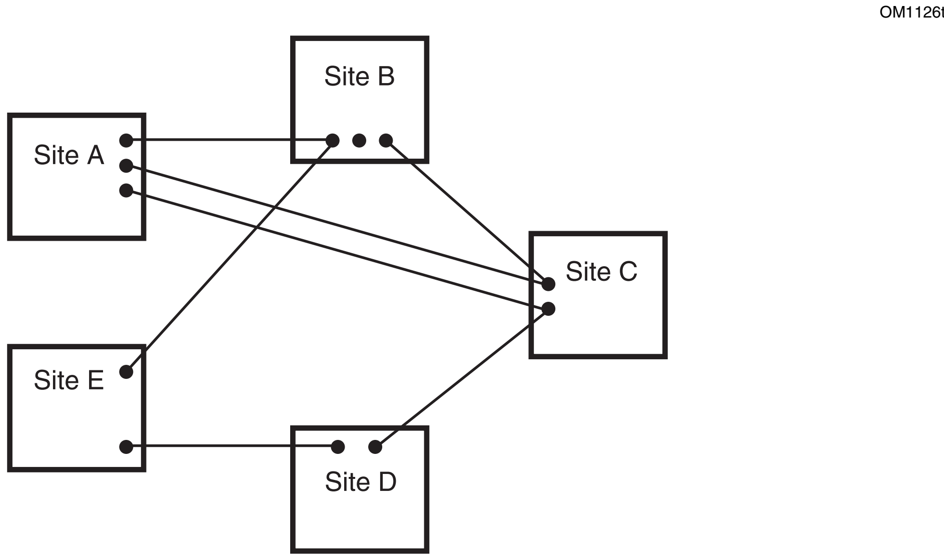
If there are two sites that originate all of the traffic signals and multiple remote sites that terminate the traffic signals, the network is a dual-hubbed network, as shown in Figure 3-15.

Figure 3-15
Dual-hubbed traffic



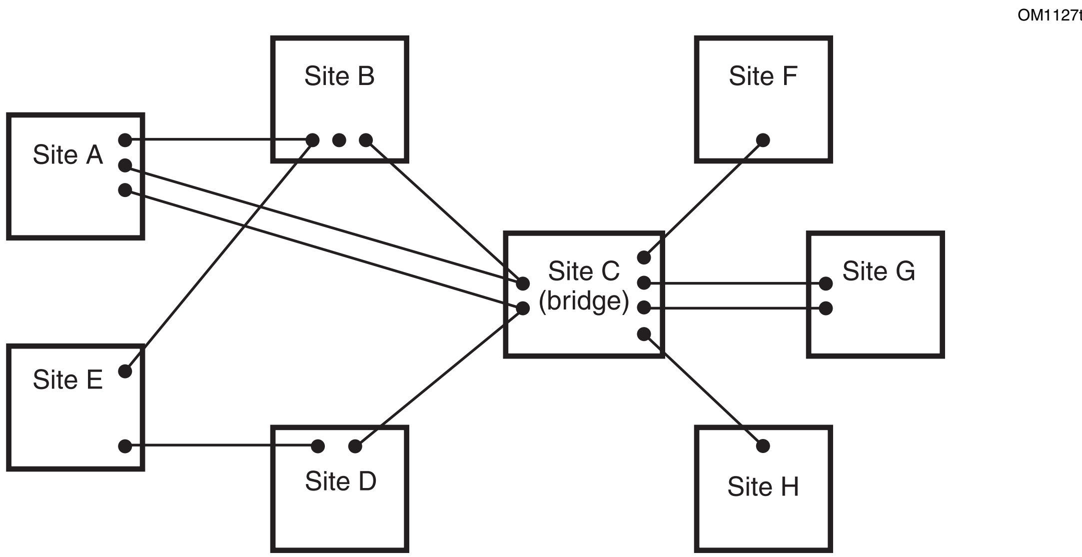
Meshed traffic
If there is no centralized location where traffic originates or terminates, but instead there is a diverse set of origination and termination points, the network is meshed. Figure 3-16 shows a meshed topology.

Figure 3-16
Meshed traffic



Bridged traffic
If the traffic patterns can be sub-divided to fit into one or more of the previous traffic pattern models, and there are common sites through which traffic flows, the overall network may be divided into systems that are bridged through common sites. These networks are referred to as bridged, as shown in Figure 3-17 on page 3-21.

Figure 3-17
Bridged traffic



Optical layer

Description

The optical layer consists of the components that define traffic patterns, independently from the signals that are being carried. The following sections describe the optical layer topologies that are supported by the Optical Metro 5100/5200. At the highest level, optical topologies specify the means by which the sites are interconnected by the spans of fiber.

There are two main types of network topologies:

- Basic network topologies
- Compound network topologies

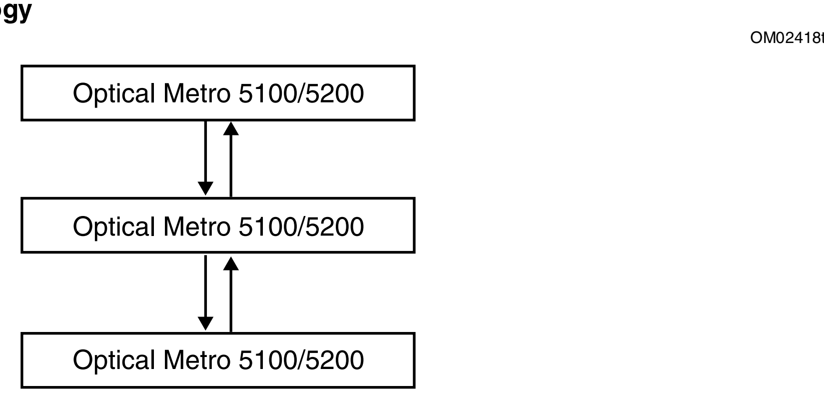
Basic network topologies

Basic network topologies are the simplest way to combine network elements. A basic network topology is considered one optical system where all the line side equipment is assigned the same optical system identifier (OSID). The OSID is used to identify all line-side optical components that interact with a common optical fiber system. Basic topologies form the fundamental building blocks from which all compound topologies can be built.

Linear

Basic linear topologies minimally consist of two sites that form the end points. These sites are referred to as **terminal sites**. There can be intermediate sites in between. Each terminal site in a linear topology has a single fiber pair connected to it. Each intermediate site has two fiber pairs connected to it. Figure 3-18 shows an example of a linear topology.

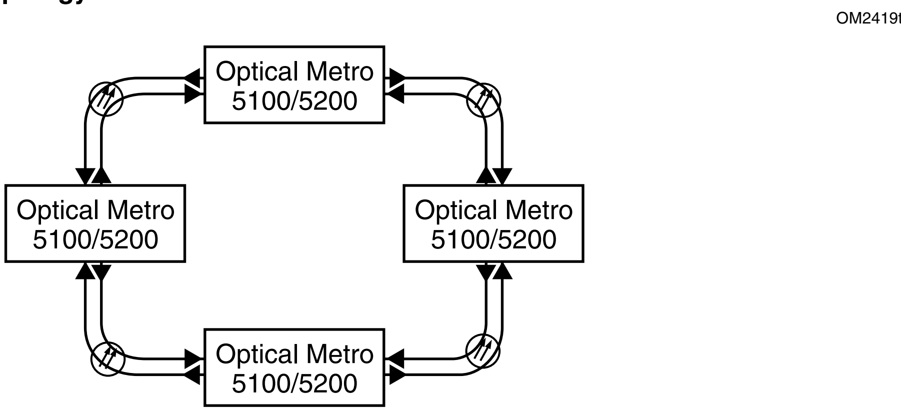
Figure 3-18
Linear topology



Ring

Basic ring topologies consist of sites connected in a closed loop pattern. Each site in a ring topology has two fiber pairs connected to it. Figure 3-19 on page 3-23 shows an example of a ring topology.

Figure 3-19
Ring topology



Compound network topologies

Compound network topologies are more complex combinations of network elements. These are formed by combining the basic network topologies into a single homogeneous network. Different optical system identifiers (OSID) are assigned to line side equipment in a compound network topology, based on the individual optical systems used to build the compound topology. For example, a bridged ring topology will have two OSIDs, one for the line equipment belonging to each ring. Linear networks can be combined to form hub and spoke topologies, and both rings and linear networks can be bridged together to form new topologies. The following compound network topologies are supported:

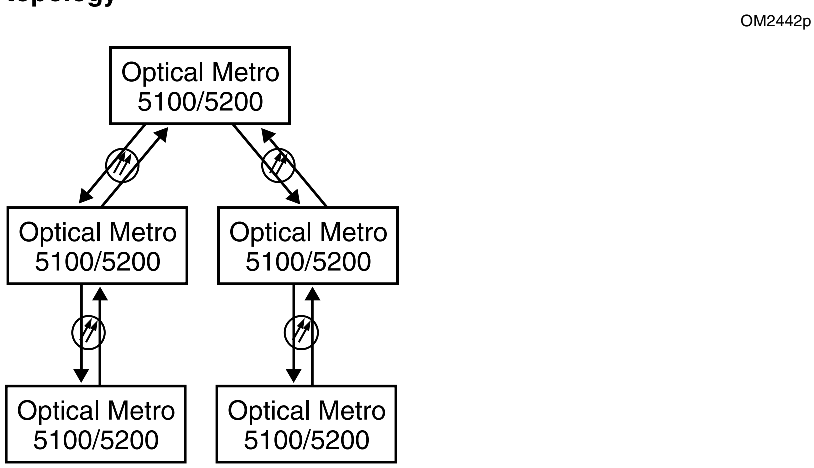
- Bridged linear, including
  - Hub and spoke
  - Dual hub and spoke
- Bridged ring, including
  - Bridged ring
  - Dual bridged ring
- Bridged linear and ring, including
  - Bridged hub and spoke and ring
  - Bridged dual hub and spoke and ring

In addition, you can combine these topologies by bridging signals or by sharing common equipment between independent systems. These additional topologies are described in "Combining compound topologies" on page 3-31.

Bridged linear

A bridged linear topology is a combination of two linear systems that share a common Optical Metro 5100/5200 shelf. The shelf that bridges the two linear systems can be an endpoint where channels for each system originate or terminate, or it can bridge the channel from one linear system to the other. Figure 3-20 shows an example of a bridged linear system.

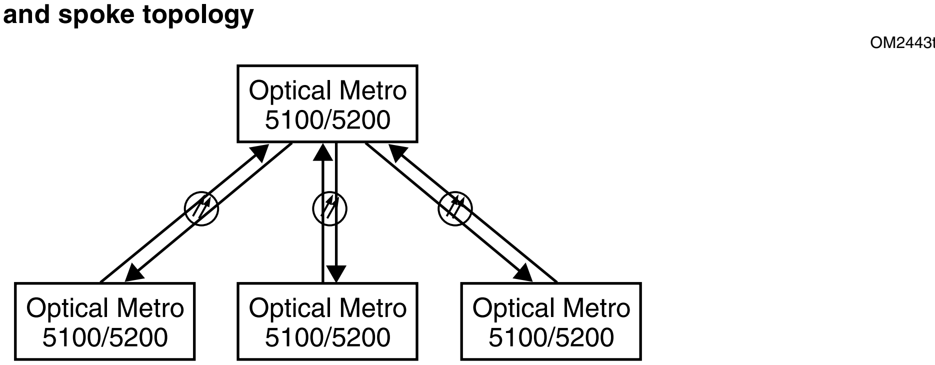
Figure 3-20
Bridged linear topology



Hub and spoke

Hub and spoke topologies consist of remote sites connected to a hub site. A hub and spoke network is a combination of many linear networks, which all have a common site as one of the end points. The common site can be a point where channels for each system originate or terminate, or it can bridge the channel from one linear system to another. When the common site is used to bridge two spokes, it is called a bridged linear topology. Figure 3-21 on page 3-24 shows an example of a hub and spoke topology.

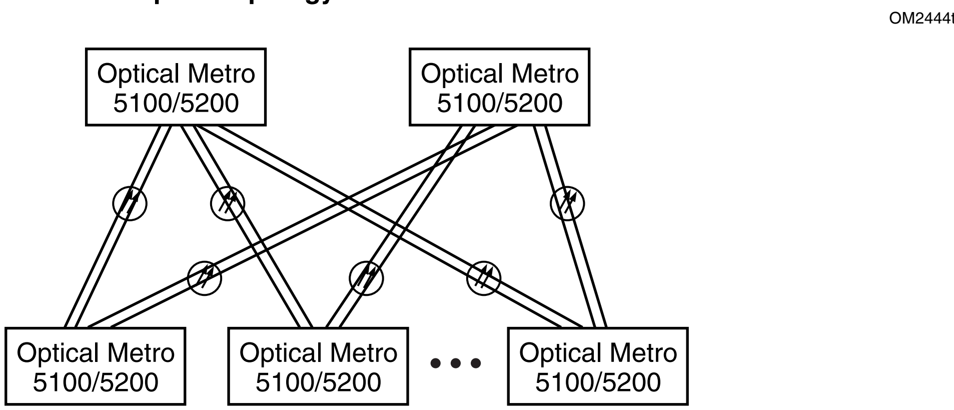
Figure 3-21
Hub and spoke topology



Dual hub and spoke

Dual hub and spoke topologies consist of remote sites connected to two hub sites. A dual hub and spoke network is a combination of two hub and spoke networks, which have the remote sites in common and each of these are connected to both hub sites. Figure 3-22 shows an example of a dual hub and spoke topology.

Figure 3-22
Dual hub and spoke topology



Bridged ring

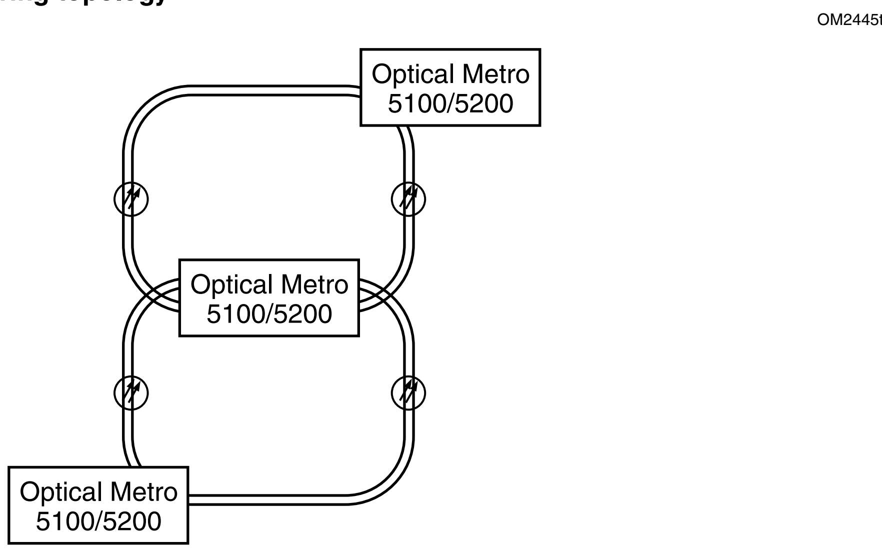
Bridged ring

Bridged ring topologies consist of two ring networks that are interconnected through a single bridge site. The following options are supported for bridged ring topologies:

- DWDM to DWDM
- CWDM to CWDM
- ITU CWDM to ITU CWDM
- DWDM to CWDM
- DWDM to ITU CWDM
- CWDM to ITU CWDM

For example, you can connect two Optical Metro 5200 rings, two Optical Metro 5100 rings, or an Optical Metro 5200 ring and an Optical Metro 5100 ring. Figure 3-23 shows an example of bridged rings.

Figure 3-23
Bridged ring topology



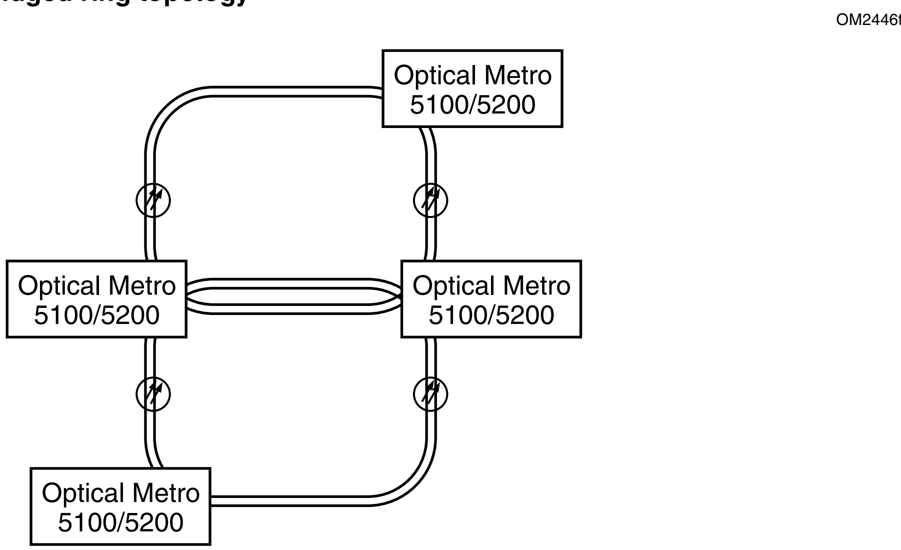
Dual bridged ring

Dual bridged ring topologies consist of two ring networks that are interconnected using two diverse bridge sites. The following options are supported for dual bridged ring topologies:

- DWDM to DWDM
- CWDM to CWDM
- ITU CWDM to ITU CWDM
- DWDM to CWDM
- DWDM to ITU CWDM
- CWDM to ITU CWDM

For example, in a dual bridged topology you can connect two Optical Metro 5200 rings, two Optical Metro 5100 rings, or an Optical Metro 5200 ring and an Optical Metro 5100 ring. Figure 3-24 shows an example of dual bridged ring networks.

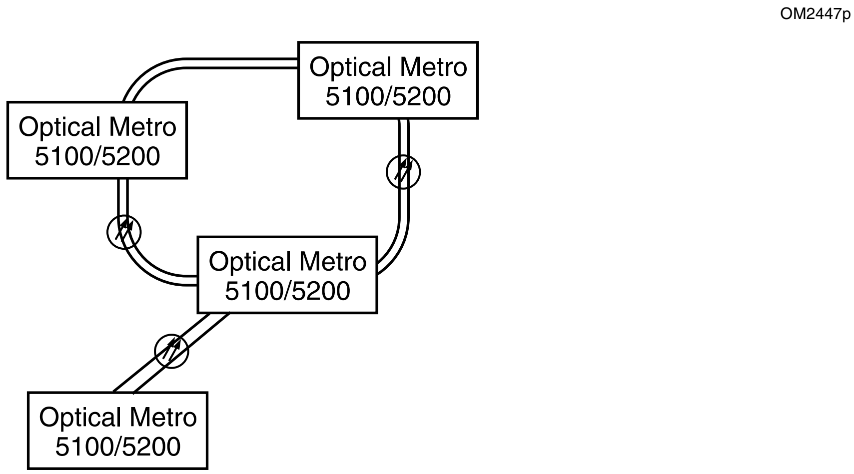
Figure 3-24
Dual bridged ring topology



Bridged linear and ring

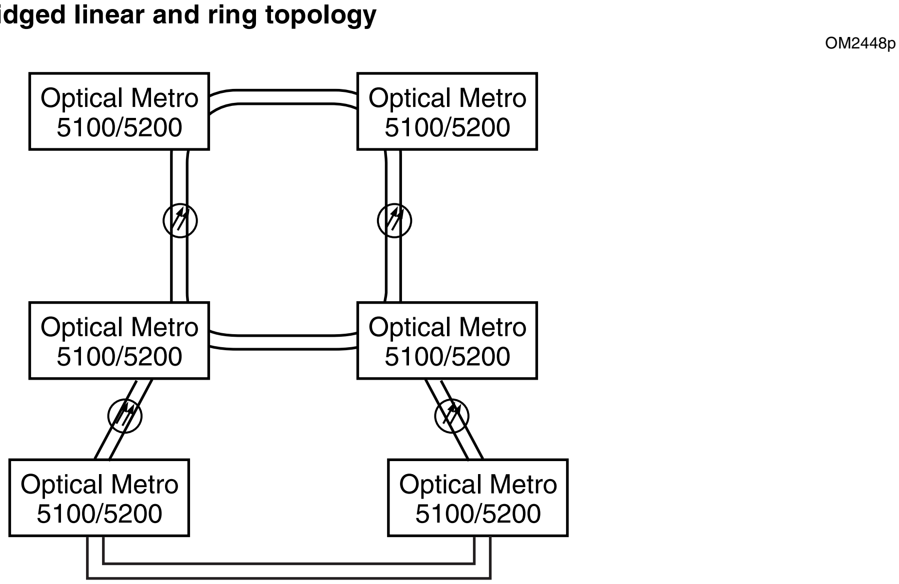
Bridged linear and ring topologies combine linear and ring networks. Figure 3-25 on page 3-28 shows an example of a bridged linear and ring topology.

Figure 3-25
Bridged linear and ring topology



You can also interconnect a ring and linear network using two bridge sites. This variant of the dual bridged ring topology is called a dual bridged linear and ring. Figure 3-26 shows a dual bridged linear and ring topology.

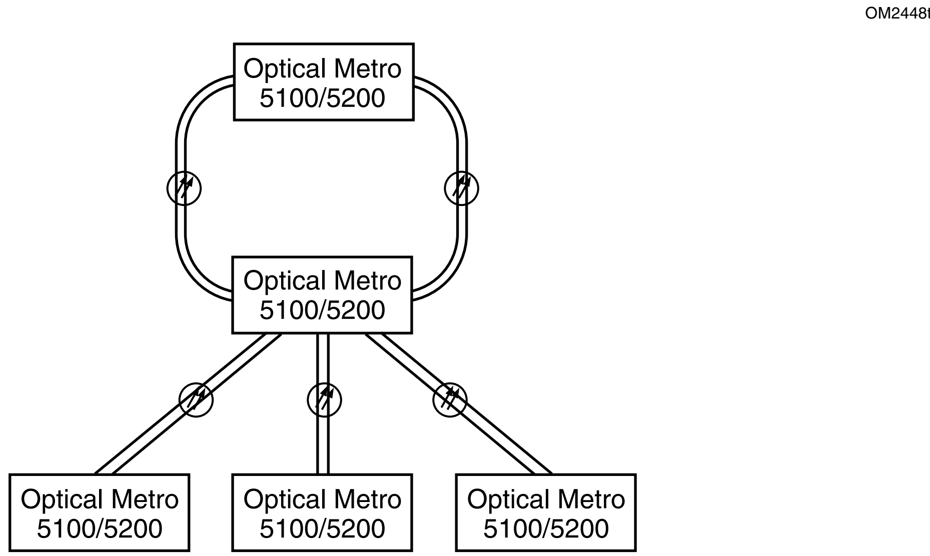
Figure 3-26
Dual bridged linear and ring topology



Bridged hub and spoke and ring

Bridged hub and spoke topologies consist of a hub and spoke network interconnected with a ring network. This topology is referred to as a bridged linear and ring. Figure 3-27 on page 3-29 shows an example of a bridged hub and spoke network. Figure 3-25 shows a bridged linear and ring network.

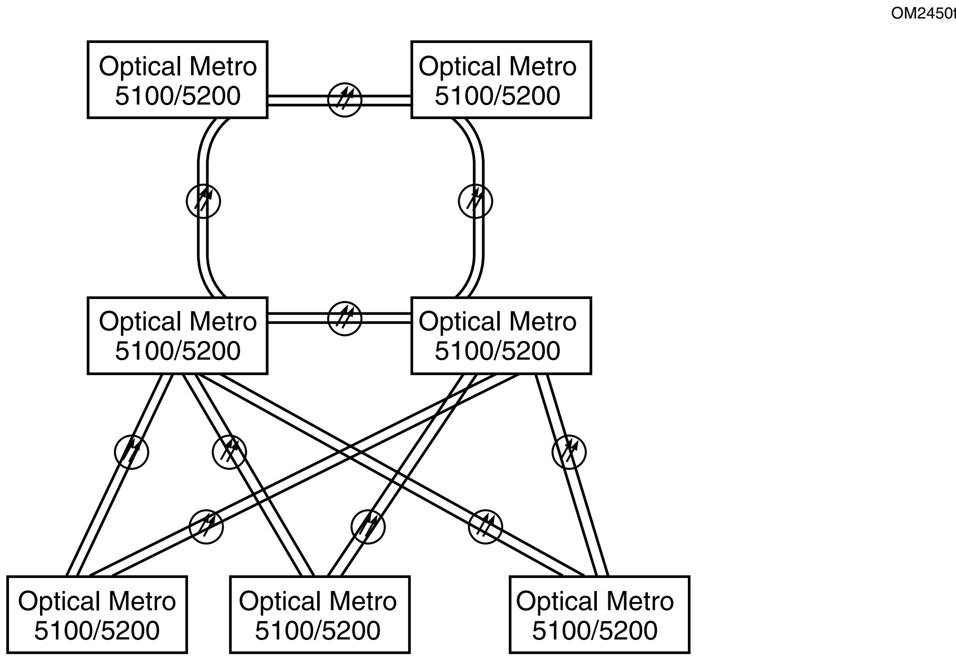
Figure 3-27
Bridged hub and spoke topology



Bridged dual hub and spoke and ring

Bridged dual hub and spoke topologies consist of a dual hub and spoke network interconnected with a ring network through two diverse bridge sites. Each of the hub sites is bridged into the ring network. Figure 3-28 shows an example of a bridged dual hub and spoke network.

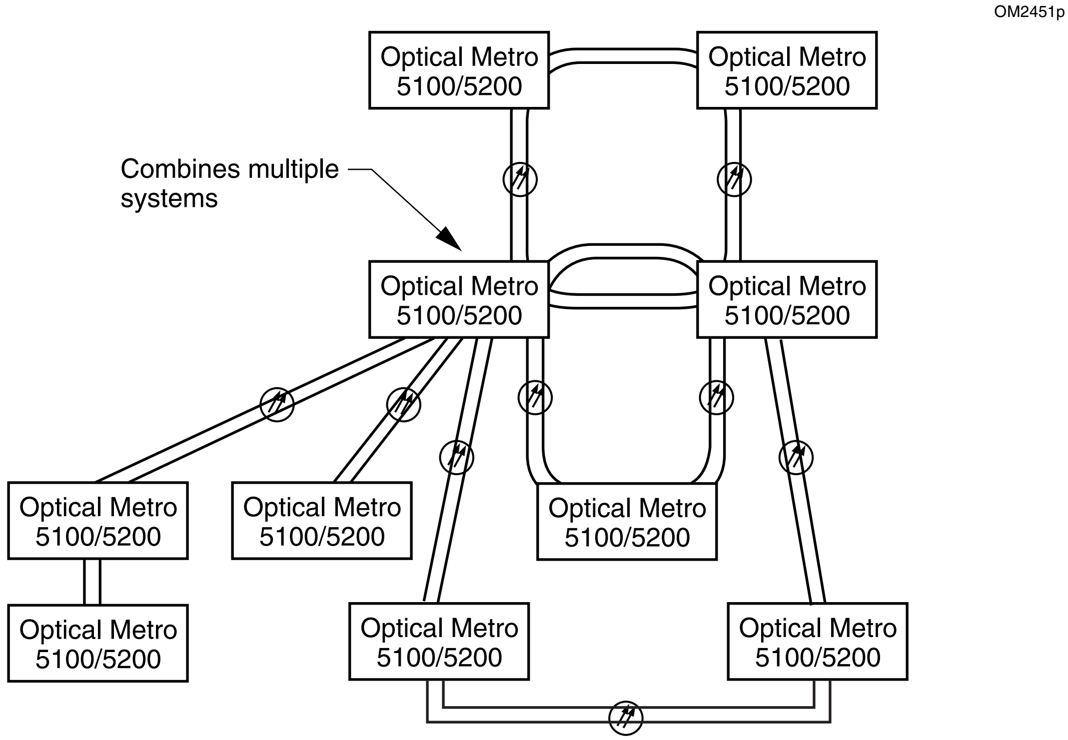
Figure 3-28
Bridged dual hub and spoke topology



Combining compound topologies

In shared topologies, you can combine multiple systems using the same shelf. The systems that are connected at this shelf may be independent systems, or some may be bridged together. For example, the hub site in a network may be used to connect a hub and spoke network to a ring; at the same time, the hub site may also be used to connect a ring system to another ring. Figure 3-29 shows a topology where the shared shelf passes the signal between the systems.

Figure 3-29
Combined topology



Network topology deployment rules

Network topologies are built using the Optical Metro 5100/5200 building blocks. Optical Metro 5100 and Optical Metro 5200 shelves with circuit packs and optical components are deployed at the sites to implement the network topology. The following sections describe the systems that are supported for basic and compound topologies.

- Linear systems
  - Optical Metro 5100/5200 DWDM linear system
  - Optical Metro 5100/5200 CWDM linear system
  - Optical Metro 5100/5200 ITU CWDM linear system
  - Optical Metro 5100/5200 linear system without OMXs
- Ring systems
  - Optical Metro 5100/5200 DWDM ring system
  - Optical Metro 5100/5200 CWDM ring system
  - Optical Metro 5100/5200 ITU CWDM ring system
- Bridged linear system
- Bridged ring and dual bridged ring systems
- Bridged linear and ring and dual bridged linear and ring systems
- Combining compound topologies

Optical Metro 5100/5200 DWDM linear system

The deployment requirements for this type of system are:

- all DWDM shelves must be connected to a DWDM OMX
  - the OMX 4CH + Fiber Manager and OMX 4CH Enhanced can be shared between up to four Optical Metro 5200 shelves
  - the OMX 16CH can be shared between multiple Optical Metro 5200 or Optical Metro 5100 shelves, within the limitations of the number of WDM shelves allowed at a site
  - the OMX (Standard) cannot be shared between two Optical Metro 5200 shelves
- when using the OMX 16CH:
  - amplification is not supported
  - optical pass-through is not supported by the OMX 16CH, it can only be used at terminal or hub sites
  - mixing the OMX 16CH with any other OMX type is not supported at the same site

— only the OMX 4CH + Fiber Manager DWDM and the OMX 4CH DWDM Enhanced are supported at remote OADM sites, the OMX (Standard) DWDM is not supported

— OCLD 1.25 Gbit/s, OCLD 2.5 Gbit/s, and OTR 10 Gbit/s circuit packs are not supported

— OCLD 2.5 Gbit/s Flex, OCLD 2.5 Gbit/s Universal, OTR 2.5 Gbit/s Flex, OTR 2.5 Gbit/s Universal, OTR 10 Gbit/s Enhanced and Muxponder circuit packs are supported

- intermediate sites may be deployed to regenerate signals within an optical channel
- intermediate sites may be deployed to optionally add or drop signals. If an intermediate site adds or drops any signals, the topology is referred to as **linear OADM** system; otherwise, it is referred to as a **point-to-point** system, with or without regeneration.
- dual homed protection schemes are supported
- there can be up to eight WDM shelves at each terminal and intermediate site
- there can be a maximum of 64 shelves
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no single band can add/drop at more than nine sites. For more detailed information about the maximum number of sites supported, see "Data communications engineering guidelines" in the "Data communications in the Optical Metro 5100/5200 network" chapter of this book.

The following special deployment requirements apply for Extended Metro DWDM linear systems:

- only Optical Metro 5200 shelves can be deployed
- all DWDM shelves must be connected to a OMX 4CH Enhanced
- for links whose maximum line bit rate is 2.5 Gbit/s, no DSCMs are required. The following line-side circuit packs must be used in these Extended Metro links:

— OCLD 2.5 Gbit/s Universal

— OTR 2.5 Gbit/s Universal 1310 nm

— OTR 2.5 Gbit/s Universal 850 nm

Note: Standard reach or Extended Reach OCLD/OTR circuit packs cannot be used since they do not meet the dispersion and OSNR specifications required for Extended Metro links.

- for links whose maximum line bit rate is 10 Gbit/s (10 Gbit/s only or mix of 2.5 Gbit/s and 10 Gbit/s), DSCMs are required. DSCMs are only supported on NDSF. The following line-side circuit packs must be used in these Extended Metro links:
  - OCLD 2.5 Gbit/s Universal
  - OTR 2.5 Gbit/s Universal 1310 nm
  - OTR 2.5 Gbit/s Universal 850 nm
  - OTR 10 Gbit/s Enhanced
  - Muxponder 10 Gbit/s GbE/FC
  - Muxponder 10 Gbit/s GbE/FC VCAT

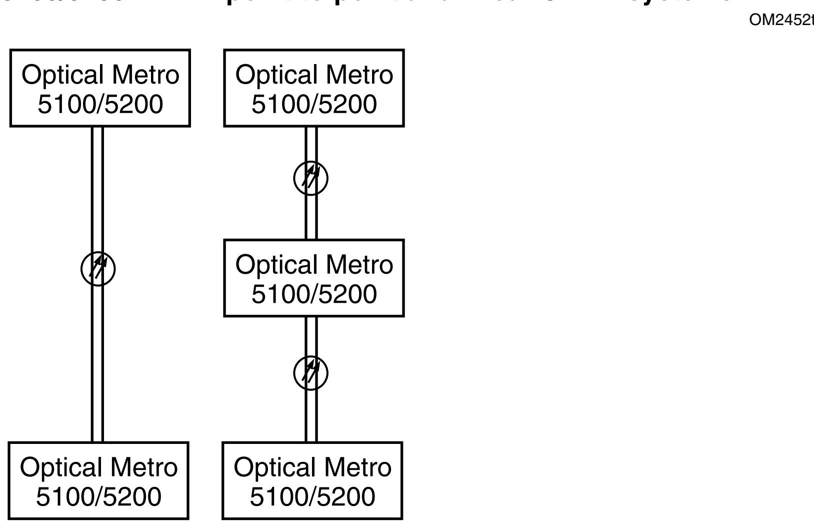
  Note: Standard reach or Extended Reach OCLD/OTR circuit packs cannot be used since they do not meet the OSNR specifications required for Extended Metro links that use DSCMs.

- standard OFAs are not supported, only the Variable Gain and High Input Power OFAs are supported
- ECTs are not supported, only enhanced APBEs, APBEs, PBEs, Discrete VOAs and fixed pads are supported to control the power into an OFA
- intermediate sites may be deployed to regenerate signals within an optical channel
- Inter-site fault sectionalization is supported but intra-site fault sectionalization is not
- single shelf OMX wiring is not supported
- only protocols with a line rate of 1 Gbit/s or higher are supported
- the network design must be in complete compliance with the requirements as per the custom link engineering report
- optical attenuator pads need to be installed to limit launch powers as required by the custom link engineering report
- since Stimulated Raman Scattering (SRS) transfers power from low wavelengths to higher wavelengths a power differential can build up between bands and can cause performance degradation if not corrected. Therefore, re-equalization as per the custom link engineering report is necessary at least every three sites even if no bands have been added or dropped.
- intermediate sites may be deployed to optionally add or drop signals. If an intermediate site adds or drops any signals, the topology is referred to as **linear OADM** system; otherwise, it is referred to as a **point-to-point** system, with or without regeneration.
- dual homed protection schemes are supported

- there can be up to eight WDM shelves at each terminal and intermediate site
- there can be a maximum of 64 shelves
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no single band can add/drop at more than nine sites. For more detailed information about the maximum number of sites supported, see "Data communications engineering guidelines" in the "Data communications in the Optical Metro 5100/5200 network" chapter of this book.

Figure 3-30 shows examples of point-to-point and linear OADM systems.

Figure 3-30
Optical Metro 5100/5200 DWDM point-to-point and linear OADM systems



Optical Metro 5100/5200 CWDM linear system

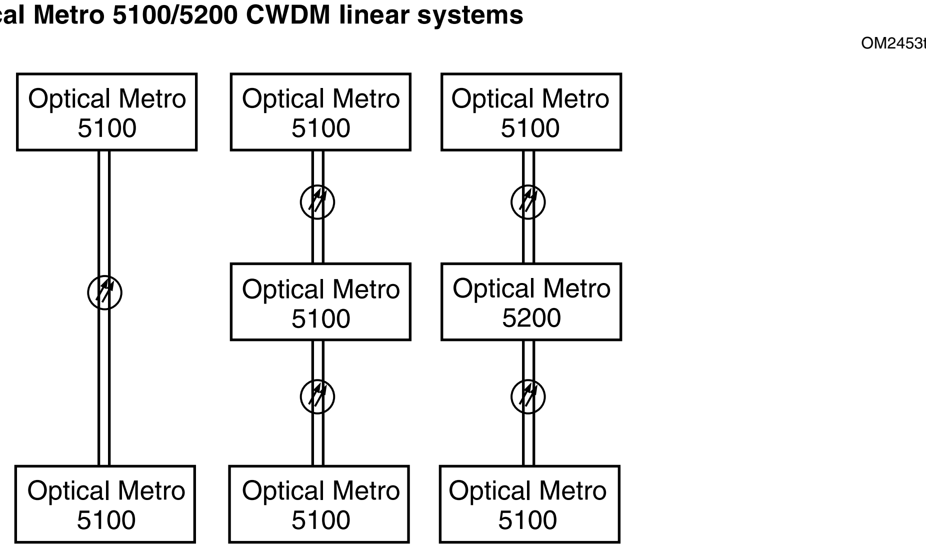
The deployment requirements for this type of system are:

- Optical Metro 5100 or Optical Metro 5200 shelves can be deployed
- all shelves must be connected to a CWDM OMX
  - — Optical Metro 5200 shelves must use the OMX 4CH CDWM
  - — Optical Metro 5100 shelves can use the OMX 1CH CWDM or the OMX 4CH CWDM
  - — the OMX 4CH CWDM can be shared between two Optical Metro 5100 shelves
- intermediate sites may be deployed to regenerate signals within an optical channel
- amplification is not supported

- linear OADM systems and point-to-point systems with regeneration are supported
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no single band can add/drop at more than nine sites. For more detailed information about the maximum number of sites supported, see "Data communications engineering guidelines" in the "Data communications in the Optical Metro 5100/5200 network" chapter of this book.
- dual homed protection schemes are supported
- there can be up to eight WDM shelves at each terminal and intermediate site
- there can be a maximum of 64 shelves

Figure 3-31 shows an example of an Optical Metro 5100/5200 CWDM point-to-point system and an Optical Metro 5100/5200 CWDM point-to-point system with regeneration.

Figure 3-31
Optical Metro 5100/5200 CWDM linear systems



Optical Metro 5100/5200 ITU CWDM linear system

The deployment requirements for this type of system are:

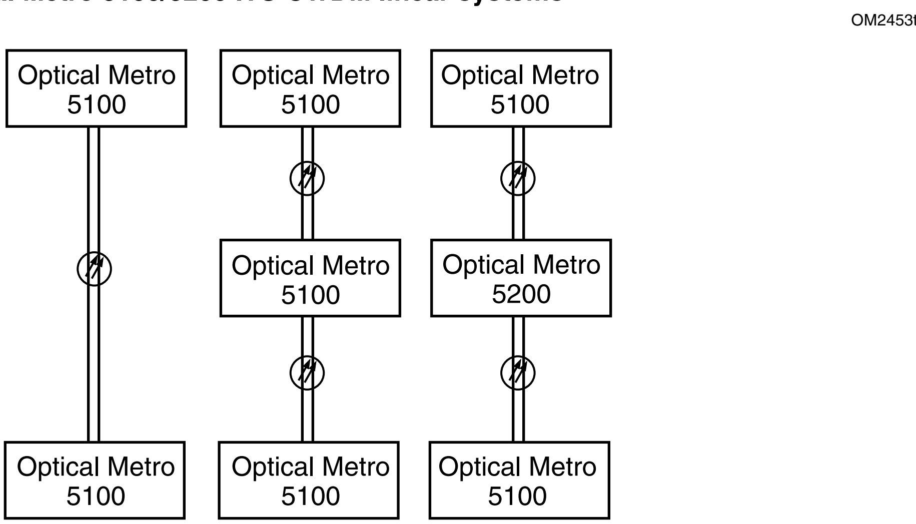
- Optical Metro 5100 or Optical Metro 5200 shelves can be deployed
- all shelves must be connected to an ITU CWDM OMX or an OADM ITU CWDM OMX
  - — one OMX 4CH ITU CWDM or OMX 4CH OADM ITU CWDM can be shared by up to four shelves
  - — one OMX 8CH ITU CWDM can be shared by up to eight shelves

— you cannot mix the OMX 4CH ITU CWDM and the OMX 8CH ITU CWDM within the same site

- intermediate sites may be deployed to regenerate signals within an optical channel
- amplification is not supported
- linear OADM systems and point-to-point systems with regeneration are supported
- up to nine sites supported per system
- OSC is not supported
- dual homed protection schemes are supported
- there can be up to eight WDM shelves at each terminal and intermediate site
- there can be a maximum of 64 shelves

Figure 3-32 shows an example of an Optical Metro 5100/5200 ITU CWDM point-to-point system and an Optical Metro 5100/5200 ITU CWDM point-to-point system with regeneration.

Figure 3-32
Optical Metro 5100/5200 ITU CWDM linear systems



Optical Metro 5100/5200 linear system without OMXs

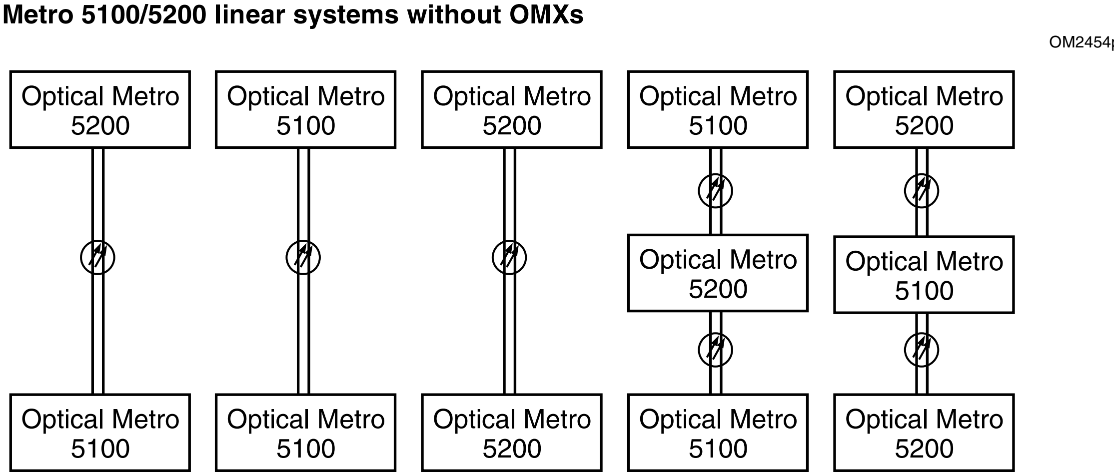
The deployment requirements for this type of system are:

- Optical Metro 5100 or Optical Metro 5200 shelves can be deployed
- all shelves must be deployed without an OMX
- intermediate sites may be deployed to regenerate signals within an optical channel

- amplification is not supported
- OSC is not supported
- linear OADM and point-to-point systems with regeneration are supported
- up to nine sites supported per system
- dual homed protection schemes are supported
- there can be up to eight WDM shelves at each terminal and intermediate site
- there can be a maximum of 64 shelves, consisting of any combination of WDM and OFA shelves

Figure 3-33 shows examples of several Optical Metro 5100/5200 point-to-point systems without OMXs, using Optical Metro 5100 shelves and Optical Metro 5200 shelves. These examples show systems with and without regeneration.

Figure 3-33
Optical Metro 5100/5200 linear systems without OMXs



Optical Metro 5100/5200 DWDM ring system

The deployment requirements for this type of system are:

- all DWDM shelves must be connected to a DWDM OMX
  - — the OMX 4CH + Fiber Manager and OMX 4CH Enhanced can be shared between up to four Optical Metro 5200 shelves
  - — the OMX 16CH can be shared between multiple Optical Metro 5200 or Optical Metro 5100 shelves, within the limitations of the number of WDM shelves allowed at a site
  - — the OMX (Standard) cannot be shared between two Optical Metro 5200 shelves
- when using the OMX 16CH:

- amplification is not supported
- optical pass-through is not supported by the OMX 16CH, it can only be used at terminal or hub sites
- mixing the OMX 16CH with any other OMX type is not supported at the same site
- only the OMX 4CH + Fiber Manager DWDM and the OMX 4CH DWDM Enhanced are supported at remote OADM sites, the OMX (Standard) DWDM is not supported
- OCLD 1.25 Gbit/s, OCLD 2.5 Gbit/s, and OTR 10 Gbit/s circuit packs are not supported
- OCLD 2.5 Gbit/s Flex, OCLD 2.5 Gbit/s Universal, OTR 2.5 Gbit/s Flex, OTR 2.5 Gbit/s Universal, OTR 10 Gbit/s Enhanced and Muxponder circuit packs are supported

- there can be a maximum of 64 shelves, consisting of any combination of WDM and OFA shelves
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no single band can add/drop at more than nine sites. For more detailed information about the maximum number of sites supported, see “Data communications engineering guidelines” in the “Data communications in the Optical Metro 5100/5200 network” chapter of this book.

The following special deployment requirements apply for Extended Metro DWDM ring systems:

- only Optical Metro 5200 shelves can be deployed
- all DWDM shelves must be connected to a OMX 4CH Enhanced
- for links whose maximum line bit rate is 2.5 Gbit/s, no DSCMs are required. The following line-side circuit packs must be used in these Extended Metro links:
  - OCLD 2.5 Gbit/s Universal
  - OTR 2.5 Gbit/s Universal 1310 nm
  - OTR 2.5 Gbit/s Universal 850 nm

  Note: Standard reach or Extended Reach OCLD/OTR circuit packs cannot be used since they do not meet the dispersion and OSNR specifications required for Extended Metro links.

- for links whose maximum line bit rate is 10 Gbit/s (10 Gbit/s only or mix of 2.5 Gbit/s and 10 Gbit/s), DSCMs are required. DSCMs are only supported on NDSF. The following line-side circuit packs must be used in these Extended Metro links:
  - OCLD 2.5 Gbit/s Universal

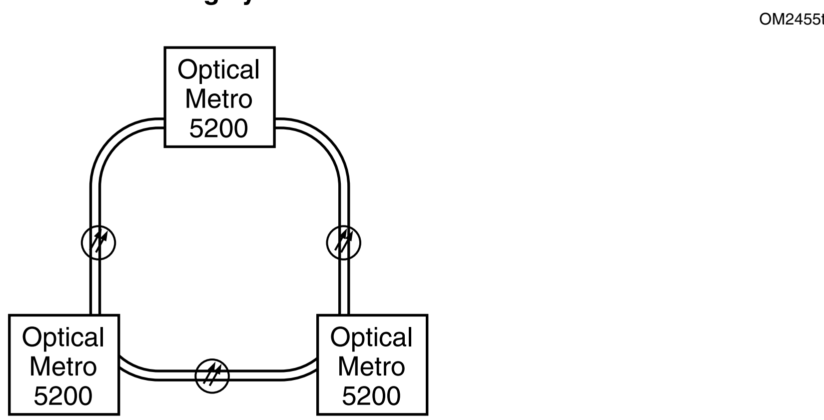
- — OTR 2.5 Gbit/s Universal 1310 nm
- — OTR 2.5 Gbit/s Universal 850 nm
- — OTR 10 Gbit/s Enhanced
- — Muxponder 10 Gbit/s GbE/FC
- — Muxponder 10 Gbit/s GbE/FC VCAT

Note: Standard reach or Extended Reach OCLD/OTR circuit packs cannot be used since they do not meet the OSNR specifications required for Extended Metro links that use DSCMs.

- standard OFAs are not supported, only the Variable Gains and the High Input Power OFAs are supported
- ECTs are not supported, only enhanced APBEs, APBEs, PBEs, Discrete VOAs, and fixed pads are supported to control the power into an OFA
- intermediate sites may be deployed to regenerate signals within an optical channel
- Inter-site fault sectionalization is supported but intra-site fault sectionalization is not
- single shelf OMX wiring is not supported
- only protocols with a line rate of 1 Gbit/s or higher are supported
- the network design must be in complete compliance with the requirements as per the custom link engineering report
- optical attenuator pads need to be installed to limit launch powers as required by the custom link engineering report
- since Stimulated Raman Scattering (SRS) transfers power from low wavelengths to higher wavelengths a power differential can build up between bands and can cause performance degradation if not corrected. Therefore, re-equalization as per the custom link engineering report is necessary at least every three sites even if no bands have been added or dropped.
- there can be a maximum of 64 shelves
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no single band can add/drop at more than nine sites. For more detailed information about the maximum number of sites supported, see “Data communications engineering guidelines” in the “Data communications in the Optical Metro 5100/5200 network” chapter of this book.

Figure 3-34 shows an example of an Optical Metro 5200 DWDM ring system.

Figure 3-34
Optical Metro 5200 DWDM ring system



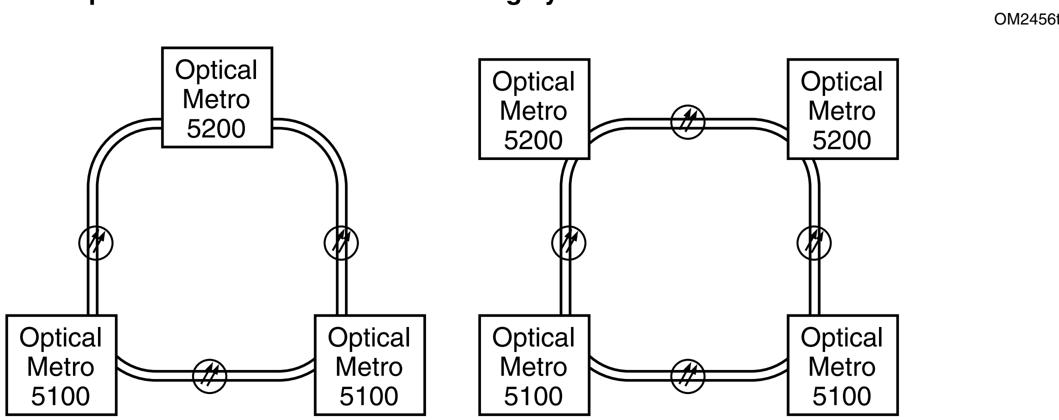
Optical Metro 5100/5200 CWDM ring system

The deployment requirements for this type of system are:

- hubbed, dual-hubbed, and meshed traffic is supported
- each site in the ring can consist exclusively of Optical Metro 5100 shelves, exclusively of Optical Metro 5200 shelves, or of a combination of both
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no single band can add/drop at more than nine sites. For more detailed information about the maximum number of sites supported, see "Data communications engineering guidelines" in the "Data communications in the Optical Metro 5100/5200 network" chapter of this book.
- there can be a maximum of 64 shelves
- all shelves must be connected to a CWDM OMX
  - — Optical Metro 5200 shelves must use the OMX 4CH CWDM
  - — Optical Metro 5100 shelves can use the OMX 1CH CWDM or the OMX 4CH CWDM
  - — a OMX 4CH CWDM can be shared between two Optical Metro 5100 shelves
- amplification is not supported

Figure 3-35 shows an Optical Metro 5100/5200 CWDM ring system with a single site with Optical Metro 5200 shelves and another Optical Metro 5100/5200 ring system with two sites with Optical Metro 5200 shelves.

Figure 3-35
Optical Metro 5100/5200 CWDM ring system



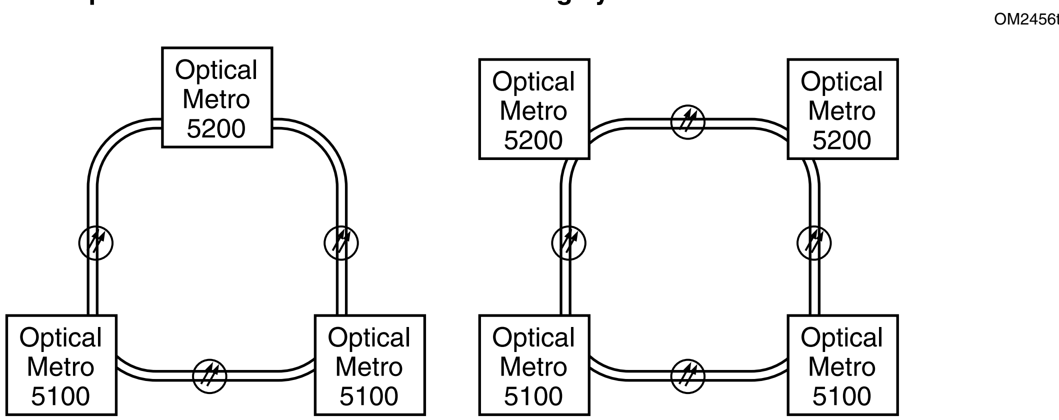
Optical Metro 5100/5200 ITU CWDM ring system

The deployment requirements for this type of system are:

- hubbed, dual-hubbed, and meshed traffic is supported
- each site in the ring can consist exclusively of Optical Metro 5100 shelves, exclusively of Optical Metro 5200 shelves, or of a combination of both
- up to nine sites supported per system
- there can be a maximum of 64 shelves
- all shelves must be connected to an ITU CWDM OMX or an OADM ITU CWDM OMX
  - — one OMX 4CH ITU CWDM or OMX 4CH OADM ITU CWDM can be shared by up to four shelves
  - — one OMX 8CH ITU CWDM can be shared by up to eight shelves
  - — you cannot mix the OMX 4CH ITU CWDM and the OMX 8CH ITU CWDM within the same site
- amplification is not supported

Figure 3-36 shows an Optical Metro 5100/5200 ITU CWDM ring system with a single site with Optical Metro 5200 shelves and another Optical Metro 5100/5200 ring system with two sites with Optical Metro 5200 shelves.

Figure 3-36
Optical Metro 5100/5200 ITU CWDM ring system



Bridged linear system

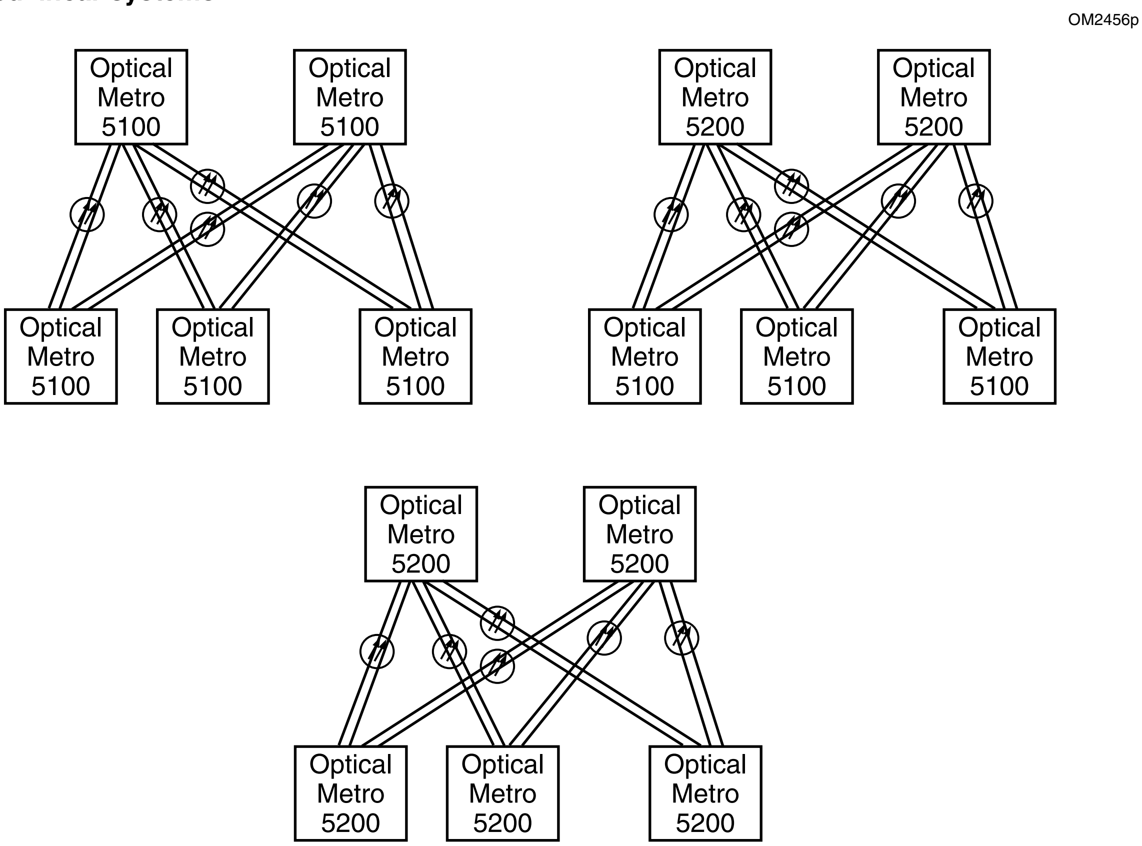
The deployment requirements for these types of systems are:

- any two linear systems can be bridged. This allows the following possibilities:
  - — DWDM to DWDM
  - — DWDM to CWDM
  - — DWDM to ITU CWDM
  - — DWDM to a system without OMXs
  - — CWDM to CWDM
  - — CWDM to ITU CWDM
  - — CWDM to a system without OMXs
  - — ITU CWDM to ITU CWDM
  - — ITU CWDM to a system without OMXs
  - — a system without OMXs to another system without OMXs
- the two linear systems being bridged must have different optical system identifiers (OSID)

- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no site can be more than nine add/drop sites, of the same or equivalent (bridged) band, away from any other site. To count band add/drop sites within a single DWDM, CWDM or ITU-CWDM system, count all sites that add/drop the same band. For systems without OMXs, count all sites. To count band add/drop sites across bridged systems, take into account the potential change of bands across the bridge site, which is determined by the bridge channel assignments, and count these bands as equivalent; count all sites of equivalent bands. For more detailed information about the maximum number of sites supported, see "Data communications engineering guidelines" in the "Data communications in the Optical Metro 5100/5200 network" chapter of this book.
- all rules governing the deployment of the individual linear systems still apply

Figure 3-37 shows three examples of bridged linear systems using sites with Optical Metro 5100 and Optical Metro 5200 shelves.

Figure 3-37
Bridged linear systems



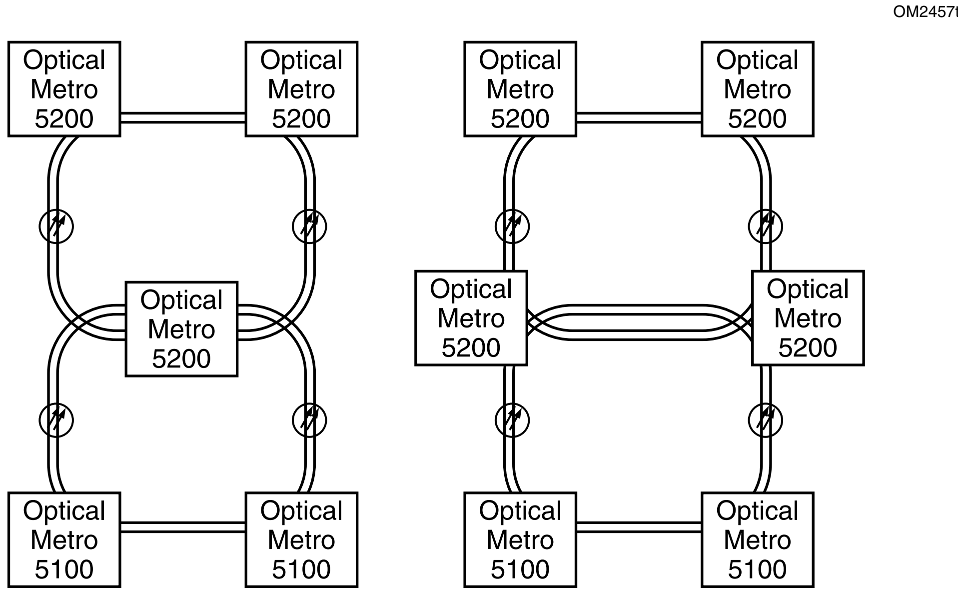
Bridged ring and dual bridged ring systems

The deployment requirements for sites in these types of systems are:

- any two ring systems can be bridged. This allows for the following possibilities:
  - DWDM to DWDM
  - DWDM to CWDM
  - DWDM to ITU CWDM
  - CWDM to CWDM
  - CWDM to ITU CWDM
  - ITU CWDM to ITU CWDM
- the two rings can have two bridge sites in common (dual-homed bridging)
- there can be a maximum of 64 shelves, consisting of any combination of WDM and OFA shelves
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no site can be more than nine add/drop sites, of the same or equivalent (bridged) band, away from any other site. To count band add/drop sites within a single DWDM, CWDM or ITU-CWDM system, count all sites that add/drop the same band. For systems without OMXs, count all sites. To count band add/drop sites across bridged systems, take into account the potential change of bands across the bridge site, which is determined by the bridge channel assignments, and count these bands as equivalent; count all sites of equivalent bands. For more detailed information about the maximum number of sites supported, see "Data communications engineering guidelines" in the "Data communications in the Optical Metro 5100/5200 network" chapter of this book.
- the two ring systems being bridged must have different optical system identifiers (OSID)
- all rules governing the deployment of the individual ring systems still apply

Figure 3-38 shows an Optical Metro 5100/5200 CWDM ring system bridged with an Optical Metro 5200 DWDM ring system using one bridge site, and using two bridge sites.

Figure 3-38
Bridged ring systems



Bridged linear and ring and dual bridged linear and ring systems

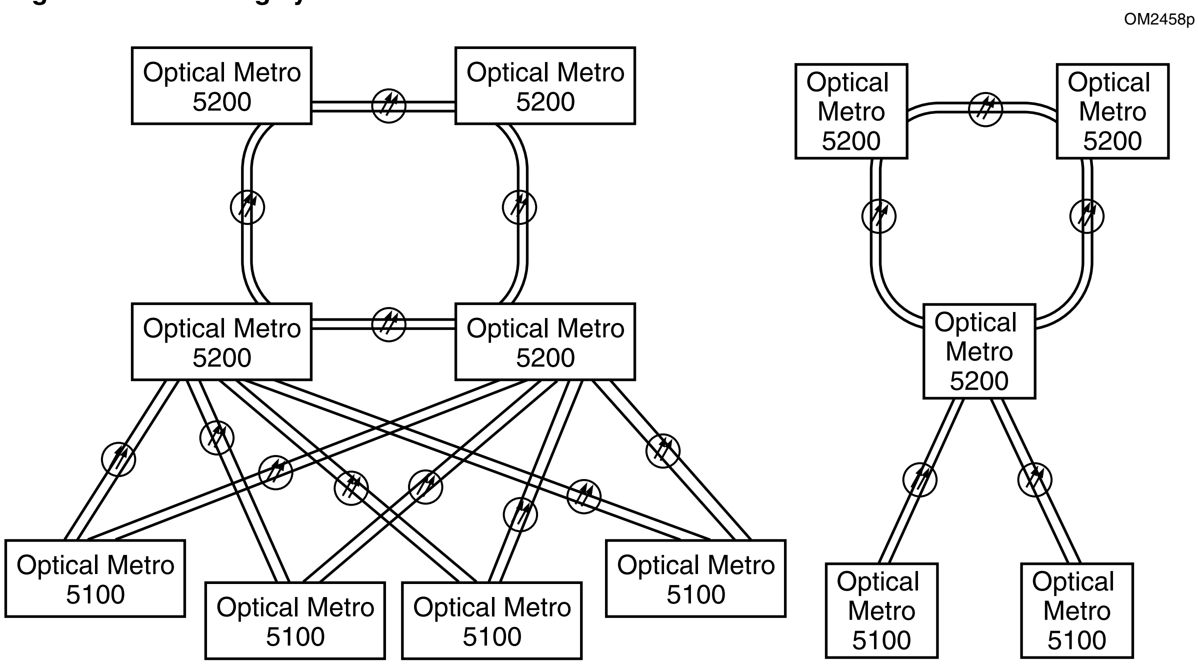
The deployment requirements for sites in these types of systems are:

- any linear system and any ring system can be bridged. This allows for the following possibilities:
  - DWDM linear to DWDM ring
  - DWDM linear to CWDM ring
  - DWDM linear to ITU CWDM ring
  - CWDM linear to DWDM ring
  - CWDM linear to CWDM ring
  - CWDM linear to ITU CWDM ring
  - ITU CWDM linear to DWDM ring
  - ITU CWDM linear to CWDM ring
  - ITU CWDM linear to ITU CWDM ring
  - linear system without OMXs to DWDM ring
  - linear system without OMXs to CWDM ring
  - linear system without OMXs to ITU CWDM ring
- linear systems must be bridged at an end-point or terminal site of each individual linear system

- the two systems can have two bridge sites in common (dual-homed bridging)
- there can be a maximum of 64 shelves, consisting of any combination of WDM and OFA shelves
- up to 16 sites supported with the following limitation: if the network does not have OSC at every site, then no site can be more than nine add/drop sites, of the same or equivalent (bridged) band, away from any other site. To count band add/drop sites within a single DWDM, CWDM or ITU-CWDM system, count all sites that add/drop the same band. For systems without OMXs, count all sites. To count band add/drop sites across bridged systems, take into account the potential change of bands across the bridge site, which is determined by the bridge channel assignments, and count these bands as equivalent; count all sites of equivalent bands. For more detailed information about the maximum number of sites supported, see "Data communications engineering guidelines" in the "Data communications in the Optical Metro 5100/5200 network" chapter of this book.
- the two systems being bridged must have different optical system identifiers (OSID)
- all rules governing the deployment of the individual systems still apply

Figure 3-39 shows an Optical Metro 5100/5200 hub and spoke system bridged with an Optical Metro 5200 ring system using one bridge site, and using two bridge sites.

Figure 3-39
Bridged linear and ring systems



Combining compound topologies

By combining basic or compound system topologies at a single shelf, you can create more complex compound topologies.

For instance, a hub and spoke topology is simply a combination of several linear systems without OMXs sharing a common Optical Metro 5200 shelf. By creating bridged channel assignments between these linear systems without OMXs and a DWDM ring, you create a bridged hub and spoke compound system.

The following deployment requirements apply when you combine multiple systems at the same shelf:

- for an Optical Metro 5200 bridge shelf, a maximum of 16 systems (8 bridge channel assignments) can be bridged at a single Optical Metro 5200 bridge shelf. This can be any combination of valid combined systems, as described in this section.
- for an Optical Metro 5100 bridge shelf, a maximum of 4 systems (2 bridge channel assignments) can be bridged at a single Optical Metro 5100 bridge shelf
- up to 16 sites supported, with the following limitation: if the network does not have OSC at every site, then no single band can add/drop at more than nine sites. For more detailed information about the maximum number of sites supported, see “Data communications engineering guidelines” in the “Data communications in the Optical Metro 5100/5200 network” chapter of this book.

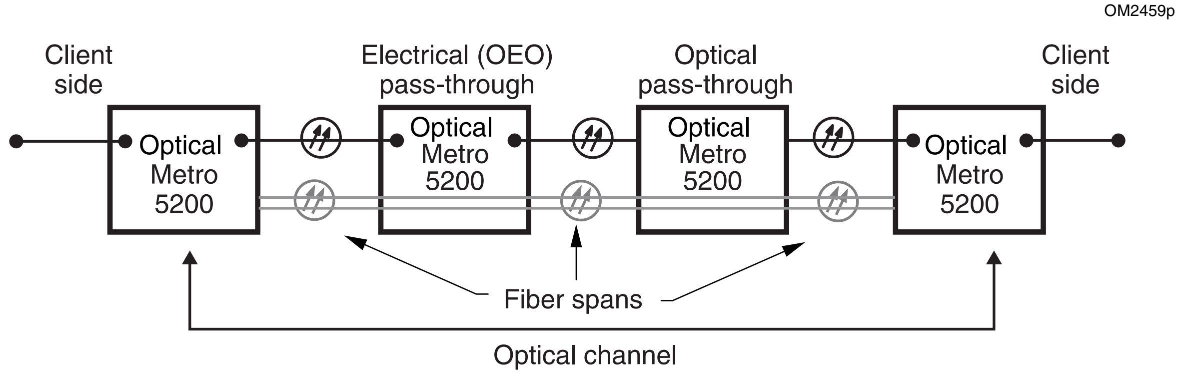
Overlaying the service layer onto the optical layer

Mapping optical channels on network topologies

This section describes how network topologies carry services. The service layer topologies, starting with simple optical channels, protected optical channels, and more complex traffic patterns are mapped onto the supported optical topologies. This allows you to relate the supported optical network topologies to the service requirements of the network.

In the following diagrams, the optical channel is shown as a series of lines starting with the client interface and terminating with the client interface. If the wavelength carrying the optical channel is dropped at a site for regeneration or bridging, it is shown by a broken line segment at that site. If the signal flows through optically, then the line is shown to pass through that site unbroken. Figure 3-40 shows the conventions.

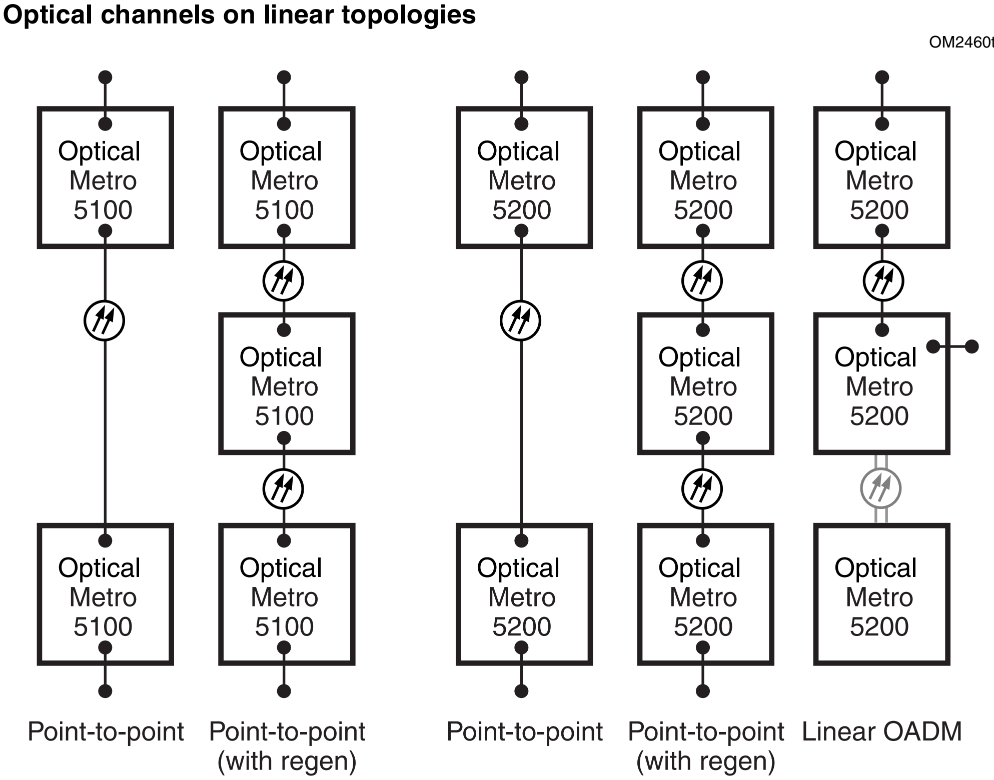
Figure 3-40
Symbols used for optical channel descriptions



Optical channels on linear topologies

Figure 3-41 on page 3-49 shows the optical channel on a variety of linear networks. This includes Optical Metro 5100 point-to-point networks with and without regeneration, Optical Metro 5200 point-to-point networks with and without regeneration, and an Optical Metro 5200 linear OADM network.

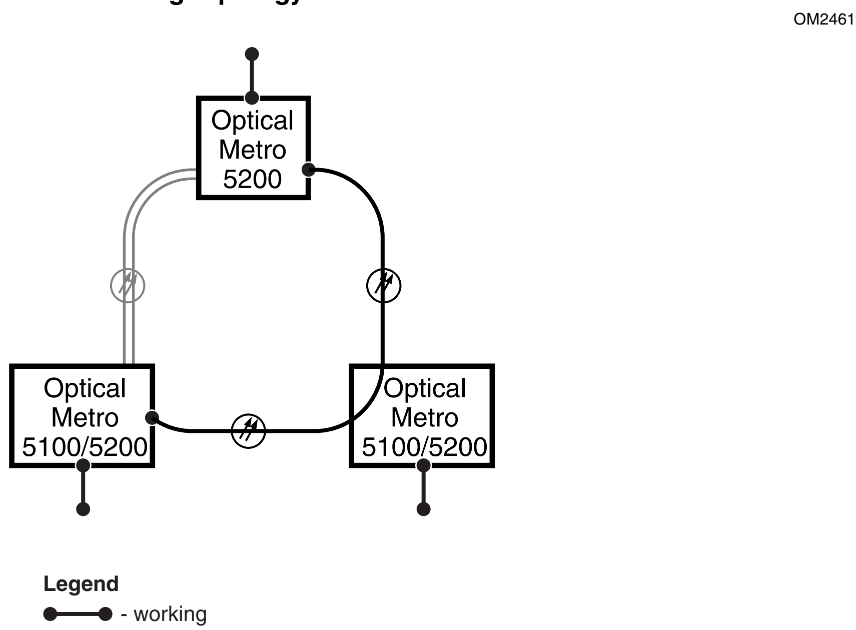
Figure 3-41
Optical channels on linear topologies



Optical channels on ring topologies

Figure 3-42 shows an optical channel on a ring topology.

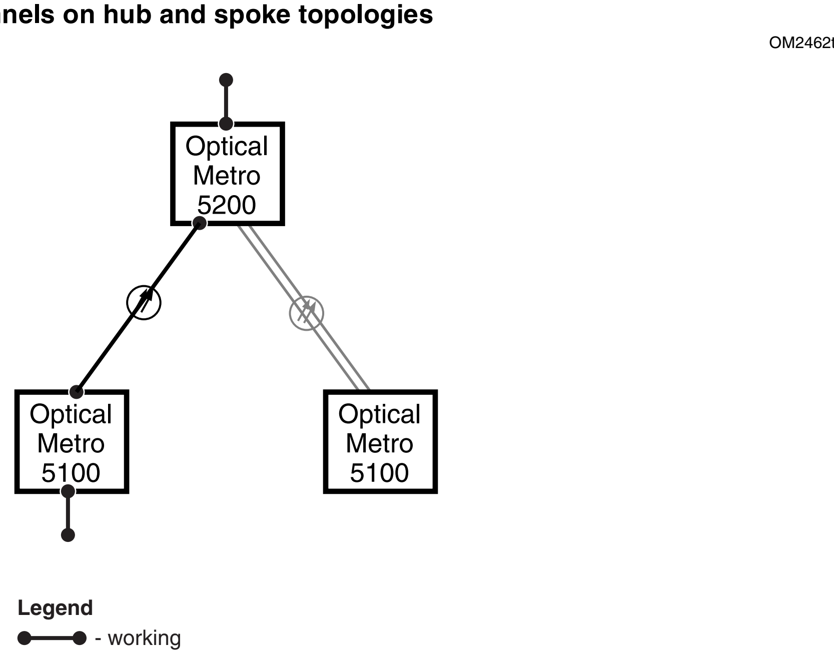
Figure 3-42
Optical channel on a ring topology



Optical channels on hub and spoke topologies

Figure 3-43 shows an optical channel in a hub and spoke topology.

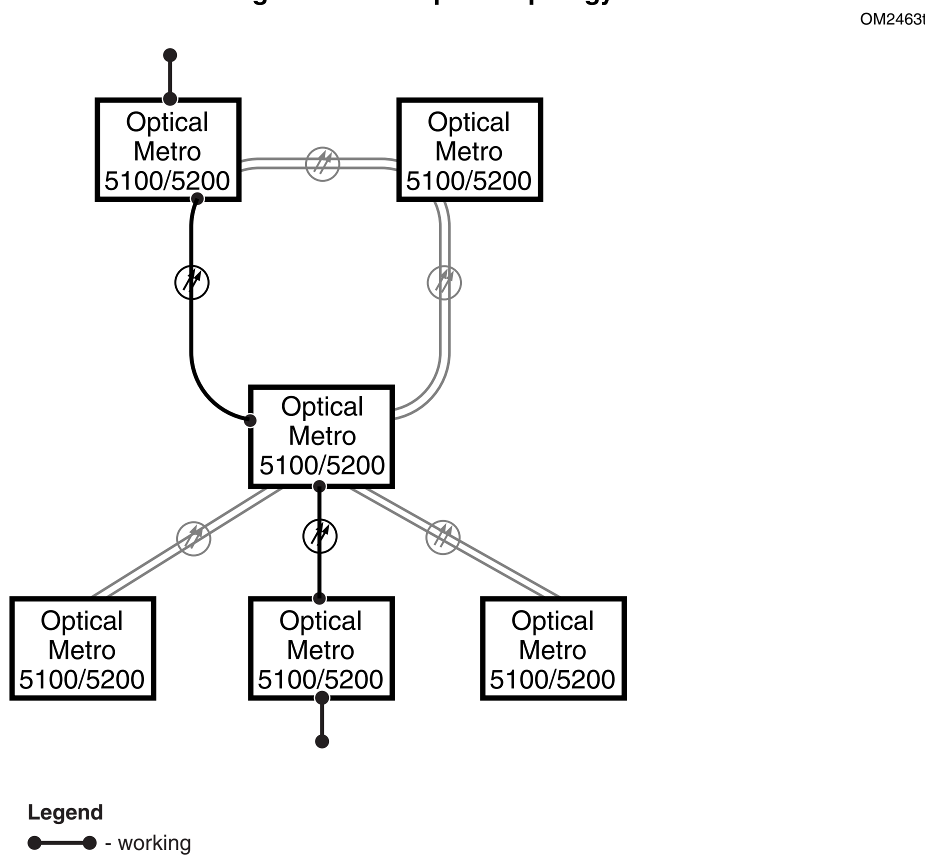
Figure 3-43
Optical channels on hub and spoke topologies



Optical channels on bridged hub and spoke topologies

Figure 3-44 shows an optical channel in a bridged hub and spoke topology.

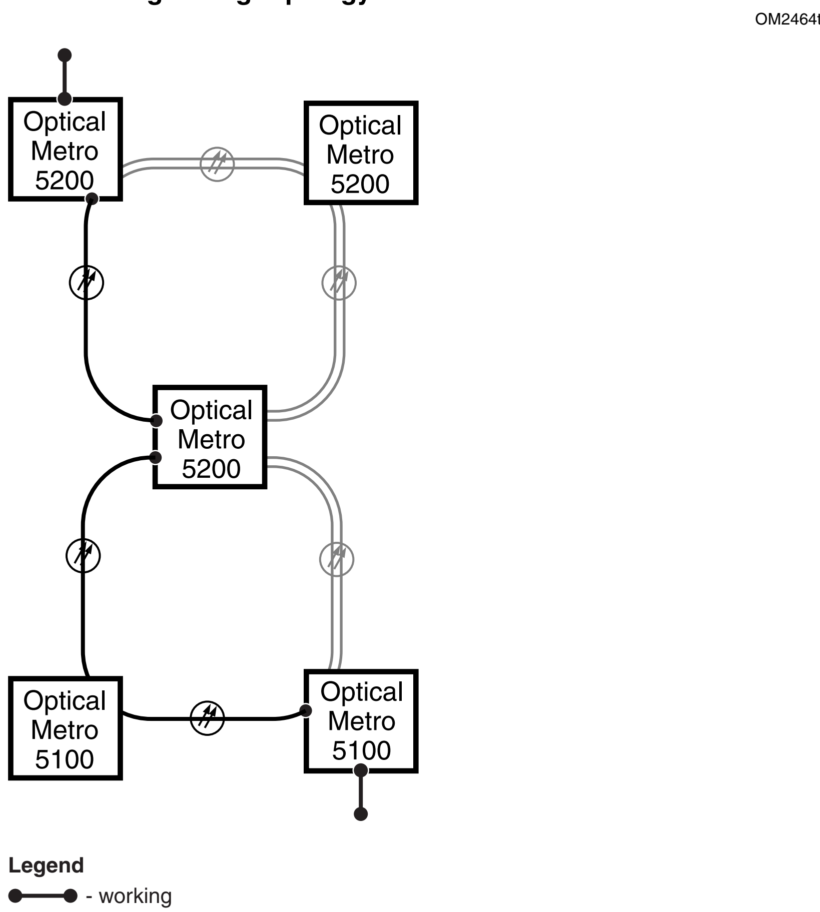
Figure 3-44
Optical channel on a bridged hub and spoke topology



Optical channels on bridged ring topologies

Figure 3-45 shows an optical channel in a bridged ring topology.

Figure 3-45
Optical channel on a bridged ring topology



Service layer topologies

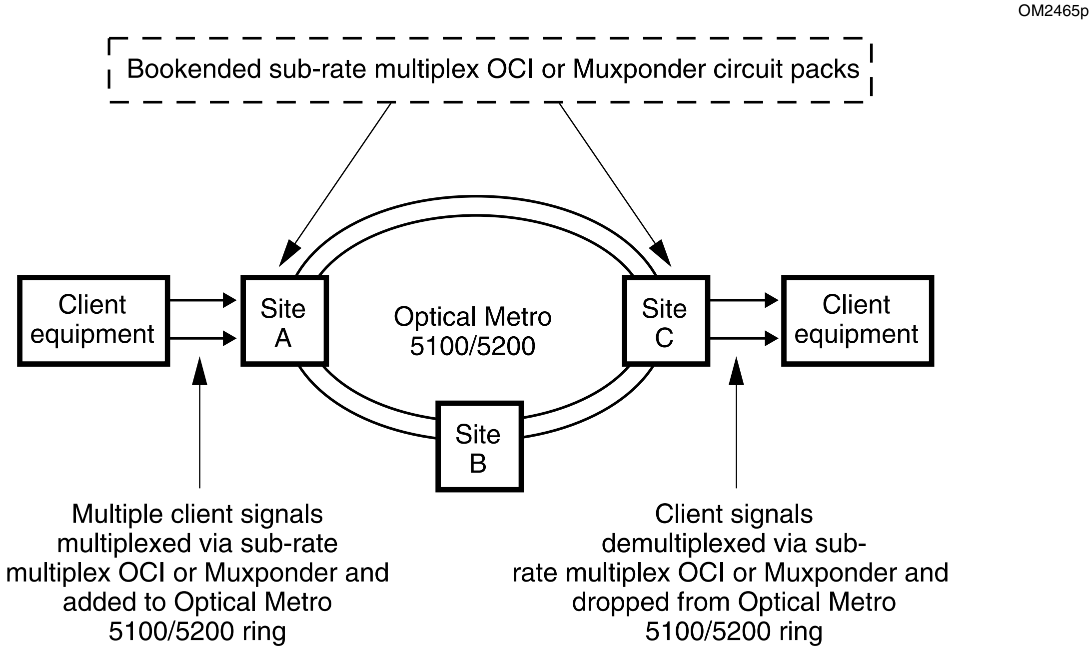
Optical Metro 5100/5200 networks that contain sub-rate multiplex OCI or Muxponder circuit packs can be configured in one of two ways:

- bookended topology
- interoperable topology

Bookended topology

In a bookended topology, a sub-rate multiplex OCI or Muxponder circuit pack at the starting point of an optical channel is paired with another sub-rate multiplex OCI or Muxponder circuit pack at the end point of the same optical channel. The individual client signals must be demuliplexed when dropped from an Optical Metro 5100/5200 network. Figure 3-46 on page 3-53 shows an example of a bookended topology.

Figure 3-46
Bookended service layer topology



Implementing bookended topologies with sub-rate multiplex OCI or Muxponder circuit packs

You can implement bookended configurations with all sub-rate multiplex OCI or Muxponder circuit packs. In Figure 3-46, the sub-rate multiplex OCI or Muxponder circuit packs are paired at Sites A and C. The paired sub-rate multiplex OCI must be the same type. The paired Muxponder circuit packs can be either the same or different type. Refer to Table 3-1 on page 3-53 to verify Muxponder circuit packs mixing rules.

Table 3-1
Muxponder 10 Gbit/s circuit pack type mixing rules in a bookended topology

Site A Muxponder 10 Gbit/s circuit pack type	Site C Muxponder 10 Gbit/s circuit pack type	Support	Rules
Muxponder 10 Gbit/s GbE/FC	Muxponder 10 Gbit/s GbE/FC	√	None
Muxponder 10 Gbit/s GbE/FC VCAT	Muxponder 10 Gbit/s GbE/FC VCAT	√	None
Muxponder 10 Gbit/s GbE/FC	Muxponder 10 Gbit/s GbE/FC VCAT	√	See Table 3-2 on page 3-54
Muxponder 10 Gbit/s GbE/FC VCAT	Muxponder 10 Gbit/s GbE/FC	√	See Table 3-2 on page 3-54

The Muxponder 10 Gbit/s GbE/FC circuit pack and the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack can interwork with one another. However, the functionality is limited to that available on the Muxponder 10 Gbit/s GbE/FC circuit pack. Table 3-2 on page 3-54 lists the rules or attributes that must be followed when these two Muxponder 10 Gbit/s circuit pack types interwork with one another.

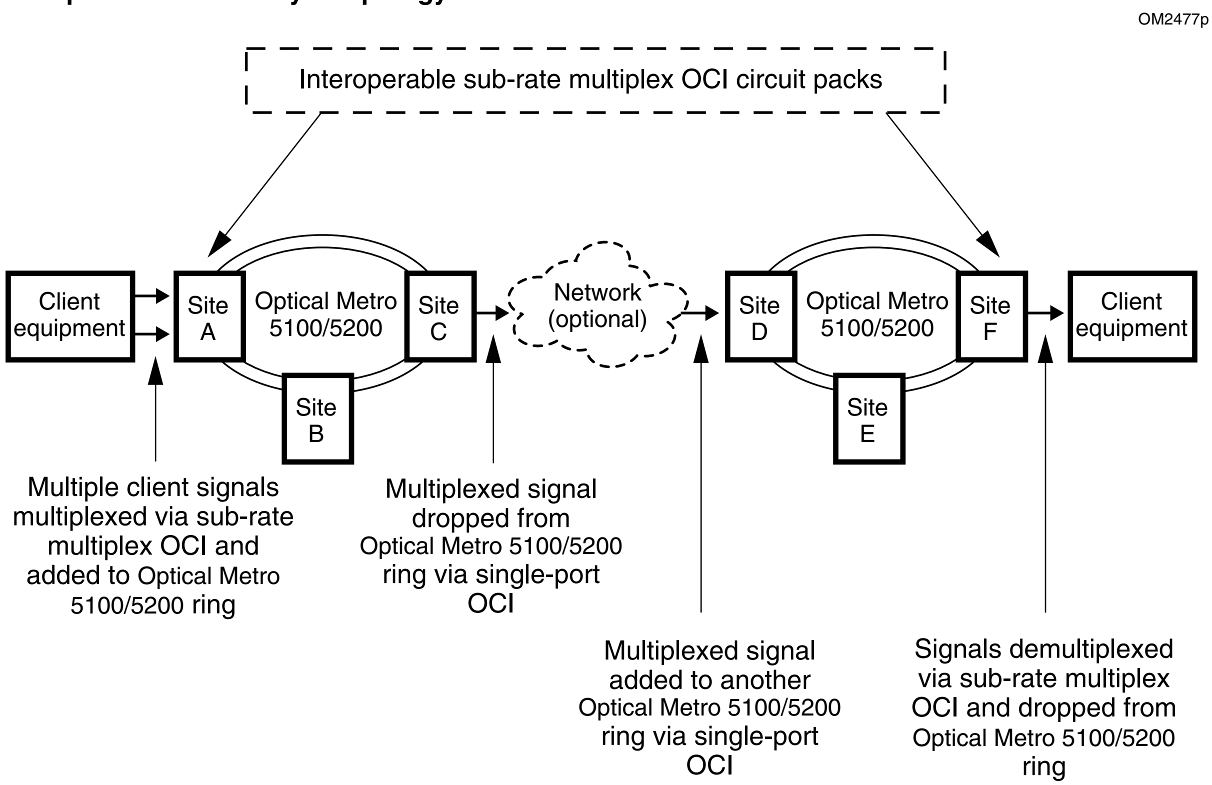
Table 3-2
Muxponder circuit pack type mixing rules

Rules or attributes
Virtual concatenation is not supported
Both GbE and FC traffic are GFP-T mapped
No subrate transports are supported: • GbE: STS-24c/VC-4-8c only • FC-100, FICON:: STS-24c/VC-4-8c only • FC-200, FICON Express: STS-48c/VC-4-16c only
Only ports 1 to 8 are provisionable (9 and 10 are not used): • For GbE, FC-100 or FICON protocol: ports 1 to 8 are provisionable • For FC-200 or FICON Express protocol: only ports 1, 3, 5 and 7 are provisionable
Client ports are fixed mapped to the line side path (24n+1; n=0…7)
Autonegotiation and PAUSE are not supported for GbE protocol
Interoperability on the network side is restricted to LH1600 only where the SONET/SDH OC-192/STM-64 signal is not line terminated
Interoperability with the OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced, and OCI SRM GbE circuit packs is not supported
Generic and Ethernet OMs are not supported on the Muxponder 10 Gbit/s GbE/FC circuit pack, they are supported on the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack
Path PMs are not supported on the Muxponder 10 Gbit/s GbE/FC circuit pack, they are supported on the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack
The Muxponder 10 Gbit/s circuit packs forming the working and protection 1+1 pair at one end of the bookended topology must be the same Muxponder 10 Gbit/s circuit pack type

Interoperable topologies with sub-rate multiplex OCI circuit packs

In interoperable topologies with sub-rate multiplex OCI circuit packs, a sub-rate multiplex OCI circuit pack at the starting point of an optical channel is paired with an OCI circuit pack at the end point of the same optical channel. The individual client signals are not demultiplexed when dropped from the Optical Metro 5100/5200 network. Figure 3-47 on page 3-55 shows an example of an interoperable topology.

Figure 3-47
Interoperable service layer topology



Implementing interoperable topologies with OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced or OCI SRM GbE circuit packs

You can implement interoperable topologies with OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced or OCI SRM GbE circuit packs, as shown in Figure 3-48 on page 3-56. The OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced, or OCI SRM GbE circuit packs are paired at Sites A and F. Because no multiplexing or demultiplexing is required at Sites C or D, various combinations of single-port OCI and OCLD, or OTR circuit packs can be used at these sites.

Figure 3-48
Interoperable OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced or OCI SRM GbE circuit packs

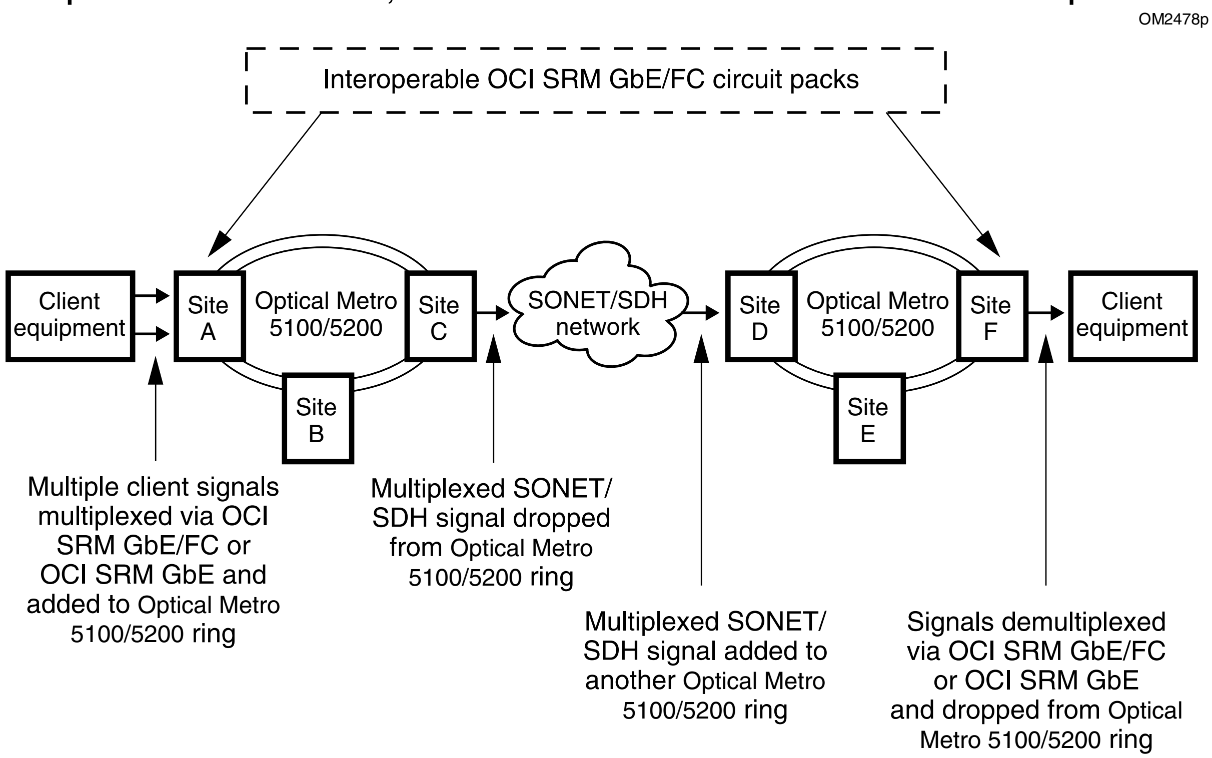


Table 3-3 lists the valid combinations of circuit packs for each site in the Figure 3-48 example.

Table 3-3
OCI SRM GbE/FC OCI SRM GbE/FC Enhanced or OCI SRM GbE circuit pack compatibility for interoperable topologies

Site (see Figure 3-48)	Client-side circuit pack	Line-side circuit pack
A and F	OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced or OCI SRM GbE	OCLD 2.5 Gbit/s Flex
B and E	—	OCLD 2.5 Gbit/s Flex (2)
		OCLD 2.5 Gbit/s Fixed (2)
		OCLD 2.5 Gbit/s Fixed (1) OCLD 2.5 Gbit/s Flex (1)

Table 3-3 (continued)
OCI SRM GbE/FC OCI SRM GbE/FC Enhanced or OCI SRM GbE circuit pack compatibility for interoperable topologies

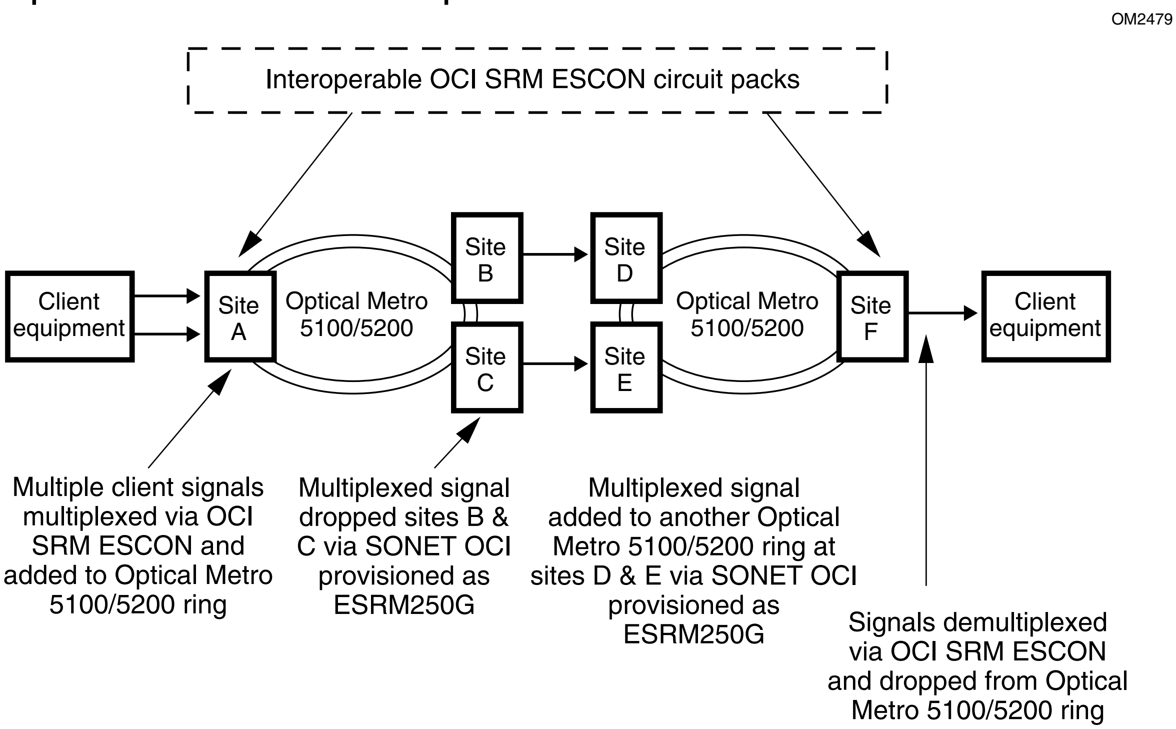
Site (see Figure 3-48)	**Client-side circuit pack**	**Line-side circuit pack**
C and D (see Note)	OTR 2.5 Gbit/s Flex 1310 nm	
	OCI SONET/SDH 1310 nm or OCI SONET/SDH IR 1310 nm provisioned with OC-48 or STM-16 channel assignment	OCLD 2.5 Gbit/s Flex
		OCLD 2.5 Gbit/s Fixed
	OCI OC-48/STM-16 1310 nm	OCLD 2.5 Gbit/s Flex
		OCLD 2.5 Gbit/s Fixed
Note: Line-side circuit packs can be a mix of OCLD 2.5 Gbit/s Fixed and Flex.		

Implementing interoperable topologies with OCI SRM ESCON circuit packs

You can implement interoperable topologies with OCI SRM ESCON circuit packs. Figure 3-49 shows OCI SRM ESCON circuit packs configured in an interoperable topology. In this example, the interoperable topology is used for dual homing protection. The OCI SRM ESCON circuit packs are paired at Sites A and F. For sites B, C, D, and E, the only valid circuit packs (which must be provisioned with the ESRM-250 protocol) are:

- OCI SONET/SDH
- OTR 2.5 Gbit/s Flex/Universal 1310 nm
- OTR 2.5 Gbit/s Flex 100 GHz 1310 nm

Figure 3-49
Interoperable OCI SRM ESCON circuit packs

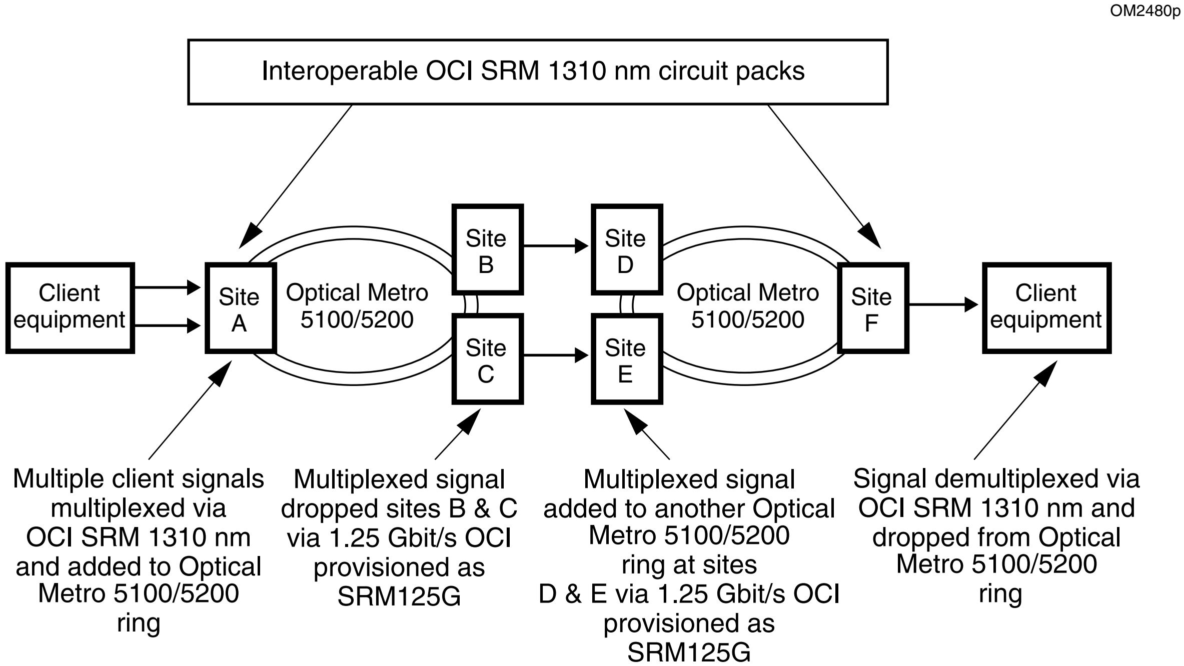


Implementing interoperable topologies with OCI SRM 1310 nm and OCI SRM 1310 nm LC circuit packs

You can implement interoperable topologies with OCI SRM 1310 nm and OCI SRM 1310 nm LC circuit packs. Figure 3-50 shows OCI SRM 1310 nm circuit packs configured in an interoperable topology. In this example, the interoperable topology is used for dual homing protection. The OCI SRM 1310 nm circuit packs are paired at Sites A and F. For sites B, C, D, and E, the only valid circuit packs (which must be provisioned with the SRM-125 protocol) are:

- OCI 1.25 Gbit/s
- OTR 2.5 Gbit/s Flex/Universal 1310 nm
- OTR 2.5 Gbit/s Flex 100 GHz 1310 nm.

Figure 3-50
Interoperable OCI SRM 1310 nm and OCI SRM 1310 nm LC circuit packs



Interoperable topologies with Muxponder circuit packs

In interoperable topologies with Muxponder circuit packs, a Muxponder circuit pack at the starting point of an optical channel is paired with an OTR 10 Gbit/s Enhanced circuit pack at the end point of the same optical channel. The individual client signals are not demultiplexed when dropped from the Optical Metro 5100/5200 network.

Implementing interoperable topologies with Muxponder 10 Gbit/s GbE/FC circuit packs

You can implement interoperable topologies with Muxponder 10 Gbit/s GbE/FC circuit packs, as shown in Figure 3-51 on page 3-61, Figure 3-52 on page 3-63 and Figure 3-53 on page 3-64.

SONET/SDH Section Terminal Equipment (STE) interoperable topologies

You can implement SONET/SDH STE interoperable topologies with Muxponder 10 Gbit/s circuit packs, as shown in Figure 3-2 on page 3-5.

Each end of the interoperable topology link can be equipped with the same Muxponder 10 Gbit/s circuit pack type or different Muxponder 10 Gbit/s circuit pack types according to Table 3-4 on page 3-60.

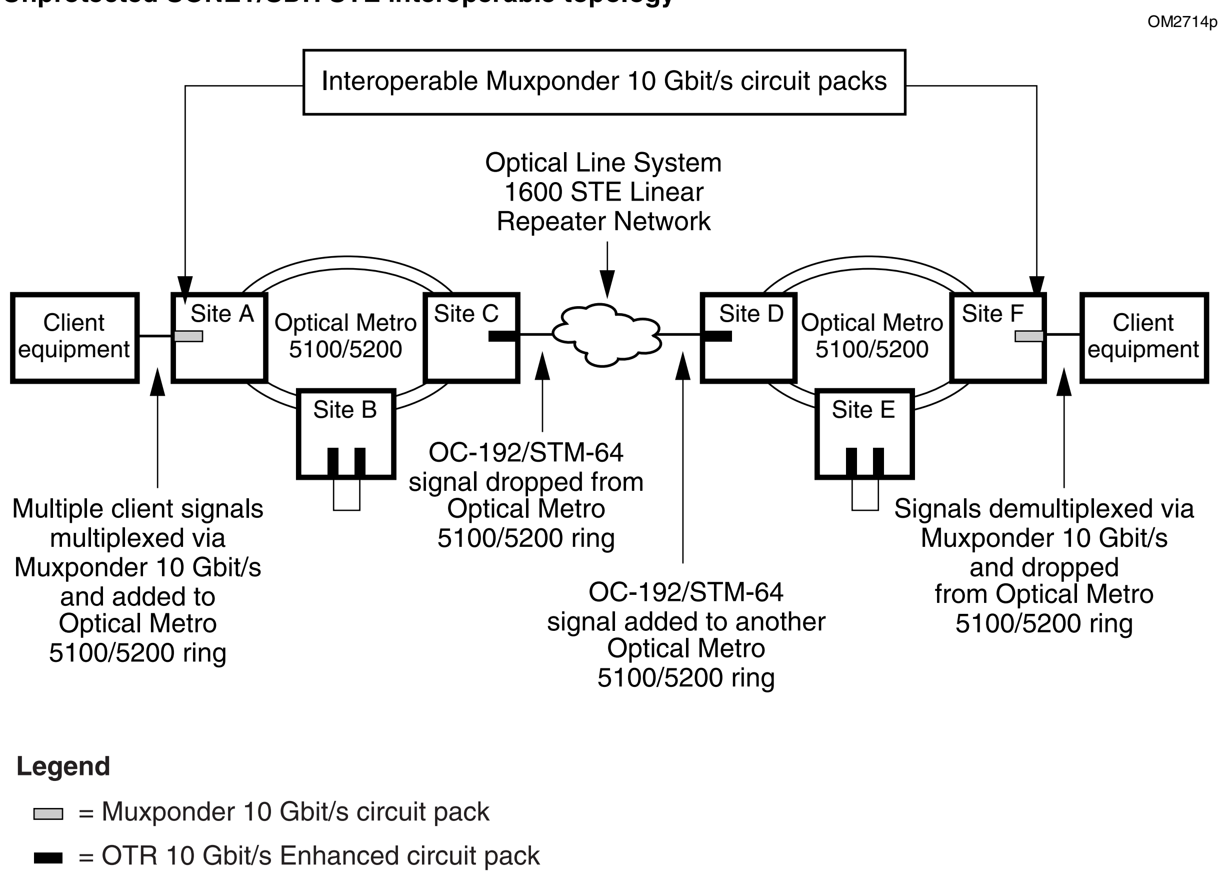
Table 3-4
Muxponder 10 Gbit/s circuit pack type mixing rules in a SONET/SDH STE interoperable topology

Site A Muxponder 10 Gbit/s circuit pack type	Site F Muxponder 10 Gbit/s circuit pack type	Support	Rules
Muxponder 10 Gbit/s GbE/FC	Muxponder 10 Gbit/s GbE/FC	√	None
Muxponder 10 Gbit/s GbE/FC VCAT	Muxponder 10 Gbit/s GbE/FC VCAT	√	None
Muxponder 10 Gbit/s GbE/FC	Muxponder 10 Gbit/s GbE/FC VCAT	√	See Table 3-2 on page 3-54
Muxponder 10 Gbit/s GbE/FC VCAT	Muxponder 10 Gbit/s GbE/FC	√	See Table 3-2 on page 3-54

In the unprotected SONET/SDH STE interoperable topology displayed in Figure 3-51 on page 3-61,

- the Muxponder 10 Gbit/s circuit packs are paired at Sites A and F
- the OTR 10 Gbit/s Enhanced circuit packs at Sites C and D provide the OC-192 or STM-64 signal hand-off to the Optical Long Haul 1600 Linear Repeater network as they unwrap the G.709 signal received from the Muxponder 10 Gbit/s circuit packs to an OC-192/STM-64 signal
- the Optical Long Haul 1600 circuit packs that interface with the Optical Metro 5100/5200 circuit packs must be WT or XR circuit packs
- the OTR 10 Gbit/s Enhanced circuit packs at Sites B and E provide a regeneration function.

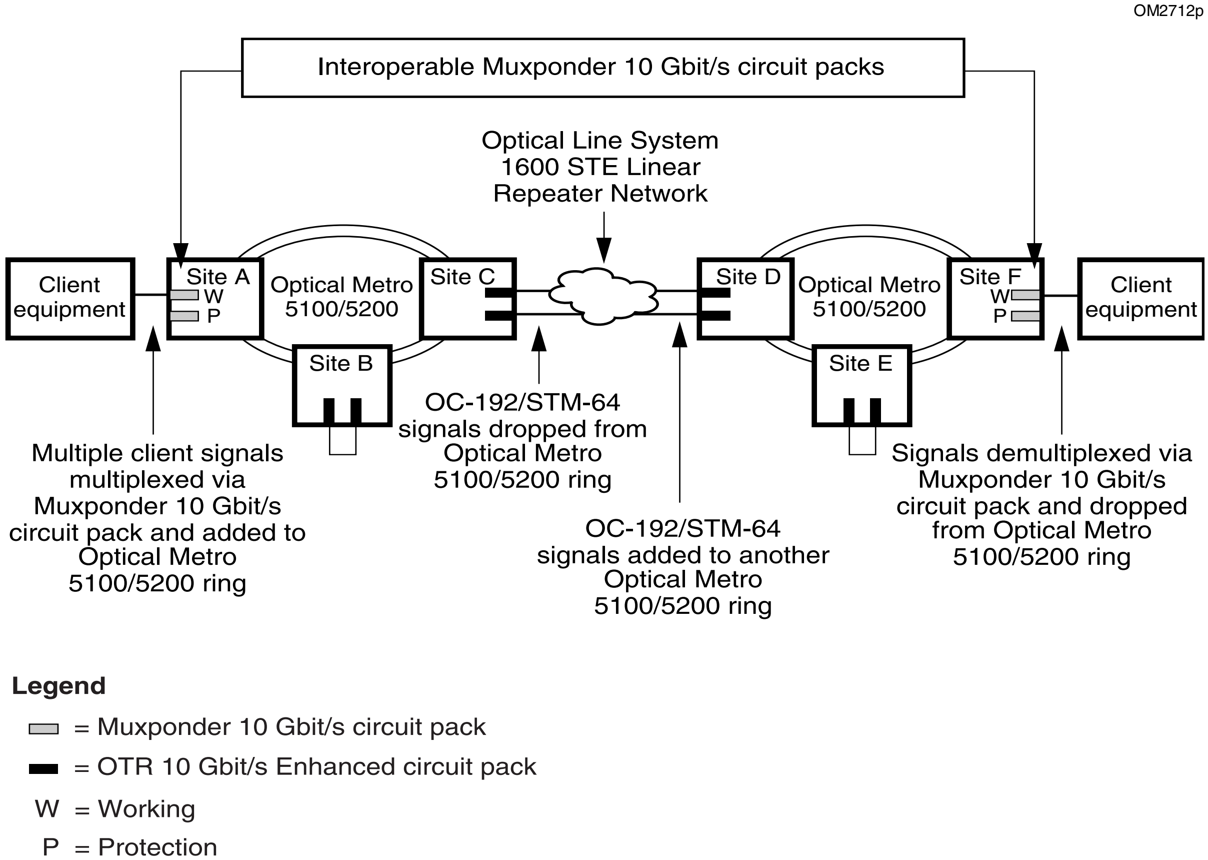
Figure 3-51
Unprotected SONET/SDH STE interoperable topology



In the protected SONET/SDH STE interoperable topology displayed in Figure 3-52 on page 3-63,

- the Muxponder 10 Gbit/s circuit packs are paired at Sites A and F. There are two Muxponder 10 Gbit/s circuit packs at each of these sites provisioned in 1+1 APS protection mode.
- the OTR 10 Gbit/s Enhanced circuit packs at Sites C and D provide the OC-192 or STM-64 signal hand-off to the Optical Long Haul 1600 Linear Repeater network as they unwrap the G.709 signal received from the Muxponder 10 Gbit/s circuit packs to an OC-192/STM-64 signal. There are two OTR 10 Gbit/s Enhanced circuit packs at Site C and two more at Site D. Two are required, one for the working signal and one for the protection signal. Each OTR 10 Gbit/s Enhanced circuit pack is configured in unprotected mode since the 1+1 APS protection is performed between the Muxponder 10 Gbit/s circuit packs equipped at Site A and F.
- the Optical Long Haul 1600 circuit packs that interface with the Optical Metro 5100/5200 circuit packs must be WT or XR circuit packs. These circuit packs are provisioned as unprotected in the Optical Long Haul 1600 Linear Repeater network.
- the OTR 10 Gbit/s Enhanced circuit packs at Sites B and E provide a regeneration function.

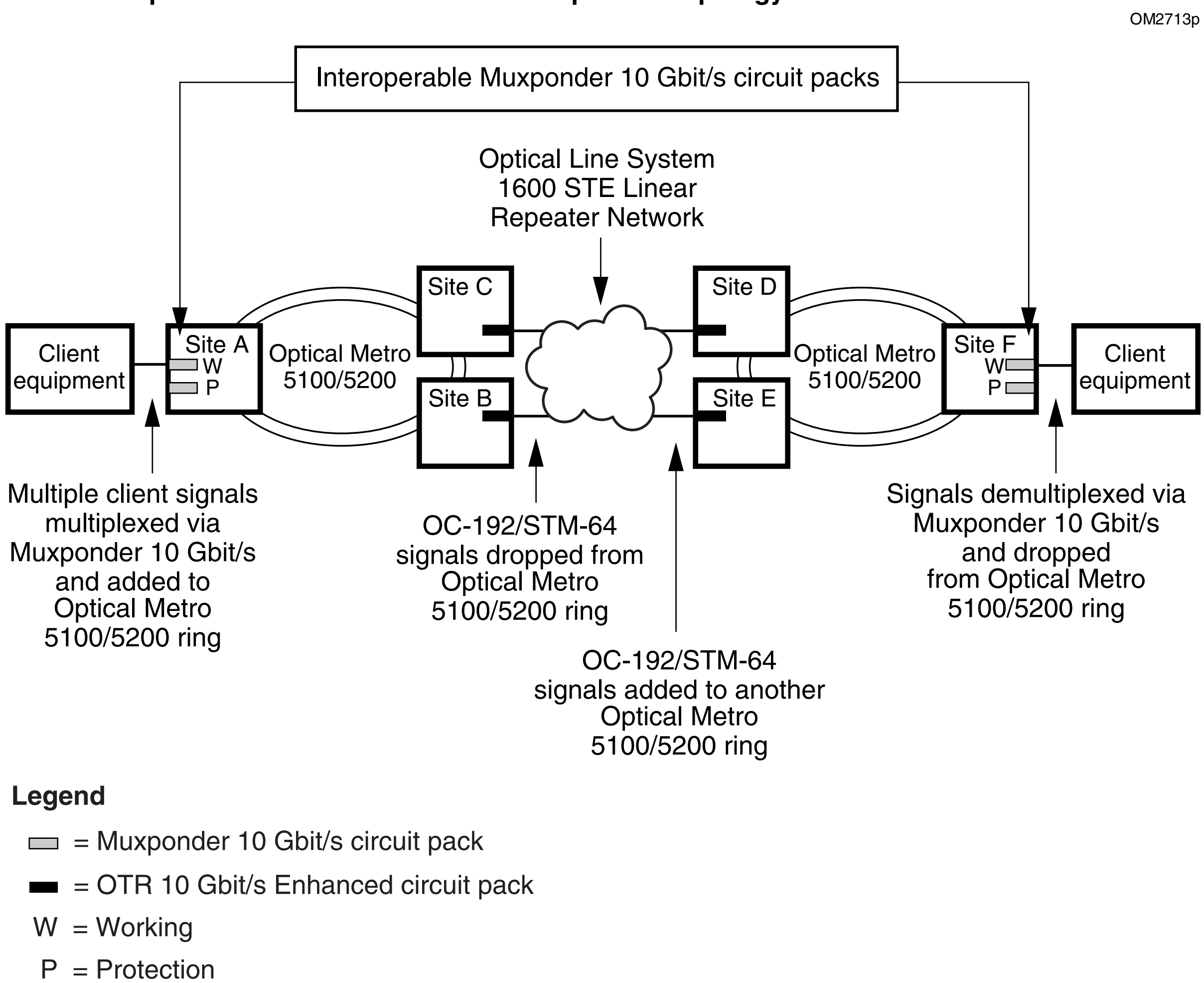
Figure 3-52
Protected SONET/SDH STE interoperable topology



In the dual homing protection SONET/SDH STE interoperable topology displayed in Figure 3-53 on page 3-64,

- the Muxponder 10 Gbit/s circuit packs are paired at Sites A and F. There are two Muxponder 10 Gbit/s circuit packs at each of these sites provisioned in 1+1 APS protection mode.
- the OTR 10 Gbit/s Enhanced circuit packs at Sites B, C, D and E provide the OC-192 or STM-64 signal hand-off to the Optical Long Haul 1600 Linear Repeater network as they unwrap the G.709 signal received from the Muxponder 10 Gbit/s circuit packs to an OC-192/STM-64 signal. Each OTR 10 Gbit/s Enhanced circuit pack is configured in unprotected mode since the 1+1 APS protection is performed between the Muxponder 10 Gbit/s circuit packs equipped at Site A and F.
- the Optical Long Haul 1600 circuit packs that interface with the Optical Metro 5100/5200 circuit packs must be WT or XR circuit packs. These circuit packs are provisioned as unprotected in the Optical Long Haul 1600 Linear Repeater network.

Figure 3-53
Dual-homed protected SONET/SDH STE interoperable topology



SONET/SDH Line Terminating Equipment (LTE) network interoperable topologies

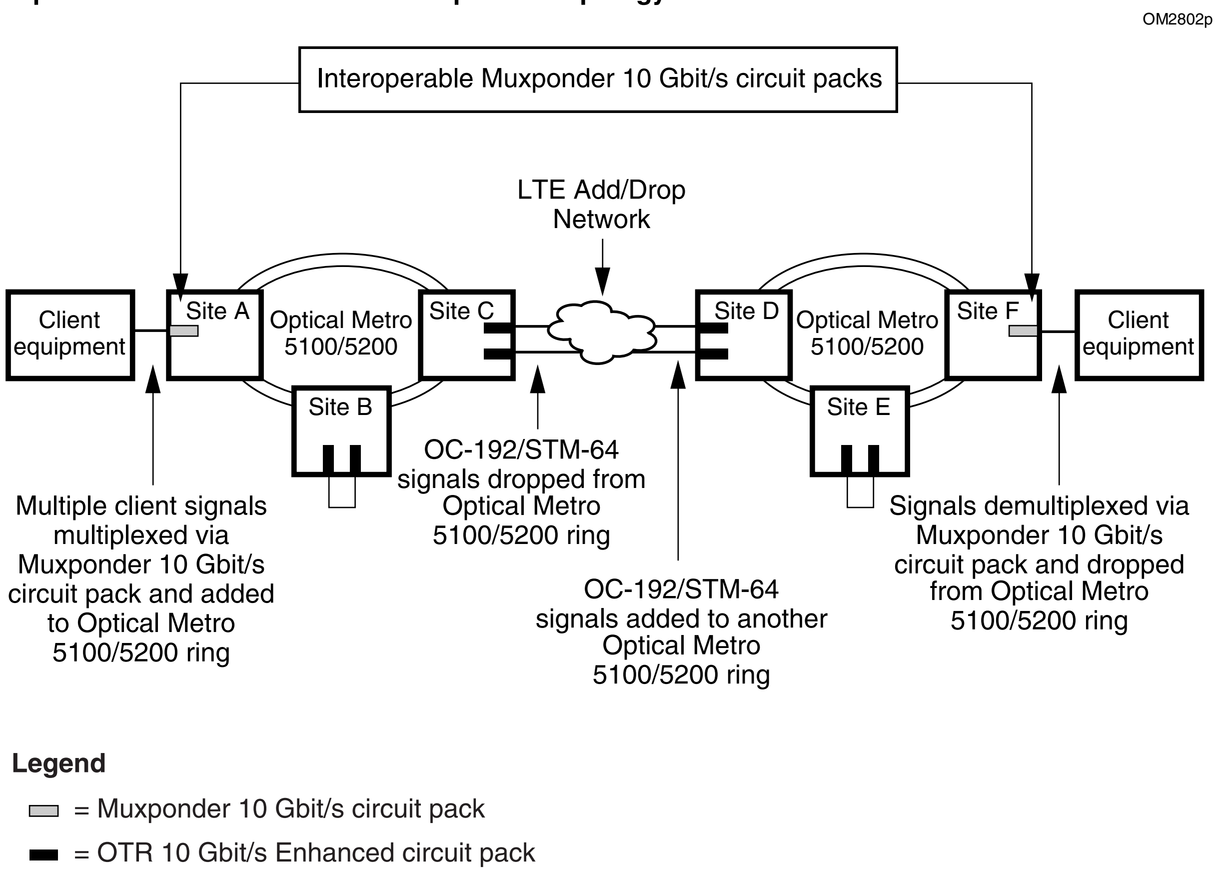
You can implement SONET/SDH LTE interoperable topologies with Muxponder 10 Gbit/s GbE/FC VCAT circuit packs, as shown in Figure 3-54 on page 3-66 or Figure 3-55 on page 3-67.

Each end of the interoperable topology link must be equipped with the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack. The SONET/SDH LTE interoperable topologies are not supported with the Muxponder 10 Gbit/s GbE/FC circuit pack.

In the unprotected SONET/SDH LTE interoperable topology displayed in Figure 3-54 on page 3-66,

- the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs are paired at Sites A and F
- the entire aggregate signal between the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs at Sites A and F is passed “end-to-end” through a SONET/SDH network as a contiguous STS-192/STM-64 signal
- the OTR 10 Gbit/s Enhanced circuit packs at Sites C and D provide the OC-192 or STM-64 signal hand-off to the LTE add/drop network as they unwrap the G.709 signal received from the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs to an OC-192/STM-64 signal
- the OC-192/STM-64 signal can be protected within the LTE add/drop network if desired
- the OTR 10 Gbit/s Enhanced circuit packs at Sites B and E provide a regeneration function

Figure 3-54
Unprotected SONET/SDH LTE interoperable topology



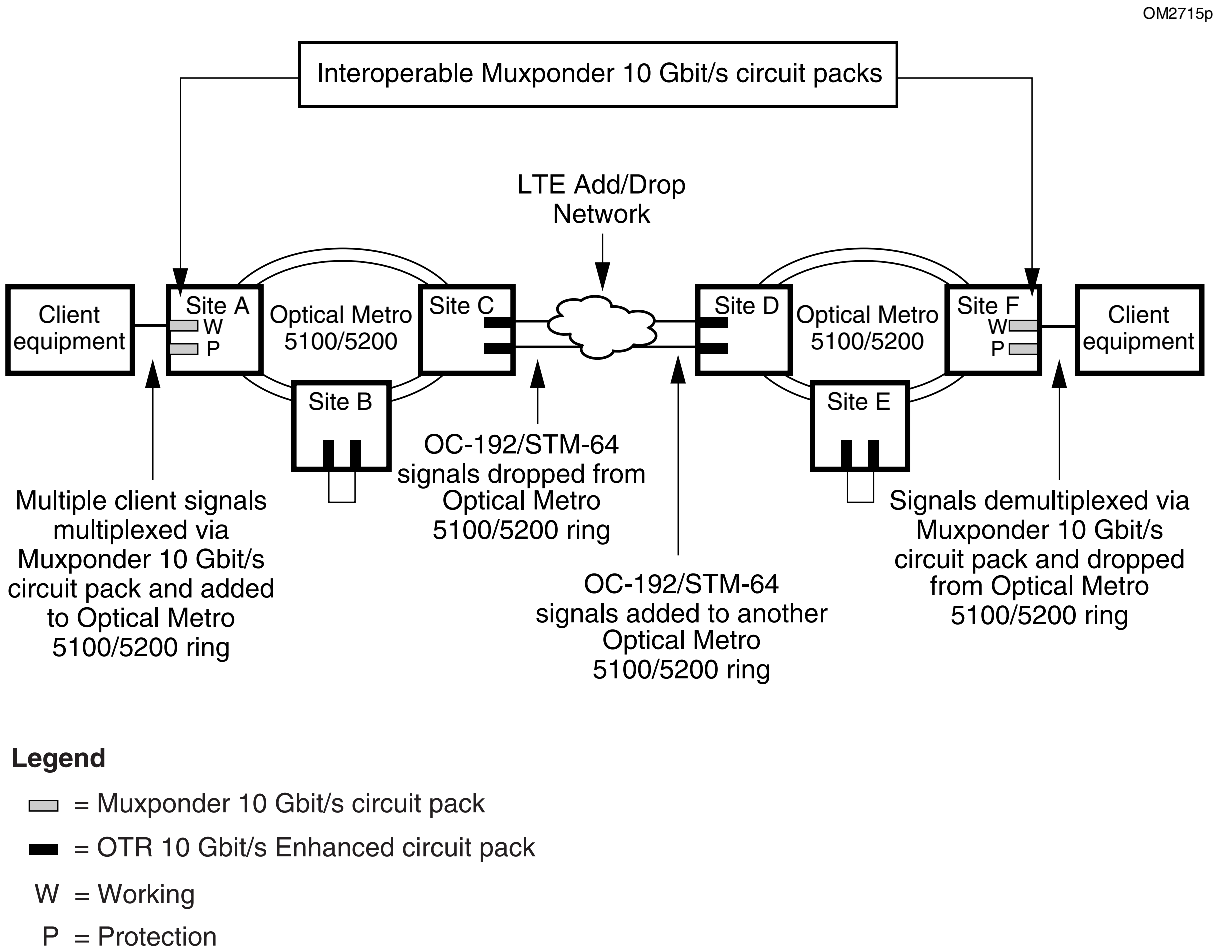
In the protected SONET/SDH LTE interoperable topology displayed in Figure 3-55 on page 3-67,

- the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs are paired at Sites A and F. There are two Muxponder 10 Gbit/s GbE/FC VCAT circuit packs at each of these sites provisioned in 1+1 APS protection mode.
- the entire aggregate signal between the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs at Sites A and F is passed “end-to-end” through a SONET/SDH network as a contiguous STS-192/STM-64 signal
- the OTR 10 Gbit/s Enhanced circuit packs at Sites C and D provide the OC-192/STM-64 signal hand-off to the LTE add/drop network as they unwrap the G.709 signal received from the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs to an OC-192/STM-64 signal. There are two OTR 10 Gbit/s Enhanced circuit packs at Site C and two more at Site D. Two are required, one for the working signal and one for the protection signal. Each OTR 10 Gbit/s Enhanced circuit pack is configured in unprotected mode since the 1+1 APS protection is performed between the Muxponder 10

Gbit/s GbE/FC VCAT circuit packs equipped at Site A (or Site F) and the OC-192/STM-64 circuit packs (provisioned in 1+1 APS mode) interfacing with the OTR 10 Gbit/s Enhanced circuit packs at Site C (or Site D).

- the OC-192/STM-64 signal is protected within the LTE add/drop network (using BLSR protection for example)
- the OTR 10 Gbit/s Enhanced circuit packs at Sites B and E provide a regeneration function

Figure 3-55
Protected SONET/SDH LTE interoperable topology



SONET/SDH Line Terminating Equipment (LTE) Diverse Route network interoperable topologies

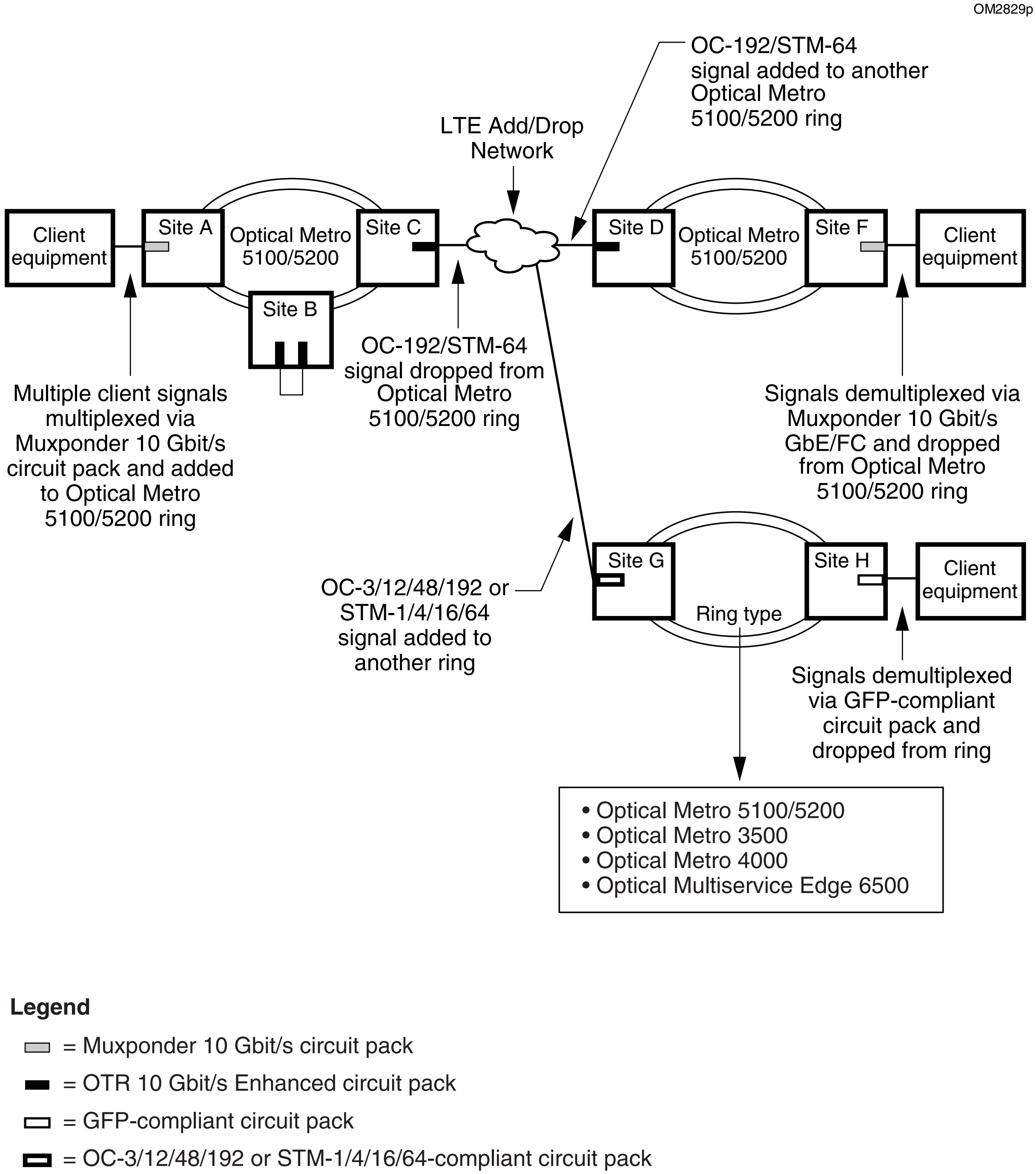
You can implement SONET/SDH LTE Diverse Route interoperable topologies with Muxponder 10 Gbit/s GbE/FC VCAT circuit packs, as shown in Figure 3-56 on page 3-69 or Figure 3-57 on page 3-71.

The SONET/SDH LTE Diverse Route interoperable topologies are not supported with the Muxponder 10 Gbit/s GbE/FC circuit pack.

In the unprotected SONET/SDH LTE Diverse Route interoperable topology displayed in Figure 3-56 on page 3-69,

- after the STS-192/STM-64 aggregate signal leaves the Optical Metro 5100/5200 network, the LTE add/drop network can break or groom the signal into smaller payloads as well as being able to route the signals to different end points. In the case of C-cat, each pipe consists of one path only. In the case of V-cat, each pipe may consist of multiple diversely routed STS-3c V-cat connections. These diverse routes can accommodate up to 14 msec of differential delay.
- the OTR 10 Gbit/s Enhanced circuit packs at Sites C and D provide the OC-192 or STM-64 signal hand-off to the LTE add/drop network as they unwrap the G.709 signal received from the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs to an OC-192/STM-64 signal
- the OC-3/12/48 or STM-1/4/16 compliant circuit packs at Site G provide the signal hand-off to the LTE add/drop network
- the GFP-compliant circuit pack at Site H must support:
    - — GFP-F or GFP-T encapsulation for GbE
    - — GFP-T encapsulation for FC-100, FICON, FC-200, FICON Express
    - — STS-3c granularity
- the STS-3c signals can be protected within the LTE add/drop network if desired
- the OTR 10 Gbit/s Enhanced circuit packs at Site B provide a regeneration function

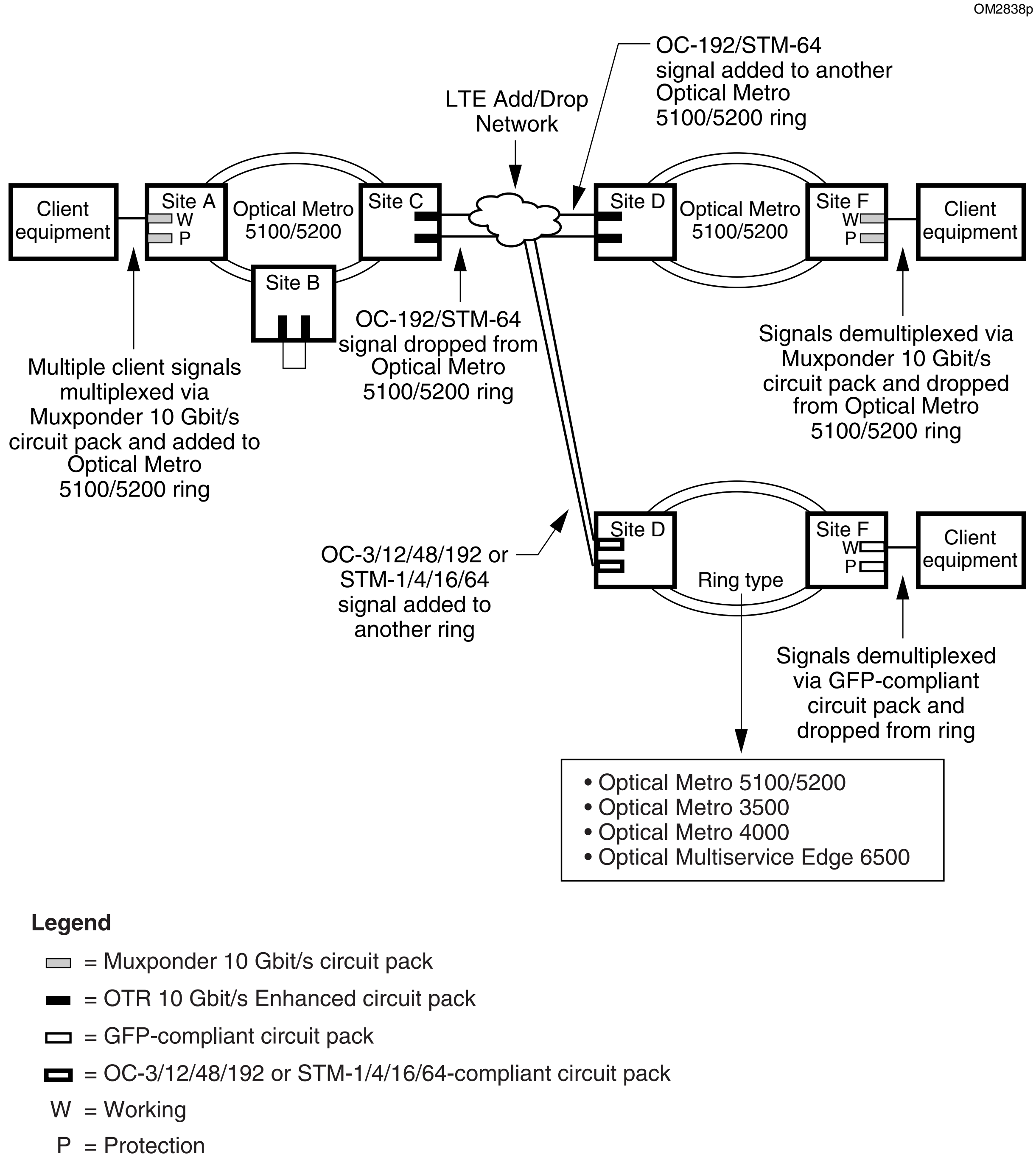
Figure 3-56
Unprotected SONET/SDH LTE Diverse Route interoperable topology



In the protected SONET/SDH LTE Diverse Route interoperable topology displayed in Figure 3-57 on page 3-71,

- after the STS-192/STM-64 aggregate signal leaves the Optical Metro 5100/5200 network, the LTE add/drop network can break or groom the signal into smaller payloads as well as being able to route the signals to different end points. In the case of C-cat, each pipe consists of one path only. In the case of V-cat, each pipe may consist of multiple diversely routed STS-3c V-cat connections. These diverse routes can accommodate up to 14 msec of differential delay.
- the OTR 10 Gbit/s Enhanced circuit packs at Sites C and D provide the OC-192/STM-64 signal hand-off to the LTE add/drop network as they unwrap the G.709 signal received from the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs to an OC-192/STM-64 signal. There are two OTR 10 Gbit/s Enhanced circuit packs at Site C and two more at Site D. Two are required, one for the working signal and one for the protection signal. Each OTR 10 Gbit/s Enhanced circuit pack is configured in unprotected mode since the 1+1 APS protection is performed between the Muxponder 10 Gbit/s GbE/FC VCAT circuit packs equipped at Site A (or Site F) and the OC-192/STM-64 circuit packs (provisioned in 1+1 APS mode) interfacing with the OTR 10 Gbit/s Enhanced circuit packs at Site C (or Site D).
- the OC-3/12/48 or STM-1/4/16 compliant circuit packs at Site G provide the signal hand-off to the LTE add/drop network
- the GFP-compliant circuit pack at Site H must support:
  - — GFP-F or GFP-T encapsulation for GbE
  - — GFP-T encapsulation for FC-100, FICON, FC-200, FICON Express
  - — STS-3c granularity (not STS-1)
- the STS-3c signals are protected within the LTE add/drop network (using BLSR protection for example)
- the OTR 10 Gbit/s Enhanced circuit packs at Site B provide a regeneration function

Figure 3-57
Protected SONET/SDH LTE Diverse Route interoperable topology



Operational considerations for protected and unprotected SONET/SDH LTE Diverse Route interoperable topology

When operating protected or unprotected SONET/SDH LTE Diverse Route interoperable topologies, you must take into account the following considerations:

- GFP Encapsulation and Transport Structure on page 3-72
- GFP Client Management Frames on page 3-72
- VCAT sequence numbering on page 3-76
- Preamble and Start Of Frame Delimiter transparency on page 3-77
- VCAT defect condition and conditioning on page 3-77
- Round Trip Delay Measurement on page 3-77
- 1+1 APS Protection switching on page 3-78

Note: In the sections below, when OCI SRM GbE/FC is stated, this corresponds to the OCI SRM GbE/FC and OCI SRM GbE/FC Enhanced circuit packs or the OCI SRM GbE circuit pack (Gigabit Ethernet protocol only).

GFP Encapsulation and Transport Structure

- The Muxponder 10 Gbit/s GbE/FC VCAT circuit pack supports GFP-F and GFP-T encapsulation for Gigabit Ethernet or GFP-T for Fibre Channel.
- The OCI SRM GbE/FC, Optical Metro 3500 2-port GFP circuit pack and Optical Multiservice Edge (OME) 4-port GFP circuit pack support GFP-F for Gigabit Ethernet and GFP-T for Fibre Channel.

  Note: When the Muxponder 10 Gbit/s GbE/FC VCAT interworks with these circuit packs, ensure that the encapsulation is set to GFP-F for Gigabit Ethernet and GFP-T for Fibre Channel.

- The Muxponder 10 Gbit/s GbE/FC VCAT and OCI SRM GbE/FC Transport Structure can be provisioned with an STS-3c/VC-4 granularity.
- The Optical Metro 3500 2-port GFP circuit pack and the OME 4-port GFP circuit pack can be provisioned with an STS-1/VC-3 and an STS-3c/VC-4 granularity.

  Note: When these circuit packs interwork with the Muxponder 10 Gbit/s GbE/FC VCAT and OCI SRM GbE/FC, ensure that the Transport Structure granularity is STS-3c/VC-4.

GFP Client Management Frames

The Muxponder 10 Gbit/s GbE/FC VCAT circuit pack only recognizes GFP Client Management Frames (CMF) that contain a non-zero payload. The Muxponder 10 Gbit/s GbE/FC VCAT does not accept CMFs with a zero payload.

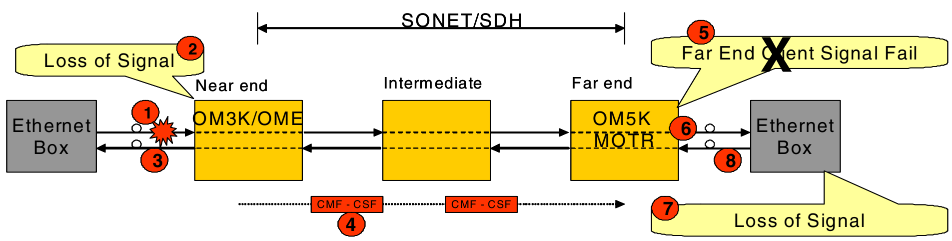
The OCI SRM GbE/FC circuit packs can send CMFs with a non-zero payload (when running Release 8.0 or higher software). However, the Optical Metro 3500 2-port GFP circuit pack and the Optical Multiservice Edge (OME) 4-port GFP circuit pack send CMFs with a zero payload. As a result, when the Muxponder 10 Gbit/s GbE/FC VCAT interworks with the Optical Metro 3500 2-port GFP circuit pack and the Optical Multiservice Edge (OME) 4-port GFP circuit pack be aware of impacts during the following fault conditions:

- Gigabit Ethernet client Rx fiber cut
- Gigabit Ethernet client Tx fiber cut
- Gigabit Ethernet SONET/SDH path failure
- Fibre Channel client Rx fiber cut

Gigabit Ethernet client Rx fiber cut

Figure 3-58 shows the situation for a Gigabit Ethernet client Rx fiber cut.

Figure 3-58
GFP CMF impact - Gigabit Ethernet client Rx fiber cut



The sequence of events of the Gigabit Ethernet client Rx fiber cut shown in Figure 3-58 is:

1 A fiber cut at the near-end receiver is detected.

2 The “Loss Of Signal” alarm is raised at the near end.

3 Auto-negotiation is initiated with the near-end device, but never completes.

4 Client Management Frames (CMF) are periodically sent towards the far end.

5 The Muxponder discards the received CMF, and does not raise the “Far End Client Signal Fail” alarm.

6 The far-end transmitter does not shut down, and instead GbE idles are sent.

7 The “Loss Of Signal” alarm is not raised at the far-end Ethernet box.

8 Auto-negotiation is not initiated by the far-end device.

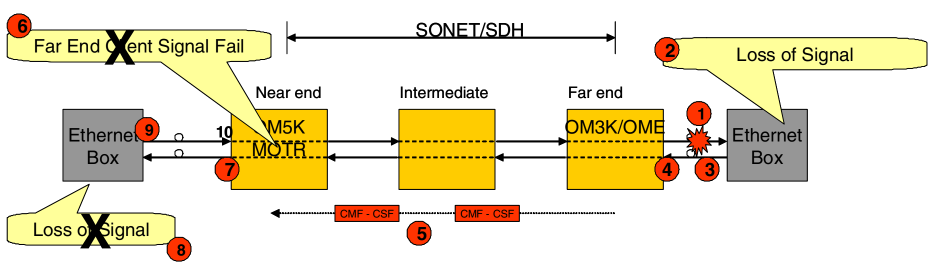
In general, the impact of this issue is that no far-end conditioning occurs when the near-end failure is detected. More specifically, if the client switch/router does not take the link down, the following impacts can occur:

- The switch/router continues to send traffic and control protocol packets into the broken link.
- The traffic is re-routed after bridging/routing protocols timeout (typically 20 seconds for STP, 40 seconds for OSPF).
- If link aggregation is used between switches then the protocol may detect link failures rapidly.
- MPLS switches may run fast hello polls (for example, every 5 ms) and detect link failures rapidly.
- Network behavior can vary, depending on protocols running over the link. This may result in longer periods of traffic loss then when the client takes the link down.

Gigabit Ethernet client Tx fiber cut

Figure 3-59 shows the situation for a Gigabit Ethernet client Tx fiber cut. The impact of the Gigabit Ethernet client Tx fiber cut is improper conditioning and missing alarms at the near-end. Also the client switch/router does not take the link down.

Figure 3-59
GFP CMF impact - Gigabit Ethernet client Tx fiber cut



The sequence of events of the Gigabit Ethernet client Tx fiber cut shown in Figure 3-59 is:

1. Fiber cut at far-end Ethernet box receiver is detected.
2. The “Loss of Signal” alarm is raised at the far-end Ethernet box.
3. Auto-Negotiation is initiated with the far-end device.
4. Auto-Negotiation is detected at the far-end node. The “LAN Link Down” alarm is raised by the Optical Metro 3500/OME system.
5. GFP Client Management Frames (CMF) are sent periodically.
6. The Muxponder discards received CMFs, and does not raise the “Far End Client Signal Fail” alarm. The Muxponder OM and PM counts become unreliable.

7 The near-end transmitter does not shut down.

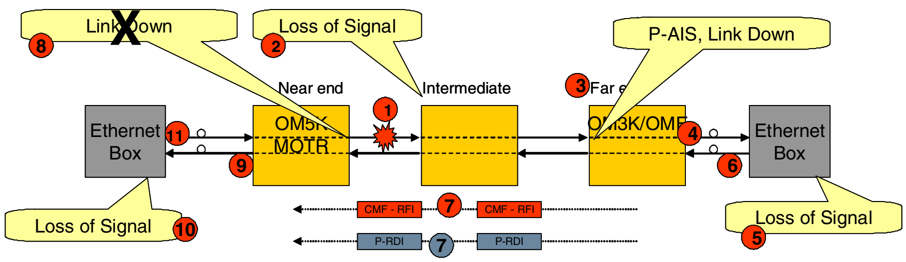
8 The “Loss of Signal” alarm is not raised at near-end Ethernet box.

9 Auto-Negotiation is not initiated by the near-end Ethernet box.

Gigabit Ethernet SONET/SDH path failure

Figure 3-60 shows the situation for a Gigabit Ethernet SONET/SDH path failure. The impact of the Gigabit Ethernet SONET/SDH path failure is missing alarms.

Figure 3-60
GFP CMF impact - Gigabit Ethernet SONET/SDH path failure



The sequence of events of the Gigabit Ethernet SONET/SDH path failure shown in Figure 3-60 is:

1 Fiber cut between the near-end and intermediate node.

2 The “Loss of Signal” alarm is raised at the intermediate node.

3 “P-AIS” and “Link Down” alarms are raised at the far-end node.

4 The far-end transmitter shuts down.

5 The “Loss of Signal” alarm is raised at the far-end Ethernet box.

6 Auto-Negotiation is initiated by the far-end device.

7 GFP Client Management Frames (Remote Fault Indicator) are sent periodically.

8 Received RFI CMFs are discarded by near-end Muxponder, but R-RDI causes conditioning without raising a “Link Down” alarm. The Muxponder OM and PM counts become unreliable.

9 Near-end transmit laser shuts down.

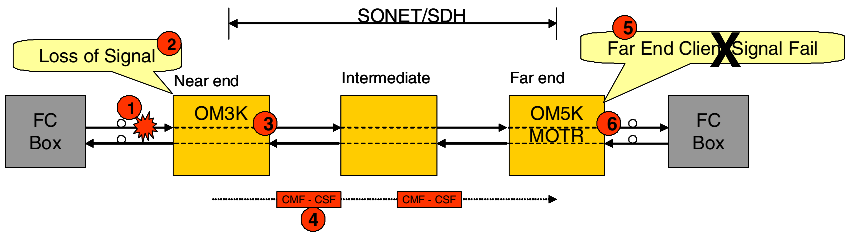
10 The “Loss of Signal” alarm is raised at near-end Ethernet box.

11 Auto-Negotiation is initiated by the near-end device.

Fibre Channel client Rx fiber cut

Figure 3-61 shows the situation for Fibre Channel. The impact on the Fibre Channel protocol is the absence of alarms at the far-end Optical Metro 5100/5200 to indicate that 10B_ERR is being transmitted.

Figure 3-61
GFP CMF impact - Fibre Channel client Rx fiber cut



The sequence of events of the Fibre Channel shown in Figure 3-61 is:

1. Fiber cut at near-end receiver is detected.
2. The “Loss of Signal” alarm is raised at near end.
3. No GFP-T frames are sent.
4. Client Management Frames (CMF) are sent periodically towards the far end.
5. The Muxponder discards the received CMFs, and does not raise the “Far End Client Signal Fail” alarm. The Muxponder OM and PM counts become unreliable.
6. Since no GFP-T frames are being received, the 10B_ERRs are transmitted at the far end.

   Note: Fibre Channel is not yet supported on Optical Multiservice Edge (OME).

VCAT sequence numbering

The VCAT sequence numbering is done according to the following guidelines:

- For Optical Metro 5100/5200 Muxponder 10 Gbit/s GbE/FC VCAT and OCI SRM GbE/FC, the sequence numbers assigned to the members of a virtually concatenated group is in ascending order according to the STS number, regardless of which STS group is provisioned first.
- For the Optical Metro 3500 2-port GFP circuit pack and the OME 4-port GFP circuit pack, the sequence numbers are assigned depending on which STS group is provisioned first. For instance, if you create the connection from path 7 first, this path is assigned sequence number 1; if the second path you add is path 4, this path is assigned sequence number 2.
- To carry traffic in an interworking scenario, ensure that you provision the paths on OME and Optical Metro 3500 in ascending order according to the STS number. Doing so ensures the sequence numbers match those of the Muxponder 10 Gbit/s GbE/FC VCAT and OCI SRM GbE/FC circuit packs.

Note: The “Loss Of Sequence” alarm is raised by the Muxponder 10 Gbit/s GbE/FC VCAT if this last condition is not met.

Preamble and Start Of Frame Delimiter transparency

When using GFP-F, Gigabit Ethernet Preamble and Start Of Frame (SOF) Delimiter transparency is provisionable on the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack. This uses a proprietary GFP User Payload Identifier (UPI) code (0xF0). Two settings are available:

- Enable: preamble is transparently passed through
- Disable: preamble is processed and removed

The OCI SRM GbE/FC, Optical Metro 3500 2-port GFP and OME 4-port GFP circuit pack do not support this feature. When these circuit packs interwork with the Muxponder 10 Gbit/s GbE/FC VCAT, the Gigabit Ethernet Preamble and Start Of Frame Delimiter transparency feature must be disabled on the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack.

VCAT defect condition and conditioning

The support for VCAT defect condition and conditioning is as follows:

- For V-cat alarms (Loss Of Alignment, Loss Of Multiframe, Loss Of Sequence), the Optical Metro 3500 2-port GFP and the OME 4-port GFP circuit packs condition back P-RDI.
- For V-cat alarms, the Muxponder 10 Gbit/s GbE/FC VCAT, OCI SRM GbE/FC, and the OME 4-port GFP circuit packs condition back GFP RDI.
- When the OME 4-port GFP and the Optical Metro 3000 2-port GFP circuit packs receive the GFP RDI condition, the “WAN Link Down” alarm is raised.
- When the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack receives the GFP RDI condition, the “GFP Remote Defect Indication” alarm is raised.

Round Trip Delay Measurement

The differences in how Optical Metro 5100/5200, Optical Metro 3500, and OME equipment measure round-trip delay are as follows:

- The OCI SRM GbE/FC and Muxponder 10 Gbit/s GbE/FC VCAT circuit packs round off the measured round trip delay to the nearest 500 µs. For example, if the measure value is 249 µs or less, the interface displays 0 µs. If the measured value is between 249 µs and 500 µs, then the interface displays 500 µs.
- The OME 4-port GFP and the Optical Metro 3500 2-port GFP circuit packs do not round off the measured value.

1+1 APS Protection switching

When Muxponder 10 Gbit/s GbE/FC VCAT circuit packs are interworking with OME 10 Gbit/s circuit packs and using 1+1 APS, ensure that the remote standard setting on the OME protection pair is set to either GR253 or G-841. Do not select EN300.

Mapping optical channel protection on network topologies

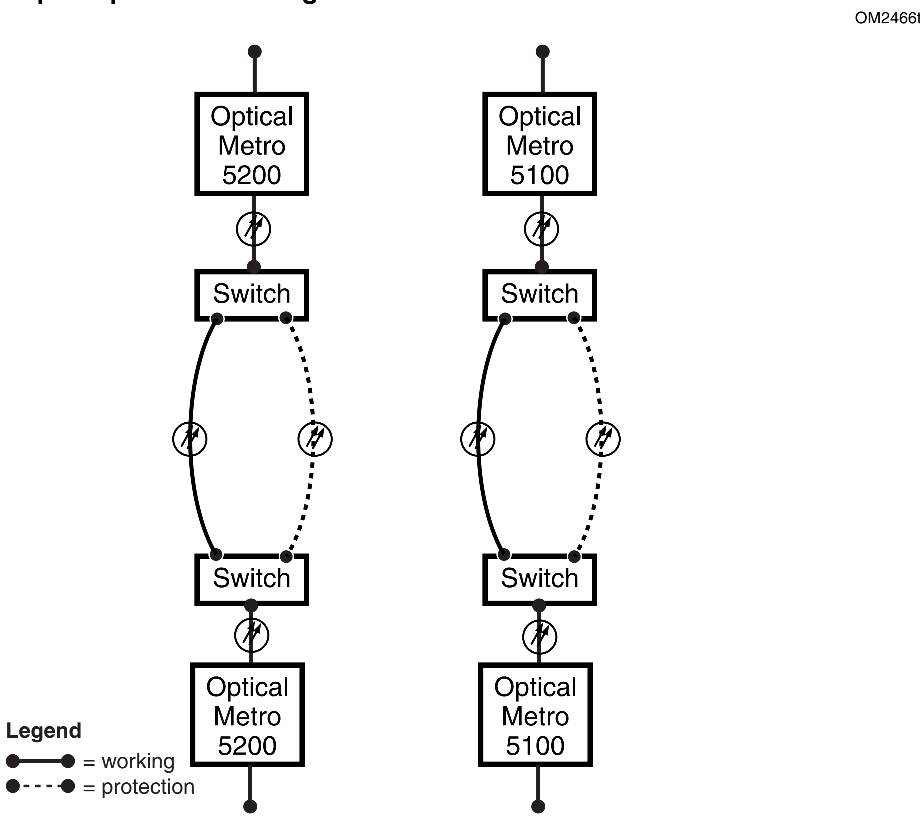
In the following diagrams, the same symbols are used for showing the optical channels in a network topology. Protection is shown by having two diverse paths for the optical channel: one is a solid line and the other is a dashed line.

Point-to-point protection using a trunk switch

You can only implement protection in Optical Metro 5100/5200 point-to-point networks by installing a trunk switch at each terminal site.

In this protection scheme, a single fiber pair through an Optical Metro 5100/5200 shelf is mapped onto a dual fiber pair (primary and standby) by the trunk switch. Figure 3-62 shows point-to-point protection using a trunk switch.

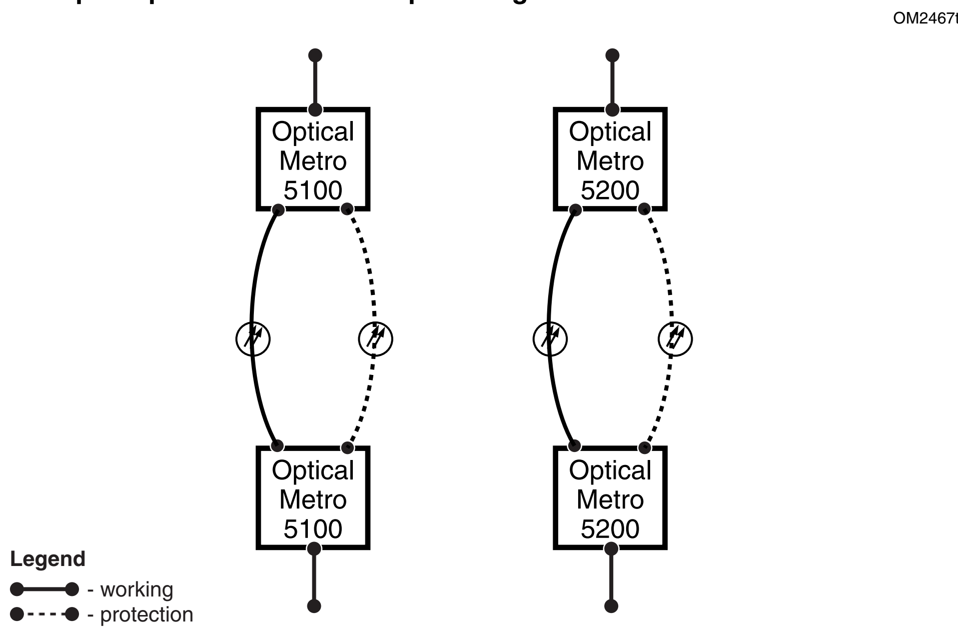
Figure 3-62
Point-to-point protection using a trunk switch



Point-to-point protection on a ring

In a ring, you can implement protection by routing the optical channel on two diverse paths. If there are only two sites on the ring, then this is referred to as a point-to-point ring or collapsed ring. Figure 3-63 shows protection in an Optical Metro 5200 and Optical Metro 5100 point-to-point network configured as a collapsed ring.

Figure 3-63
Point-to-point protection on a collapsed ring



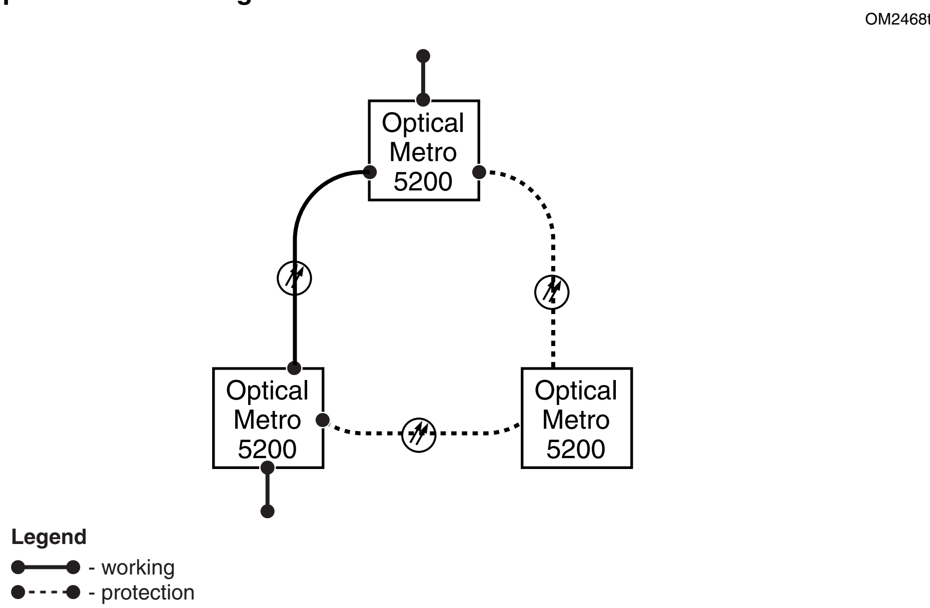
Path protection on a ring

Path switching on rings provides end-to-end protection for signals carried between sites in an Optical Metro 5100/5200 network. The client traffic originates at a single shelf and terminates at another single shelf on the same ring.

Channels are protected by transmitting the same signal, one traveling east and one traveling west, on two diverse paths. Path protection also gives you the ability to remove a signal from a path to perform network upgrades and modifications without interrupting traffic.

You can implement path protection by mapping the optical channel onto two fiber pairs (working and protected), each of which may pass through another shelf on the path. Figure 3-64 on page 3-80 shows path protection on a ring.

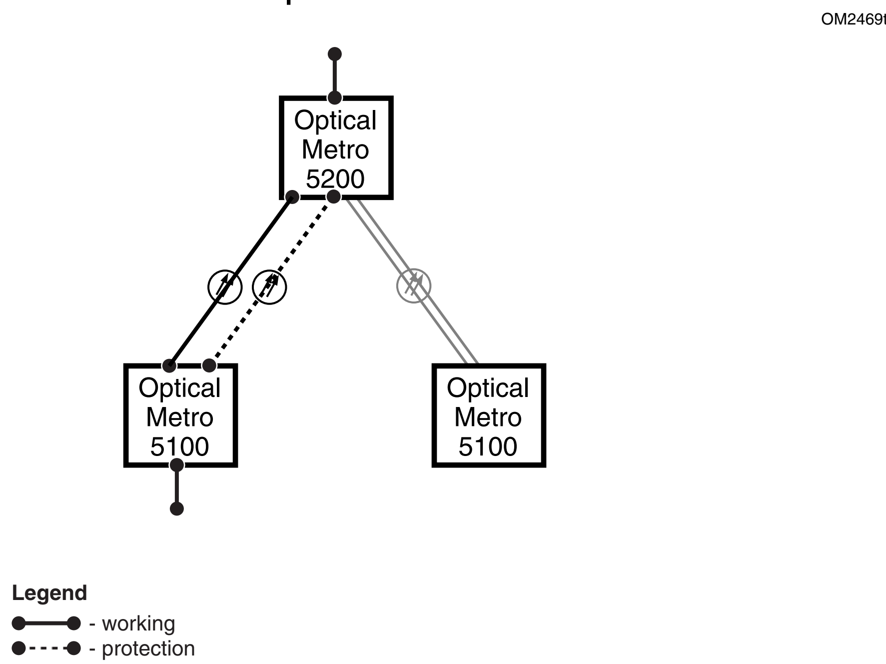
Figure 3-64
Path protection on a ring



Path protection on a hub and spoke

Path protection on a hub and spoke topology is similar to point-to-point path protection on a collapsed ring. The optical channel is always between the hub site and one of the remote sites. There must be two fiber pairs connecting the hub to the spoke in order to protect the optical channel, since there are no OMX modules in this configuration. Figure 3-65 on page 3-81 shows path protection on a hub and spoke network.

Figure 3-65
Path protection on a hub and spoke network



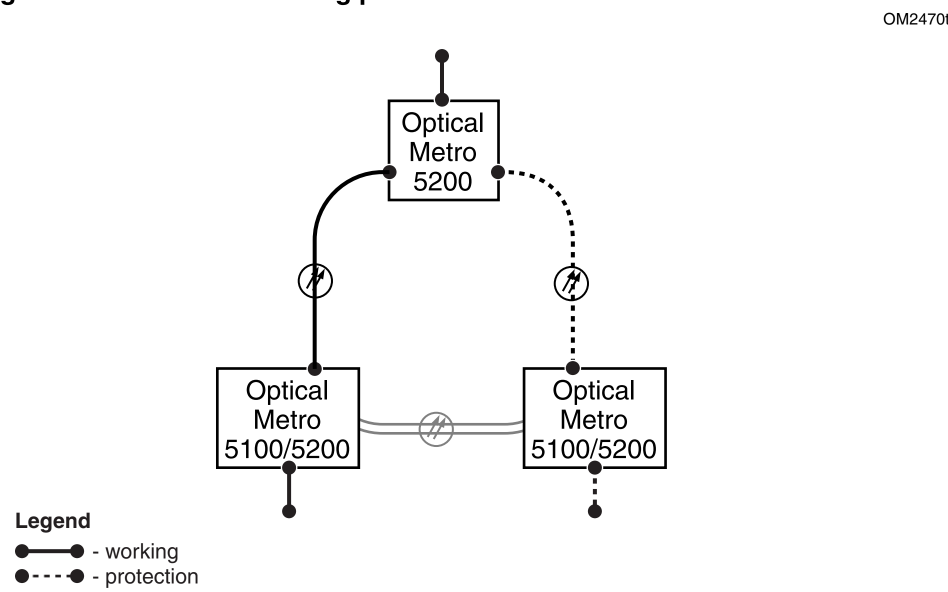
Dual homing ring protection

Dual homing protection on a ring topology is implemented by routing the optical channel on two diverse paths around the ring. The optical channel terminates on two different client interfaces. These client interfaces may be, but do not have to be, at different sites.

Similarly to protection on a ring network, each path may pass through another shelf.

This protection scheme is typically mated with an equivalent protection scheme on another network, where the client signal ultimately terminates. Figure 3-66 on page 3-82 shows a ring network with dual homing protection.

Figure 3-66
Ring network with dual homing protection



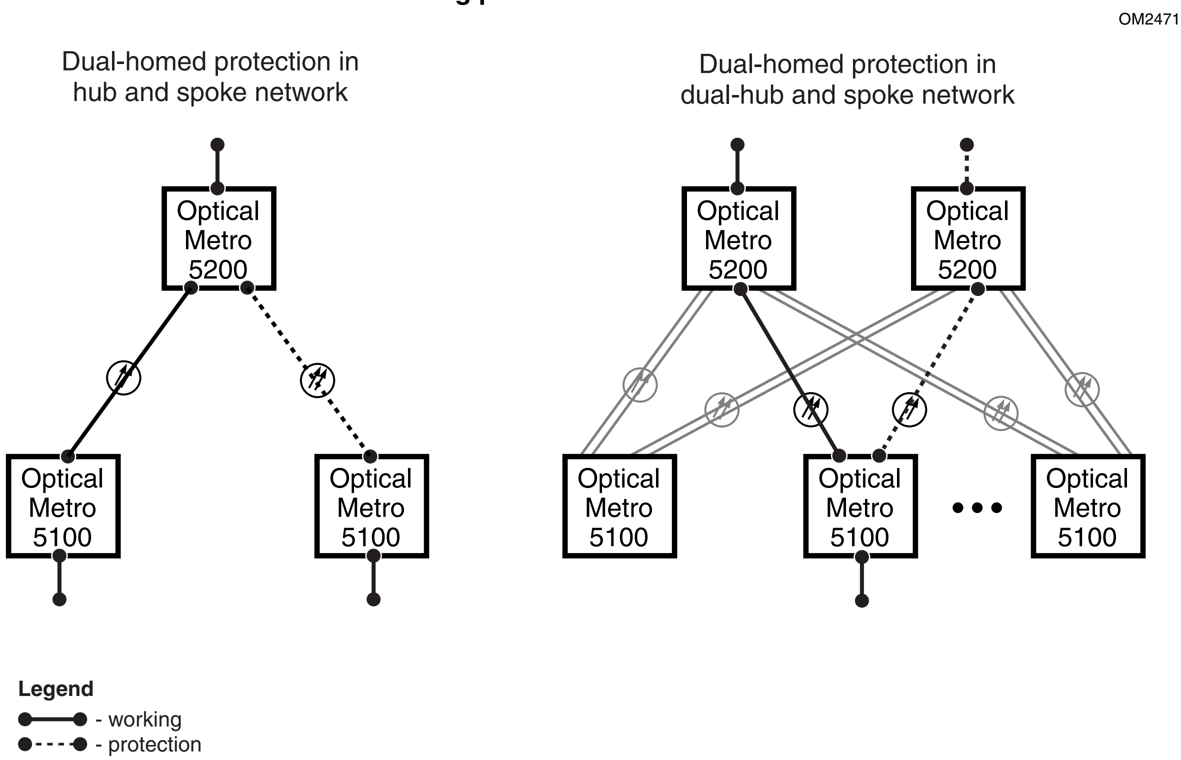
Dual homing linear OADM protection

Dual homing protection on a linear OADM system (for example, a hub and spoke topology) is implemented by routing the optical channel on two diverse fiber pairs from the hub. The optical channel terminates on two different client interfaces. These client interfaces may be, but do not have to be, at different sites.

Dual homing protection on a dual-hub and spoke topology is implemented by routing the optical channel from a single remote site to two different hub sites. The optical channel terminates on two different client interfaces.

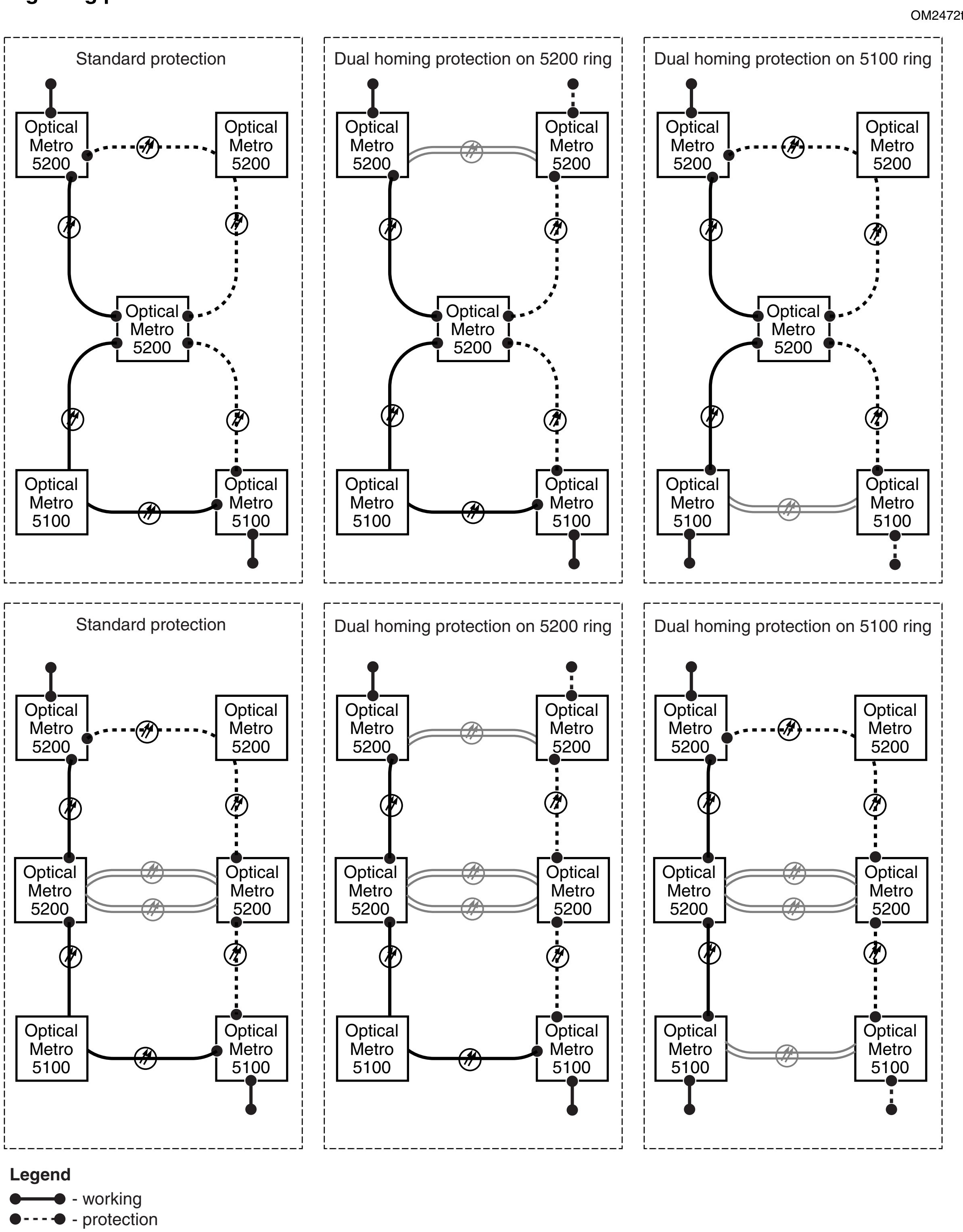
These protection schemes are typically mated with equivalent protection schemes on another network, where the client signal ultimately terminates. Figure 3-67 on page 3-83 shows a hub and spoke and a dual-hub and spoke network with dual homing protection.

Figure 3-67
Linear OADM network with dual homing protection



Bridged ring network protection
Protection within bridged ring networks is implemented by combining the dual-homed protection topologies for ring networks over two rings. At the bridge site or sites, each diverse route of the optical channel is bridged independently. The protection criteria are not applied at a bridge shelf, but are applied at the terminating point of the optical channel. Figure 3-68 on page 3-84 shows the protection models that are supported over bridged ring networks.

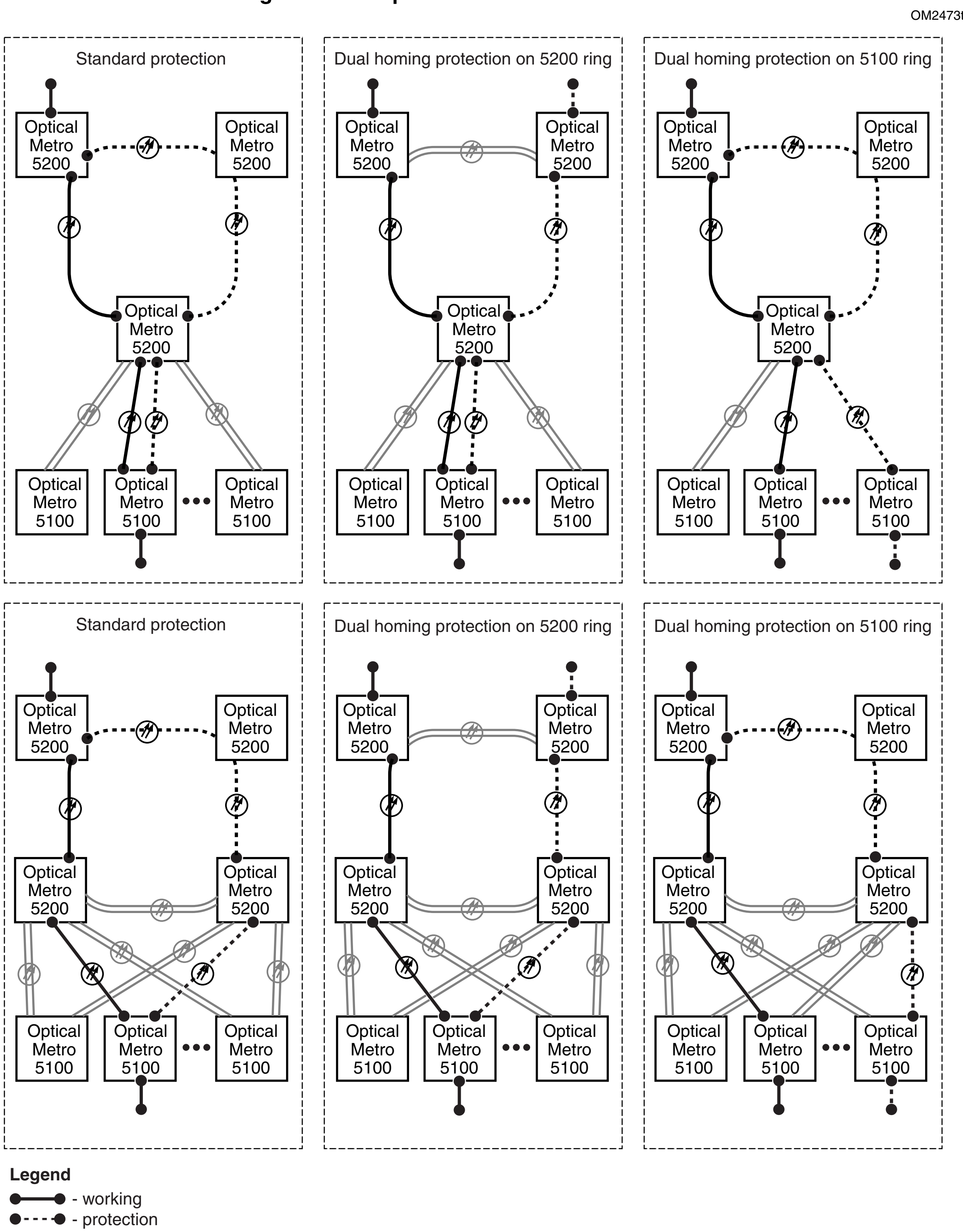
Figure 3-68
Bridge ring protection models



Bridged hub and spoke network protection

Protection within bridged hub and spoke networks is implemented by combining the dual-homed protection topologies for ring networks, or hub and spoke networks respectively, over the two sub-networks. At the bridge site or sites, each diverse route of the optical channel is bridged independently. The protection criteria are not applied at a bridge shelf, but are applied at the terminating point of the optical channel. Figure 3-69 on page 3-86 shows the supported protection schemes for bridged hub and spoke networks.

Figure 3-69
Protection models in a bridge hub and spoke network



Mapping traffic pattern models onto supported optical networks

This section establishes a relationship between the traffic pattern models described in the section "Traffic patterns" and the optical layer networks described in the section "Network topology deployment rules".

Traffic pattern models are based on the patterns established by the logical flow of traffic between sites in the network. This flow of traffic is implemented on the optical layer by creating an optical channel, which may or may not be protected. By creating the complete set of optical channels on the network topologies defined in the previous sections, the service layer models are implemented by the various optical network topologies.

In this section, each of the traffic pattern models is related to one or more of the supported optical networks.

Point-to-point traffic

Point-to-point traffic can be implemented on the following optical networks:

- Optical Metro 5100/5200 DWDM linear system
- Optical Metro 5100/5200 CWDM linear system
- Optical Metro 5100/5200 ITU CWDM linear system
- Optical Metro 5100/5200 linear system without OMXs
- Optical Metro 5100/5200 DWDM ring system (collapsed ring only)
- Optical Metro 5100/5200 CWDM ring system (collapsed ring only)
- Optical Metro 5100/5200 ITU CWDM ring system (collapsed ring only)

Linear OADM traffic

Linear OADM traffic can be implemented on the following optical networks:

- Optical Metro 5100/5200 DWDM linear system
- Optical Metro 5100/5200 CWDM linear system
- Optical Metro 5100/5200 ITU CWDM linear system
- Optical Metro 5100/5200 linear system without OMXs

Hubbed traffic

Hubbed traffic can be implemented on the following optical networks:

- Optical Metro 5100/5200 CWDM ring system
- Optical Metro 5100/5200 DWDM ring system
- Optical Metro 5100/5200 ITU CWDM ring system
- Optical Metro 5100/5200 linear system without OMXs (hub and spoke)

Dual-hubbed traffic

Dual-hubbed traffic can be implemented on the following optical networks:

- Optical Metro 5100/5200 CWDM ring system

- Optical Metro 5100/5200 DWDM ring system
- Optical Metro 5100/5200 ITU CWDM ring system
- Optical Metro 5100/5200 linear system without OMXs (dual hub and spoke)

Meshed traffic

Meshed traffic can be implemented on the following optical networks:

- Optical Metro 5100/5200 DWDM ring system
- Optical Metro 5100/5200 CWDM ring system
- Optical Metro 5100/5200 ITU CWDM ring system

Bridged traffic

Bridged traffic can be implemented on the following optical networks:

- Bridged linear system
- Bridged ring and dual bridged ring systems
- Bridged linear and ring and dual bridged linear and ring systems

Service layer topologies when using 100 GHz line-side interfaces with Common Photonic Layer

The Common Photonic Layer-compliant 100 GHz line-side interfaces circuit packs, including OTR 10 Gbit/s Enhanced, Muxponder 10 Gbit/s GbE/FC, OTR/OCLD 2.5 Gbit/s Flex, are intended to be deployed with the Common Photonic Layer optical layer. The description of the topologies which can be implemented using the Common Photonic Layer optical layer is beyond the scope of this document. Refer to the Common Photonic Layer NTPs for information on these network topologies.

The service layer topologies implemented using these circuit packs are defined by their equivalent counterparts in Optical Metro 5100/5200 DWDM systems. For example, the Muxponder 10 Gbit/s GbE/FC supports all the same service layer topologies (or traffic patterns) whether it is deployed with Optical Metro 5100/5200 DWDM optical layer or with Common Photonic Layer optical layer.

Bridging between DWDM 100 GHz (Common Photonic Layer) and Optical Metro 5100/5200 optical layer

Bridging between a Common Photonic Layer optical system and a Optical Metro 5100/5200 optical system is supported. The implementation of a bridge between a Common Photonic Layer optical system and a Optical Metro 5100/5200 optical system (DWDM, CWDM, ITU-CWDM or OMX-less) is implemented using the circuit pack variants as for Optical Metro 5100/5200 system bridging. That is:

- signals that originate or terminate with an OTR 2.5 Gbit/s Flex circuit pack or an OCI and OCLD 2.5 Gbit/s Flex pair can be bridged by creating a channel assignment between an OCLD 2.5 Gbit/s Flex 100 GHz circuit pack on the Common Photonic Layer side and the appropriate variant of OCLD 2.5 Gbit/s Flex on the Optical Metro 5100/5200 optical layer side (DWDM, CWDM or ITU-CWDM).

- signals that originate or terminate with an OTR 10 Gbit/s Enhanced or Muxponder 10 Gbit/s Enhanced circuit pack can be bridged by deploying two independent OTR 10 Gbit/s Enhanced circuit packs in a shelf and connecting them with a fiber pair on the client side. One of these circuit packs is a OTR 10 Gbit/s Enhanced 100 GHz variant and the other can be either the OTR 10 Gbit/s Enhanced 100 GHz variant or the OTR 10 Gbit/s Enhanced 200 GHz variant.

Bridging can be used in situations where a service provider uses the Common Photonic Layer managed optical layer to build out the core network, but uses one of the variants of the Optical Metro 5100/5200 passive optical layer, or OMX-less optical layer, for the access points.

Optical layer functional blocks

The optical layer is implemented by deploying optical components at sites that govern the flow of the wavelengths around the network. This section examines the functional blocks of sites, the optical components that make up the functional blocks, and the relationships between optical components.

The functional blocks for Extended Metro networks are slightly different. For details, refer to "New Extended Metro DWDM with DSCM topologies" on page 3-135.

Table 3-5 lists the optical components in the Optical Metro 5100/5200 optical layer:

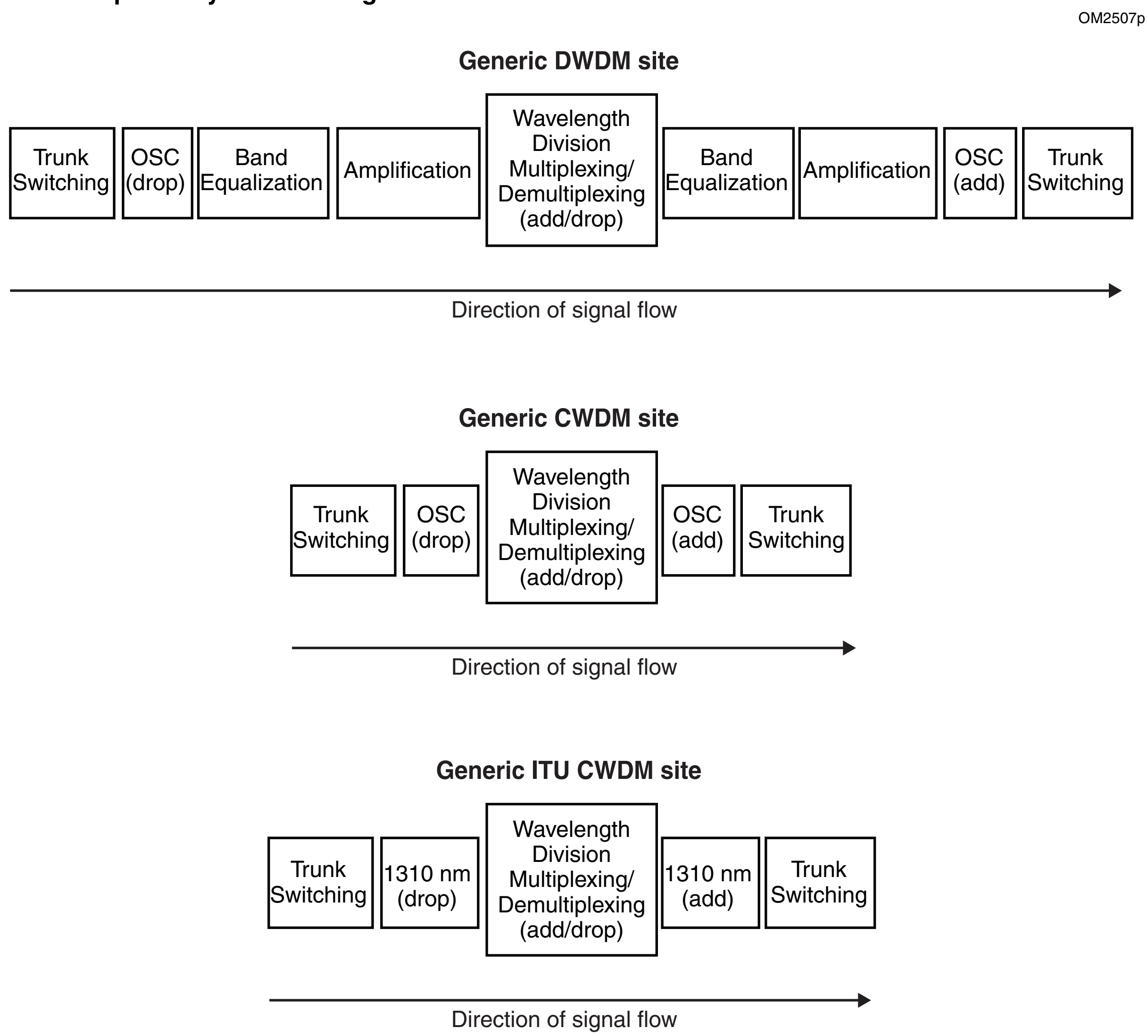
Table 3-5
Optical components

Functional block	Functionality	Applies to
Multiplex and demultiplex	add or drop the bands, channels, or wavelengths of the signal	DWDM CWDM ITU CWDM
Amplification	amplify the signal	DWDM
Band equalization	equalize the bands within a signal	DWDM
OSC	add or drop the optical supervisory channel	DWDM CWDM
Optical trunk switching	select the working fiber pair for the signal	DWDM CWDM ITU CWDM
Attenuation	attenuate the signal	DWDM CWDM ITU CWDM
1310 nm add or drop	add and drop a 1310 nm wavelength	ITU CWDM
Split and couple the client signal	provide protection for client signals	DWDM CWDM ITU CWDM

With the exception of the last item (splitting and coupling the client signal), all of these functional blocks make up the topology of the optical layer. The presence or absence of each functional block at a site determines the behavior of the optical signal at that site.

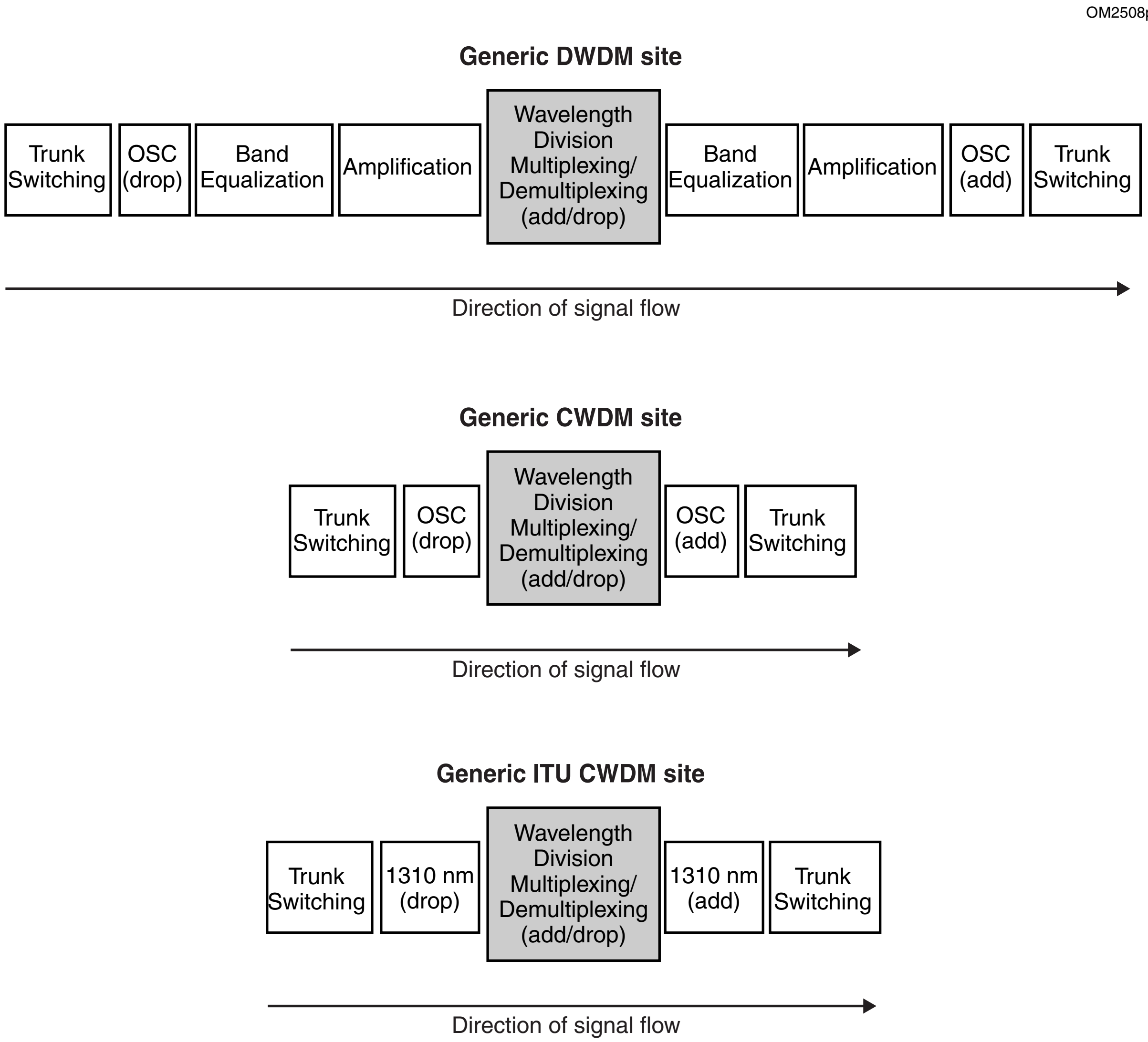
Figure 3-70 on page 3-91 shows the functional blocks in a generic configuration for a site. This configuration can apply to any site in a network. All functional blocks are optional, depending on the requirements at that site.

Figure 3-70
Generic optical layer site configuration



The following sections describe the components that make up each of these functional areas.

Wavelength division multiplexing/demultiplexing (add/drop)



The OMX is the key component that determines which wavelengths are dropped and added at a site. Depending on the OMX variant, one, four, eight, or 16 wavelengths can be dropped or added at a shelf. All other wavelengths in the spectrum optically pass through this OMX. Multiple OMXs can be associated with one shelf, and multiple shelves can be associated with one OMX.

> ***Note:*** 16CH OMXs do not support optical pass-through.

The ordering of the OMXs depends on the order in which the OMXs are fibered together. The fibering method affects the number of OMX filters a signal passes through, and therefore affects the link budget of that signal. It is important to understand the supported OMX fibering methods in order to properly plan your optical layer.

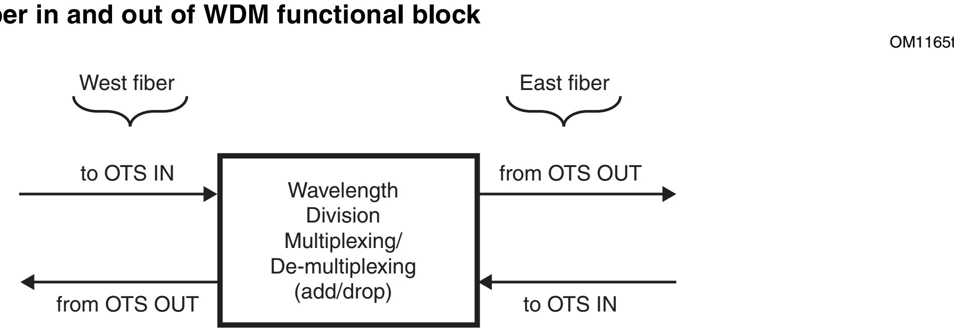
West and east fiber pairs

At all sites in ring topologies or at intermediate sites in linear topologies, there are two fiber pairs that carry traffic in and out of the site. The **west fiber pair** refers to the fiber that is connected to OMX modules that add and drop traffic from the West plane of the shelf (slots 1 through 8 for Optical Metro 5200 shelves and slots 1 and 2 for Optical Metro 5100 shelves). The **east fiber pair** refers to the fiber that is connected to OMX modules that add and drop traffic from the East plane of the shelf (slots 11 through 18 for Optical Metro 5200 shelves and slots 3 and 4 for Optical Metro 5100 shelves).

For terminal sites that are the end points of a linear network, only one fiber pair enters the site. In this case, the concept of west fiber pair versus east fiber pair does not apply.

Each fiber pair has a Rx fiber on which the signal is received and a Tx fiber on which the signal is transmitted. The Rx fiber is often referred to as OTS IN and the Tx fiber is often referred to as OTS OUT. All OMX connections, regardless of ordering or fibering method are bounded by an OTS IN and an OTS OUT for each fiber pair, as shown in Figure 3-71.

Figure 3-71
Fiber in and out of WDM functional block



OMX fibering methods

OMX fibering refers to the way that the OMXs are interconnected, either between shelves or within shelves, and apply to DWDM, CWDM, and ITU CWDM systems that support multiple OMXs per direction with optical pass-through. There are four methods for fibering OMXs:

- standard fibering
- stacked fibering
- single-shelf fibering
- OMX 16CH DWDM fibering

Table 3-6 lists the features and applications for each fibering method.

Table 3-6
OMX fibering methods

Method	Use	Applicable to site type
standard (see Note)	optimal link budgets	• terminal • OADM • bridge
stacked	allows for the addition of shelves without breaking a fiber	• terminal • bridge
single-shelf	single-shelf site	• OADM • bridge
OMX 16CH DWDM	terminal or bridge site with more than 16 channels	• terminal • bridge
Note: The internal fibering for the four CWDM band filters in the quad-band CWDM OMX is fixed with standard OMX fibering.		

Standard OMX fibering

Use standard fibering for optimal link budgets. Adding shelves to sites with standard fibering involves breaking the fiber. All the drops are executed first followed by all the adds. Drops and adds are executed in the same order:

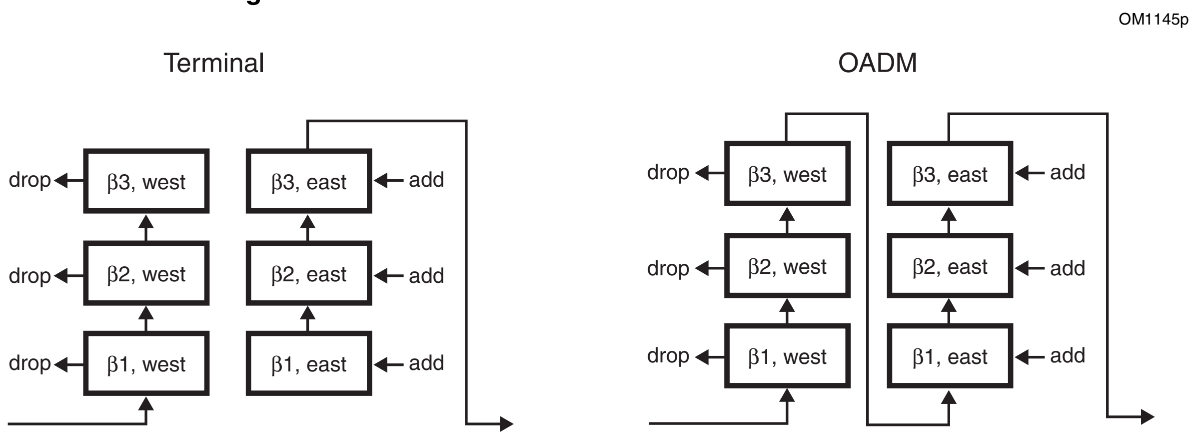
- drop 1, drop 2, drop 3
- add 1, add 2 and add 3

If all bands are being dropped (to the client interface or for electrical regeneration) and then added at a site, there is no need to optically connect the west OMX modules with the east OMX modules. In this case, there is no optical pass-through at this site and this site is referred to as a terminal site and is said to use **terminal standard fibering.** Terminal sites can exist in linear or ring network topologies.

If there are bands carrying signals on the fiber entering the site that are not dropping and adding, they optically pass through this site. In this case, you must connect the west OMX modules to the east OMX modules. The site is referred to as an OADM site and is said to use **OADM standard fibering**.

Figure 3-72 shows an example of OMXs with standard OMX fibering. These diagrams show the traffic flow in one direction only. For the opposite direction, the signal flow is reversed.

Figure 3-72
Standard OMX fibering



Stacked fibering

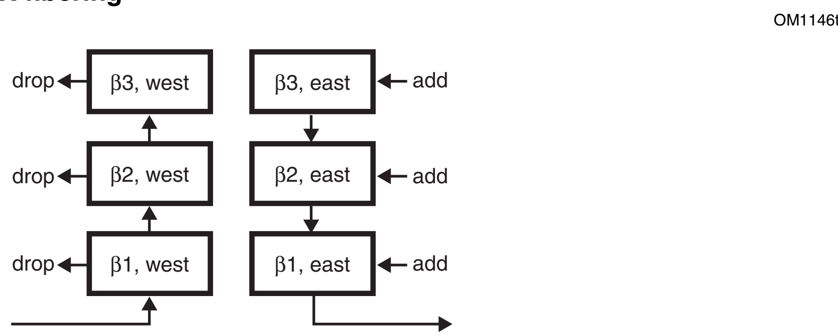
Use stacked fibering if you will be adding more shelves to a terminal site in the future. Note that all drops are done first, then all adds are done. Drops and adds are executed in reverse order:

- drop 1, drop 2, drop 3,
- add 3, add 2 and add 1

Stacked fibering is only used if all bands are being optically dropped (to the client interface or for electrical regeneration) and added at a site, and there is therefore no need to optically connect the west OMX modules with the east OMX modules. This includes cases where a channel is being regenerated, (since in this case it is being electrically passed-through the shelf there is no need for optical pass-through). In this case, there is no optical pass-through at this site and this site is referred to as a terminal site and is said to use **terminal stacked fibering.** Terminal sites can appear in a linear or ring network.

Figure 3-73 shows an example of OMXs with stacked fibering. This diagram shows the traffic flow in one direction only. For the opposite direction, the signal flow is reversed.

Figure 3-73
Stacked OMX fibering

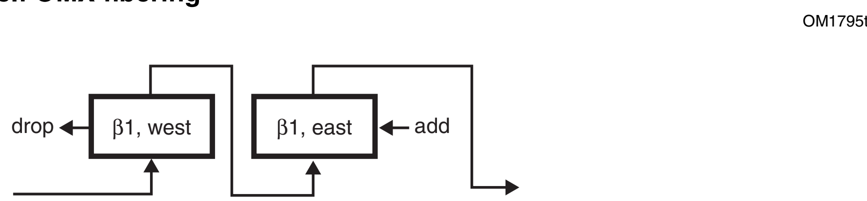


Single-shelf fibering

Use single shelf fibering to drop and add bands and wavelengths at a site with only one band in a single shelf.

If there are other bands in the network that must optically pass through this site, then the west OMX must be fibered to the east OMX. Note that this is a special case of standard OADM fibering, where there is only one band. Figure 3-74 shows an example of single-shelf fibering. These diagrams show the traffic flow in one direction only. For the opposite direction, the signal flow is reversed.

Figure 3-74
Single-shelf OMX fibering



Single-shelf fibering at a multi-shelf site

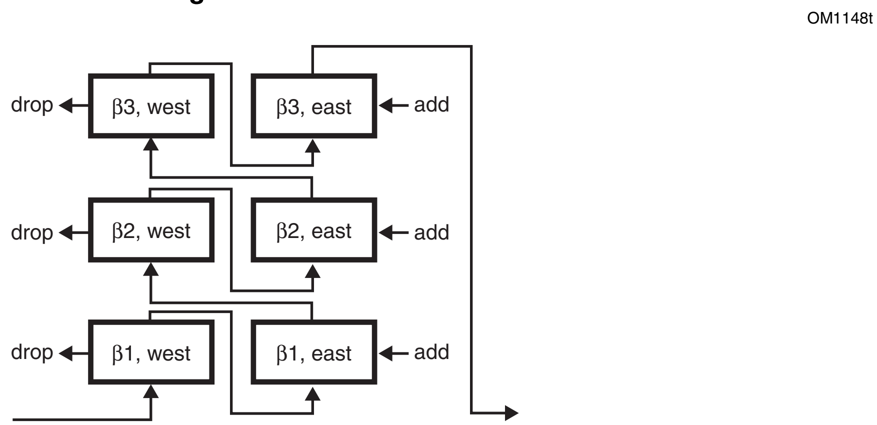
In some instances it may be desirable to fiber all OMX modules within a shelf using single-shelf fibering even though there is more than one shelf at the site. This is not recommended since it is costly from a link budget perspective and it does not allow shelves to be added without breaking the fiber. This method of fibering always has optical pass-through; any site that is fibered using single-shelf fibering must be an OADM site.

Figure 3-75 shows an example of single-shelf fibering at a multishelf site. The drops and adds are interleaved:

- drop 1, add 1
- drop 2, add 2,
- drop 3 and add 3

These diagrams show the traffic flow in one direction only. For the opposite direction, the signal flow is reversed.

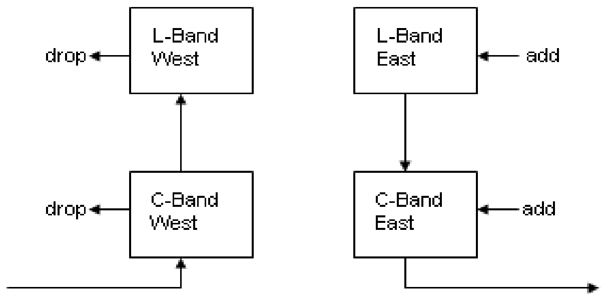
Figure 3-75
Single-shelf OMX fibering at a multishelf site



OMX 16CH DWDM fibering

Use OMX 16CH DWDM fibering at a terminal or bridge site which has more than 16 channels. Figure 3-76 shows an example of OMX 16CH DWDM fibering. The L-band OMX 16CH DWDM is not needed if the channel count is 16 channels or less.

Figure 3-76
OMX 16CH DWDM fibering

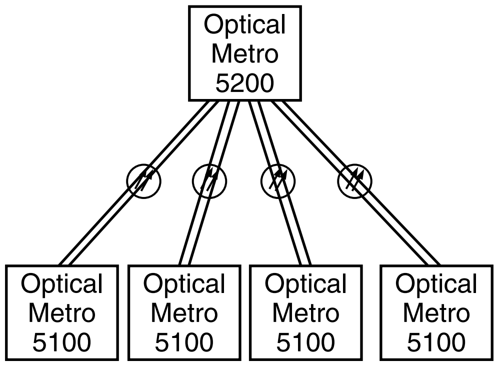


Sites without OMXs

Sites without OMXs are used in fiber rich environments where a separate fiber pair is used for each optical channel being carried. This applies to unamplified linear topologies only. All other topologies require OMXs. Figure 3-77 shows an example of a hub and spoke network without OMXs.

Figure 3-77
Network without OMXs

OM2474t



Shelf configurations

In most cases, two OMX modules are used per band—one for the east direction and one for the west direction.

However, for unprotected point-to-point networks, a single fiber pair is connected to each terminal site. The concept of east and west fibers, therefore, does not apply. In this case, you can use one OMX module for each band to map multiple bands from the same shelf onto the single fiber pair. Alternately, you can use one OMX 16CH module to map multiple bands from the same shelf onto the single fiber pair. For OCLD circuit packs, you can increase the density of the shelf to two full bands for each shelf; this is called dual density fibering. For OTR 2.5 Gbit/s circuit packs, you can increase the density of the shelf to four full bands for each shelf; this is called quad density fibering.

Dual density fibering method

The dual density fibering method is used at terminal sites within an unprotected point-to-point network. All channels are unprotected. Previously, point-to-point configurations used only half the slots in a shelf because the maximum number of channels for one band is four, which requires four OCLDs and four OCIs. By adding another band to the shelf, all slots can be used. Pass-through sites using regeneration of OCLDs can also support the dual density fibering method

For the dual density fibering method, the OMXs need to be wired in a daisy-chain pattern.

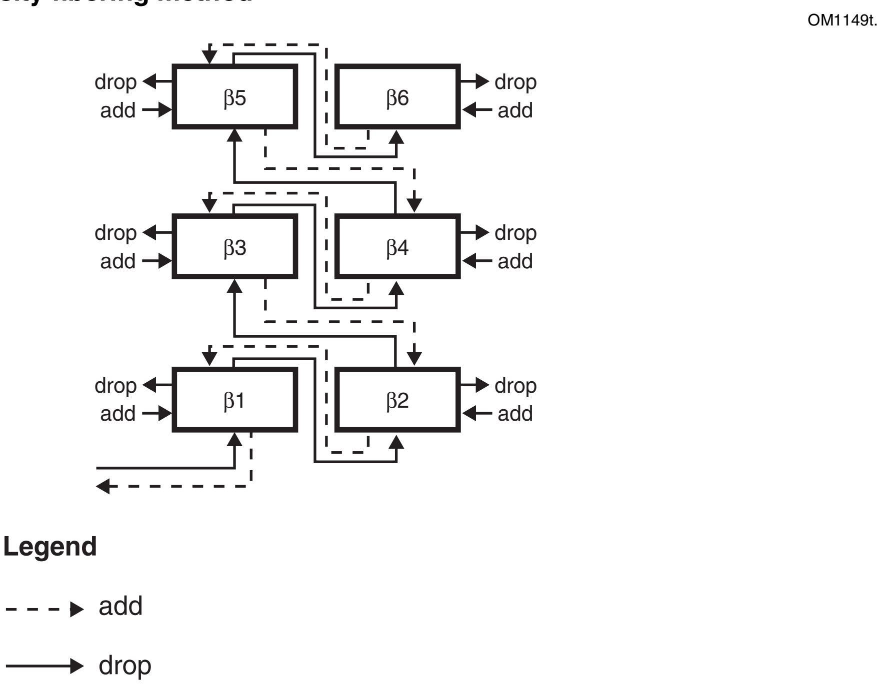
Operational considerations:

- valid for point-to-point configurations only (see Table 3-7 on page 3-101)
- the connections are provisioned as East or West
- the OMXs are displayed in the inventory screens of System Manager as East or West

  Note: Passive devices connected to (Equipment Inventory Port) EIP 1 and 2 and to (Equipment Inventory Unit) EIU ports 1 to 8 are considered West by software. Passive devices connected to EIP 3 and 4 and to EIU ports 9 to 16 are considered East by software.

Figure 3-78 on page 3-99 shows an example of the dual density fibering method at a terminal site in an unprotected point-to-point network. This diagram shows the traffic flow for both directions.

Figure 3-78
Dual density fibering method



Quad density fibering method
The quad density fibering method allows the support of up to 4 full-fill bands of traffic, through the use of OTR 2.5 Gbit/s circuit packs as traffic-carrying cards. This allows for a maximum of 16 unprotected connections in a full-filled shelf. The traffic is unprotected by the shelf, as there is only a single pair of fibers connecting the shelves.

> ***Note:*** Facility protection can be added through the use of the Optical Trunk Switch.

For the quad density fibering method, the OMXs need to be wired in a daisy-chain pattern. All the channels are provisioned as unprotectedWest (for slots 1-8) or unprotectedEast (for slots 11-18).

Operational considerations:

- valid for point-to-point configurations only (see Table 3-7 on page 3-101)
- the connections are provisioned as East or West
- the OMXs are displayed in the inventory screens of System Manager as East or West

  Note: Passive devices connected to (Equipment Inventory Port) EIP 1 and 2 and to (Equipment Inventory Unit) EIU ports 1 to 8 are considered West by software. Passive devices connected to EIP 3 and 4 and to EIU ports 9 to 16 are considered East by software.

- Intrasite Fault Sectionalization (IFS) is not supported

Figure 3-79 shows an example of the quad density fibering method at a terminal site in an unprotected point-to-point network. This diagram shows the traffic flow for both directions.

Figure 3-79
Quad density fibering method

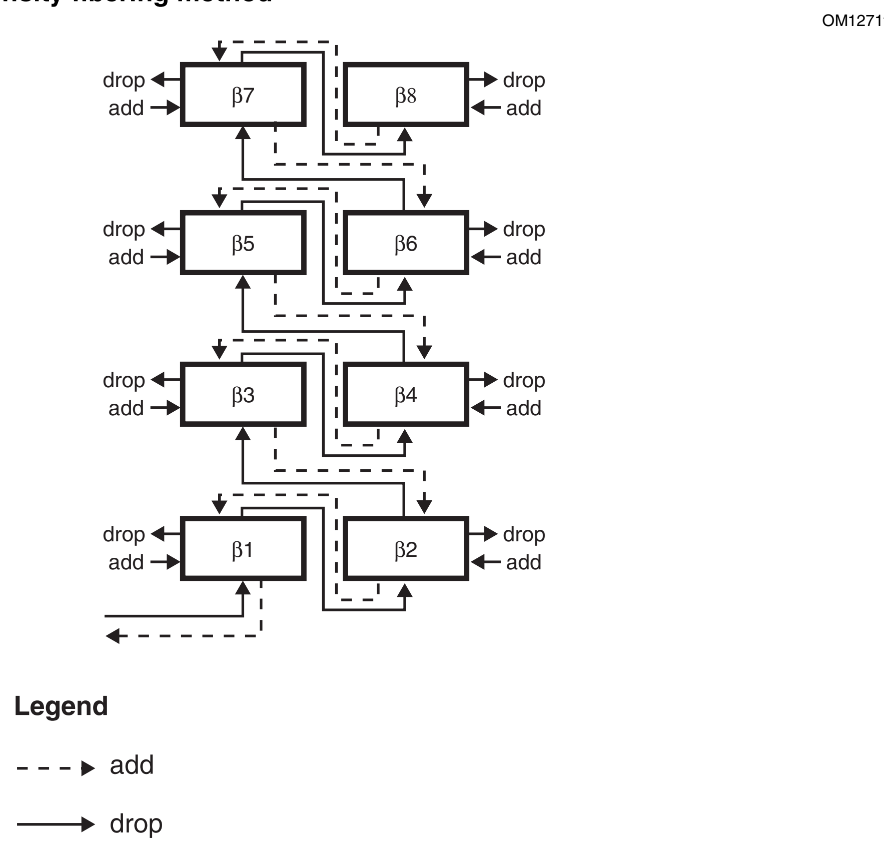


Table 3-7
Fibering methods

Fibering Method	Use	Applicable to site type
dual density fibering	in unprotected point-to-point networks, allows for the full use of all shelf slots (2 OMXs fibered in serial)	• terminal site using OCLDs
quad density fibering (see Note)	in unprotected point-to-point networks, allows for the full use of all shelf slots (4 OMXs fibered in serial)	• terminal site using OTRs
Note: At a terminal site, you can have more than one shelf fibered as quad density fibering, point-to-point unprotected. In this case, the fibering between the shelves is the same as for the case of dual-density fibering point-to-point unprotected.		

OMX 16CH DWDM

One OMX 16CH DWDM allows the support of up to 4 full-fill bands of traffic, through the use of OTR 2.5 Gbit/s circuit packs as traffic-carrying cards. This allows for a maximum of 16 unprotected connections in a full-filled shelf. The traffic is unprotected by the shelf, as there is only a single pair of fibers connecting the shelves.

> ***Note:*** Facility protection can be added through the use of the trunk switch.

All the channels are provisioned as unprotectedWest (for slots 1-8) or unprotectedEast (for slots 11-18).

Operational considerations:

- valid for point-to-point configurations only
- the connections are provisioned as East or West
- the OMX is displayed in the inventory screens of System Manager as East or West

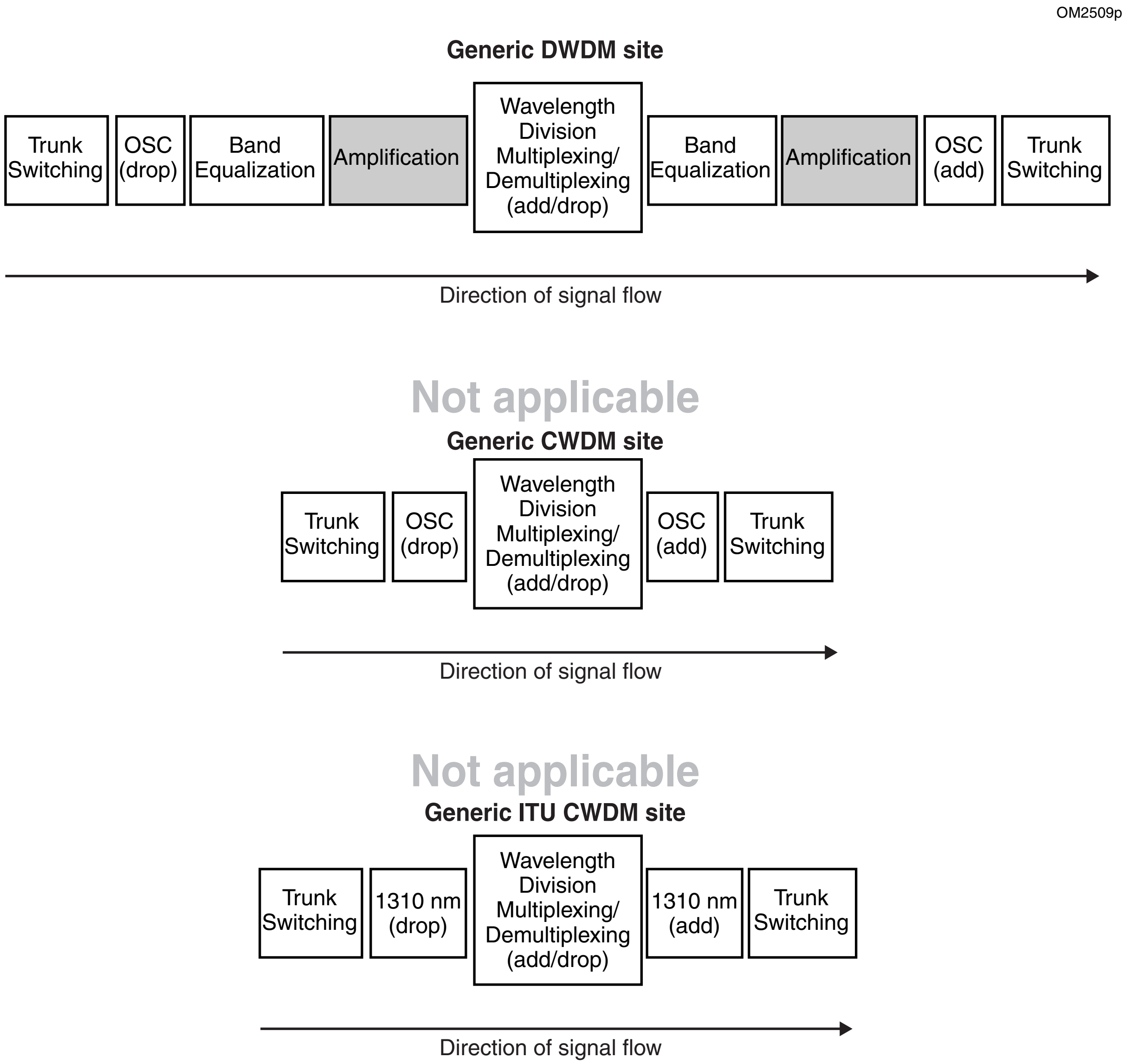
  Note: Passive devices connected to (Equipment Inventory Port) EIP 1 and 2 and to (Equipment Inventory Unit) EIU ports 1 to 8 are considered West by software. Passive devices connected to EIP 3 and 4 and to EIU ports 9 to 16 are considered East by software.

- Intrasite Fault Sectionalization (IFS) is not supported

Amplification

Figure 3-80 on page 3-102 shows amplification at a DWDM site. Amplification is provided by the OFA circuit pack. There is a C-band OFA and an L-band OFA. Normally the signal must be split into the C-band and L-band prior to being amplified. Exceptions to this is if there is only traffic being carried in the C-band or L-band, and there are no plans to add traffic to the bands not carrying traffic. In this case, it is not necessary to split the C-band and L-band prior to amplifying.

Figure 3-80
Amplification



Conversely, after amplifying a C-band and/or L-band signal, the two amplified signals are coupled into a common traffic signal.

Amplification can be applied at a site regardless of whether or not there are bands and wavelengths being dropped or added at that site. If no wavelengths are being added or dropped and only amplification is being applied, this is said to be an **OFA site**. If bands are being dropped and added, amplification can be applied prior to the signal going into the WDM OMX modules (a **pre-amp site)** or after the signal has gone through the WDM OMX modules (a **post-amp site**). A site can have both a pre-amp and a post-amp.

The OFA circuit pack amplifies a signal in one direction only. Each direction of the signal must therefore be amplified independently, if necessary.

Figure 3-81 shows the amplifier placement in relation to the WDM shelves for parallel configurations.

Figure 3-81
Pre-amp and post-amp with parallel OMX configurations

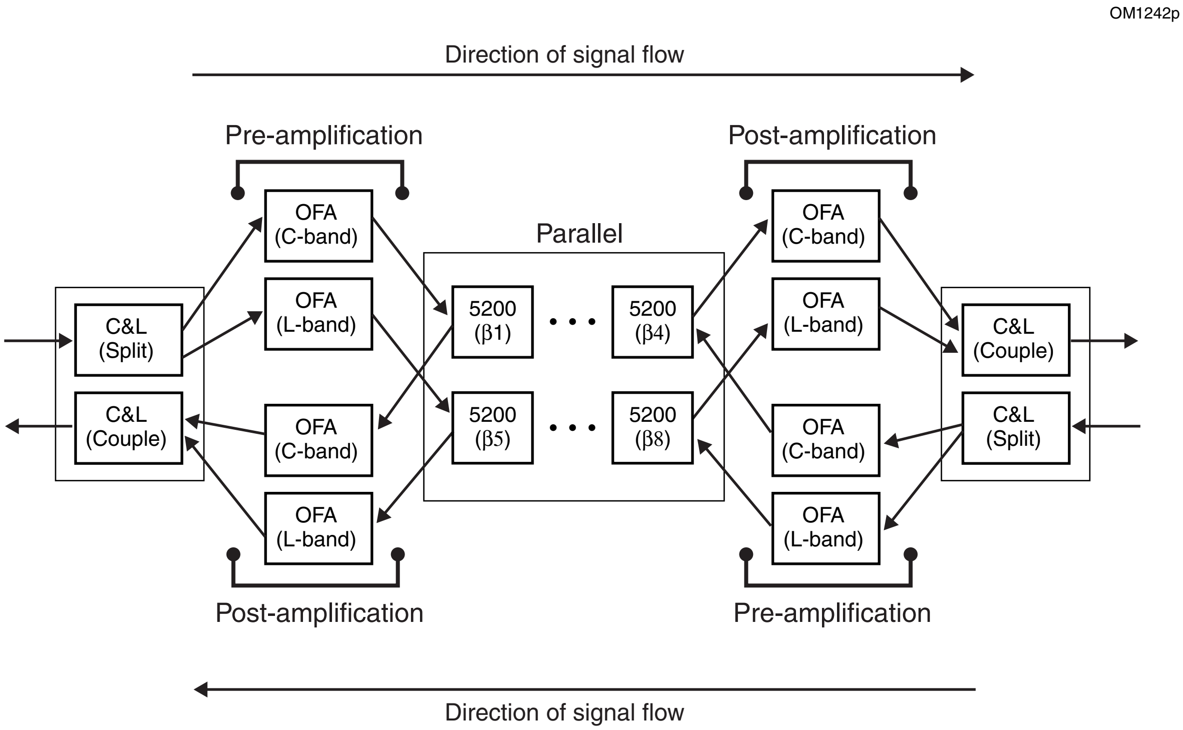
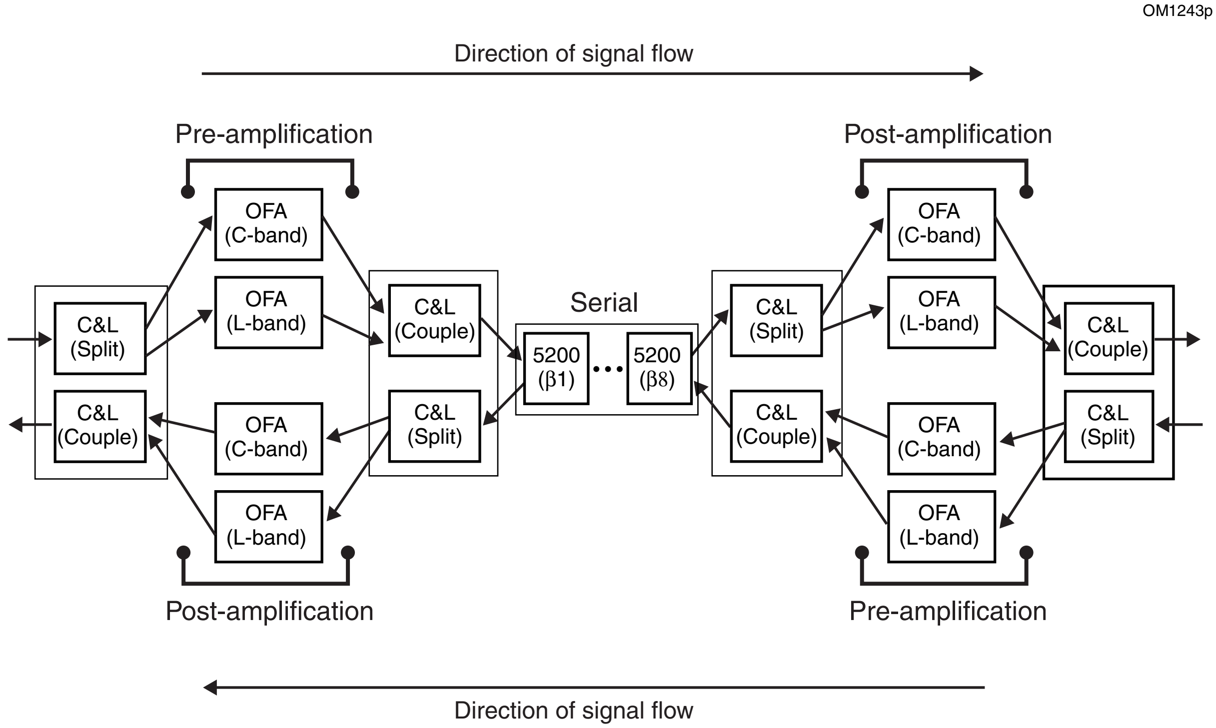


Figure 3-82 shows the amplifier placement in relation to the WDM shelves for serial configurations.

Figure 3-82
Pre-amp and post-amp with serial OMX configurations



Dual OFA optical layer topologies

Release 8.0 introduces two new OFA optical layer topologies that use the dual OFA configuration where two OFAs are connected back-to-back at a site in a pre-amplifier or a thru-amplifier topology.

The value of these configurations is to increase the overall gain available at a site. This increased gain can be useful in the following cases:

- Since the OFA VGA only provides 17 dB gain, the site output power can be too weak if the site input power is very low. Assuming –28 dBm per channel into the amplifier, the output power will be –11 dBm per channel, well below the +3 dBm per channel optimal value. The second amplifier at the site allows the output power level to reach the optimal value.
- In Extended Metro networks, it is sometimes required to re-equalize with PBEs or APBEs to compensate for SRS tilt or to compensate for dispersion by introducing a DSCM. As these components can be quite lossy, having only one amplifier results in very low amplifier input power when the high loss components precede the amplifier or very low launch power when the high loss components follow the amplifier. With dual OFA configurations, it is possible to first amplify the input signal to a reasonable level then introduce the lossy components and then amplify again to obtain the optimal launch power.

Figure 3-83
Thru-amplifier dual OFA optical layer topology example

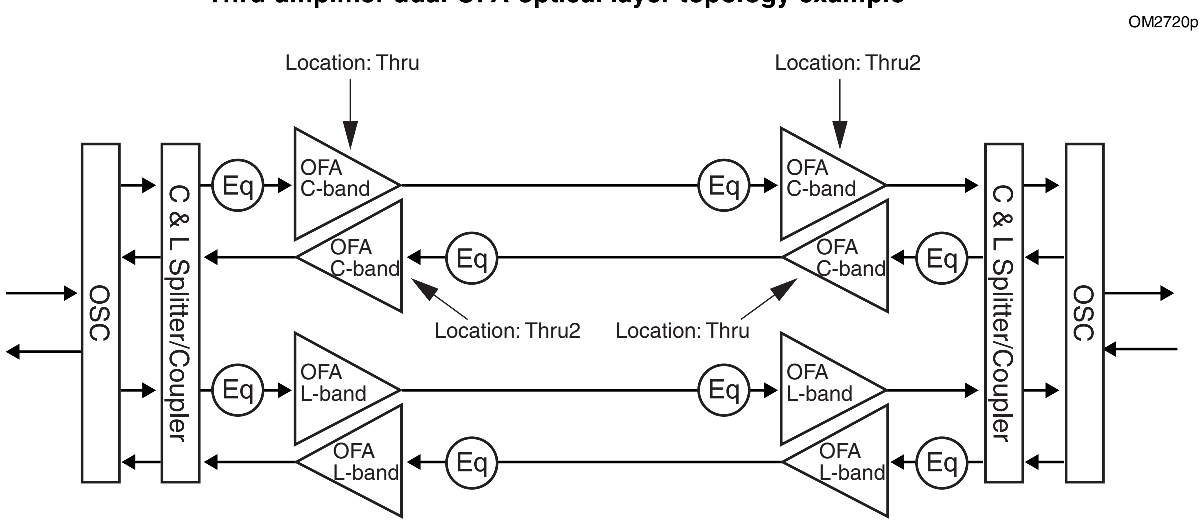


Figure 3-83 on page 3-105 shows an example site layout for the thru-amplifier dual OFA optical layer topology.

In System Manager and TL1, the OFA location “Thru” identifies the first OFA circuit pack in a dual OFA configuration, and the new Release 8.0 OFA location “Thru2” identifies the second OFA circuit pack.

Equalization components in the diagram (labeled “Eq”) are optional (for example, they may not be required in a back-to-back amplifier chain not requiring re-equalization or in the event that distributed equalization is being used). Available equalization components include:

- APBE/APBE Enhanced
- PBE

C&L coupler/splitter represents the C&L splitter/coupler module in a drawer. A C&L coupler/splitter module is not required if the system does not include both C and L band, but is optional either way.

OSC splitter/couplers are required only when the OSC is deployed at a site.

The thru-amplifier dual OFA optical layer topology is also applicable to Extended Metro networks. An example configuration is shown in Figure 3-84.

Figure 3-84
Thru-amplifier dual OFA optical layer topology example for Extended Metro networks

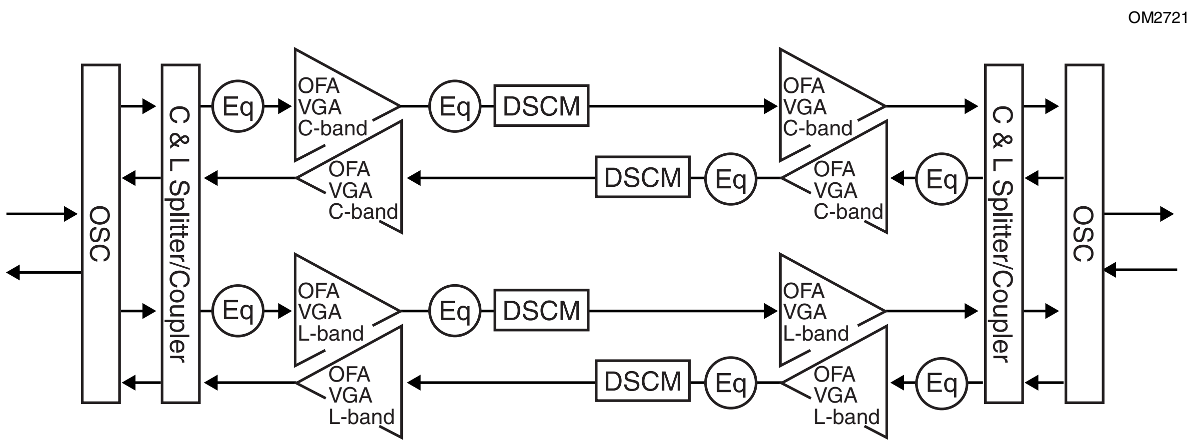


Figure 3-85 on page 3-108 shows the standard site layout for the pre-amplifier dual OFA optical layer topology. The pre-amplifier dual OFA optical layer topology is only applicable in Extended Metro networks when DSCMs are required.

In System Manager and TL1, the OFA location “Pre” is used to identify the first OFA circuit pack in a dual OFA configuration and the new Release 8.0 OFA location “Pre2” is used to identify the second OFA circuit pack.

All OFAs shown in the diagram are optional and are only placed if required by link engineering. Pre-amplifiers to the left most and right most of the site are only allowed in configurations that drop signals using OMXs.

Equalization components in the diagram (labeled “Eq”) are optional (for example, equalization may not be required in the same locations at every site and may not be required at all at some sites depending on the link engineering requirements). Available equalization components include:

- APBE/APBE Enhanced
- PBE

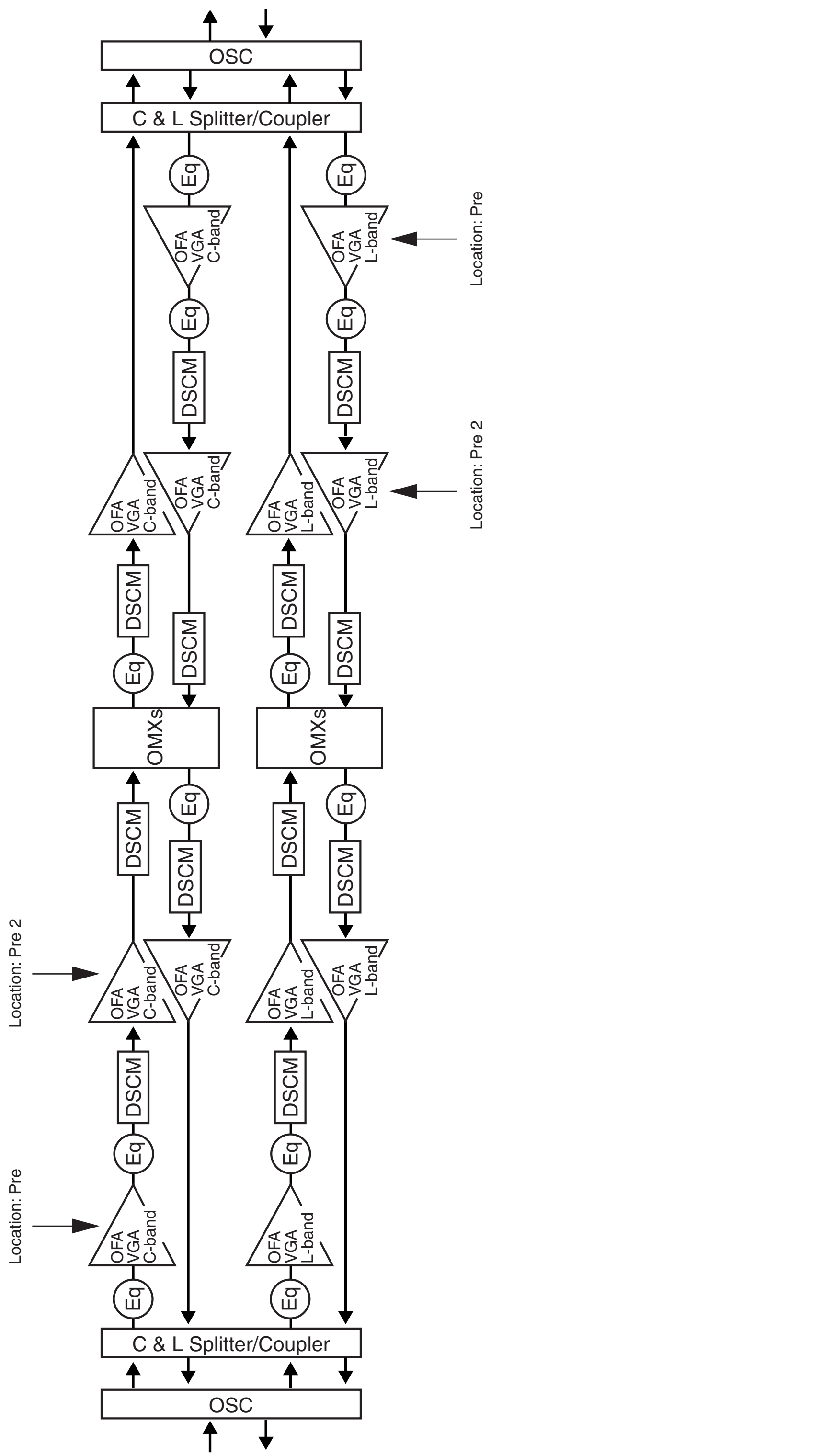
DSCMs are optional as required by link engineering.

C&L coupler/splitter represents the C&L splitter/coupler module in a drawer. A C&L coupler/splitter module is not required if the system does not include both C and L band, but is optional either way.

OSC splitter/couplers are required only when the OSC is deployed at a site.

The topology can be used to support terminal sites by simply considering only the OMX onward (i.e. remove the east or west half of the site appropriately), remembering that the additional pre-amplifier is placed as necessary when a DSCM precedes the site.

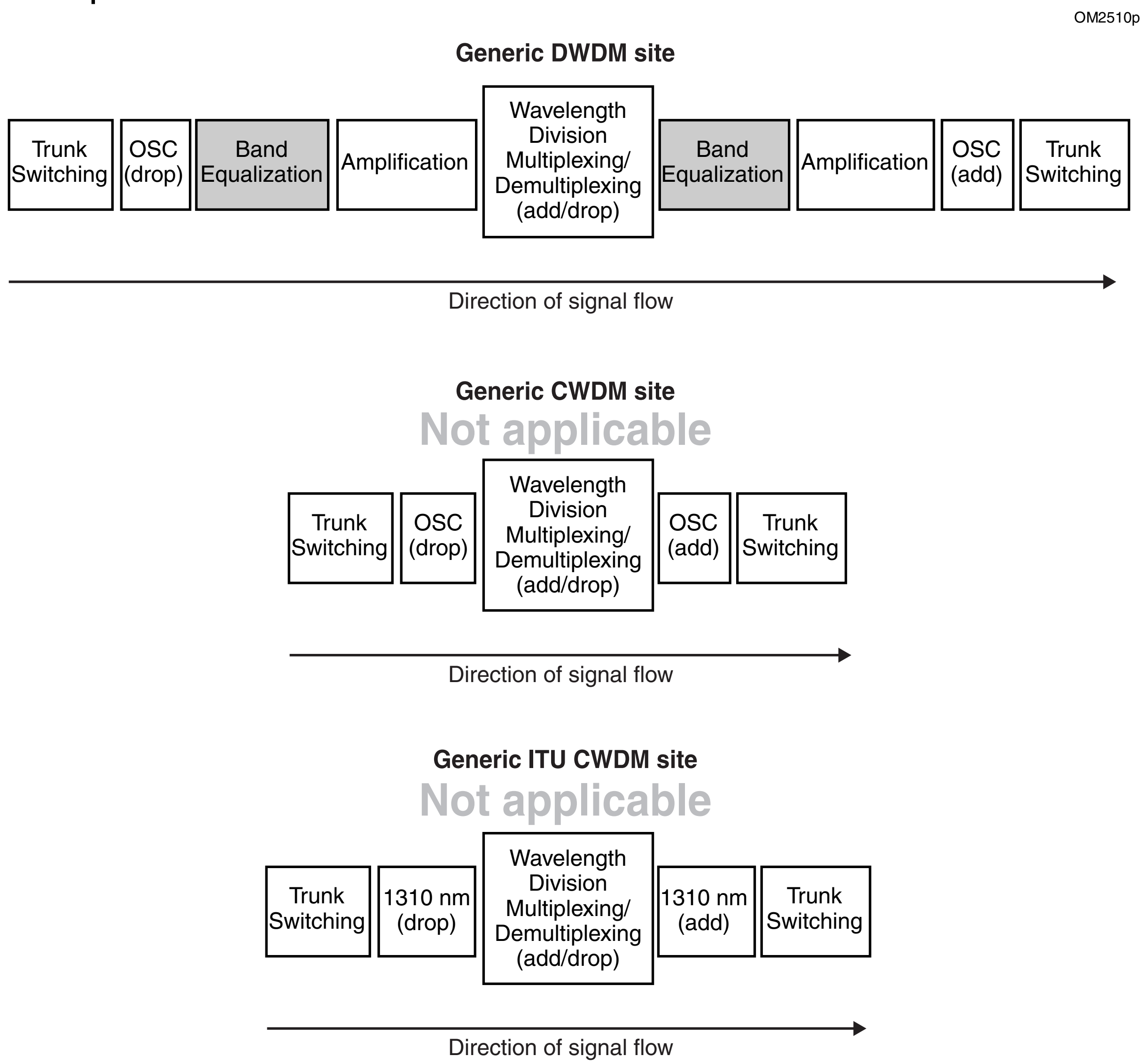
Figure 3-85
Pre-amplifier dual OFA optical layer topology



Band equalization

Figure 3-86 shows band equalization at a generic DWDM site.

Figure 3-86
Band equalization



When you add amplifiers to your network, you must balance or equalize the power levels of the bands going into the OFA circuit packs to ensure that:

- channel power is evenly distributed at an amplifier site
- power inputs to the amplifier fall within acceptable ranges
- OSNR requirements are met

You can choose one of two methods to equalize power levels:

- distributed equalization
- centralized equalization

Distributed equalization

With distributed equalization, you equalize the bands by installing attenuators at the point where the band is added to the signal, upstream of the amplifier. This will likely occur at many different sites within the network, and is likely to be at a site other that the one where the amplifier is deployed.

This method of power equalization is more difficult to carry out as it must be applied at multiple different physical sites. It is recommended that centralized equalization be used.

Centralized equalization

Centralized equalization occurs at the point in the network where the OFA circuit pack is located.

Centralized equalization uses per band equalizers to provide equalization. There are many variants of per band equalizers that may be used to provide centralized equalization. These include:

- Equalizer Coupler Tray (ECT), which includes a per band equalizer and a C&L splitter/coupler
- PBE, which provides only the per band equalizer functionality
- APBE, which is a circuit pack providing PBE functionality
- discrete VOA, which provides attenuation on an aggregate C-band or L-band signal

ECTs and PBEs contain variable optical attenuators (VOAs) for manually adjusting attenuation on a per band basis. Discrete VOAs contain variable optical attenuators for manually adjusting attenuation on an aggregate signal. APBEs contain electronic VOAs (eVOAs), which can be adjusted through software. Once the channels are provisioned using System Manager or a TL1 interface, eVOAs automatically adjust the attenuation on each band according to the number of provisioned channels. Once the correct output power is reached, the eVOAs switch to a fixed attenuation mode until the provisioning information is changed.

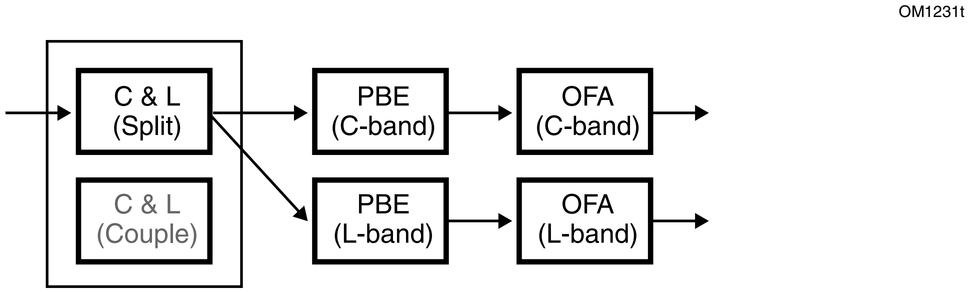
In all cases, if centralized per band equalization is required, the PBE functionality must be applied before the signal enters the amplifier. The signal can be connected directly from the output of the PBE to the input of the OFA circuit pack. Make sure that the C-band PBE output is connected to the C-band OFA and the L-band PBE output is applied to the L-band OFA.

There may be a need to split C-band and L-band traffic prior to connecting to the PBE. This depends on the packaging selected. In the case of the ECT packaging, the C&L splitter functionality is integrated into the ECT; there is no need for a separate C&L splitter/coupler module. However, in the case of the PBE in a drawer, the APBE, and the discrete VOA, the C-band and L-band must be split explicitly by using a separate C&L splitter/coupler module.

A C&L splitter/coupler may not be required if there is traffic carried in either the C-band or L-band—but not both. In this case, it is not necessary to split the C-band and L-band traffic prior to band equalization. Consider future traffic requirements when planning amplification and equalization schemes.

Figure 3-87 shows the centralized per band equalization placement in relation to the OFA circuit packs for amplified site configurations.

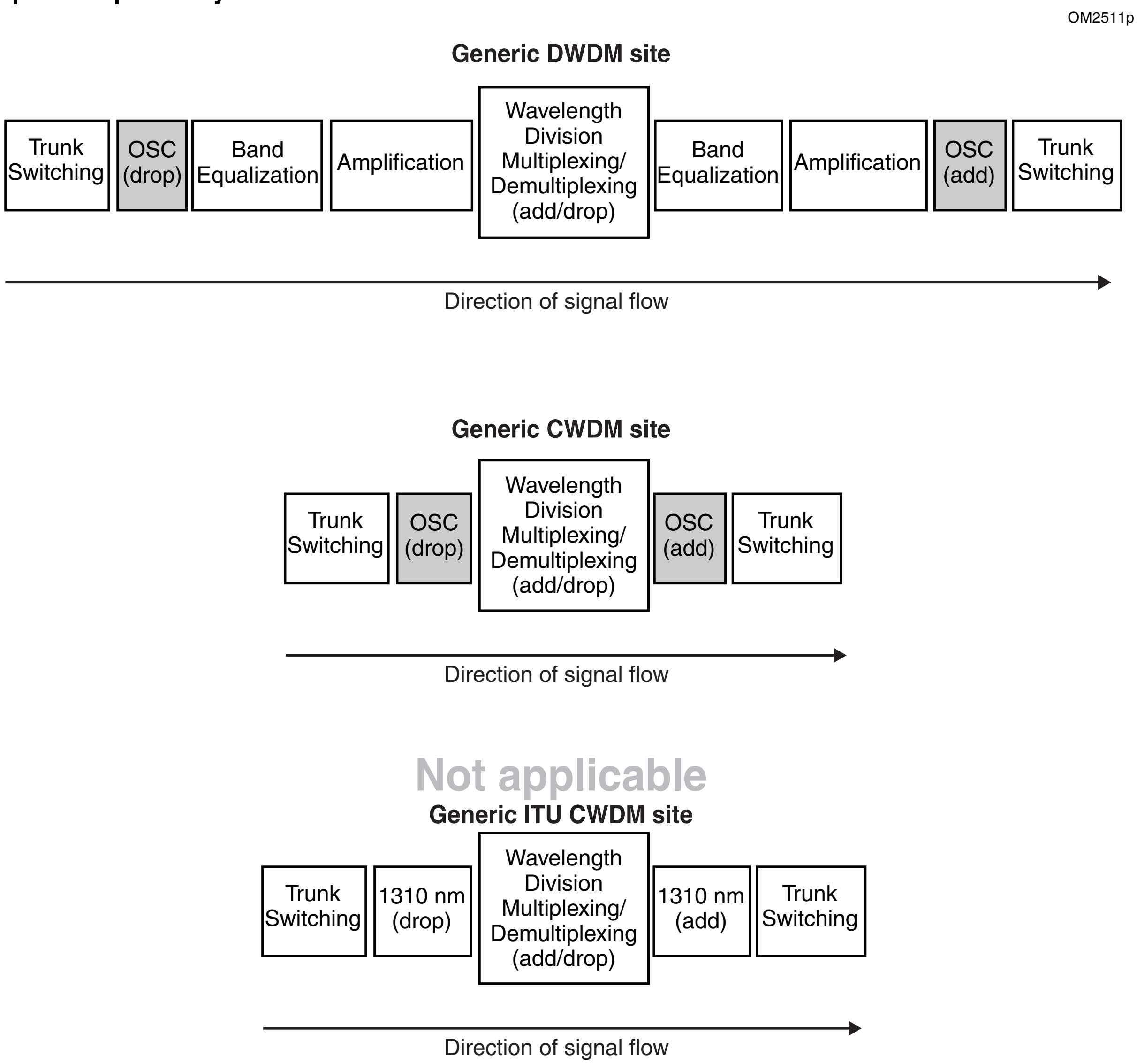
Figure 3-87
Centralized band equalization configuration



Optical supervisory channel

OSC is an optional component in DWDM and CWDM networks. If the OSC is used in a network, the OSC add/drop filter must be fibered to drop the OSC wavelength prior to any C&L splitter, centralized per band equalization, amplification or WDM add/drop filter functionality at the site (see Figure 3-88 on page 3-112). Similarly, it must be fibered in order to add the OSC wavelength following any C&L coupler, centralized per band equalization, amplification or WDM add/drop filter functionality at the site.

Figure 3-88
Optical supervisory channel



At any site in a ring topology or at an intermediate site in a linear topology, there is an OSC wavelength on the west fiber pair and another OSC wavelength on the east fiber pair. Two OSC add/drop filter trays are required to add and drop the OSC signal in each of the directions. At a terminal site in a linear topology, only a single OSC add/drop filter tray is required.

Depending on the site topology, the OSC trays can connect to:

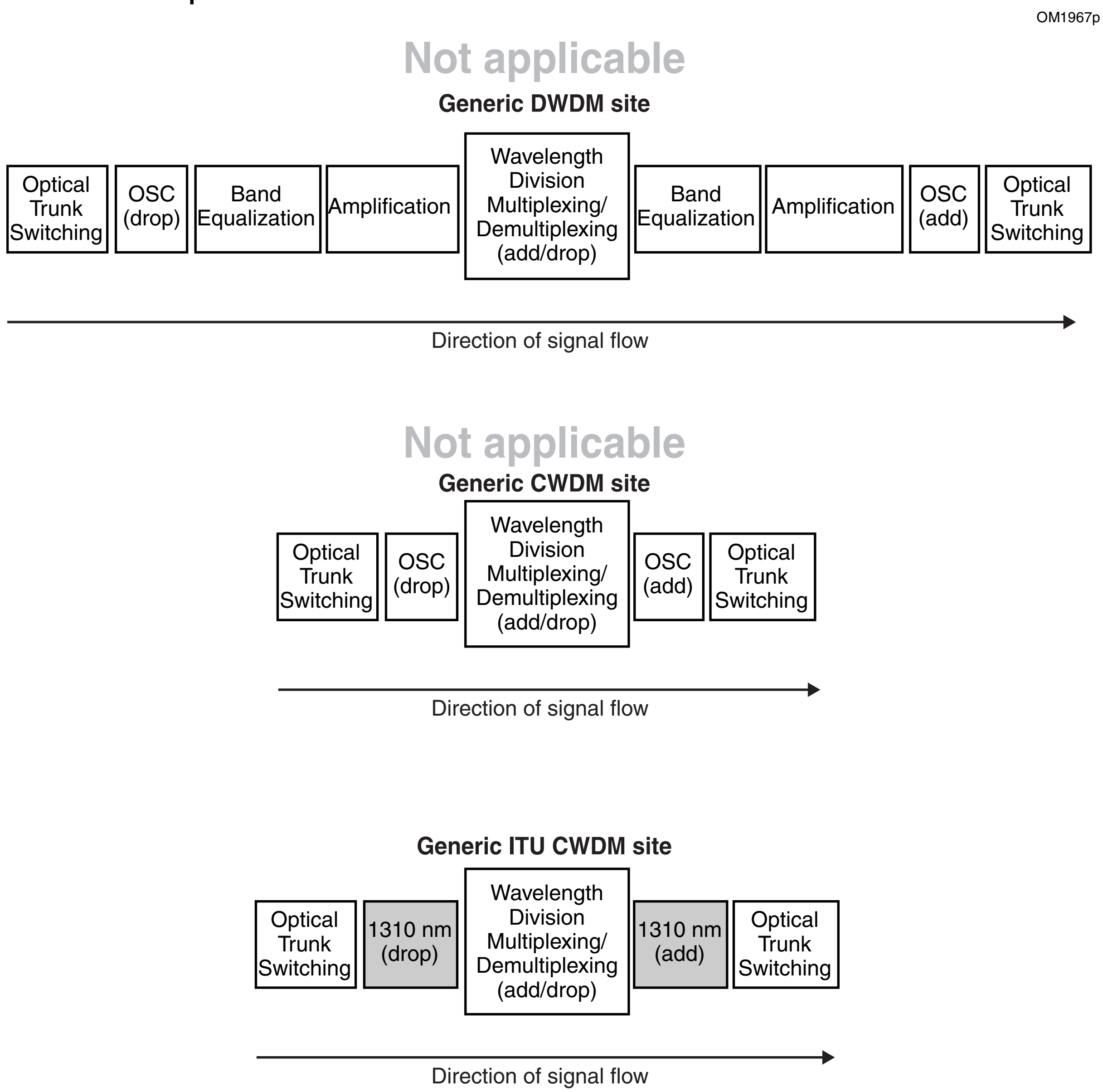
- C&L splitter/coupler
- PBE equipment (ECT, PBE, APBE, or discrete VOA)
- amplifiers
- wavelength division multiplexing/demultiplexing equipment (OMXs)

The OSC cannot be deployed in configurations without OMXs. This means that an Optical Metro 5200—Optical Metro 5100 hub and spoke configuration cannot include an OSC. Nor can an Optical Metro 5100 linear configuration if it does not include OMXs.

1310 nm add and drop

The 1310 nm add and drop functionality is an optional component in ITU CWDM networks. If an ITU CWDM network is overlaid onto a network using 1310 nm wavelengths, the 1310 nm add/drop filter must be fibered to drop the 1310 nm wavelength prior to any WDM add/drop filter functionality at the site (see Figure 3-89). Similarly, it must be fibered to add the 1310 nm wavelength following any WDM add/drop filter functionality at the site.

Figure 3-89
1310 nm add/drop



At any site in a ring topology or at an intermediate site in a linear topology, there is a 1310 nm wavelength on the west fiber pair and another 1310 nm wavelength on the east fiber pair. Two 1310 nm add/drop filter trays are required to add and drop the 1310 nm signal in each direction. At a terminal site in a linear topology, only one 1310 nm add/drop filter tray is required.

The 1310 nm trays can connect to wavelength division multiplexing/demultiplexing equipment (OMX).

Trunk switching

Optical Metro 5100/5200 offers the following two trunk switch variants

- Optical Trunk Switch (OTS)
- Enhanced Trunk Switch (ETS)

The OTS can be deployed in a point-to-point configuration only. You cannot have amplification in a network with the Optical Trunk Switch.

The ETS module consists of three components: the ETS shelf, the ETS Switch module and the ETS Comms module. The ETS can be deployed in unamplified point-to-point configurations, and in amplified point-to-point configurations that contain a single pre-amplifier in the link.

> ***Note:*** The ETS does not replace the OTS, nor is it backward compatible with the OTS. You cannot deploy the ETS and the OTS modules in the same point-to-point link.

Figure 3-90 displays generic sites that use the Optical Trunk Switch and Figure 3-91 displays generic sites that use the Enhanced Trunk Switch.

Figure 3-90
Optical trunk switching

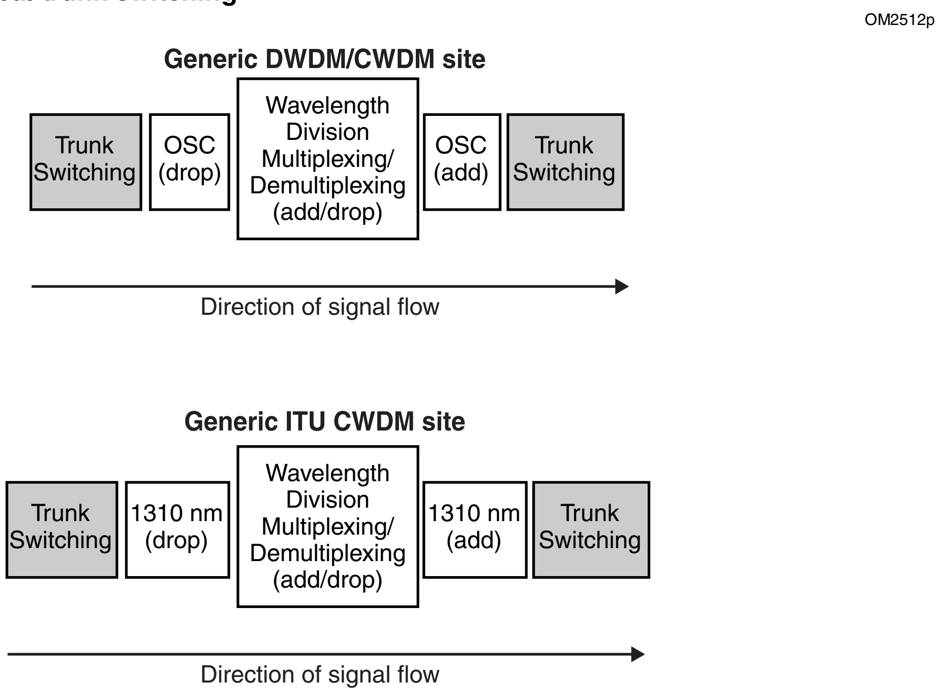
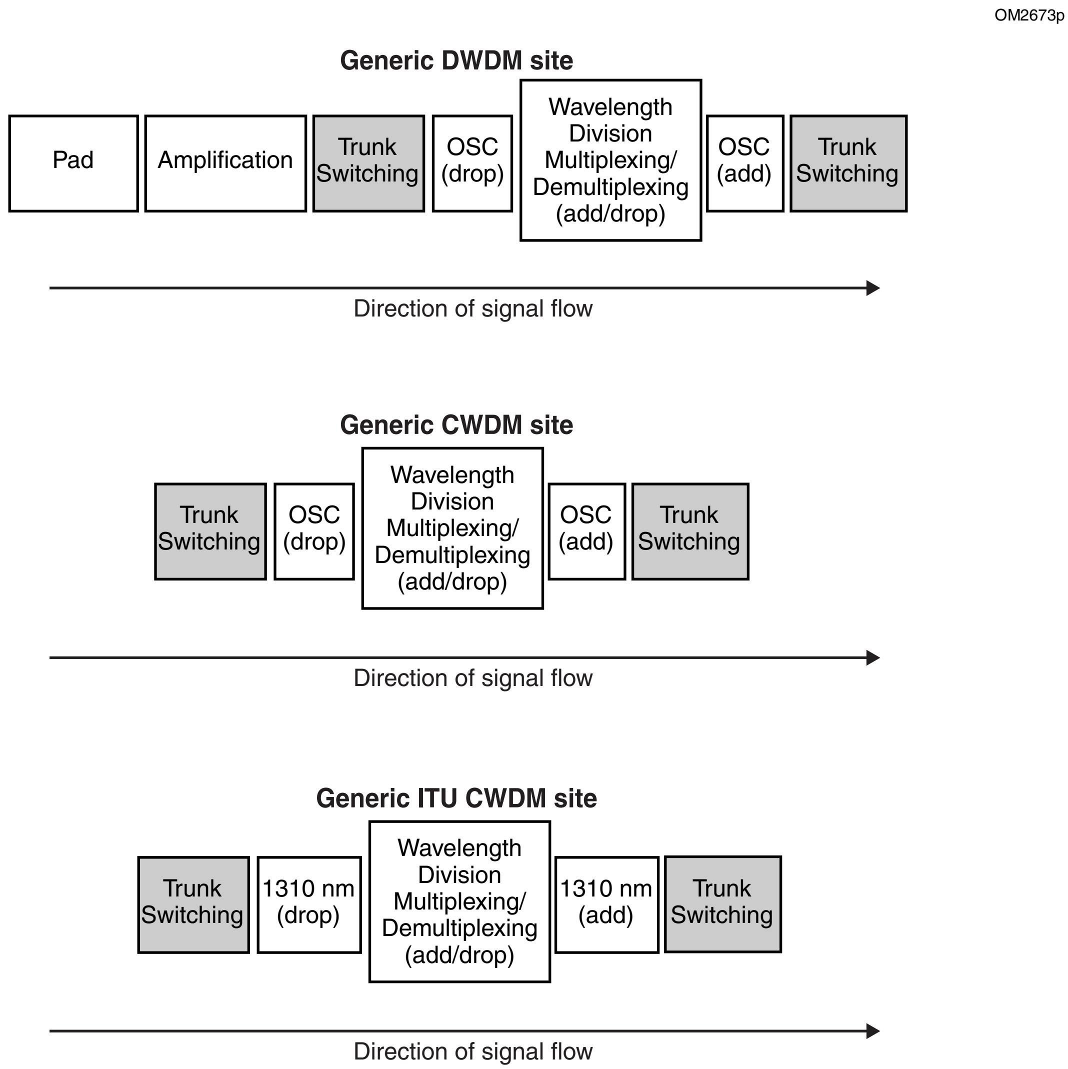


Figure 3-91
Enhanced trunk switch



Depending on the site topology, the trunk switch can connect to:

- OSC tray
- C&L splitter/coupler
- wavelength division multiplexing/demultiplexing equipment (OMXs)
- 1310 nm splitter/coupler
- an amplifier (ETS only)

Fixed pad attenuators

Fixed pad attenuators can be deployed at various locations in a network. These influence the performance of the optical layer, although they do not influence the flow of traffic. Table 3-8 lists the possible placements for fixed pad attenuators:

Table 3-8
Fixed pad attenuator placement

Location	Application	Applies to
OMX Band Add	• Distributed Equalization • Limit the launch power into a DSCM or the fiber plant	DWDM
OMX Band Drop	Prevent OCLD/OTR/Muxponder Rx overload	DWDM CWDM ITU CWDM
OMX Ch Drop on the OMX 16CH DWDM	Prevent OCLD/OTR/Muxponder Rx overload	DWDM
OFA IN	• Prevent OFA Rx overload conditions on aggregate signal • Distributed Equalization	DWDM
OFA OUT	• Limit the launch power into a DSCM or the fiber plant • Prevent coherent crosstalk • Distributed Equalization (attenuation for the passthrough bands)	DWDM
OSC Add	• Prevent OSC channel cross talk and to prevent OSC circuit pack Rx overload when using the OSC Splitter/Coupler tray or the OSC Splitter/Coupler tray, with optical tap • Prevent OSC circuit pack Rx overload when using the OSC Splitter/Coupler tray, with dual taps	DWDM CWDM
Patch panel	• Prevent OCLD/OTR/Muxponder line-side Rx overload for configurations without OMXs • Prevent OCI/OTR/Muxponder client-side Rx overload • For client side attenuation on the OTR 10 Gbit/s or OTR 10 Gbit/s Enhanced circuit pack for electrical pass-through connections	DWDM CWDM ITU CWDM OMX-less

Building the optical layer

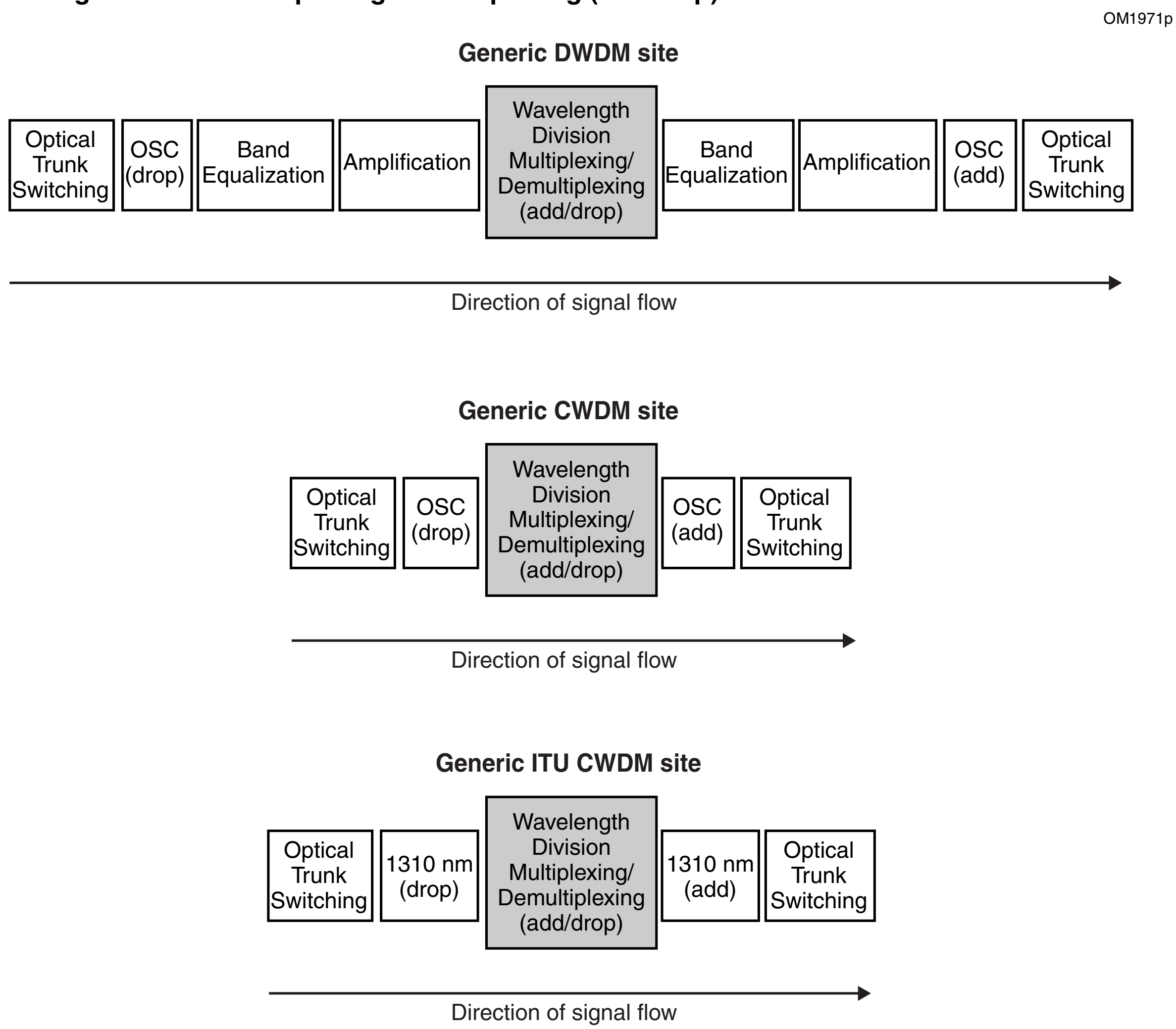
This section expands upon the optical layer functional blocks presented in the previous section. For each of the functional blocks, the physical components available to implement these functional blocks are described. Any restrictions that may exist when choosing the physical components are also outlined in this section.

To see examples of all of the supported configurations for connecting the physical components, refer to the "Preparing to connect optical components" chapter of *Connection Procedures*, 323-1701-221.

Wavelength division multiplexing/demultiplexing (add/drop)

Figure 3-92 shows network placement of multiplexing/demultiplexing functionality.

Figure 3-92
Wavelength Division Multiplexing/Demultiplexing (add/drop)



The wavelength division multiplexing/demultiplexing functionality is provided by the OMX modules. In the case of network topologies that do not use OMX modules, the fiber is connected to the OCLD/OTR/Muxponder circuit pack through a patch panel since there is no multiplexing or demultiplexing required.

Figure 3-93 on page 3-120 shows the physical components that make up the wavelength division multiplexing/demultiplexing functional block of the optical layer in CWDM or DWDM systems, including the fiber connections to and from the functional block.

Figure 3-93
Fiber connections to WDM components - CWDM or DWDM systems

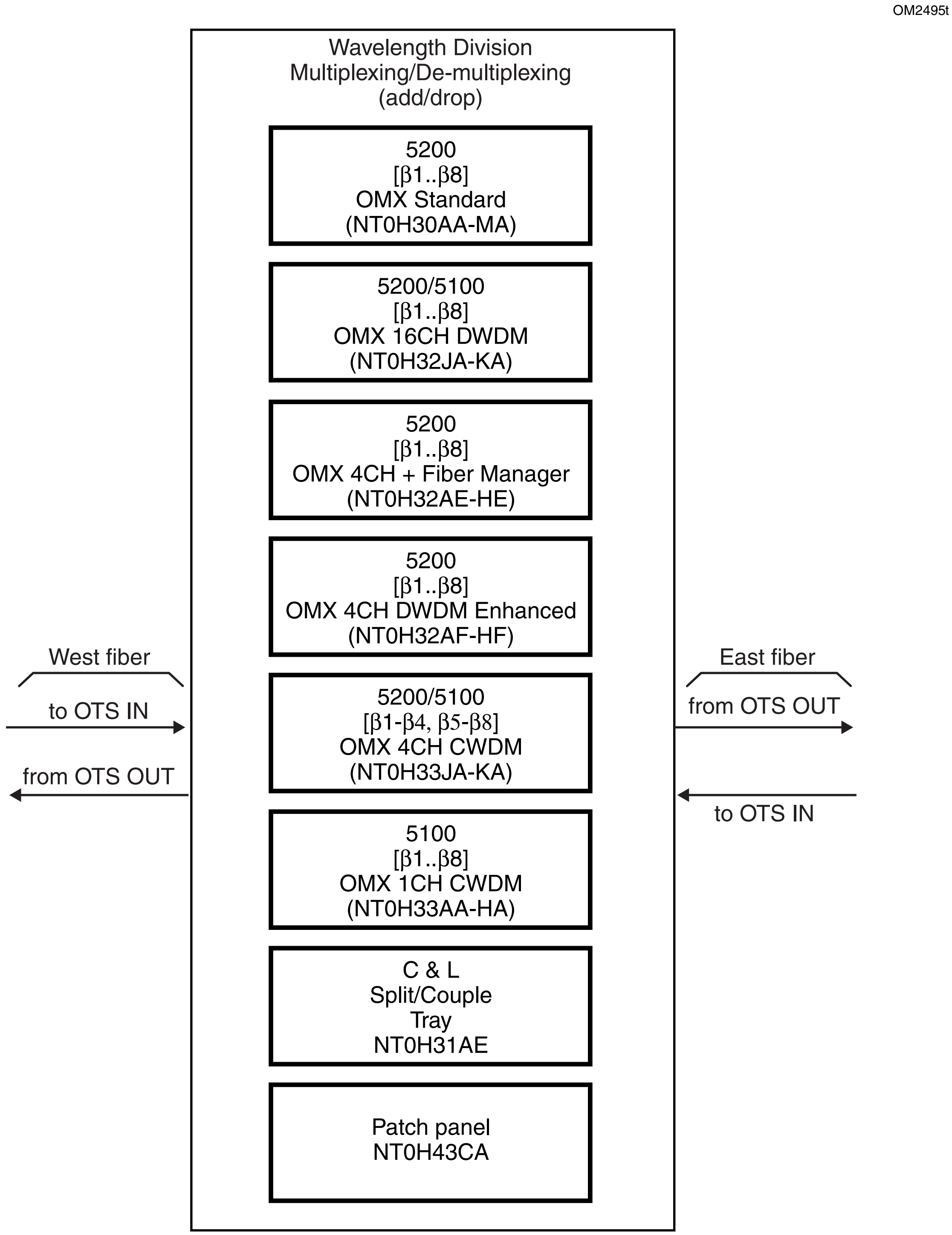
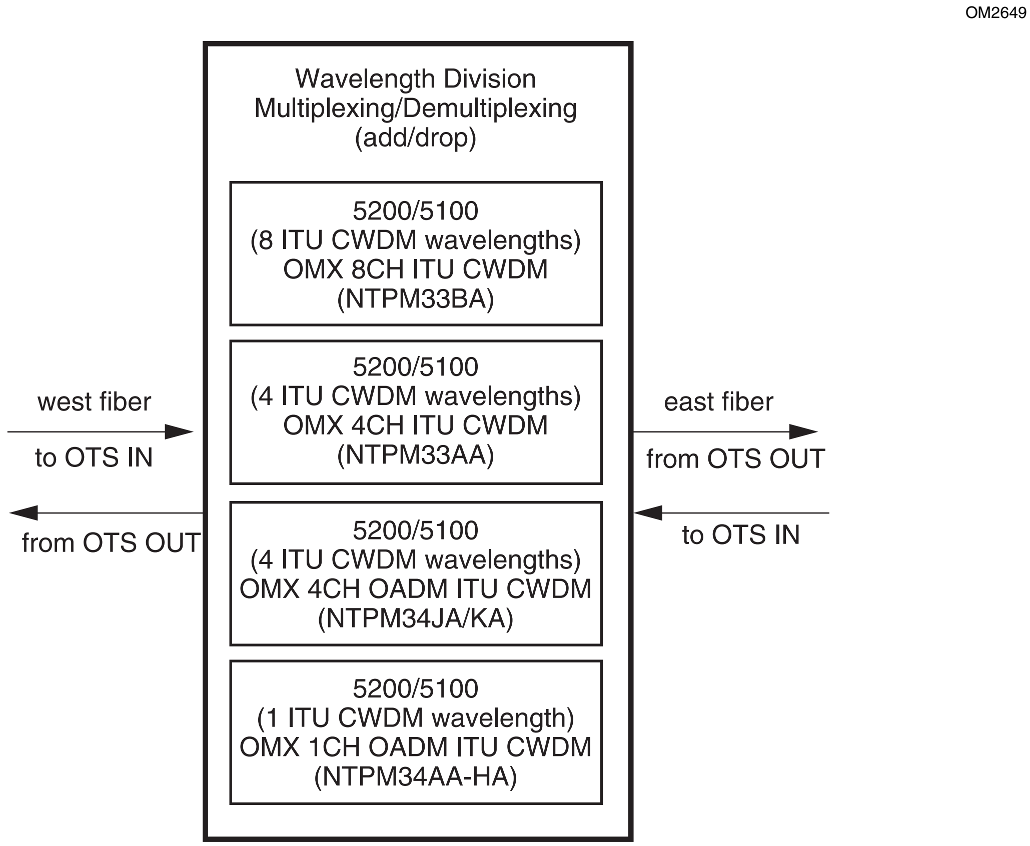


Figure 3-94 shows the physical components that make up the wavelength division multiplexing/demultiplexing functional block of the optical layer in ITU CWDM systems, including the fiber connections to and from the functional block.

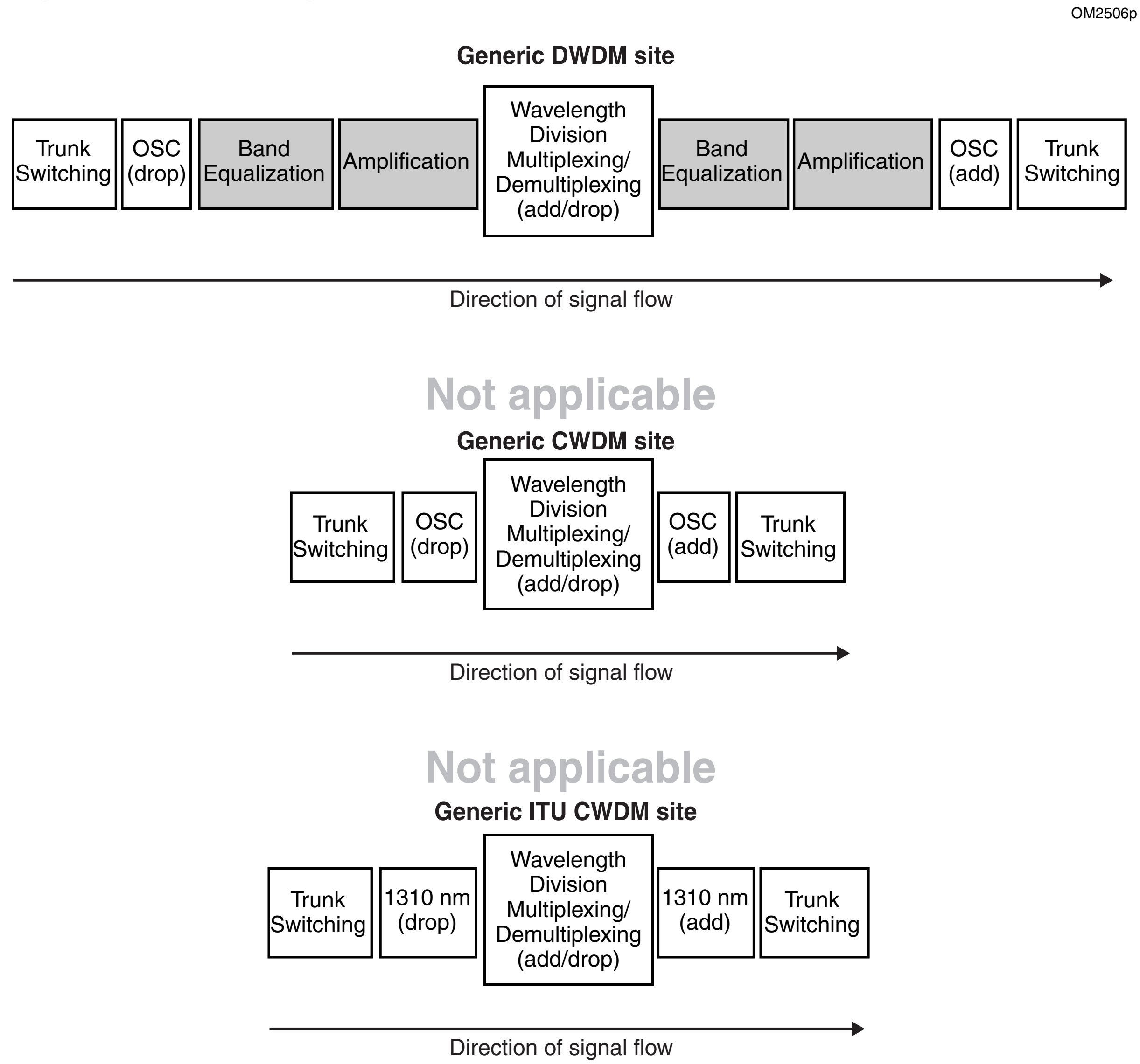
Figure 3-94
Fiber connections to WDM components - ITU CWDM systems



Amplification and band equalization

Amplification and band equalization are presented together (see Figure 3-95). If you use distributed equalization (instead of centralized equalization), only the amplification details of this section apply.

Figure 3-95
Amplification and band equalization



The amplification functionality is provided by the OFA circuit packs. Two types of OFA circuit packs are available: standard OFA and high input power OFA. Each type has two variants: C-band OFA and L-band OFA.

The centralized band equalization functionality is provided by a per band equalizer, which may be packaged in an ECT, a PBE, or the APBE circuit pack.

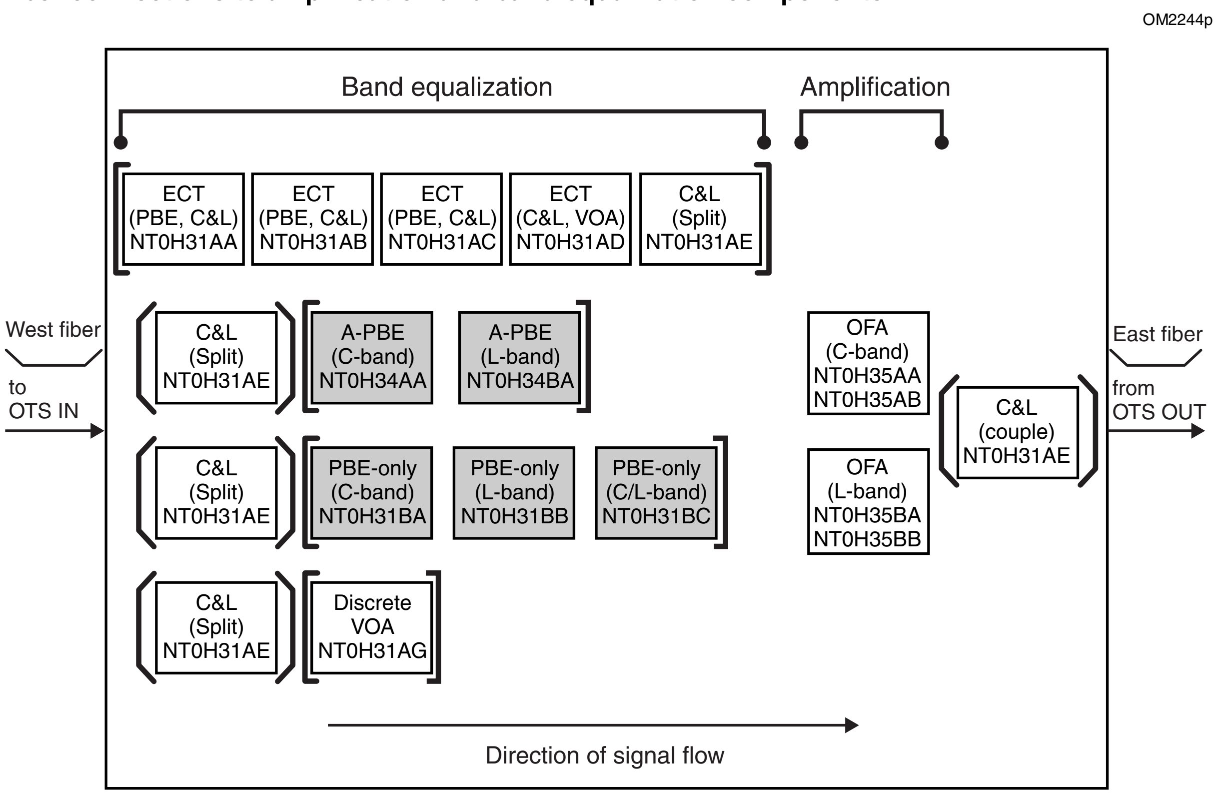
While the ECT provides an integrated C&L splitter/coupler module, the PBE and the APBE, a separate C&L splitter/coupler module may be required.

Figure 3-96 shows the physical components that make up the amplification and band equalization functional block of the optical layer, including the fiber connections to and from the functional block. In the illustration, note the following notation:

— angled brackets represent optional components

— square brackets represent a mandatory choice among components (one of which must be chosen)

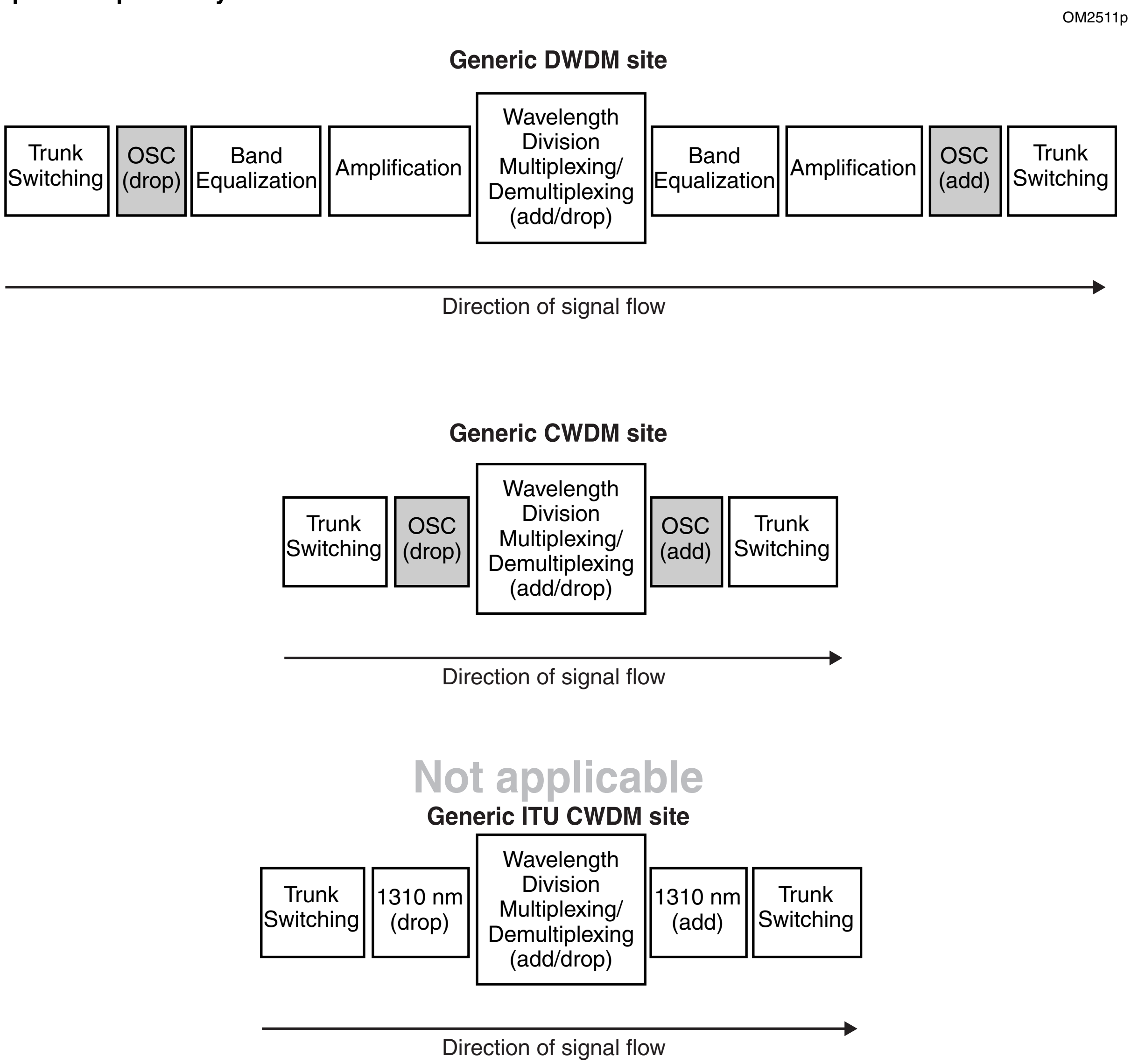
Figure 3-96
Fiber connections to amplification and band equalization components



Optical supervisory channel

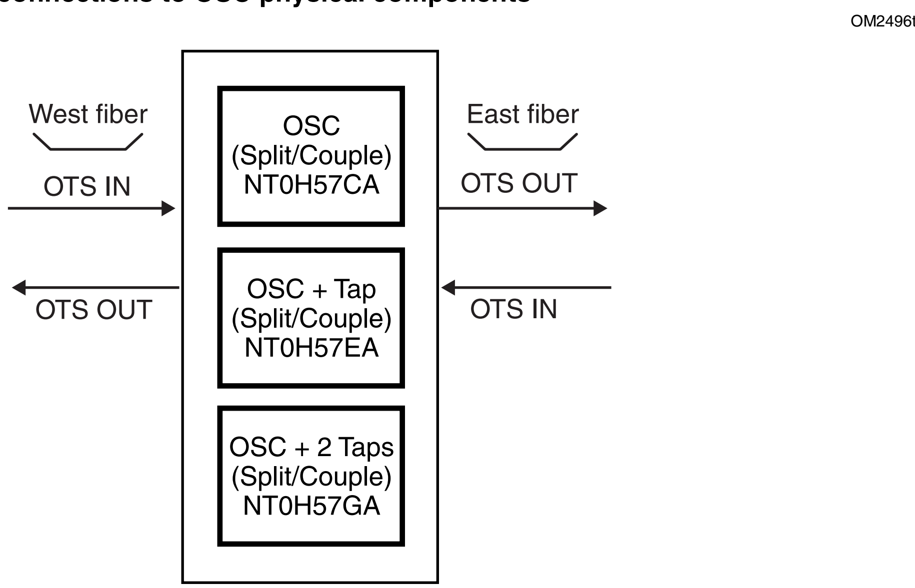
Figure 3-97 shows placement of the Optical Supervisory Channel.

Figure 3-97
Optical Supervisory Channel



There are three variants of the OSC add/drop filter: one with two optical taps, one with an optical tap and one without. Figure 3-98 shows the physical components that make up the OSC functional block of the optical layer, including the fiber connections to and from the functional block.

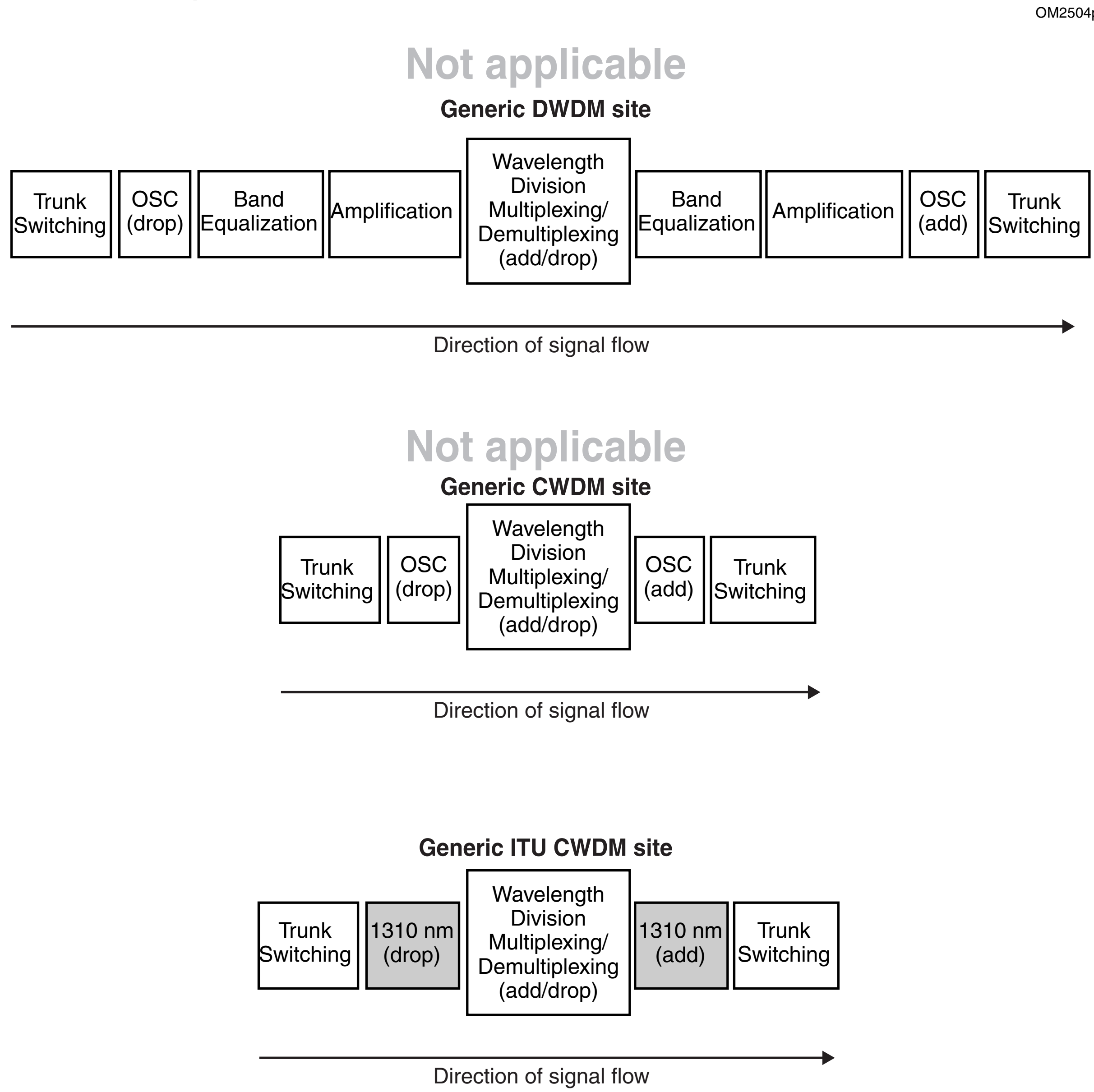
Figure 3-98
Fiber connections to OSC physical components



1310 nm add/drop filter

There is only one variant of the 1310 nm add/drop filter, as shown in Figure 3-99. In the above topologies, any time the 1310 add/drop filter appears, it is the NT0H31AF.

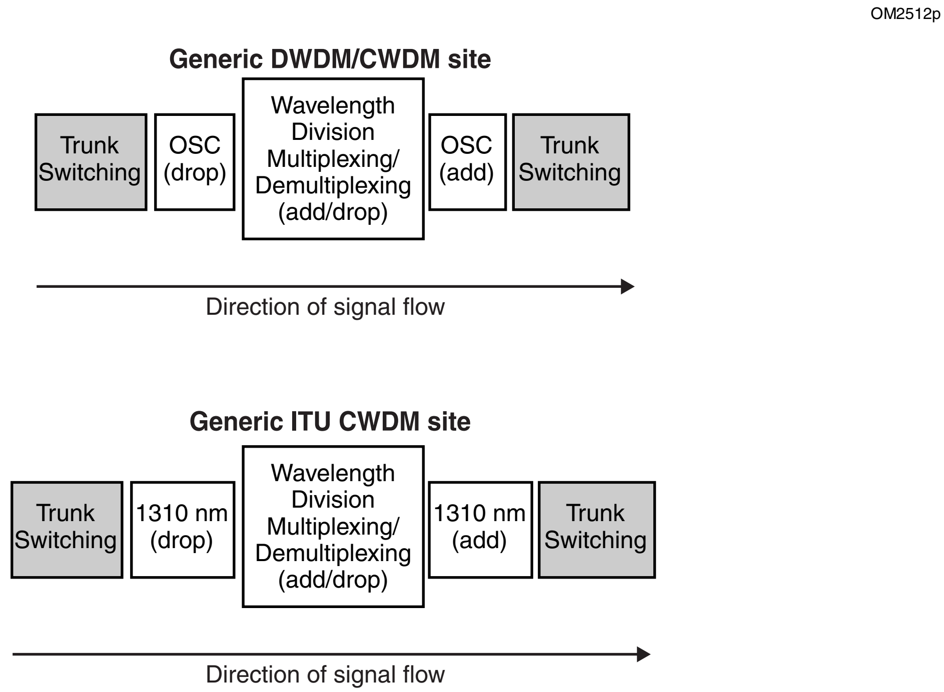
Figure 3-99
1310 nm add/drop filter



Trunk switch

You can deploy either the Optical Trunk Switch (OTS) or the Enhanced Trunk Switch (ETS). However, the two trunk switch variants do not interoperate, and you must use the same type of trunk switch in any given point-to-point link. Figure 3-100 displays the topologies when using the OTS.

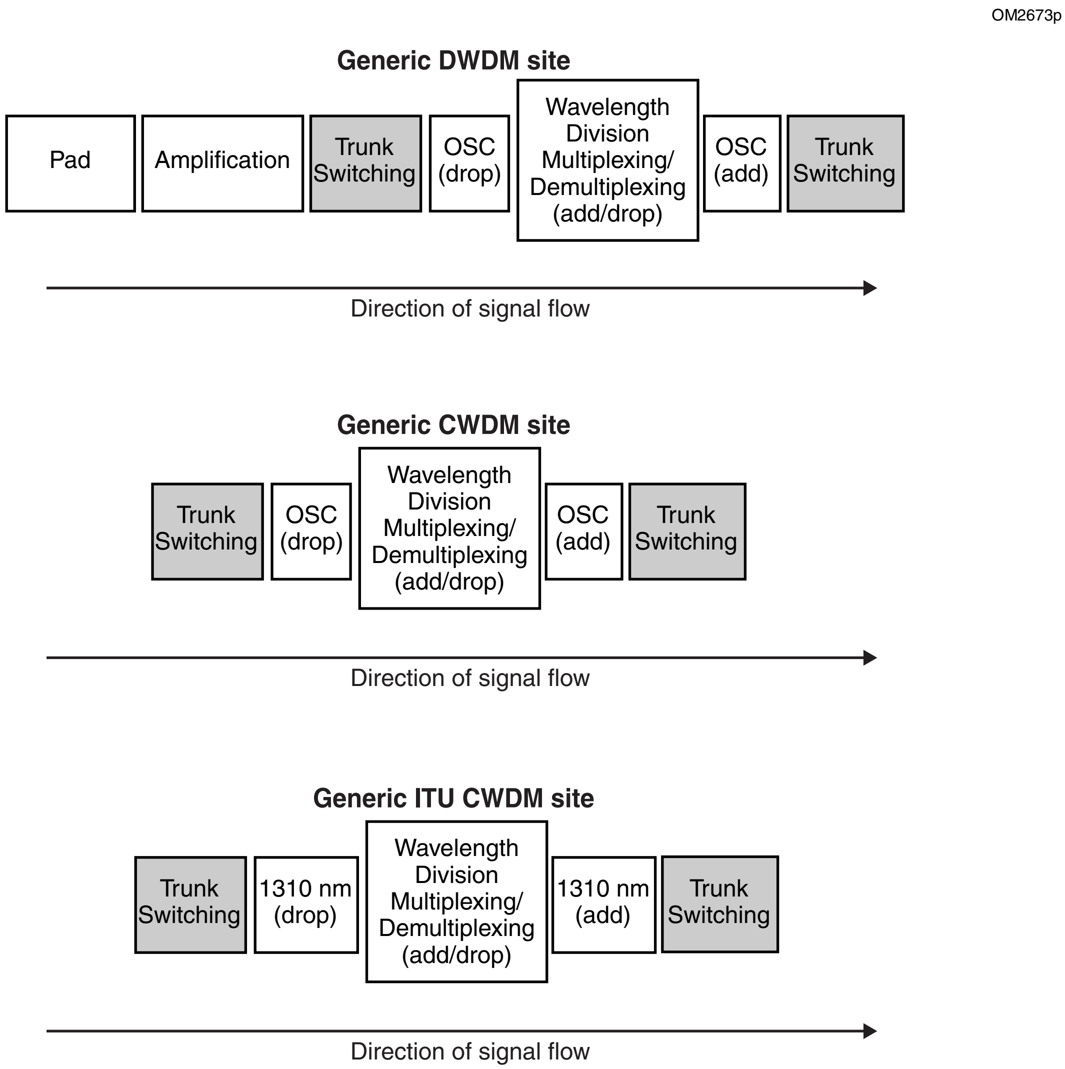
Figure 3-100
Optical Trunk switching



There is only one variant of the OTS. In the above topologies, any time Trunk Switching appears, it is the NTUG75AA.

Figure 3-101 displays the topologies when using the ETS.

Figure 3-101
Enhanced trunk switch



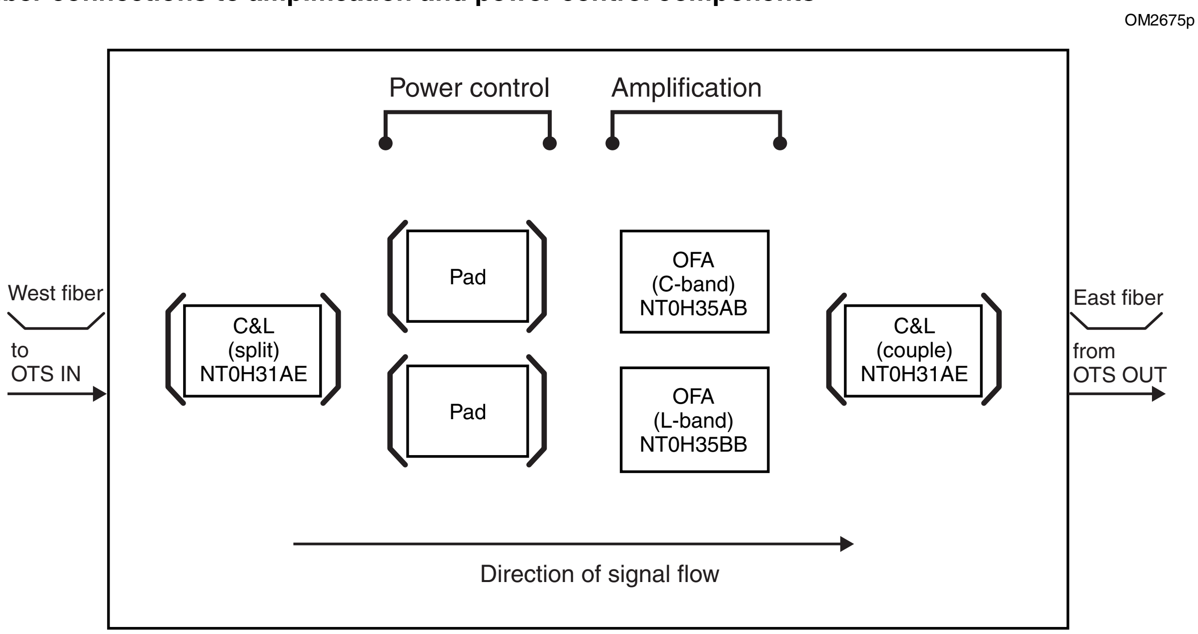
There is only one variant of the ETS. In the above topologies, any time Trunk Switching appears, it is the NTUG90AN.

The optional amplification functionality is provided by the OFA circuit pack. Only the high input power OFA can be used in this configuration. The high input power OFA is available in two variants: C-band OFA and L-band OFA.

The only supported power control device for the OFA in this configuration is a fixed attenuator pad.

Figure 3-102 shows the physical components that make up the amplification and power control functional block of the optical layer, including the fiber connections to and from the functional block. In the illustration, note that the angled brackets represent optional components.

Figure 3-102
Fiber connections to amplification and power control components



Site configurations

Serial and parallel WDM site configurations

In Optical Metro 5100/5200 networks, depending on the number of shelves present in a site, it may be desirable to fiber all C-band and L-band WDM shelves in sequence (serial configuration), or it may be advantageous to separate the C-band and L-band with the use of a C&L splitter/coupler and fiber the C-band and L-band WDM shelves in two parallel series (parallel configuration).

The determining factor for the advantages of serial or parallel configurations is the amount of OMX filter losses as the signal optically passes through the OMX modules, versus the amount of loss due to the splitter and the coupler.

If you have a site with few shelves, the OMX filter losses are most likely not significant and a serial configuration would be appropriate. For a detailed example of optimizing link budgets by splitting C-band and L-band shelves, see “Example of reconfiguring serial and parallel sites for optimal link budgets”in the “Remodeling a network plan for optimal link budgets” chapter in this book.

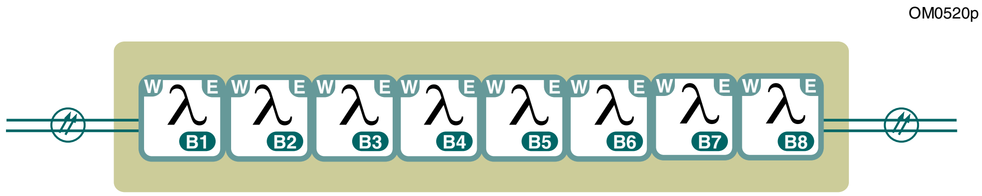
If you have bands that experience significant power loss from passing through numerous shelves at a site, a parallel configuration at that site may be advantageous. You must weigh any advantages gained from avoiding OMX filter losses against the losses associated with the C/L splitter/coupler.

Another factor that can influence the decision to fiber the OMX modules in a parallel or a serial configuration is the future growth requirements. If all wavelengths that are carrying traffic are in the C-band when the system is first installed, then it may be worth deploying the C&L splitter/coupler around the WDM shelves anyway. This way, future traffic can be added to the network in the L-band without impacting the C-band traffic.

Serial configuration

For a serial site configuration, all C-band and L-band WDM shelves are fibered in sequence. Figure 3-103 shows a site with a serial configuration. In this example, band 1, when added to the signal coming in from the east side (in the west-bound direction), would pass through the OMX filters of bands 2 through band 8 before travelling to downstream sites. Similarly, band 8, when dropped from the signal coming in from the east side (from the west-bound direction), would pass through the OMX filters of bands 1 through band 7 before being dropped from the network.

Figure 3-103
Serial WDM shelves

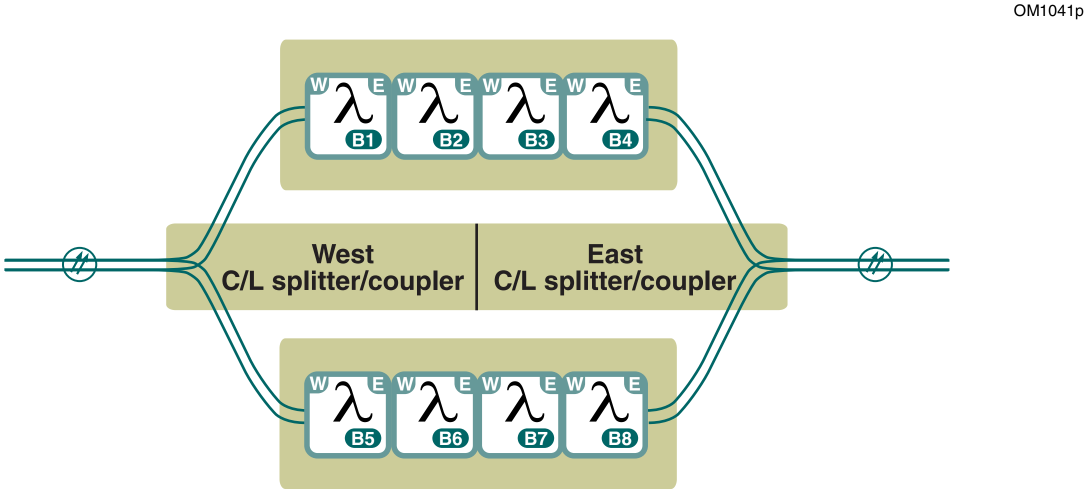


Serial configurations can be applied to sites with Optical Metro 5100 shelves and sites with Optical Metro 5200 shelves.

Parallel configuration

In Optical Metro 5100/5200 networks, you can use C/L splitters and C/L couplers to separate and recombine the C-band and L-band shelves in a site. Figure 3-104 on page 3-132 shows a site with a parallel configuration. In this example, band 1, when added in the west-bound direction, would pass through the OMX filters of bands 2 through band 4 before travelling to downstream sites. Similarly, band 8, when dropped from the west-bound direction, would pass through the OMX filters of bands 5 through band 7 before being dropped from the network. Although the OMX losses would be less than in a serial site, the C/L splitter/couplers would introduce additional losses for each signal.

Figure 3-104
Parallel WDM shelves



In a parallel configuration the set of OMX modules in the C-band shelves (bands 1 through 4) and the set of OMX modules in the L-band shelves (bands 5 through 8) are fibered independently. The fibering methods presented in the previous section (stacked, standard, or single-shelf fibering) are applied to the two sets of OMX modules separately.

Parallel configurations apply to sites with Optical Metro 5200 shelves only. You cannot apply parallel configurations to a site with Optical Metro 5100 shelves.

Straddled or bookended C/L splitter/couplers

Components that contain C/L splitter/couplers can be configured in one of two ways:

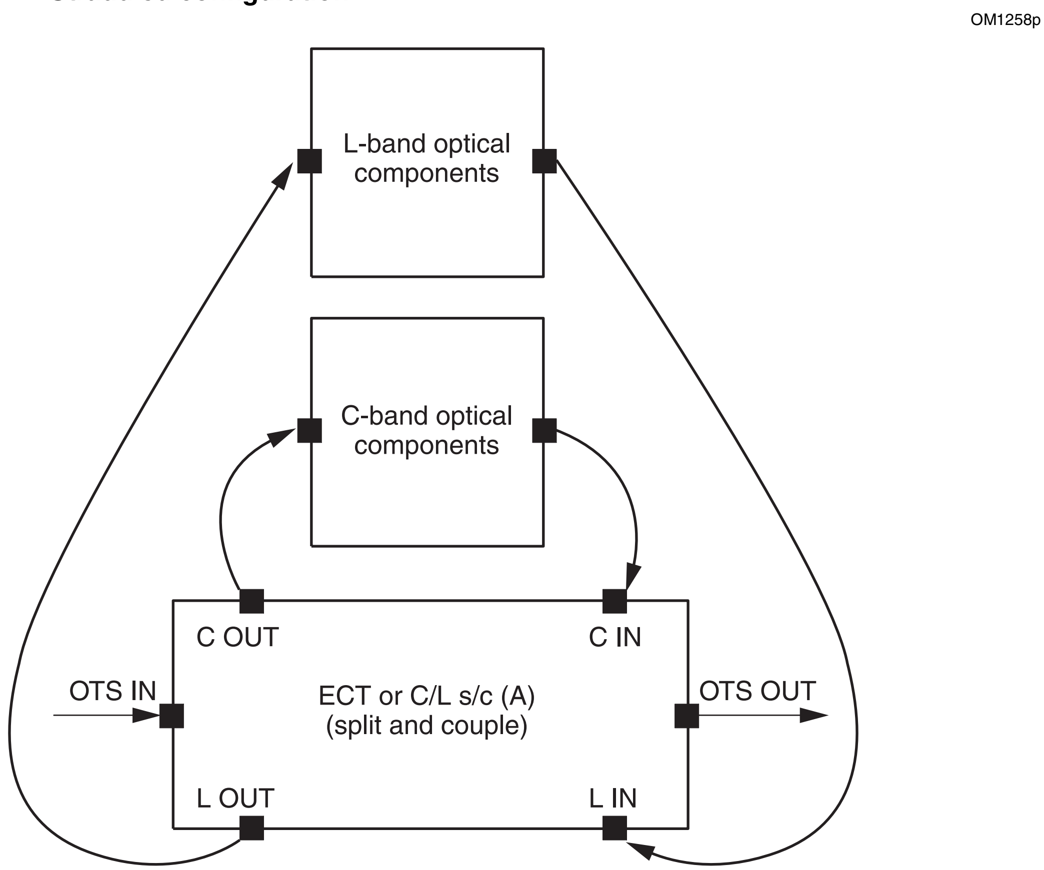
- straddled configurations
- bookended configurations

In straddled configurations, one component (east or west) performs both the splitting and coupling operations.

In most cases, C/L splitter/couplers should not straddle WDM shelves; if the straddled C/L splitter/coupler fails, a loss of traffic could occur in both directions. Use straddled C/L splitter/couplers around amplifiers where the C-band and L-band signals require splitting and coupling in one direction only.

Figure 3-105 shows a straddled configuration. For simplicity, only one direction of signal flow is shown.

Figure 3-105
Straddled configuration

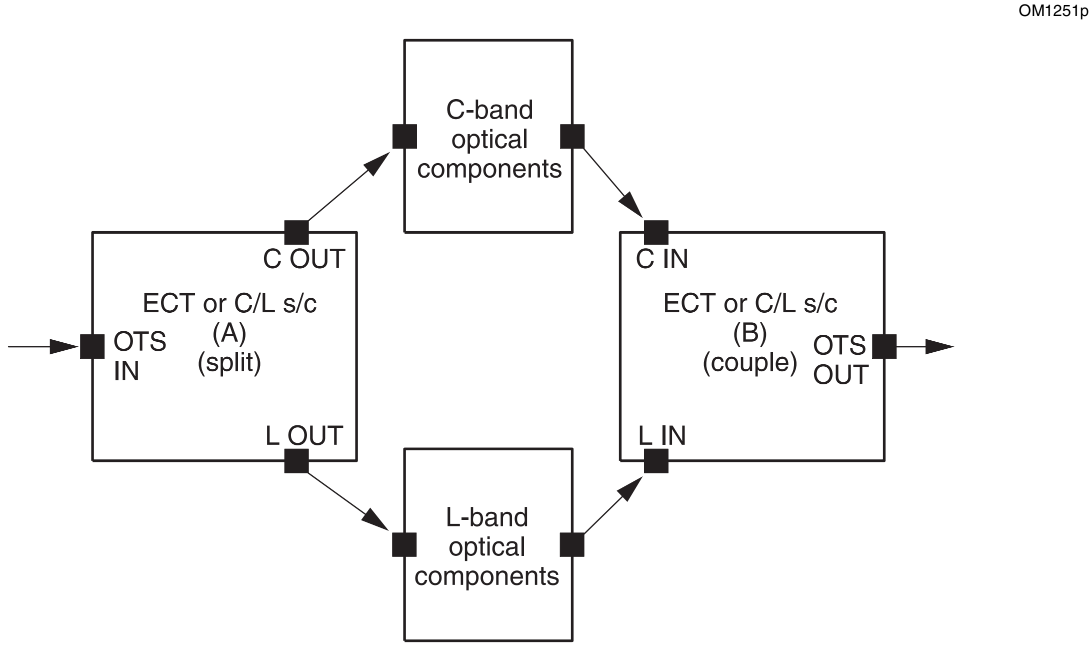


In bookended configurations, one component (east or west) performs the splitting operation and another component (west or east) performs the coupling operation.

Bookended configurations are recommended for sites with WDM shelves, and sites where the C-band and L-band signals require splitting and coupling in both directions. Bookended configurations ensure that one direction of traffic remains in service in the event of a failure at a single C/L splitter/coupler.

Figure 3-106 shows a bookended configuration. For simplicity, only one direction of signal flow is shown.

Figure 3-106
Bookended configuration



Site configurations using the OMX 16CH DWDM

For initial installs which have 16 channels or less, it is recommended to deploy the OMX 16CH DWDM C-band instead of the OMX 16CH DWDM L-band. This will allow for the in-service addition of additional channels. This is because the OMX 16CH DWDM C-band supports an upgrade port and the OMX 16CH DWDM L-band does not.

New Extended Metro DWDM with DSCM topologies

New Extended Metro DWDM with DSCM topologies are introduced as a result of the new OFA VGA circuit pack and new OFA dual configurations.

A power control device of some type is required prior to each amplifier in a site. The exact positioning of the power control devices (equalizer or VOA) is dependant on amplifier type and the presence of a DSCM. If the OFA VGA circuit pack is used, the eVOA within the circuit pack can be used to control the total power into the amplifier but an equalizer is still needed if that functionality is required.

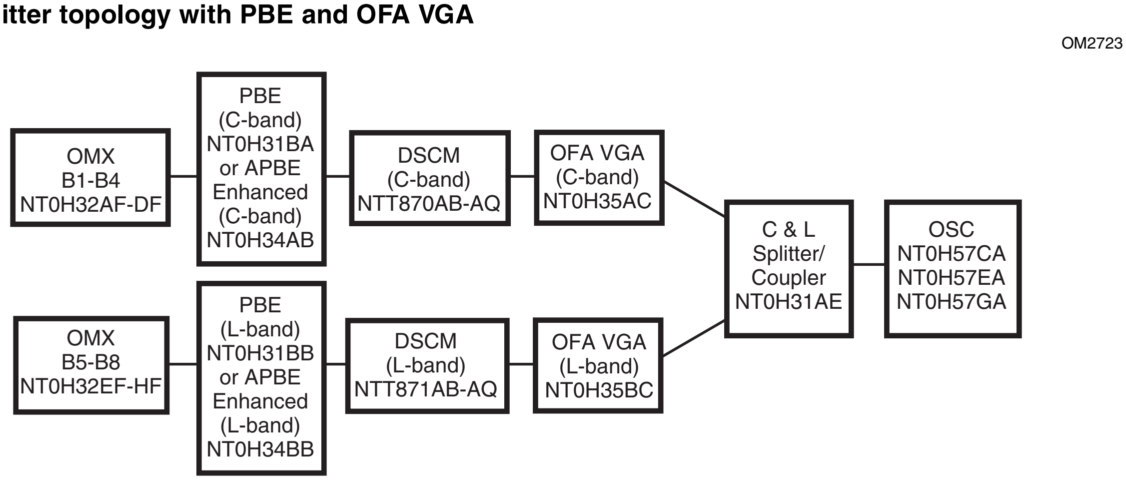
This section only illustrates example topologies. The Nortel Networks custom link engineering report provides the detailed placement of components in a site topology.

In the example illustrations below, C-band and L-band only systems use the same site topologies without the C&L Splitter/Coupler. The OSC tray and OSC circuit pack are optional but recommended.

Transmitter topologies

Figure 3-107 shows a transmitter topology with PBE/APBE Enhanced circuit packs and OFA VGA circuit packs. The PBE/APBE Enhanced is placed before the DSCM and is responsible for per-band equalization. The eVOA in the OFA VGA circuit pack is used to control the aggregate power into the amplifier.

Figure 3-107
Transmitter topology with PBE and OFA VGA



Receiver topologies

Figure 3-108 shows a receiver topology with an OFA VGA as a single pre-amplifier. A small DSCM can be placed prior to the OMXs. A fixed attenuator pad is required at the OFA output to limit the power into the DSCM.

Figure 3-108
Receiver topology with OFA VGA circuit packs in a single pre-amplifier configuration

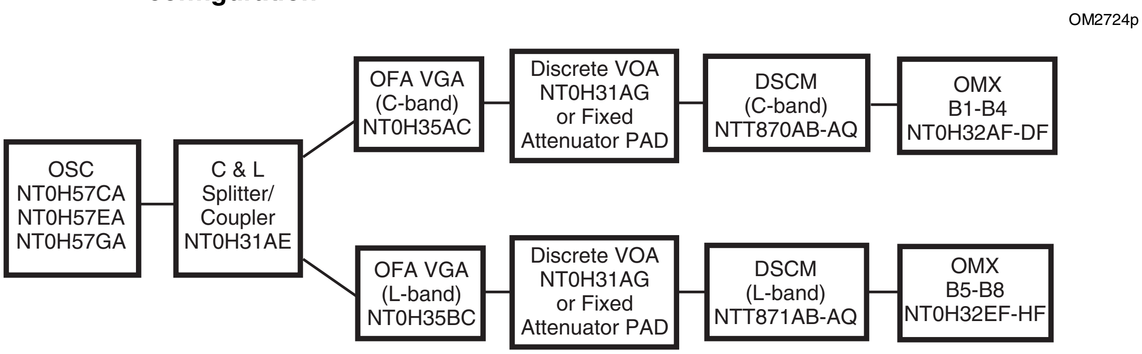


Figure 3-109 shows a receiver topology if a larger DSCM is required. An additional pre-amplifier is needed to overcome the extra loss of the DSCM. A fixed attenuator pad is required at the OFA output to limit the power into the DSCM.

Figure 3-109
Receiver topology with OFA VGA circuit packs in a dual pre-amplifier configuration

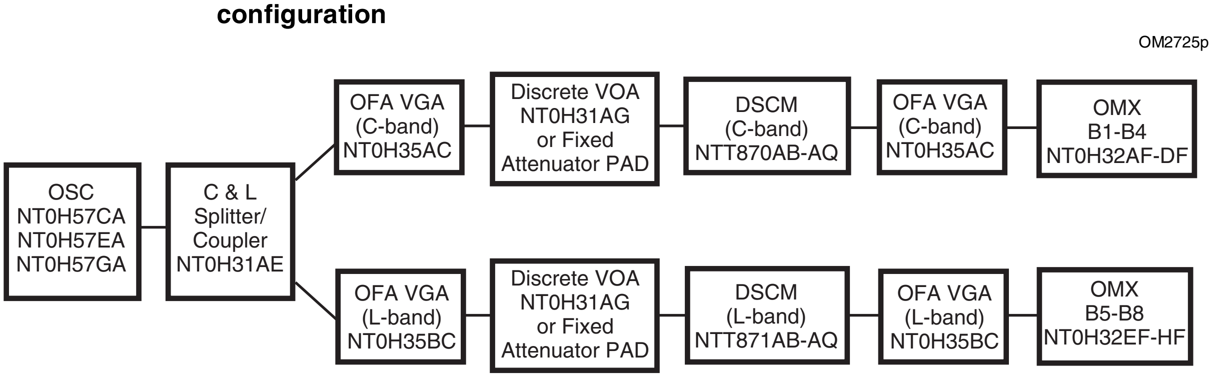
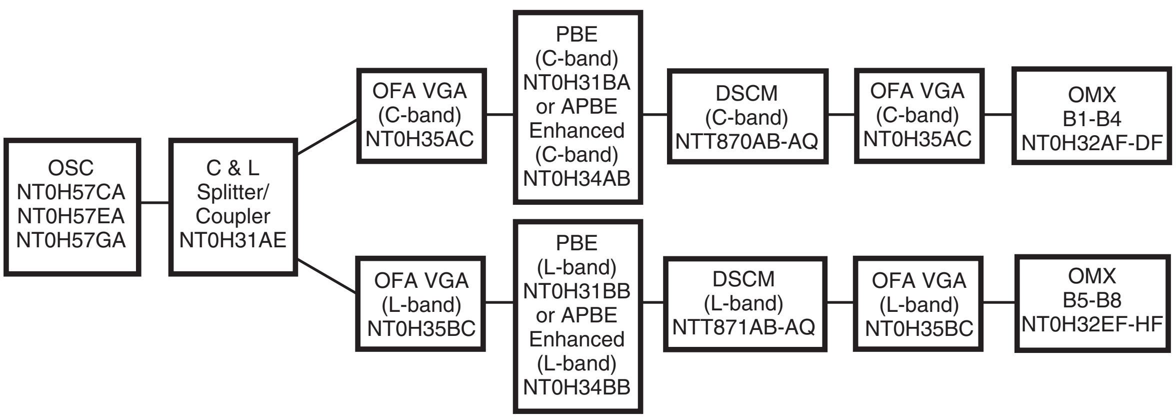


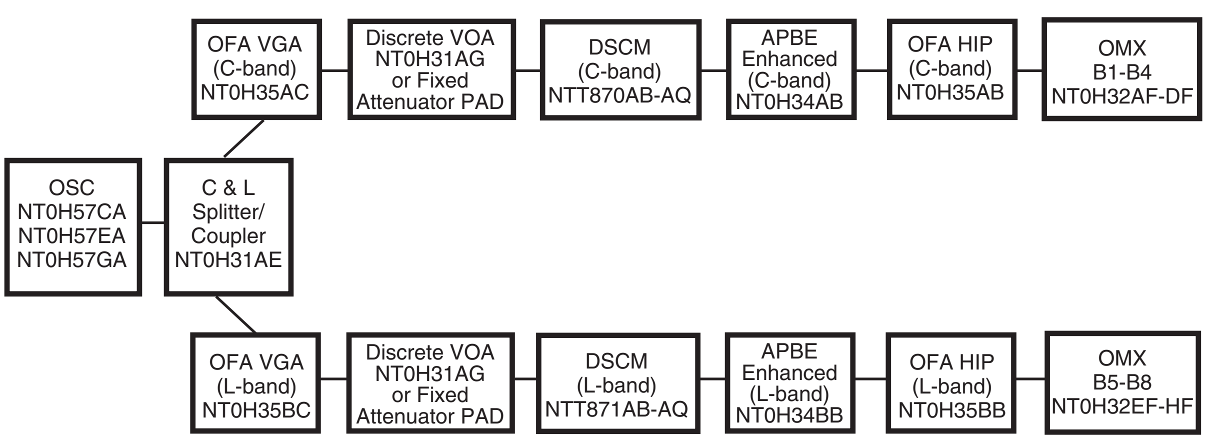
Figure 3-110 shows a receiver topology when equalization is required before the second pre-amplifier. The PBE/APBE Enhanced is used for per-band equalization and is placed before the DSCM. The eVOA in the OFA VGA circuit pack is used to control the aggregate power into the amplifier.

Figure 3-110
Receiver topology with OFA VGA circuit packs in a dual pre-amplifier configuration when equalization is required before the second pre-amplifier



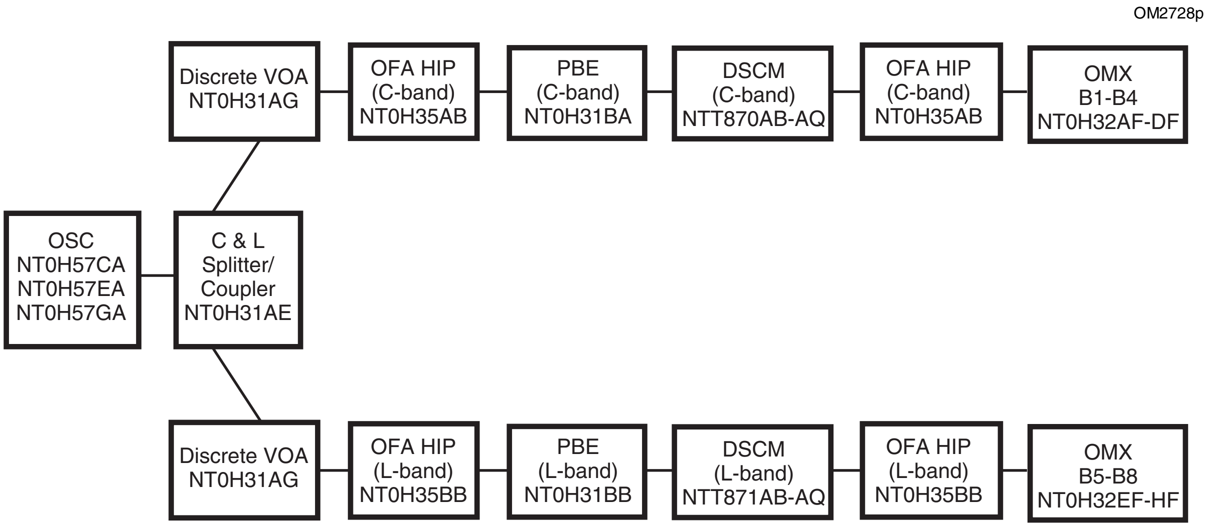
If the OFA HIP circuit pack is the second pre-amplifier then the PBE/APBE Enhanced is used to control both the per-band equalization and the aggregate power. In this case, the PBE/APBE Enhanced must be placed directly before the OFA HIP circuit pack as shown in Figure 3-111. A fixed attenuator pad is required at the OFA output to limit the power into the DSCM.

Figure 3-111
Receiver topology with OFA VGA and OFA HIP circuit packs in a dual pre-amplifier configuration when equalization is required before the second pre-amplifier



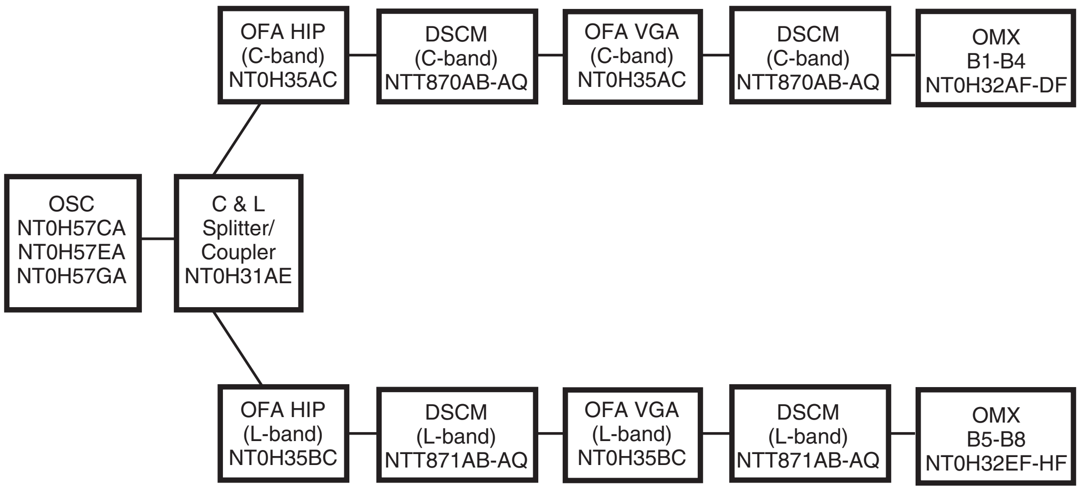
In all of the receiver topologies, the first pre-amplifier can also be a OFA HIP circuit pack as shown in Figure 3-112 on page 3-138. However, a discrete VOA is required at the input to control the aggregate power.

Figure 3-112
Receiver topology with OFA HIP circuit packs in a dual pre-amplifier configuration when equalization is required before the second pre-amplifier



In all of the receiver topologies, a second DSCM can be located after the final pre-amplifier as shown in Figure 3-113 on page 3-139. This is useful when a large amount of compensation is required which would have a high loss. If the second DSCM is placed before the second pre-amplifier, then an unacceptable OSNR hit would occur. A fixed attenuator pad is required at the OFA output to limit the power into the DSCMs.

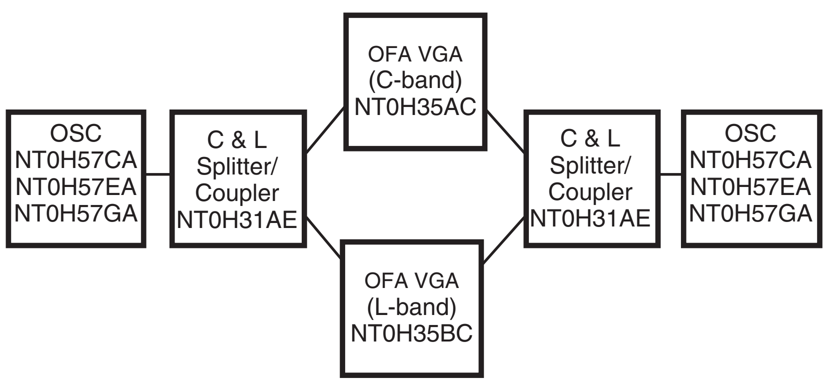
Figure 3-113
Receiver topology with OFA VGA circuit packs in a dual pre-amplifier configuration with two DSCMs



Line amplifier topologies

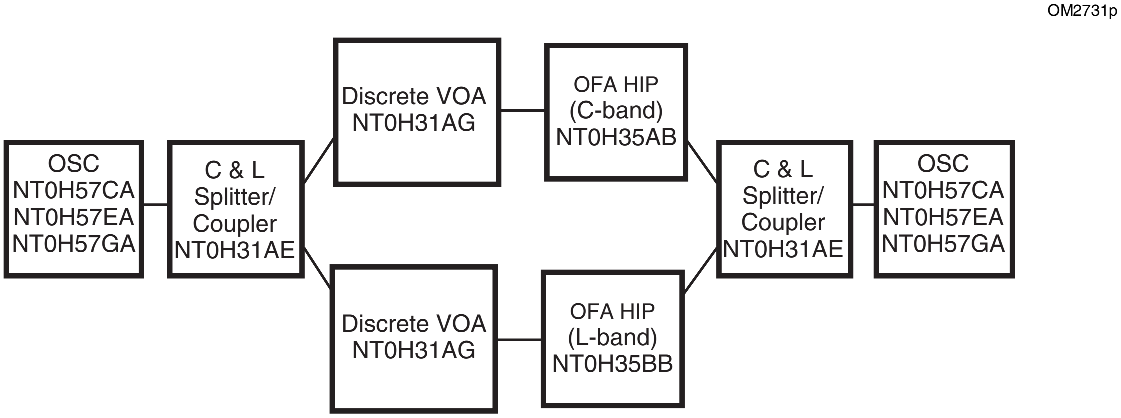
At line amplifier sites where equalization and dispersion compensation are not required, a single amplifier can be deployed as shown in Figure 3-114 on page 3-139. A fixed attenuator pad may be required at the OFA output to limit the power launched into the fiber.

Figure 3-114
Line amplifier topology with no equalization and dispersion compensation using OFA VGA circuit packs



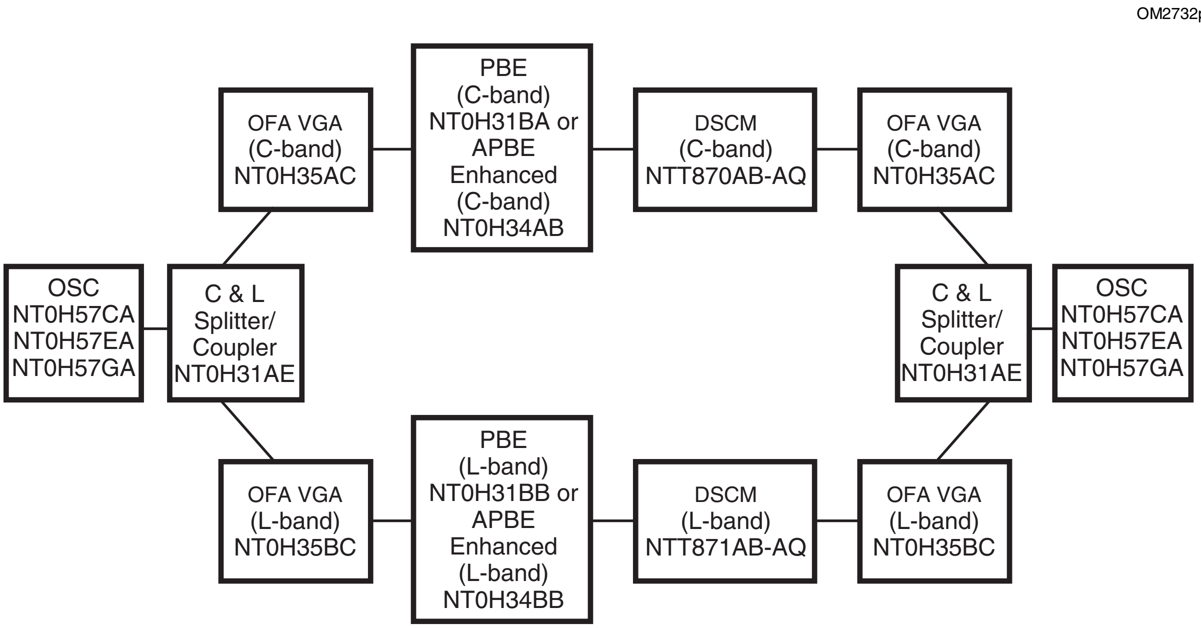
If OFA HIP circuit packs are used, then a discrete VOA is required at the input to the amplifier to control the aggregate power as shown in Figure 3-115 on page 3-140. A fixed attenuator pad may be required at the OFA output to limit the power launched into the fiber.

Figure 3-115
Line amplifier topology with no equalization and dispersion compensation using OFA HIP circuit packs



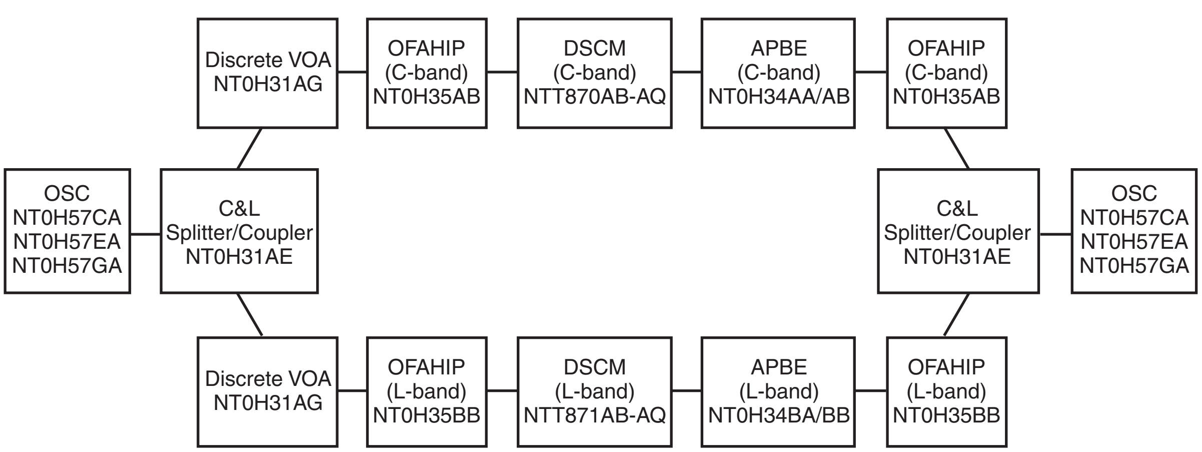
If dispersion compensation or equalization is required at a line amplifier site, a dual line amplifier configuration as shown in Figure 3-116 is required. The PBE/APBE Enhanced is connected before the DSCM and the bands are equalized at the input of the second amplifier. A fixed attenuator pad may be required at the second OFA output to limit the power launched into the fiber.

Figure 3-116
Line amplifier topology with equalization and dispersion compensation using OFA VGA circuit packs



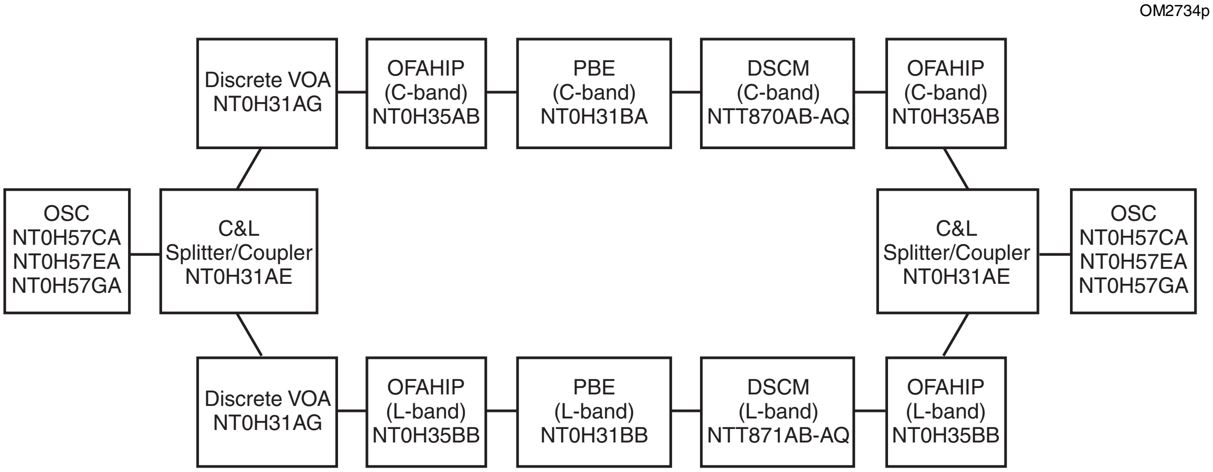
If OFA HIP circuit packs are used, then the PBE/APBE/APBE Enhanced must be connected before the second amplifier so it can control both the aggregate power and the equalization as shown in Figure 3-117. The output of the first amplifier may require attenuating to limit the power into the DSCM. A fixed attenuator pad may be required at the second OFA output to limit the power launched into the fiber.

Figure 3-117
Line amplifier topology with equalization and dispersion compensation using OFA HIP and APBE/APBE Enhanced circuit packs



If a PBE is used in conjunction with an OFA HIP circuit pack, then it should be connected before the DSCM as shown in Figure 3-118 on page 3-141. The bands are equalized at the input of the second amplifier. A fixed attenuator pad may be required at the second OFA output to limit the power launched into the fiber.

Figure 3-118
Line amplifier topology with equalization and dispersion compensation using OFA HIP circuit packs and PBEs



Network interoperability

In this chapter

Interoperability considerations for the OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced, OCI SRM GbE, Muxponder circuit packs

The OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced, OCI SRM GbE, Muxponder 10 Gbit/s GbE/FC and Muxponder 10 Gbit/s GbE/FC VCAT circuit packs provide cost-efficient and flexible transport of leased-line type services across an Optical Metro 5100/5200 or SONET/SDH network.

The OCI SRM GbE/FC and OCI SRM GbE/FC Enhanced circuit packs support Gigabit Ethernet and FC-100/FICON whereas the OCI SRM GbE circuit pack supports Gigabit Ethernet only. The Muxponder 10 Gbit/s GbE/FC circuit pack supports Gigabit Ethernet, FC-100/FICON and FC-200/FICON Express.

ATTENTION

To prevent loss of Fibre Channel traffic between Muxponder and OCI SRM GbE/FC circuit packs, you must ensure that the Frame Check Sequence (FCS) settings at both ends of the connection are the same.

The OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced and OCI SRM GbE circuit packs provide two independent LAN ports allowing for transport of Gigabit Ethernet or FC-100/FICON signals across a SONET/SDH network where the traffic can be groomed, switched and monitored by the network. This can be used to leverage existing SONET/SDH infrastructure for long hauls transport or as a means to terminate Gigabit Ethernet or FC-100/FICON signals that originate at one OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced or OCI SRM GbE circuit pack at two distinct geographic locations.

Efficient use of SONET / SDH network resources and bandwidth is achieved by using the standard Generic Framing Procedures (GFP) and Virtual Concatenation (v-cat) for mapping the non-SONET/SDH signals to a SONET/SDH infrastructure.

The Muxponder 10 Gbit/s GbE/FC circuit pack provides eight independent LAN ports and the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack provides ten independent LAN ports allowing for transport of Gigabit Ethernet, FC-100/FICON or FC-200/FICON Express signals. Unlike the OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced or OCI SRM GbE circuit packs the Gigabit Ethernet, FC-100/FICON or FC-200/FICON Express signals of the Muxponder 10 Gbit/s GbE/FC circuit pack cannot be transported across a SONET/SDH network where the traffic can be groomed, switched and monitored by the network. However, they can be handed off to an Optical Long Haul 1600 Linear Repeater network with the use of the OTR 10 Gbit/s Enhanced circuit pack. See "Implementing interoperable topologies with Muxponder 10 Gbit/s GbE/FC circuit packs" on page 3-59.

Generic framing procedure

The ITU-T recommendation G.7041 standardizes the Generic Framing Procedure (GFP), and coordinates its standardization effort with ANSI T1.105. GFP provides a uniform mapping structure for packet, storage, and future services to the global transport network to minimize the cost of interfaces that support multiple packet data formats. GFP ensures efficient data transport through deterministic, low-overhead, high-integrity mapping, and flexible mapping schemes.

The GFP standard defines two implementations: Transparent GFP (GFP-T), for byte-oriented data streams that require low latency transmission, and Framed-mapped GFP (GFP-F), which maps one frame or packet of client signal in one GFP frame.

The GFP-T mapping scheme is transparent; control characters are encoded and transmitted, not interpreted. However, the far-end GFP client must have knowledge of the client signal type to handle client-specific issues correctly. Client signals are decoded and mapped into GFP-T frames, which can be transmitted immediately without waiting for the reception of an entire client data frame.

In GFP-F and GFP-T, idle frames are inserted as necessary to fill the transport payload. Multiple GFP-F frames can be aggregated in a single SONET payload.

Table 4-1 on page 4-3 identifies the GFP implementations used on the different Optical Metro 5100/5200 circuit packs that support GFP.

Table 4-1
GFP implementation used on Optical Metro 5100/5200 circuit packs

Circuit pack	Protocol	GFP implementation
• OCI SRM GbE/FC • OCI SRM GbE/FC Enhanced	Gigabit Ethernet	GFP-F
	FC-100/FICON	GFP-T
OCI SRM GbE	Gigabit Ethernet	GFP-F
Muxponder 10 Gbit/s GbE/FC (see Note 1 and Note 2)	Gigabit Ethernet	GFP-T
	FC-100/FICON	GFP-T
	FC-200/FICON Express	GFP-T
Muxponder 10 Gbit/s GbE/FC VCAT (see Note 1 and Note 2)	Gigabit Ethernet	GFP-F (default) GFP-T
	FC-100/FICON	GFP-T
	FC-200/FICON Express	GFP-T

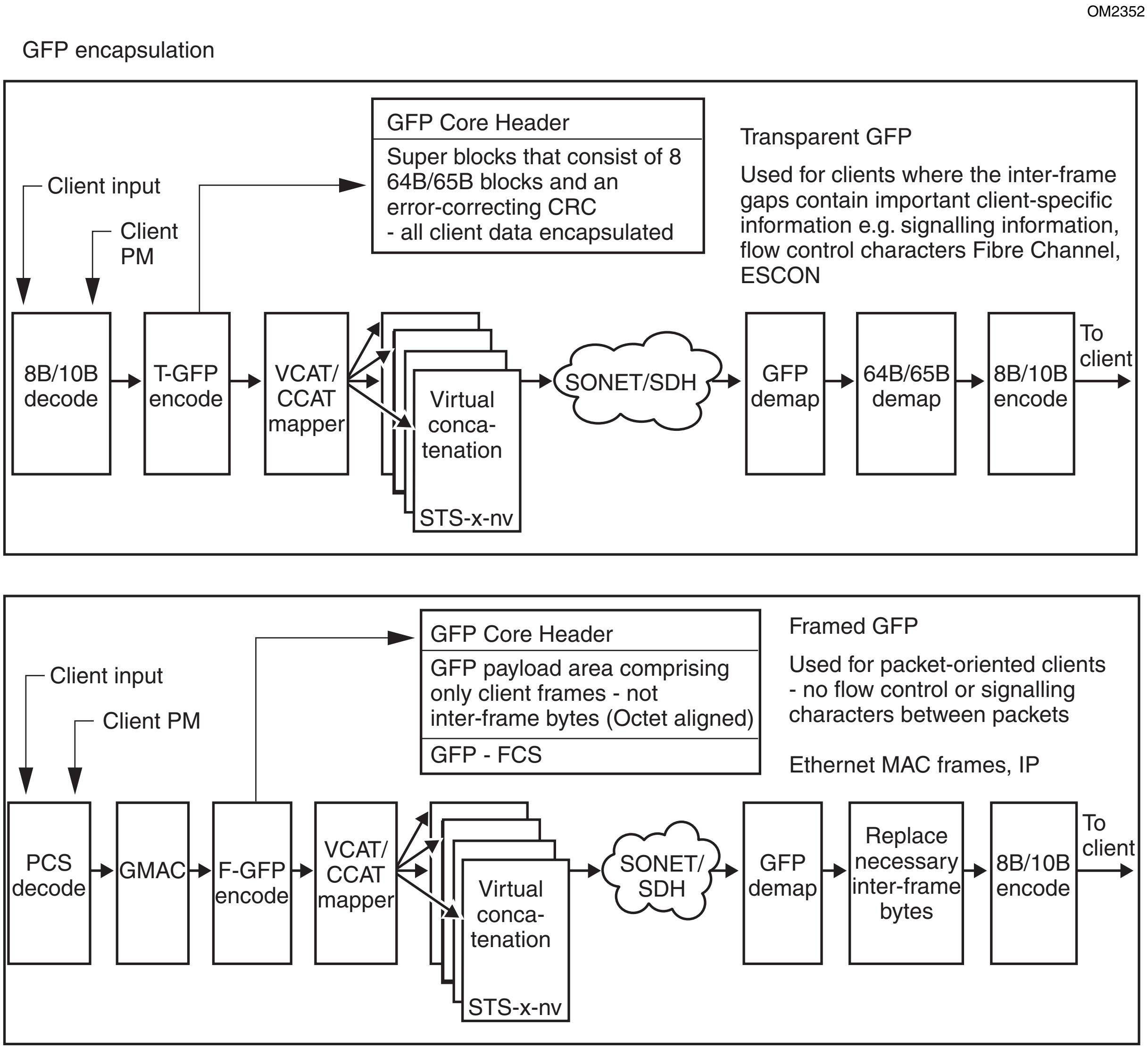
Note 1: The Gigabit Ethernet preamble and frame delimiters are included in the GFP-T frame. In release 8.0, the Gigabit Ethernet LAN Frame Check Sequence (FCS) field can be provisioned to be included in or excluded from the GFP frame.

Note 2: FC-100/FICON, FC-200/FICON Express and Gigabit Ethernet GFP-T encapsulation is transmitted without payload FCS.

FC symbols are encoded in a GFP-T frame according to G.7041 section 8. 8B/10B symbols are encoded into 64B/65B blocks (a form of symbol compression where DC balancing, error code and disparity information is lost but D and K values are preserved, achieving almost 20% compression). Eight 64B/65B blocks are grouped together as a “super block”. Each super block has an error correcting 16 bit CRC appended. Finally several super-blocks are grouped into a GFP-T frame.

Figure 4-1 shows how GFP encapsulation is executed for Transparent and Frame-mapped GFP.

Figure 4-1
GFP encapsulation



Concatenation modes and STS mapping

There are two types of concatenation modes used in the Optical Metro 5100/5200 network: contiguous concatenation and virtual concatenation.

Contiguous concatenation

Contiguously concatenated (c-cat) circuits occupy contiguous positions in the SONET/SDH frame and are grouped together to form one circuit. The path overhead in the first concatenated circuit applies to the entire concatenated group (for example, STS12c/VC4-4c, and so on). Contiguously concatenated groups form one path across the network and are routed within a SONET/SDH network as one entity. See Figure 4-2 for an example of contiguous concatenation.

Virtual concatenation

Virtual concatenation (v-cat) allows the bandwidth to be combined from smaller STS groups to virtually create a larger STS group. A virtually concatenated group can be made up of one or more contiguously concatenated groups. Unlike c-cat groups, v-cat groups are a set of distinct circuits that have separate and possibly diverse, paths across the network which allows a user to tune the bandwidth in small increments on demand. At the far end, the paths are reassembled to form the originally transmitted v-cat group. See Figure 4-3 on page 4-6 for an example of virtual concatenation.

The OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced and OCI SRM GbE maps GFP frames into SONET/SDH STS circuits which may be contiguous concatenated or virtually concatenated. The Muxponder 10 Gbit/s GbE/FC maps GFP frames into SONET/SDH STS circuits which must be contiguous concatenated. This circuit pack does not support virtual concatenation.

Figure 4-2
Example of contiguous concatenation

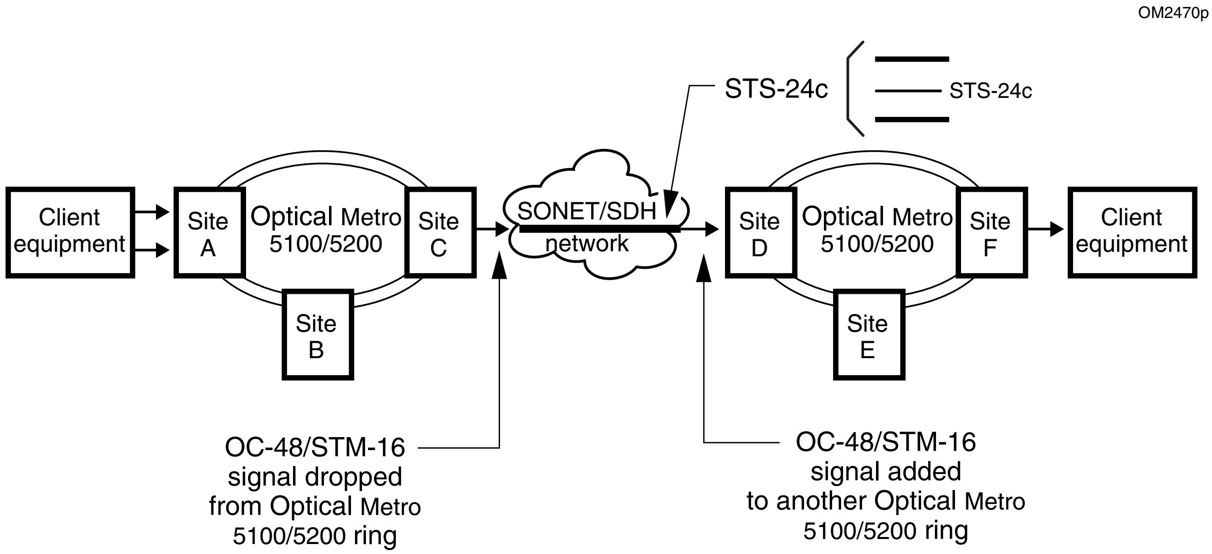
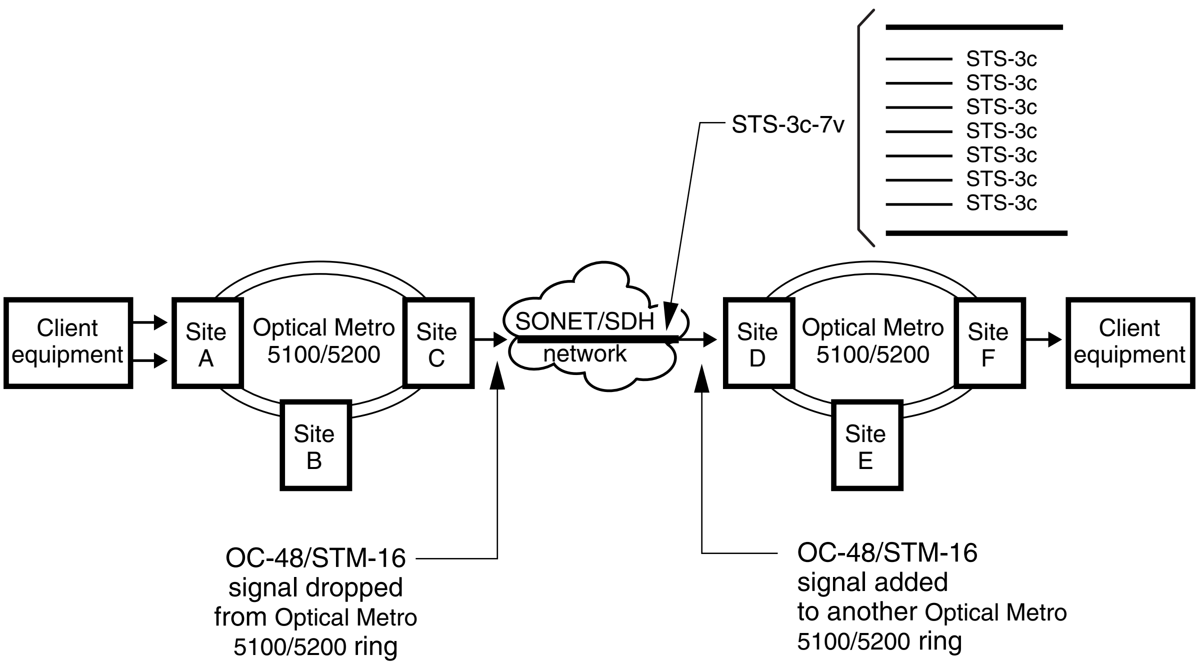


Figure 4-3
Example of virtual concatenation



Provisioning concatenation modes on the OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced and OCI SRM GbE circuit packs

The concatenation mode is determined in the provisioning of the aggregate facility.

C-cat circuits are circuits that occupy contiguous positions in the SONET/SDH frame and are grouped together to form one circuit. The path overhead in the first concatenated circuit applies to the entire concatenated group. C-cat groups form one path across the network. When c-cat is used, a single port is allocated as an STS-12c, STS-24c, or STS-48c only. In this case, the choice of where to place the STS group is fixed mapped.

> ***Note:*** STS-48c can only be provisioned on Port 1 and only when Port 2 is not provisioned.

Virtual concatenation makes it possible to increase the bandwidth of a port by allowing you to provision the bandwidth in small increments on demand. V-cat groups are a set of distinct circuits that have separate and possibly diverse paths across the network. At the far-end, the paths are reassembled to form the originally transmitted v-cat group. The smallest granularity of v-cat groups is restricted to STS-3c and the placement of the STS-3c groups must be aligned properly in the STS-48 pipe. This can provide a cost saving when interoperating with a SONET/SDH network.

Depending on the concatenation type and transport mode that you provisioned for the aggregate facility, and the bit rate that you provision for the client-side facility while making the channel assignment, the Transport drop-down list on the Channel assignments dialog box displays different entries for provisioning path assignments.

See Table 4-2 if the concatenation type is c-cat and Table 4-3 if the concatenation type is v-cat.

Table 4-2
Provisionable bit rates for contiguous concatenation

Bit rate/ Protocol	# of STS-3c/ VC-4 groups	SONET			SDH		
		SONET transport structure	Port 1 default STS-3c groups	Port 2 default STS-3c groups	SDH transport structure	Port 1 default VC-4 groups	Port 2 default VC-4 groups
FC-100 FICON	4	STS-12c (see Note 2)	1–12	25–36	VC-4-4c (see Note 2)	1–4	9–12
	8	STS-24c	1–24	25–48	VC-4-8c	1–8	9–16
	16	STS-48c	1–48	—	VC-4-16c	1–16	—
Gigabit Ethernet	4	STS-12c	1–12	25–36	VC-4-4c	1–4	9–12
	8	STS-24c	1–24	25–48	VC-4-8c	1–8	9–16
	16	STS-48c	1–48	—	VC-4-16c	1–16	—

Note 1: The default for FC-100 and GigE is STS-24c.

Note 2: The STS-12c/VC-4-4c transport structure can only be provisioned on the OCI SRM GbE/FC Enhanced circuit pack when the subrate parameter is set to Enabled.

Table 4-3
Provisionable bit rates for virtual concatenation

Bit rate/ Protocol	# of STS-3c/ VC-4 groups	SONET			SDH		
		SONET transport structure	Port 1 default STS-3c groups	Port 2 default STS-3c groups	SDH transport structure	Port 1 default VC-4 groups	Port 2 default VC-4 groups
Gigabit Ethernet FC-100 FICON	1	STS-3c-1v	1–3	25–27	VC-4-1v	1	9
	2	STS-3c-2v	1–6	25–29	VC-4-2v	1–2	9–10
	3	STS-3c-3v	1–9	25–33	VC-4-3v	1–3	9–11
	4	STS-3c-4v	1–12	25–36	VC-4-4v	1–4	9–12
	5	STS-3c-5v	1–15	25–39	VC-4-5v	1–5	9–13
	6	STS-3c-6v	1–18	25–42	VC-4-6v	1–6	9–14
	7	STS-3c-7v	1–21	25–45	VC-4-7v	1–7	9–15
	0	Nil	—	—	Nil	—	—

Note 1: Provisioning FC-100 with lower than STS-3C-6v or VC-4-6v will result in an Insufficient Link Capacity alarm when using the OCI SRM GbE/FC circuit pack or when using the OCI SRM GbE/FC Enhanced circuit pack with the subrate parameter set to Disabled.

Note 2: The default for FC-100 is STS-3c-6v. The default for Gigabit Ethernet is STS-3c-7v.

Provisioning concatenation modes on the Muxponder circuit packs

Muxponder 10 Gbit/s GbE/FC circuit pack

The Muxponder 10 Gbit/s GbE/FC circuit pack supports fixed path assignments and contiguous concatenation (C-cat) mode with the following rules:

- STS-24c/VC-4-8c contiguous concatenation (C-cat) mode is supported on ports 1 to 8
- STS-48c/VC-4-16c C-cat mode is supported on ports 1, 3, 5 and 7
- Client ports 1 to 8 support STS-24c/VC-4-8c for Gigabit Ethernet, FC-100, and FICON
- Client ports 1, 3, 5 and 7 support STS 48c/VC-4-16c for FC-200 and FICON Express
- Channel assignment provisioning on ports 9 and 10 is not supported on this circuit pack
- Table 4-4 lists the fixed-mapping assignments for the STS-24c/VC-4-8c and STS-48c/VC-4-16c contiguously concatenated groups

Table 4-4
Fixed mapping assignments for the Muxponder 10 Gbit/s GbE/FC circuit pack

Port #	Port assignment rate	SONET Transport Structure	SDH Transport Structure	SONET Path assignments	SDH Path assignments
1	GbE, FC-100, FICON or FC-200, FICON Express	STS-24c or STS-48c	VC-4-8c or VC-4-16c	1-24 or 1-48	1-8 or 1-16
2	GbE, FC-100, FICON or not provisioned if port 1 is provisioned as FC-200, FICON Express	STS-24c or not applicable	VC-4-8c or not applicable	25-48 or not applicable	9-16 or not applicable
3	GbE, FC-100, FICON or FC-200, FICON Express	STS-24c or STS-48c	VC-4-8c or VC-4-16c	49-72 or 49-96	17-24 or 17-32
4	GbE, FC-100, FICON or not provisioned if port 3 is provisioned as FC-200, FICON Express	STS-24c or not applicable	VC-4-8c or not applicable	73-96 or not applicable	25-32 or not applicable
5	GbE, FC-100, FICON or FC-200, FICON Express	STS-24c or STS-48c	VC-4-8c or VC-4-16c	97-120 or 97-144	33-40 or 33-48
6	GbE, FC-100, FICON or not provisioned if port 5 is provisioned as FC-200, FICON Express	STS-24c or not applicable	VC-4-8c or not applicable	121-144 or not applicable	41-48 or not applicable
7	GbE, FC-100, FICON or FC-200, FICON Express	STS-24c or STS-48c	VC-4-8c or VC-4-16c	145-168 or 145-192	49-56 or 49-64

Table 4-4
Fixed mapping assignments for the Muxponder 10 Gbit/s GbE/FC circuit pack

Port #	Port assignment rate	SONET Transport Structure	SDH Transport Structure	SONET Path assignments	SDH Path assignments
8	GbE, FC-100, FICON or not provisioned if port 7 is provisioned as FC-200, FICON Express	STS-24c or not applicable	VC-4-8c or not applicable	145-192 or not applicable	49-64 or not applicable
9	Not supported				
10	Not supported				

Muxponder 10 Gbit/s GbE/FC VCAT circuit pack

The Muxponder 10 Gbit/s GbE/FC VCAT circuit pack supports both contiguous concatenation (C-cat) mode and virtual concatenation (V-cat) mode. This results in the following advantages (detailed in Table 4-5 on page 4-10):

- increases the number of services supported
- increases bandwidth utilization efficiency

Table 4-5
Full rate efficiencies with the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack

Protocol	C-cat Transports		C-cat efficiency	V-cat Transports		V-cat efficiency
	SONET	SDH		SONET	SDH	
GbE	STS-24c X 8	VC-4-8c X 8	(8*21)/192=88%	STS-3c-7v X 9	VC-4-7v X 9	(9*21)/192=98%
FC-100 FICON	STS-24c X 8	VC-4-8c X 8	(8*18)/192=75%	STS-3c-6v X 10	VC-4-6v X 10	(10*18)/192=94%
FC-200 FICON Express	STS-48c X 4	VC-4-16c X 8	(4*36)/192=75%	STS-3c-12v X 5	VC-4-12v X 5	(5*36)/192=94%

The Muxponder 10 Gbit/s GbE/FC VCAT circuit pack also adds more flexibility by supporting flexible mapping assignments with the following rules:

- The circuit pack has a total of 192 STS-1s/VC-3s that can be utilized in various combinations on any of the client-side ports. This is a an STS/VC pool of paths that can be associated with any of the ten client-side ports. The smallest granularity supported is STS-3c/VC-4.

- Unlike the OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced, OCI SRM GbE and Muxponder 10 Gbit/s GbE/FC circuit packs, the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack does not have any of the 192 STS-1/VC-3 paths fixed mapped to any of the client-side ports.
- Each client-side port can have up to 48 STS-1s/VC-3s (through the provisioning of an STS-48c/VC-4-16c) provisioned against it. A maximum of 4 client-side ports can be provisioned this way, rendering the remaining 6 ports unable to carry any traffic.
- Unlike the OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced, OCI SRM GbE and Muxponder 10 Gbit/s GbE/FC circuit packs, provisioning STS-48c/VC-4-16c on a port does not render the subsequent port unavailable for use.
- A user can add more paths or delete existing paths as required provided the path is available in the pool of available STSs/VCs. This operation is service affecting.
- V-cat connections must be of the STS-3c/VC-4 granularity.
- Although there may be enough STS-1s/VC-3s available for a C-cat connection (in terms of number of paths or bandwidth), they must be contiguous in nature in order to provision the STS-Xc transport structure (where X can be 3, 12, 24, 48). For example, STS-1 numbers 1-9 and 16-18 may be available but this cannot be used to provision an STS-12c.
- All provisionable paths are STS-3c/VC-4 aligned. Meaning, STS-2 or STS-3 is not used to provision the start of an STS-Xc or STS-3c-Xv connection.

- All provisionable paths cannot cross their natural boundary. See Table 4-6 and Table 4-7 on page 4-13.

Table 4-6
Flexible C-cat mapping assignments for the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack

Port Assignment Rate	Encapsulation	SONET Transport Structure	SDH Transport Structure	Port to Path Mapping (Flex vs Fixed)	Allowed SONET paths and rules	Allowed SDH paths and rules
GbE (bidirectional, uni-add and uni-drop connections)	GFP-F	STS-3c	VC-4-1c	Flex	3n+1, where n=0...63	n = 1 to 64
		STS-12c	VC-4-4c	Flex	1, 13, 25, 37, 49, 61, 73, 85, 97, 109, 121, 133, 145, 157, 169, 181	1, 5, 9, 13, 17, 21, 25, 29, 33, 37, 41, 45, 49, 53, 57, 61
		STS-24c	VC-4-8c	Flex	1, 25, 49, 73, 97, 121, 145, 169	1, 9, 17, 25, 33, 41, 49, 57
		STS-48c	VC-4-16c	Flex	1, 49, 97, 145	1, 17, 33, 49
	GFP-T	STS-24c	VC-4-8c	Flex	1, 25, 49, 73, 97, 121, 145, 169	1, 9, 17, 25, 33, 41, 49, 57
		STS-48c	VC-4-16c	Flex	1, 49, 97, 145	1, 17, 33, 49
FC-100 FICON	GFP-T	STS-24c	VC-4-8c	Flex	1, 25, 49, 73, 97, 121, 145, 169	1, 9, 17, 25, 33, 41, 49, 57
		STS-48c	VC-4-16c	Flex	1, 49, 97, 145	1, 17, 33, 49
FC-200 FICON Express	GFP-T	STS-48c	VC-4-16c	Flex	1, 49, 97, 145	1, 17, 33, 49

Note 1: Note that protocols such as GbE, FC-100 and FICON only require STS-24c/VC-4-16c in order to carry the maximum capacity. STS-48c/VC-4-16c is offered for these protocols for interoperability reasons. However, FC-200 and FICON Express require a full STS-48c/VC-4-16c to do full rate.

Note 2: GbE is the only protocol allowed to be provisioned as sub-rate (provided that GFP-F is used). When provisioned as GFP-T, no sub-rate capabilities or AN / PAUSE is possible.

Table 4-7
Flexible V-cat mapping assignments for the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack

Port Assignment Rate	Encapsulation	SONET Transport Structure	SDH Transport Structure	Port to Path Mapping (Flex vs Fixed)	Allowed SONET/SDH paths and rules
GbE (bidirectional, uni-add and uni-drop connections)	GFP-F	STS-3c-1v	VC-4-1v	Flex	SONET: All V-cat paths can start at 3n+1, where n=0...63 SDH: All V-cat paths can start at n, where n=1...64
		STS-3c-2v	VC-4-2v	Flex	
		STS-3c-3v	VC-4-3v	Flex	
		STS-3c-4v	VC-4-4v	Flex	
		STS-3c-5v	VC-4-5v	Flex	
		STS-3c-6v	VC-4-6v	Flex	
		STS-3c-7v	VC-4-7v	Flex	
GbE (bidirectional, uni-add and uni-drop connections)	GFP-T	STS-3c-7v	VC-4-7v	Flex	• SONET: All V-cat paths can start at 3n+1, where n=0...63 • SDH: All V-cat paths can start at n, where n=1...64 • When using GFP-T, must run with full rate, no subrate transports are supported
FC-100 FICON	GFP-T	STS-3c-6v	VC-4-6v	Flex	• SONET: All V-cat paths can start at 3n+1, where n=0...63 • SDH: All V-cat paths can start at n, where n=1...64 • Must run with full rate, no subrate transports are supported • STS-3c-6v/VC-4-6v is sufficient to carry the maximum capacity. STS-3c-7v/VC-4-7v is offered for interoperability reasons (this will however reduce the number of FC-100/FICON ports supported from 10 to 9)
		STS-3c-7v	VC-4-7v	Flex	

Table 4-7
Flexible V-cat mapping assignments for the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack

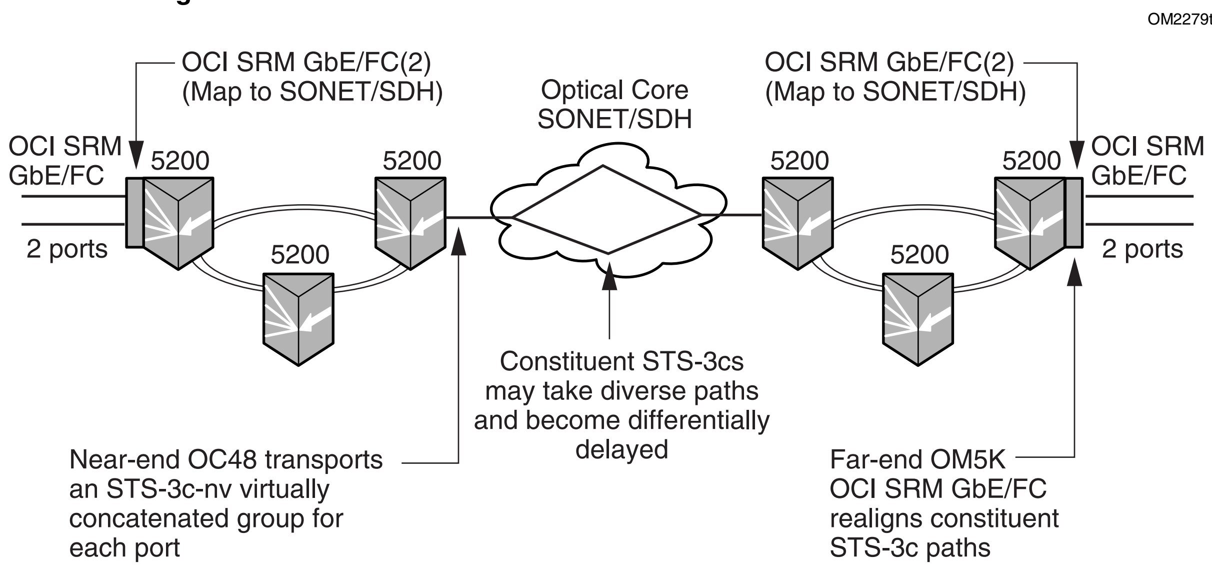
Port Assignment Rate	Encapsulation	SONET Transport Structure	SDH Transport Structure	Port to Path Mapping (Flex vs Fixed)	Allowed SONET/SDH paths and rules
FC-200 FICON Express	GFP-T	STS-3c-12v	VC-4-12v	Flex	• SONET: All V-cat paths can start at 3n+1, where n=0...63 • SDH: All V-cat paths can start at n, where n=1...64 • Must run with full rate, no subrate transports are supported • STS-3c-12v/VC-4-12v is sufficient to carry the maximum capacity. STS-3c-13v/VC-4-13v is offered for interoperability reasons (this will however reduce the number of FC-200/FICON Express ports supported from 5 to 4)
		STS-3c-13v	VC-4-13v	Flex	
Note: When provisioning V-cat paths, the “Insufficient Link Capacity” alarm is raised until the required amount of paths have been provisioned as shown above.					

Diverse routing

Diverse routing allows constituent paths of a VCAT group to diversely routed in a SONET/SDH network and to reconstituted at the far end OCI SRM GbE/FC, OCI SRM GbE/FC Enhanced or OCI SRM GbE with differential delays of up to 14 ms, as shown in Figure 4-4.

> ***Note:*** Diverse routing is not applicable for the Muxponder 10 Gbit/s GbE/FC circuit pack since it does not support virtual concatenation.

Figure 4-4
Diverse routing



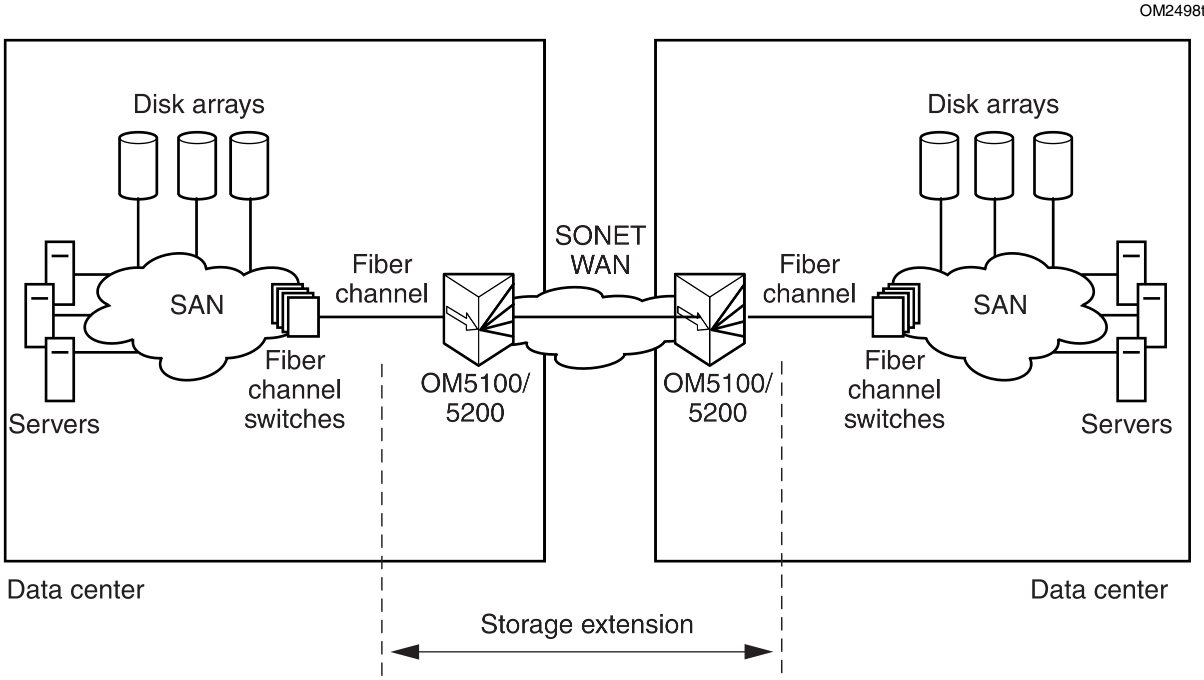
In Optical Metro 5100/5200 Release 6.0, differential delay memory is disabled. You must enable differential delay memory after upgrading to Release 6.1 or 7.0 in order implement diverse routing. Failure to do so may cause the Loss of Frame Delineation alarm to be raised if the V-cat diverse routing feature is used. Differential delay memory can be enabled by putting the OCI SRM GbE/FC or OCI SRM GbE/FC Enhanced equipment in the Out-Of-Service state and then returning the equipment back in the In-Service state.

Fibre Channel Extended Reach

Fibre Channel extended reach avoids inherent throughput degradation due to FC R_RDY protocol for distances up to 987 km at full rate or about 5900 km at sub-rate (STS3c), see Figure 4-5. Using FC at sub-rate provides the benefit of extending the reach beyond 900 km while utilizing 100% of the available WAN bandwidth.

> ***Note:*** Fibre Channel Extended Reach is only supported on OCI SRM GbE/FC Enhanced circuit packs.

Figure 4-5
Optical Manager 5100/5200 storage

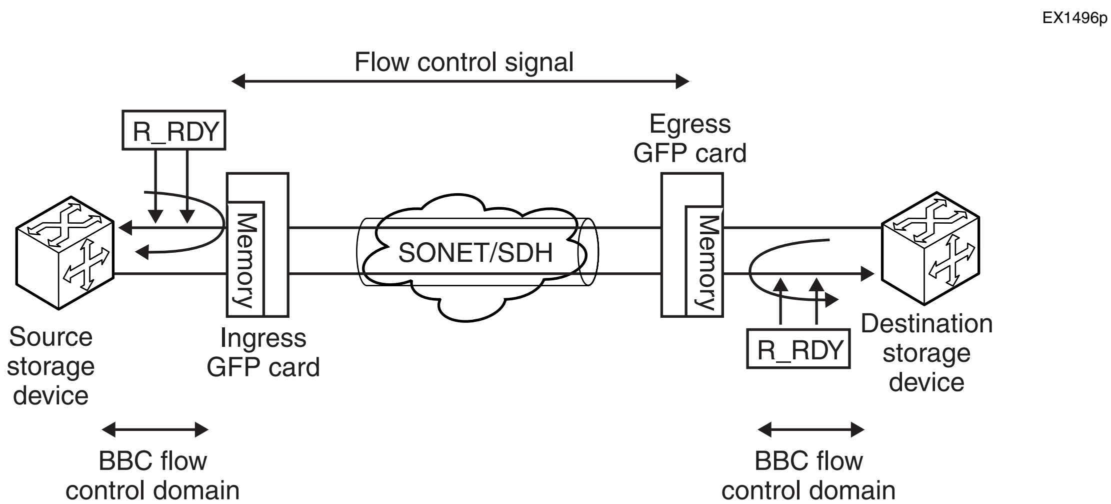


Storage networks cannot tolerate data discard. Fibre Channel devices employ a credit-based flow control mechanism to guarantee delivery between storage devices in the network and to ensure that the rate at which the data is sent by the source does not exceed that at which it can be received at the destination. To establish a link by link flow control, ports of the two connected storage devices first exchange and agree on the number of frames each can receive. This is called the Buffer-to-Buffer Credit (BBC). Whenever the source device sends out a frame, it increments the credit counter (or BBC counter) by 1. The receiving device will send back an acknowledgement message, called R_RDY, upon receipt of each transmitted frame. Once the source device receives the R_RDY, it lowers the BBC counter by 1. If the BBC counter reaches the previously agreed credit threshold, the source device simply stops sending frames until the BBC counter is lowered below its threshold by receiving another R_RDY from the destination. When storage needs to be extended over distance, the storage devices need to provide a sufficient number of buffer credits to compensate for the latency introduced by the link so that the system can still achieve maximum link efficiency Optical Metro 5100/5200 storage extension solution offers the ability to transport Fibre Channel traffic over 1,000 of kilometers. Optical Metro 5100/5200 solution enables service providers to offer a fully managed service, independent of the end user devices. Fibre Channel client traffic can be mapped into both full-rate and sub-rate SONET/SDH signal.

To support storage extension over very long distances, the Optical Metro 5100/5200 platform is equipped with buffering and flow control functionality to ensure high throughput without requiring large buffer credits from the storage devices. The implementation is illustrated in Figure 4-6.

In this solution, BBC Flow control is implemented between a source storage device and the ingress Optical Metro 5100/5200 as well as between the egress Optical Metro 5100/5200 and the destination storage device. Flow control signals are used for flow control between the Nortel Networks network elements. This solution is transparent to the source and destination storage devices. The Optical Metro 5100/5200 intercepts login and other messages from the source storage device and transmits them to the destination storage device. As far as they are concerned, the storage devices believe they are connected to each other. This is important for service providers to be able to offer a Storage Private Line service with an effective demarcation point.

Figure 4-6
GFP and Flow Control Enable Distance Extension



As the source storage device sends a Fibre Channel frame, the ingress Optical Metro 5100/5200 transmits it over the WAN connection and then returns an R_RDY to the source device. This mechanism ensures the source storage device never reaches its maximum allowed BBC count, and so enables it to maintain full throughput even at very long distances. On egress, the Optical Metro 5100/5200 will send frames to the destination storage device only at the rate at which this device sends out R_RDY. This will ensure that the rate at which the data is sent by the egress Optical Metro 5100/5200 does not exceed that at which it can be received by the destination storage device.

If congestion should occur at the destination storage device, it would begin withholding R_RDYs from the egress Optical Metro 5100/5200. All transmitted Fibre Channel frames are buffered in the egress Optical Metro

5100/5200 card memory. When a certain memory threshold is reached, a flow control signal is sent to the ingress Optical Metro 5100/5200 to stop the transmission of Fibre Channel frames. Upon receipt of these flow control messages, the ingress Optical Metro 5100/5200 would in turn withhold R_RDYs from the source storage device. This mechanism ensures that downward pressure is cascaded upstream to the source of the traffic until congestion abates. Table 4-8 lists the supported distances based on the available WAN bandwidth.

Table 4-8
Fibre Channel extended reach sample distances

Path configuration	**Round Trip Delay (µs)** See Note 1	**Equivalent Distance (km)** See Note 2
STS-3c-6v	9870	987
STS-3c-5v	11820	1182
STS-3c-4v	14770	1477
STS-3c-3v	19690	1969
STS-3c-2v	29540	2954
STS-3c-1v	59080	5908
STS-48c	9870	987
STS-24c	9870	987
STS-12c	14770	1477

Note 1: When measuring round trip delay using Procedure 3-17 “Measuring round trip delay on a client-side port” in *Provisioning and Operating Procedures*, 323-1701-310, be aware that round trip latency measurement (RTDELAY) returns the network latency to an accuracy of ±1 ms.

Note 2: These approximations assume no network propagation delays, and a 5 microsecond per kilometer fiber propagation delay.

Provisioning BBC Override for Fibre Channel Extended Reach applications

When the Fibre Channel Extended Reach option is enabled on the OCI SRM GbE/FC Enhanced circuit pack (by setting the EXTREACH and SUBRATE parameters to Enabled), the following BBC Override values can be provisioned on the OCI SRM GbE/FC Enhanced circuit pack: Disable, 1, 2, 4, 8, 16, 32, 64, 128. When connecting FC switch E-ports to the OCI SRM GbE/FC Enhanced, the BBC value is snooped and does not need to be overridden. In this case, the BBC Override value must be set to Disable. When connecting F or N ports (for example, Disk Arrays, Fibre Channel Host Bus Adapters, Testsets) directly to the OCI SRM GbE/FC Enhanced, the BBC Override value must be set to match the BBC value of the F or N port.

Fibre Channel interoperability considerations with subtending equipment

The following represent Fibre Channel interoperability considerations with subtending equipment:

- Vendor-defined flow control for Fibre Channel that is not defined within the standard is not supported. The Muxponder 10 Gbit/s GbE/FC, OCI SRM GbE/FC and OCI SRM GbE/FC Enhanced circuit packs do not support FC-AL or any primitives within this standard. Any Fibre Channel switch vendor's implementation that defines an alternate flow control mechanism that uses FC-AL primitives on a point to point link is not supported. Contact your Fibre Channel switch vendor to determine how to disable the use of FC-AL based flow control.
- When connected to a pair of Fibre Channel devices that support the autonegotiation (AN) of 1G and 2G link speeds, the speed of the ports connected to the
  - — OCI SRM GbE/FC and OCI SRM GbE/FC Enhanced circuit packs must be manually set to 1G (FC-100)
  - — Muxponder 10 Gbit/s GbE/FC port provisioned as FC-100 must be manually set to 1G (FC-100)
  - — Muxponder 10 Gbit/s GbE/FC port provisioned as FC-200 must be manually set to 2G (FC-200)

Clock synchronization

OCI SRM SONET/SDH LTE

The OCI SRM SONET/SDH LTE circuit pack supports the following timing features:

- Six possible timing references (see "Timing references" on page 4-19 for more information)
- primary and secondary timing references
- synchronization status messages (SSM) (S1 byte)
- the ability to force "do not use for synchronization" (DUS) on a per-port basis in the TX direction
- automatic DUS messaging on the TX direction of any port used as a timing reference

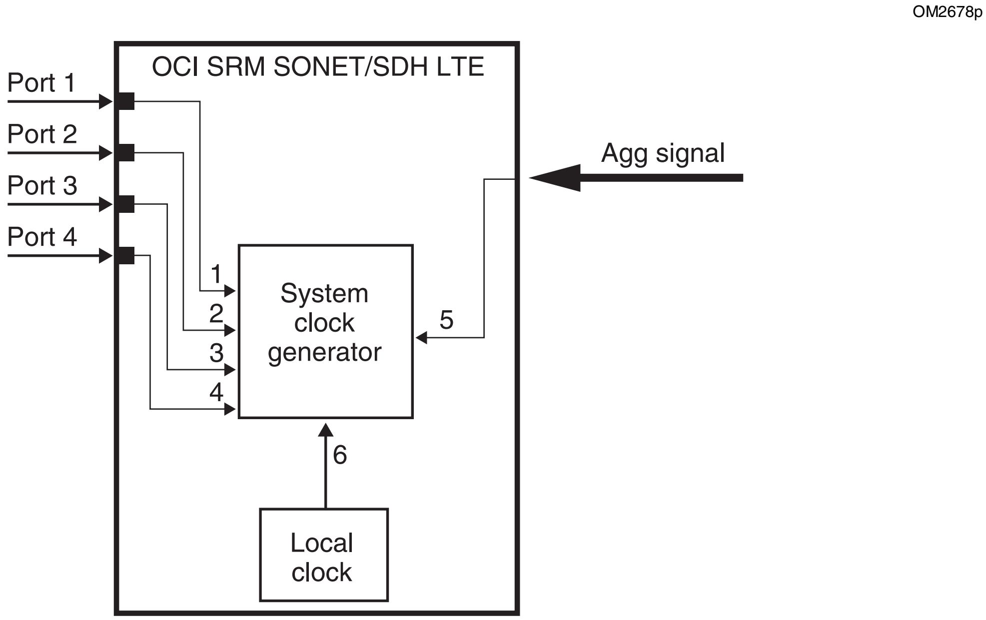
Timing references

The OCI SRM SONET/SDH LTE circuit pack supports the following six different timing references.

- onboard local clock
- ports 1 through 4
- aggregate RX signal

These timing references are used to synchronize the system clock, which in turn is used to time all outgoing data signals. Figure 4-7 on page 4-20 shows the different possible timing references.

Figure 4-7
OCI SRM SONET/SDH LTE timing references



In order to provide robust timing distribution, the OCI SRM SONET/SDH LTE circuit pack supports a primary and secondary timing reference. By default, the OCI SRM SONET/SDH LTE circuit pack is provisioned to use the local clock as its primary (and only) timing reference. This default setup can be changed by selecting an optical port, or the aggregate signal as the primary or secondary timing reference.

It is not recommended to select an optical port as a timing reference and the aggregate signal as the other timing reference as this may lead to standing synchronization alarms. Table 4-9 lists some OCI SRM SONET/SDH LTE timing reference provisioning examples.

Table 4-9
OCI SRM SONET/SDH LTE timing reference provisioning

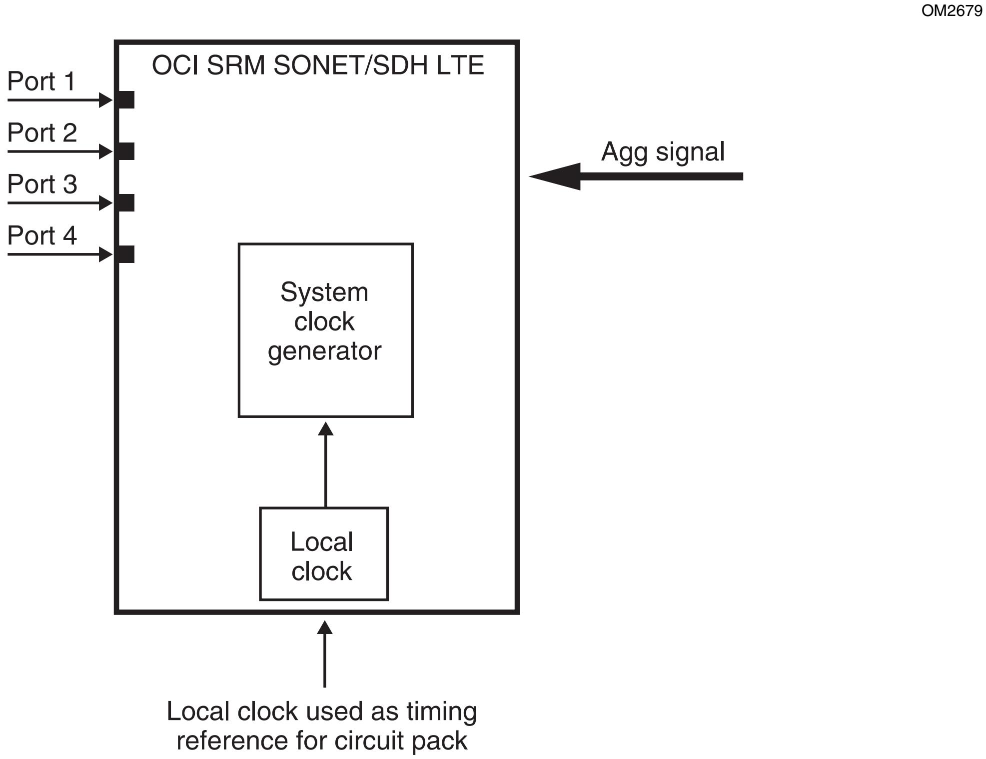
	Primary timing reference	Secondary timing reference
Recommended	Port 1	Port 2
	Port 1	Port 4
	Port 3	Port 4
	Port 1	not provisioned
	Aggregate RX signal	not provisioned
	not provisioned	not provisioned
Not recommended	Port 1	Aggregate RX signal
	Aggregate RX signal	Port 2

Local timing

Local timing is easy to implement as it uses the default setup for the OCI SRM SONET/SDH LTE circuit pack and takes advantage of the onboard clock (Free Run mode), which provides a Stratum 3 quality timing signal.

Figure 4-8 on page 4-22 shows an example of local timing.

Figure 4-8
Local timing scenario

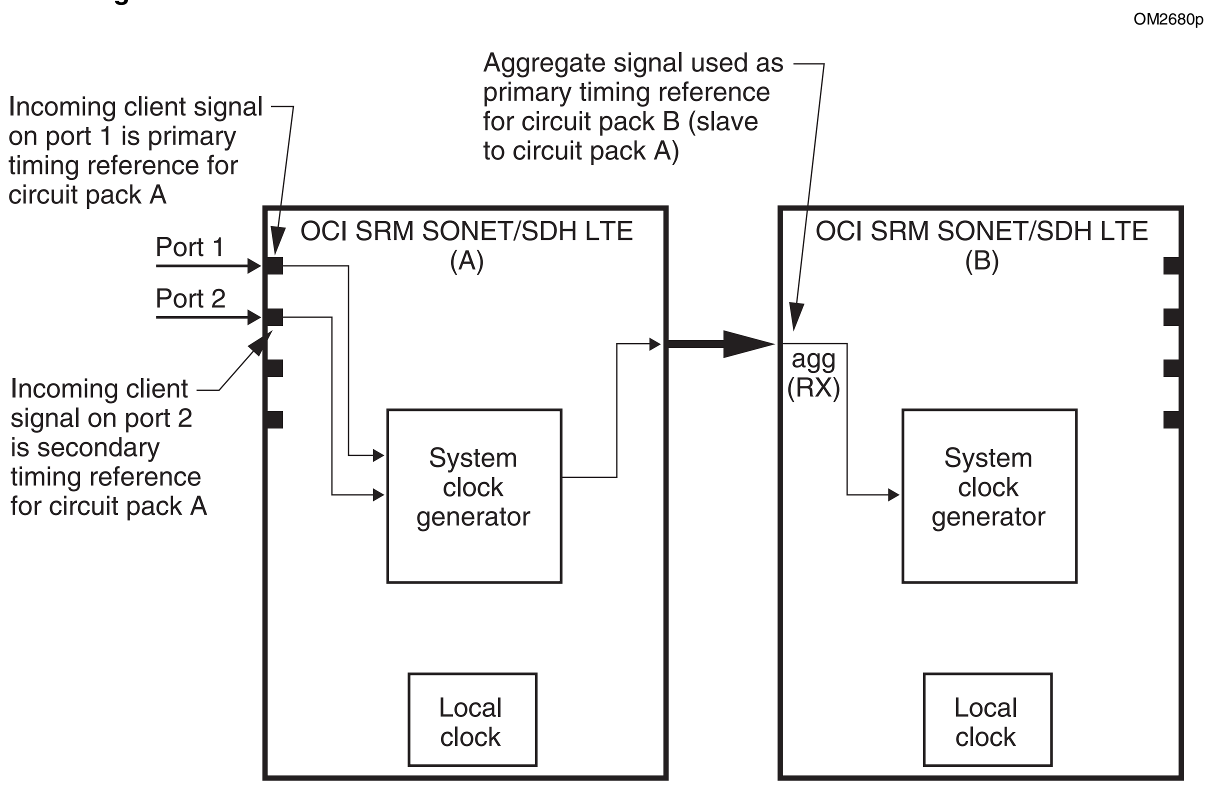


Line timing

Line timing uses incoming client signals or the aggregate signal as clock sources. When the OCI SRM SONET/SDH LTE circuit pack is provisioned to use Ports 1 through 4 or the aggregate RX signal as a timing reference, the system clock is derived from the selected incoming signal.

Figure 4-9 on page 4-23 shows an example of line timing. This is the recommended method to provision OCI SRM SONET/SDH LTE circuit packs used in the bookended configuration.

Figure 4-9
Line timing



Factors to consider for implementing a line timing scenario include:

- primary and secondary timing sources should be selected from network elements that are known to be reliable and trusted. BITS-timed network elements are the preferred option.
- in the event of a primary timing reference failure, the secondary timing reference will take over
- if no secondary timing reference is provisioned, the onboard clock takes over, and operates in holdover mode until the primary timing reference is restored
- for OCI SRM SONET/SDH LTE circuit packs that have the aggregate RX signal provisioned as a timing reference, this signal is protected when the OCI SRM SONET/SDH LTE is provisioned in a protected channel assignment since the aggregate signal from the head-end OCI SRM SONET/SDH LTE circuit pack is received on two independent fibers and OCLDs.
- all clock transitions are hitless
- the clock reference will automatically switch if:
  - — there is a loss of signal on the primary clock reference

- the signal frequency degrades on the primary clock reference
- the clock synchronization status message (SSM) indicates do not use for synchronization (DUS)
- the quality of the primary clock reference degrades to a quality less than Stratum 3

Note: Switching based on SSM quality level is not supported. For example, if both clock references are receiving the same SSM quality level and the active primary reference SSM quality level drops below the SSM quality level of the secondary reference, no switch occurs to the secondary reference.

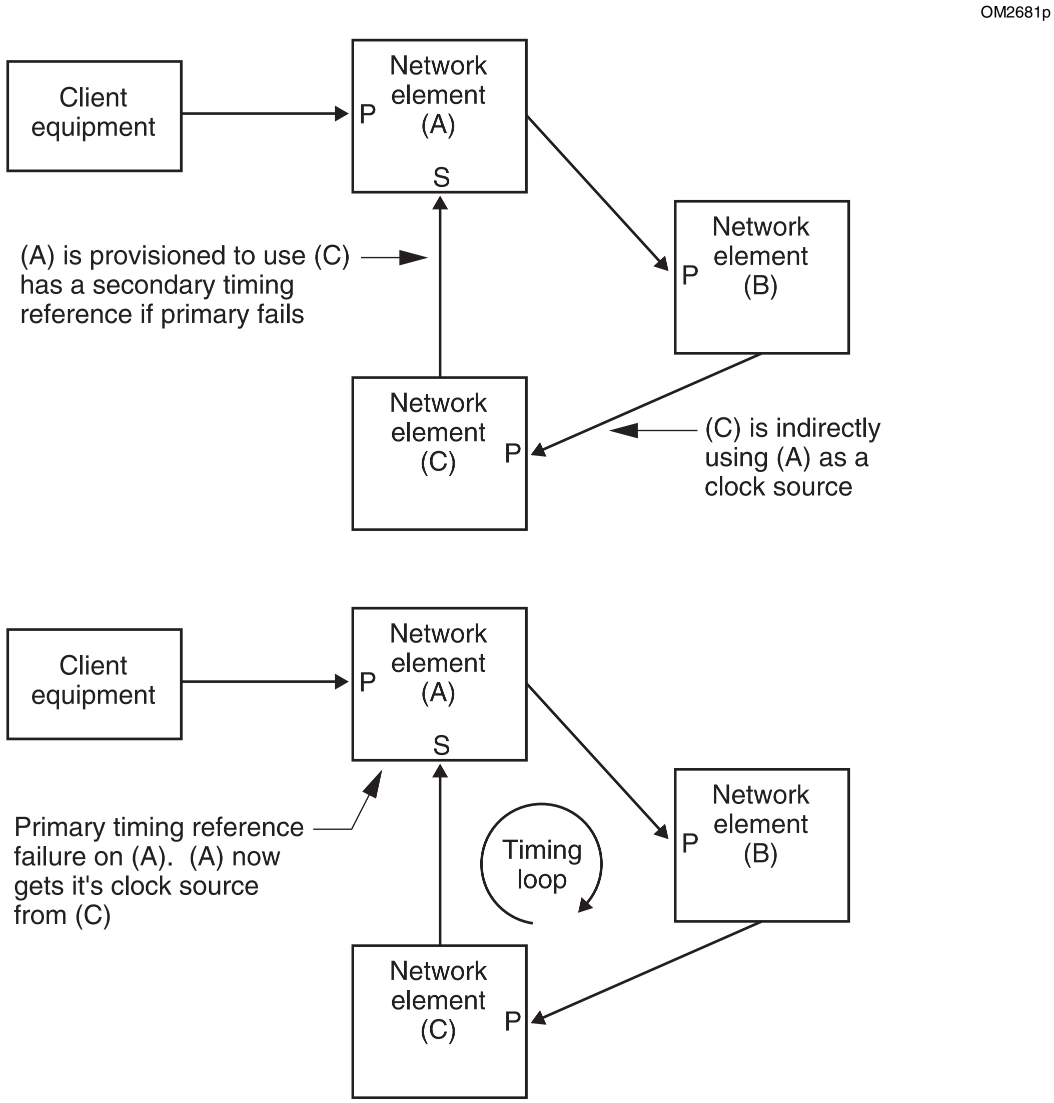
- a client network element provides non-revertive protection as a secondary timing reference; in the event of a primary reference failure, the secondary timing reference remains the active reference until the primary reference is manually restored
- the onboard clock provides revertive protection as a secondary timing reference; when a failed primary timing reference is restored, the timing reference reverts back from the onboard clock to the primary reference
- if all client sources fail, the circuit pack reverts to the local onboard clock

Timing loops

When choosing both the primary and secondary timing references, it is imperative to avoid timing loops. Timing loops occur when one or more network elements derive their timing from each other; there is no master clock source. Potential timing loops may be readily apparent when provisioning primary timing references. However, you must ensure that all combinations of primary and secondary timing references avoid the potential for timing loops.

Figure 4-10 on page 4-25 shows an example of a timing loop.

Figure 4-10
Timing loop example



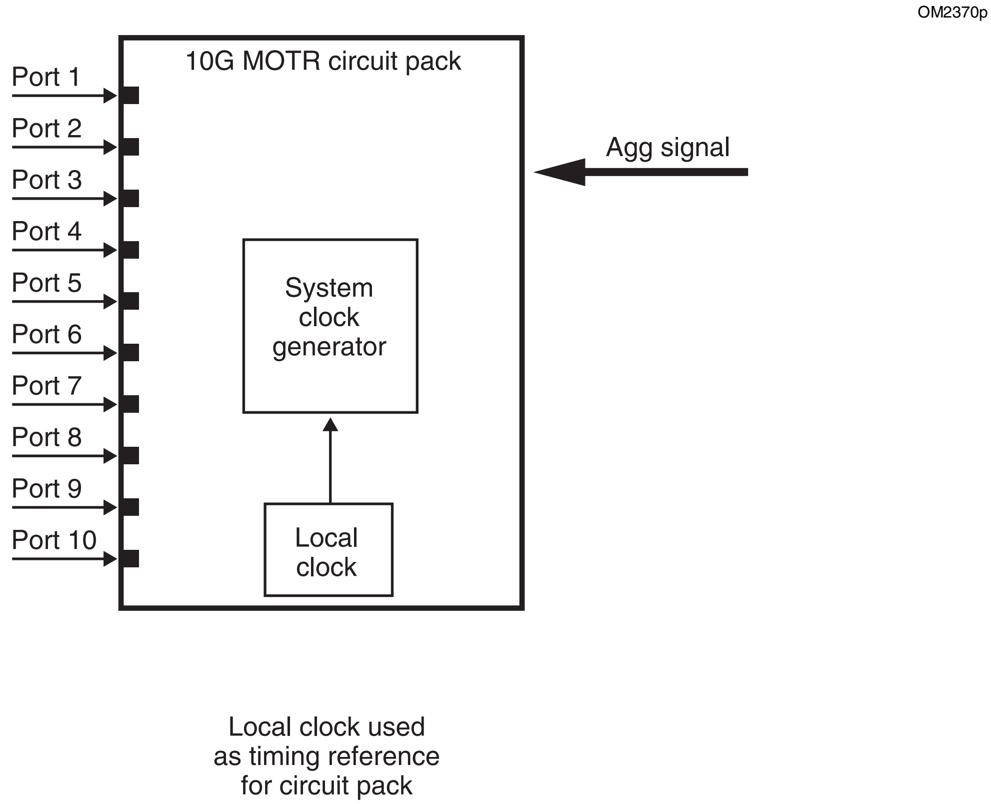
Muxponder 10Gbit/s GbE/FC VCAT

The Muxponder 10 Gbit/s GbE/FC VCAT circuit pack supports:

- local-timing reference (on working circuit pack only)
- loop-timing reference (on working circuit pack only)
- mate-timing reference (on protection circuit pack only)

Local-timing uses the on-board clock (Free Run mode) of the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack. Figure 4-11 shows an example of local timing.

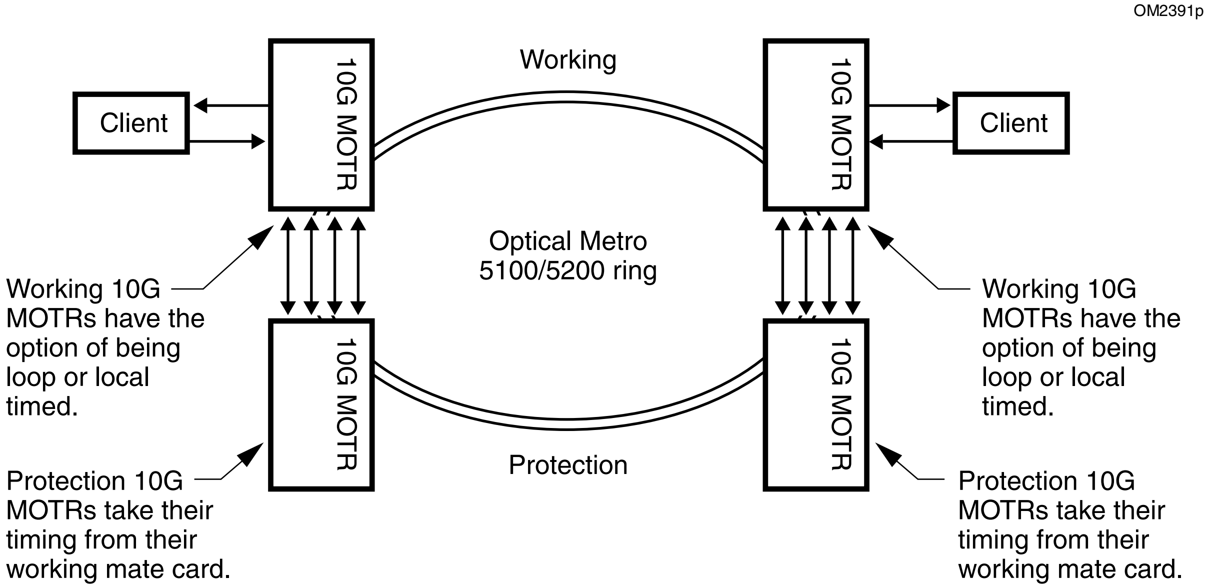
Figure 4-11
Muxponder 10 Gbit/s GbE/FC VCAT line timing



In loop-timed reference mode, the circuit pack obtains the clock from the line. This clock source is then used to clock the transmit line of the working circuit pack and the backplane signal going to the mate protection circuit pack.

The mate-timing reference is provisioned on the protection circuit pack in protected configurations and cannot be changed. A mate-timed protection Muxponder 10 Gbit/s GbE/FC VCAT circuit pack derives its timing from the working circuit pack through the backplane. See Figure 4-12 on page 4-27.

Figure 4-12
Synchronization provisioning for protected Muxponder 10 Gbit/s GbE/FC VCAT configuration



Synchronization considerations

The following synchronization considerations apply when deploying the Muxponder 10 Gbit/s GbE/FC VCAT circuit pack:

- In a bookended configuration, at least one Muxponder 10 Gbit/s GbE/FC VCAT circuit pack in each point-to-point pair must be configured in local-timing mode (free-run).
- Synchronization Status Messaging (SSM) is not supported. The S1 byte always indicates “Synchronization Traceability Unknown”.
- BITS timing is not supported on Optical Metro 5100/5200 systems.
- In loop-timing mode, if the line received clock signal is lost, the line-side transmit clock signal enters holdover mode indefinitely, to within 20 ppm of the last locked frequency.

If the protection circuit pack clock is lost in a mate-timed, protected configuration, the protection circuit pack enters holdover mode indefinitely, to within 20 ppm of the last locked frequency.

Nortel

Optical Metro 5100/5200

Network Planning and Link Engineering, Part 1 of 3

323-1701-110
Standard Release 8.0 Issue 1
April 2005
Printed in Canada and the United Kingdom

NORTEL