CHAPTER 1

System Overview

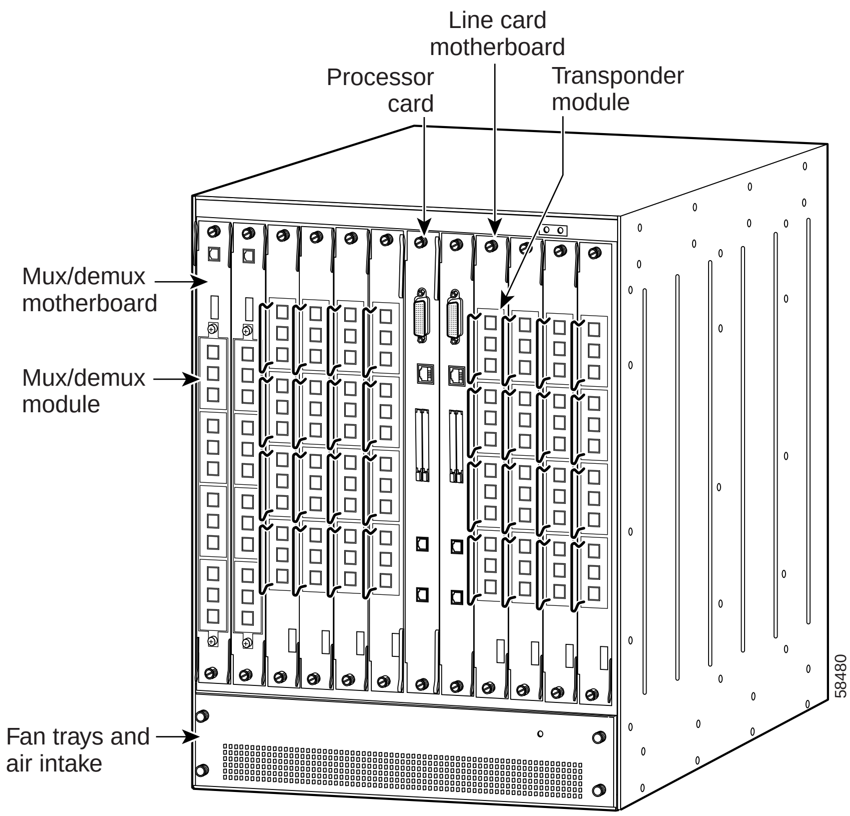
The Cisco ONS 15540 ESP is an optical transport platform that employs DWDM (dense wavelength division multiplexing) technology. With the Cisco ONS 15540 ESP, users can take advantage of the availability of dark fiber to build a common infrastructure that supports data networking (Ethernet based as well as SONET/SDH based) and storage networking.

This chapter contains the following major sections:

Chassis Description

The Cisco ONS 15540 ESP uses a 12-slot modular vertical chassis (see Figure 1-1). The system receives power through redundant –48 VDC inputs. A redundant external AC power supply is available, or DC power can be provided directly. As you face the chassis, the two leftmost slots (slots 0–1) hold the mux/demux motherboards. These slots, which are populated with optical mux/demux modules, correspond to the west and east directions, respectively. Slots 2–5 and 8–11 hold the line card motherboards, which are populated with transponder modules. Slots 6–7 hold the processor cards. Air inlet, fan tray, and cable management are located beneath the modular slots. The system has an optical backplane for carrying signals between the transponder modules and the optical mux/demux modules and an electrical backplane for system control.

Figure 1-1 Cisco ONS 15540 ESP Shelf Layout



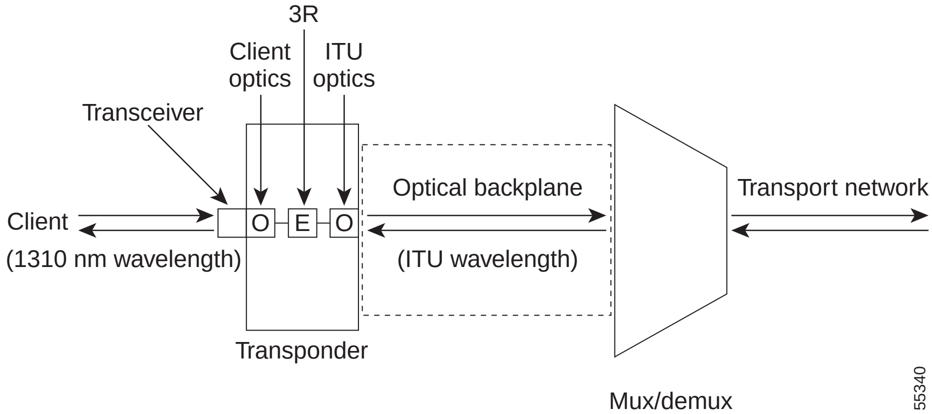
System Functional Overview

The Cisco ONS 15540 ESP connects to client equipment on one side and to the DWDM trunk (transport network) on the other side. Simply described, the Cisco ONS 15540 ESP takes a client signal and converts it to an ITU-T G.692 compliant wavelength, then optically multiplexes it with the other client signals for transmission over an optical fiber link.

The Cisco ONS 15540 ESP supports 1+1 path protection using both hardware mechanisms and software based on the APS (Automatic Protection Switching) standard. In a single-shelf configuration, a Cisco ONS 15540 ESP node can support up to 32 channels with facility (fiber) protection or 16 channels with line card protection. In a dual-shelf configuration a node can support 32 channels with line card protection. The Cisco ONS 15540 ESP can be deployed in point-to-point, linear add/drop, hubbed ring, and meshed ring topologies.

Figure 1-2 illustrates the principal functions involved in transmission of the signal between the client and trunk networks within the Cisco ONS 15540 ESP. In the transmit direction, these functions include receiving the client signal by a transceiver, converting the client signal in the transponder, transmitting the signal over the optical backplane, and multiplexing the signal with other client signals before putting it on the fiber. The opposite functions are performed in the receive direction.

Figure 1-2 Simplified Data Flow Architecture



The client signal is received through a transceiver attached to the transponder module external port. Inside the transponder module the 1310-nm input optical signal is converted to an electrical signal and the 3R (reshape, retime, retransmit) function is performed. A modulated laser diode then converts the electrical signal back to an optical one with a specific wavelength that complies with the ITU laser grid.

The optical signal leaves the transponder module and travels across the optical backplane, which is an optical fiber array circuit comprised of fiber ribbon cables. This backplane serves as a fixed optical cross connection between the transponder modules and the optical mux/demux modules. For a detailed description of the optical backplane, see the "Optical Backplane" section on page 2-3.

Inside the optical mux/demux module the input signals are multiplexed into a single DWDM signal and launched into the fiber on the trunk side. Thus, there is a one-to-one relationship between each client signal and each wavelength on the trunk side.

The Cisco ONS 15540 ESP is a duplex system; therefore where there are light emitters there are also light detectors. For example, the client side interfaces on the transponder modules both transmit and receive light. The same is true of the transponder's DWDM interface. Also, the optical mux/demux modules both multiplex the transmit signal and demultiplex the receive signal.

System Components

The Cisco ONS 15540 ESP has a modular architecture that allows flexibility in configuration and permits incremental upgrades of the system. These components are described in the following sections.

Transponder Modules

The Cisco ONS 15540 ESP supports three types of 2.5-Gbps transponder modules: Type 1 SM (single mode), Type 1 MM (multimode), and 2.5-Gbps Type 2 extended range with SFP optics.

The transponder modules populate the line card motherboards and have two interfaces: an external interface that connects to client equipment, and an internal interface that connects to the line card motherboard.

In the transponder module, the client signal is regenerated and retransmitted on an ITU-compliant wavelength across the optical backplane.

The laser on each 2.5-Gbps transponder module is capable of generating one of two wavelengths on the trunk side. Thus, there are 16 different transponder modules (for channels 1–2, 3–4,..., 31–32) to support the 32 channels; each module is available in both SM and MM versions. The software determines which wavelength a module generates based on the subslot it occupies in the line card motherboard. A module that is inserted in subslot 0 or 2 transmits on the lower of its two channels; a module inserted into subslot 1 or 3 transmits on its upper channel.

A safety protocol, LSC (laser safety control), shuts the transmit laser down on the trunk side when a fiber break or removed connector is detected. The transponder modules are hot pluggable, permitting in-service upgrades and replacement.

SM Transponder Modules and MM Transponder Modules

The client interface on the Type 1 transponder module is protocol transparent and bit-rate transparent and accepts either a single-mode or multimode client signal on the 1310-nm wavelength through SC connectors. The multimode transponder can handle 62.5 mMM, 50 mMM, and 9 or 10 mSM fiber; the single-mode transponder can handle 50 m MM fber and 9 or 10 m SM fber.

The transponder interfaces support encapsulation of client signals in either 3R enhanced mode, which allows some client protocol monitoring (such as code violations and data errors) or regular 3R mode, where the transponder is transparent to the client data stream. In either case, the content of the client data stream remains unmodified. Configurable failure and degrade thresholds for monitored protocols are also supported.

Table 1-1 shows the common client signal encapsulations supported on the single-mode transponder modules and multimode transponder modules.

Table 1-1 Common Client Signal Encapsulations Supported on Single-Mode and Multimode Transponders

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
Gigabit Ethernet (1250 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	Yes
	MM 50/125 m	Yes	No	No	No	Yes
	MM 62.5/125 m	Yes	No	No	No	—
Fast Ethernet (100 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	No
	MM 50/125 m	Yes	No	Yes	Yes	No
	MM 62.5/125 m	Yes	No	No	Yes	No
SONET STS-3/ SDH STM-1 (OC-3) (155 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	Yes
	MM 50/125 m	Yes	No	Yes	Yes	Yes
	MM 62.5/125 m	Yes	No	No	Yes	Yes

Table 1-1 Common Client Signal Encapsulations Supported on Single-Mode and Multimode Transponders (continued)

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
SONET STS-12/SDH STM-4 (OC-12) (622 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	Yes
	MM 50/125 m	Yes	No	Yes	Yes	Yes
	MM 62.5/125 m	Yes	No	No	Yes	Yes
SONET STS-48/ SDH STM-16 (OC-48) (2488 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	Yes
	MM 50/125 m	Yes	No	Yes	No	Yes
	MM 62.5/125 m	Yes	No	No	No	—
ATM 155 (OC-3) (155 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	Yes
	MM 50/125 m	Yes	No	Yes	Yes	Yes
	MM 62.5/125 m	Yes	No	No	Yes	Yes
Fiber Channel (1062 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	Yes
	MM 50/125 m	Yes	No	Yes	No	Yes
	MM 62.5/125 m	Yes	No	No	No	—
Fiber Channel (2125 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	Yes
	MM 50/125 m	Yes	No	Yes	No	Yes
	MM 62.5/125 m	Yes	No	No	No	—
FDDI (125 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	No
	MM 50/125 m	Yes	No	Yes	Yes	No
	MM 62.5/125 m	Yes	No	No	Yes	No

Table 1-2 shows the IBM storage protocols on the single-mode and multimode transponders.

Table 1-2 IBM Storage Protocols Supported on Single-Mode and Multimode Transponders

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
ESCON (200 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	Yes
	MM 50/125 m	Yes	No	Yes	Yes	Yes
	MM 62.5/125 m	Yes	No	No	Yes	Yes
FICON (1062 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	Yes
	MM 50/125 m	Yes	No	Yes[1]	No	Yes
	MM 62.5/125 m	Yes	No	Yes[2]	No	Yes
FICON (2125 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	Yes
	MM 50/125 m	Yes	No	Yes[2]	No	Yes
	MM 62.5/125 m	Yes	No	Yes[2]	No	Yes

Table 1-2 IBM Storage Protocols Supported on Single-Mode and Multimode Transponders (continued)

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
Coupling Facility, ISC[3] compatibility (1062 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	Yes
	MM 50/125 m	Yes	No	Yes[2]	No	Yes
	MM 62.5/125 m	No	No	—	—	—
Coupling Facility, ISC peer (2125 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	No
	MM 50/125 m	No	No	—	—	—
	MM 62.5/125 m	No	No	—	—	—
Sysplex Timer (ETR and CLO) (8 Mbps[4])	SM 9 or 10/125 m	No	No	—	—	—
	MM 50/125 m	Yes	No	No	Yes	No
	MM 62.5/125 m	Yes	No	No	Yes	No

1. These protocols require the use of a special mode-conditioning patch cable (available from IBM) at each end of the connection.
2. These protocols require the use of a special mode-conditioning patch cable (available from IBM) at each end of the connection.
3. ISC = InterSystem Channel
4. Sysplex Timer is the only protocol supported at a clock rate less than 16 Mbps.

Table 1-3 shows some other common protocols that are supported on the single-mode and multimode transponders without protocol monitoring.

Table 1-3 Other Client Signal Encapsulations Supported on Single-Mode and Multimode Transponders

Client Signal Encapsulation	Fiber Type	Wavelength (nm)		Transponder Type		Protocol Monitoring
		1310	850	SM	MM	
DS3 (45 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	No
	MM 50/125 m	Yes	No	Yes	Yes	No
	MM 62.5/125 m	Yes	No	No	Yes	No
OC-1 (51.52 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	Yes	No
	MM 50/125 m	Yes	No	Yes	Yes	No
	MM 62.5/125 m	Yes	No	No	Yes	No
OC-24 (933.12 Mbps)	SM 9 or 10/125 m	Yes	No	Yes	No	No
	MM 50/125 m	Yes	No	Yes	No	No
	MM 62.5/125 m	Yes	No	No	No	No

Additional discrete rates are also supported in regular 3R mode. For the SM transponder modules, these rates fall between 16 Mbps and 2.5 Gbps; for the MM transponder modules, the rates are between 16 Mbps and 622 Mbps.

Note Rates from 851,000 Kbps to 999,999 Kbps and from 160,1000 Kbps to 1,999,999 Kbps are not supported.

The system supports OFC (open fiber control) for Fibre Channel and ISC encapsulations. Alternatively, FLC (forward laser control) can be enabled to shut down the laser on the client or trunk side if a LOL (loss of light) is detected on the other side.

The Cisco ONS 15540 ESP transponder modules support autonegotiation for Gigabit Ethernet traffic.

Note The Cisco ONS 15540 ESP SM and MM transponder modules do not support autonegotiation for 2-Gbps Fibre Channel. The transponder modules only recognize the configured clock rate or protocol encapsulation.

For detailed information about client interface configuration, refer to the *Cisco ONS 15540 ESP Configuration Guide and Command Reference.*

Type 2 Extended Range Transponder Modules with SFP Optics

The Type 2 extended range transponder module accepts two types of SFP optics:

- Fixed rate
- Variable rate

Fixed rate SFP optics modules support specific protocols. Table 1-4 lists the features for the fixed rate SFP optics supported by the Type 2 extended range transponder modules.

Table 1-4 Fixed Rate SFP Optics Features

Part Number	Supported Protocols	Fiber Type	Wavelength	Connector Type
15500-XVRA-01A2	ESCON, SONET OC-3 SR, SDH STM-1	MM 50/125 m MM 62.5/125 m	1310 nm	MT-RJ
15500-XVRA-02C1	Gigabit Ethernet[1], Fibre Channel (1 Gbps)[2], FICON (1 Gbps), ISC-1 (1-Gbps)	MM 50/125 m MM 62.5/125 m	850 nm	LC
15500-SFP-GEFC-SX	Fibre Channel (1 Gbps and 2 Gbps)[3], FICON (1 Gbps and 2 Gbps), ISC-3 (1-Gbps and 2-Gbps), Gigabit Ethernet	MM 50/125 m MM 62.5/125 m	850 nm	LC
15500-XVRA-03B1	Gigabit Ethernet[4], Fibre Channel (1 Gbps)[5], FICON (1 Gbps), ISC compatibility mode (1 Gbps), ISC peer mode (1 Gbps)	SM 9/125 m	1310 nm	LC

Table 1-4 Fixed Rate SFP Optics Features (continued)

Part Number	Supported Protocols	Fiber Type	Wavelength	Connector Type
15500-XVRA-03B2	Fibre Channel (1 Gbps[6] and 2 Gbps[7]), FICON (1 Gbps and 2 Gbps), ISC compatibility mode (1 Gbps), ISC peer mode (1 Gbps and 2 Gbps)	SM 9/125 m	1310 nm	LC
15500-XVRA-06B1	SONET OC-12 SR[8], SDH STM-4	SM 9/125 m	1310 nm	LC
15500-XVRA-07B1	SONET OC-48 SR, SDH STM-16	SM 9/125 m	1310 nm	LC

1. 1000BASE-SX
2. FC-0-100-M5-SN-S and FC-0-100-M6-SN-S standards
3. FC-0-200-M5-SN-S and FC-0-200-M6-SN-S standards
4. 1000BASE-LX
5. FC-0-100-SM-LC-S standard
6. FC-0-100-SM-LC-S standard
7. FC-0-200-SM-LC-S standard
8. SR = short range

Variable rate SPF optics modules support a range of clock rates. Table 1-5 lists features for the variable rate SFP optics supported by the Type 2 extended range transponder modules.

Table 1-5 Variable Rate SFP Optics Features

Part Number	Clock Rate Range	Protocol Encapsulations Supported	Fiber Type	Wavelength	Connector Type
15500-XVRA-10A1	Low-band 8 Mbps to 200 Mbps	Sysplex (CLO and ETR)[1] (8 Mbps), Fast Ethernet[2] (125 Mbps), SONET OC-3[3] (155.52 Mbps), SDH STM-1 (622 Mbps), ESCON[4] (200 Mbps)	MM 50/125 m 62.5/125 m	1310 nm	LC
15500-XVRA-10B1	Low-band 8 Mbps to 200 Mbps	Sysplex (CLO and ETR)[1] (8 Mbps), Fast Ethernet[2] (125 Mbps), SONET OC-3[3] (155.52 Mbps), SDH STM-1 (155.52 Mbps), ESCON[4] (200 Mbps)	SM 9/125 m	1310 nm	LC
15500-XVRA-11A1	Mid-band 200 Mbps to 622 Mbps	ESCON[4] (200 Mbps), SONET OC-12[3] (622 Mbps), SDH STM-4 (622 Mbps)	MM 50/125 m 62.5/125 m	1310 nm	LC

Table 1-5 Variable Rate SFP Optics Features (continued)

Part Number	Clock Rate Range	Protocol Encapsulations Supported	Fiber Type	Wavelength	Connector Type
15500-XVRA-11B1	Mid-band 200 Mbps to 1.25 Gbps	ESCON[4] (200 Mbps), SONET OC-12[3] (622 Mbps), SDH STM-4 (622 Mbps), FC[4] (1.062 Gbps), FICON (1.062 Gbps), GE[4] (LX) (1.250 Gbps) ISC compatibility mode (1.062 Gbps), ISC peer mode (1.062 Gbps)	SM 9/125 m	1310 nm	LC
15500-XVRA-12B1	High-band 1.062 Gbps to 2.488 Gbps	FC[4] (1.062 Gbps and 2.125 Gbps), FICON (1.062 Gbps and 2.125 Gbps), GE[4] (LX) (1.250 Mbps), SONET OC-48 (2.488 Gbps), SDH STM-16 (2.488 Gbps), ISC compatibility mode (1.062 Gbps), ISC peer mode (1.062 Gbps and 2.125 Gbps)	SM 9/125 m	1310 nm	LC

1. Manchester coded
2. 4B/5B coded
3. Scrambler 2^{23-1}
4. 8B/10B coded

Note The Cisco IOS software only supports Cisco-certified SFP optics on the Type 2 extended range transponder module.

The following protocols can be monitored with the Type 2 extended range transponder modules:

- ESCON (Enterprise Systems Connection)
- Fibre Channel (1 Gbps and 2 Gbps)
- FICON (Fiber Connection) (1 Gbps and 2 Gbps)
- Gigabit Ethernet
- ISC (compatibility mode)
- SDH (Synchronous Digital Hierarchy) (STM-1, STM-4, STM-16)
- SONET (OC-3, OC-12, OC-48)

For detailed information about client interface configuration, refer to the *Cisco ONS 15540 ESP Configuration Guide.*

The Type 2 extended range transponder modules also support the OFC (open fiber control) safety protocol for Fibre Channel.

The Cisco ONS 15540 ESP Type 2 extended range transponder modules support autonegotiation for Gigabit Ethernet traffic.

Note The Cisco ONS 15540 ESP Type 2 extended range transponder modules do not support autonegotiation for 2-Gbps Fibre Channel. The transponder modules only recognize the configured clock rate or protocol encapsulation.

Caution The SFP optics supported by the Type 2 extended range transponder modules yield optimal performance at the data rates for which the transceivers are explicitly designed. Configuring a protocol encapsulation or clock rate outside of the clock rate specifications for the transceiver could result in suboptimal performance, depending on the transceiver characteristics (such as receiver sensitivity and output power).

For information on transceiver specifications, refer to the *Cisco ONS 15540 ESP Hardware Installation Guide*.

Conditions Monitored on 2.5-Gbps Transponder Modules

For GE, FC, and FICON traffic, the Cisco ONS 15540 ESP monitors the following conditions:

- CVRD (code violation running disparity) error counts
- Loss of Sync
- Loss of Lock
- Loss of Light

For SONET errors, the Cisco ONS 15540 ESP monitors the SONET section overhead only, not the SONET line overhead. Specifically, the Cisco ONS 15540 ESP monitors the B1 byte and the framing bytes. The system can detect the following defect conditions:

- Loss of Light
- Loss of Lock (when the clock cannot be recovered from the received data stream)
- Severely errored frame
- Loss of Frame

For SONET performance, the system monitors the B1 byte, which is used to compute the four SONET section layer performance monitor parameters:

- SEFS-S (second severely errored framing seconds)
- CV-S (section code violations)
- ES-S (section errored seconds)
- SES-S (section severely errored seconds)

For ISC traffic, the system monitors the following conditions:

- CVRD error counts
- Loss of CDR (clock data recovery) Lock
- Loss of Light

2.5-Gbps Line Card Motherboards

The 2.5-Gbps line card motherboards hold the 2.5-Gbps transponder modules and provide the optical connections from the transponder modules to the optical backplane. The line card motherboards are modular and can be populated according to user needs. A single system can hold up to eight line card motherboards, each of which accepts four 2.5-Gbps transponder modules.

There are three types of line card 2.5-Gbps motherboards: splitter, east, and west. The splitter 2.5-Gbps motherboard supports protection against fiber failure by delivering the ITU wavelengths emitted from their associated 2.5-Gbps transponder modules over the optical backplane to the optical mux/demux modules in both the west and east slots (slots 0 and 1, respectively). The east and west 2.5-Gbps line card motherboards deliver the ITU wavelengths from their associated transponder modules over the optical backplane to the optical mux/demux modules in either the east or west slot.

Mux/Demux Motherboards

The mux/demux motherboards hold the optical mux/demux modules. Either slot 0 or slot 1 can be populated with a single mux/demux motherboard for unprotected operation, or both slots can be populated for protected operation. Each motherboard can accept up to four optical mux/demux modules, depending upon the type of module used, and can be populated according to user needs.

OSC

There are two versions of the mux/demux motherboard, with and without the OSC (optical supervisory channel). Implemented with a dedicated laser and detector for a 33rd wavelength (channel 0) on the mux/demux motherboard, the OSC is a per-fiber duplex management channel for communicating between Cisco ONS 15540 ESP systems. The OSC allows control and management traffic to be carried without the necessity of a separate Ethernet connection to each Cisco ONS 15540 ESP in the network.

The OSC is established over a point-to-point connection and is always terminated on a neighboring node. By contrast, data channels may or may not be terminated on a given node, depending on whether the channels are express (pass-through) or add/drop.

The OSC carries the following types of information:

- CDP (Cisco Discovery Protocol) packets—Used to discover neighboring devices
- IP packets—Used for SNMP and Telnet sessions between nodes
- OSCP (OSC Protocol)—Used to determine whether the OSC link is up
- APS protocol packets—Used for controlling signal path switching

Note A Cisco ONS 15540 ESP system on which the OSC is not present is not known to other systems in the network and cannot by managed by any NMS. Without the OSC, a Cisco ONS 15540 ESP system must be managed individually by separate Ethernet or serial connections. Thus, it is important when adding a node to an existing network of Cisco ONS 15540 ESP systems that the added node have OSC support.

Optical Mux/Demux Modules

The optical mux/demux modules are passive devices that optically multiplex and demultiplex a specific band of ITU wavelengths. In the transmit direction, the optical mux/demux modules multiplex signals transmitted by the transponder modules over the optical backplane and provide the interfaces to connect the multiplexed signal to the DWDM trunk side. In the receive direction, the optical mux/demux modules demultiplex the signals from the trunk side before passing them over the optical backplane to the transponder modules.

Optical Mux/Demux Modules and Channel Bands

There are two types of optical mux/demux modules, add/drop and terminal, and each module supports a range of channels called a *band*. In the case of the add/drop mux/demux modules, a band contains 4 or 8 channels; in the case of the terminal mux/demux modules, a band contains 16 channels.

Table 1-6 lists the optical mux/demux modules that support each channel band. All modules except the 16-channel band AD module are available with or without OSC support. The AD module is available only with the OSC. For correspondence between channel numbers and wavelengths on the ITU grid, refer to the *Cisco ONS 15540 ESP Hardware Installation Guide*.

Table 1-6 Optical Mux/Demux Modules and Supported Channel Bands

Cisco ONS 15540 ESP Channels	4-Channel Add/Drop Mux/Demux Module	8-Channel Add/Drop Mux/Demux Module	16-Channel Terminal Mux/Demux Module[1]
1–4	Band A	Band AB	Band AD
5–8	Band B		
9–12	Band C	Band CD	
13–16	Band D		
17–20	Band E	Band EF	Band EH
21–24	Band F		
25–28	Band G	Band GH	
29–32	Band H		

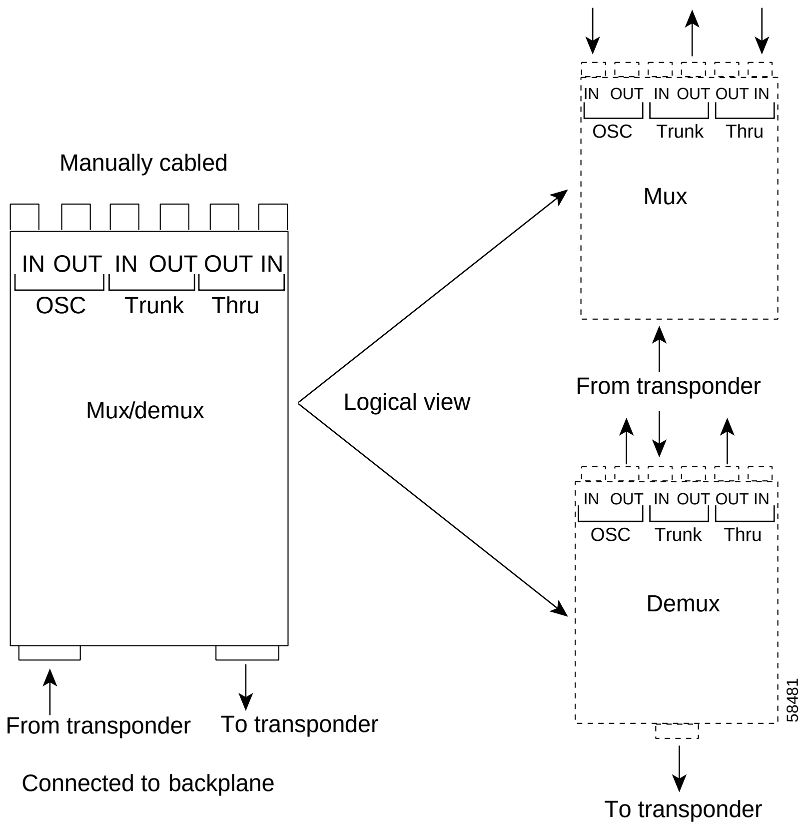
1. A 16-channel terminal mux/demux module occupies two subslots in a mux/demux motherboard.

Add/Drop Mux/Demux Modules

An add/drop mux/demux module adds a specified band of channels at a node and passes the other bands through. To support the 32-channel spectrum, there are eight different 4-channel modules and four different 8-channel modules.

Figure 1-3 shows the physical layout of the add/drop mux/demux module along with a logical view of its multiplexing and demultiplexing functions. Optical signals received from the transponder, the Thru IN connector, and the OSC IN connector are multiplexed and sent through the Trunk OUT connector. The optical signal received from the Trunk IN connector is demultiplexed and the OSC signal is sent to the OSC OUT connector; the dropped channels are sent to the transponder; and the passed channels are sent to the Thru OUT connector.

Figure 1-3 Add/Drop Mux/Demux Module



Terminal Mux/Demux Modules

The terminal mux/demux modules are based on interleaver technology and only support the ITU wavelengths within the specified band. Wavelengths outside the specified band are inaccessible. Terminal mux/demux modules are supplied in two 16-channel versions. The first, which supports band AD (channels 1–16), can be used alone, while the second, which supports band EH (channels 17–32), must be used in conjunction with the first. A 16-channel module occupies two subslots in the mux/demux motherboard.

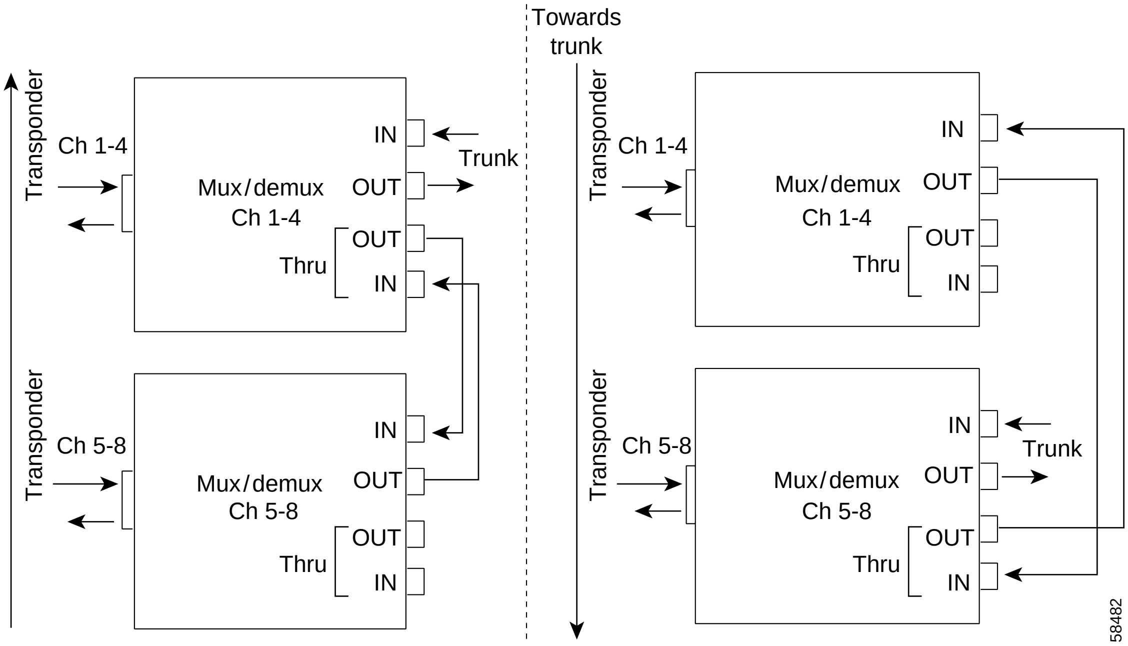
Because of their more favorable optical power loss characteristics, the terminal mux/demux modules may be preferred at nodes where selective add/drop is not required, such as in a point-to-point configuration or at the hub node in a hubbed ring.

Optical Mux/Demux Module Configurations

The modular nature of the mux/demux motherboard allows optical mux/demux modules to be added as needed to support the desired number of client signals. In the case of the 16-channel modules, the shelf can be upgraded to 32 channels with the addition of the second 16-channel module. In the case of add/drop nodes, the capacity can be increased with the addition of 4- or 8-channel modules to support increased channel demand or the requirements of a meshed ring.

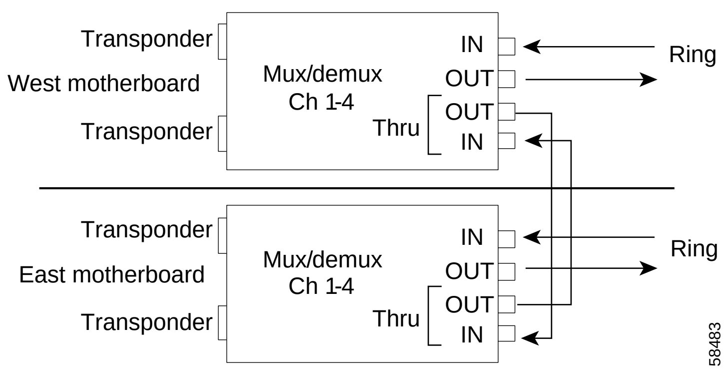
The 4- or 8-channel add/drop modules are combined in a cascading fashion using fiber optical cables with MU connectors. Figure 1-4, for example, shows how two 4-channel modules are cabled together to upgrade a point-to-point configuration from 4 channels to 8 channels.

Figure 1-4 Cascaded 4-Channel Mux/Demux Modules



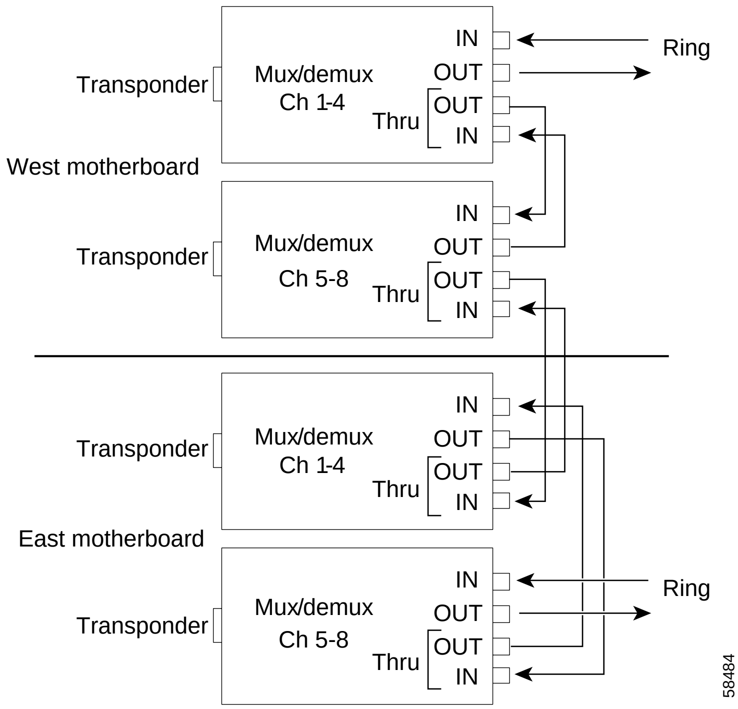
In ring configurations, channels that are not destined for a particular node are passed through that node and sent back on the ring. Figure 1-5 shows an example of how two 4-channel mux/demux modules might be cabled in a protected ring configuration.

Figure 1-5 4-Channel Mux/Demux Modules in a Protected Ring Configuration



In some ring topologies, cascading add/drop mux/demux modules may be required to support the add/drop requirements of the configuration. Figure 1-6 shows one example.

Figure 1-6 Cascaded Add/Drop Mux/Demux Modules in a Protected Ring Configuration



Processors Cards

The Cisco ONS 15540 ESP includes two processor cards for redundancy. Each processor is composed of a number of subsystems, including a CPU, a system clock, Ethernet switch for communicating between processors and with the LRC (line card redundancy controller) on the mux/demux and line card motherboards, and a processor redundancy controller. The active processor controls the node, and all cards in the system make use of the system clock and synchronization signals from the active processor.

The processor card is equipped with a console port, a Fast Ethernet interface for Telnet access and network management, and an auxiliary port. There are two slots for Flash PC Cards.

On the processor card front panel are LEDs that display the status of critical, major, and minor signals, as well as the status of alarm cutoff and history conditions. The alarm signals from the processor go to an alarm daughterboard on the backplane, which has a connector for central office alarm facilities.

The system processors run Cisco IOS software and support the following features:

- Automatic configuration at startup
- Automatic discovery of network neighbors
- Online self-diagnostics and tests
- SSH (Secure Shell)
- Arbitration of processor status (active/standby) and switchover in case of failure without loss of connections
- Automatic synchronization of startup and running configurations
- Autosynchronization of traffic statistics and performance monitoring counters.
- In-service software upgrades

- Per-channel APS (Automatic Protection Switching) in linear and ring topologies using redundant subsystems that monitor link integrity and signal quality
- System configuration and management through the CLI (command-line interface) and SNMP
- Optical power monitoring on the trunk side, digital monitoring on the client side, and per-channel transponder in-service and out-of-service loopback (client and trunk sides)
- Optional out-of-band management of other Cisco ONS 15540 ESP systems on the network through the OSC (optical supervisory channel).

Processor Redundancy and Online Insertion and Removal

When the Cisco ONS 15540 ESP is powered up, the two processors engage in an arbitration process to determine which will be the active and which will be the standby. Previous power state information is stored in the processor non-volatile random access memory (NVRAM). The processor that was previously active reassumes the active role. During operation, the two processors remain synchronized (application states, running and startup configurations, system images). The operational status of each processor is monitored by the processor redundancy controller of the other processor through the backplane Ethernet. In the event of a failure or removal of an active processor, the standby processor immediately takes over and assumes the active role. Once the problem on the faulty card has been resolved, it can be manually restored to the active function.

In addition to providing protection against hardware or software failure, the redundant processor arrangement also permits installing a new Cisco IOS system image without system downtime. For more information about processor redundancy operation, as well as other software features, refer to the *Cisco ONS 15540 ESP Configuration Guide.*

Security Features

The Cisco ONS 15540 ESP supports the following Cisco IOS software security features:

- AAA (authentication, authorization, and accounting)
- Kerberos
- RADIUS
- TACACS+
- SSH
- Traffic filters and firewalls
- Passwords and privileges

For detailed information about the security features supported on the Cisco ONS 15540 ESP, refer to the *Cisco IOS Security Configuration Guide*.

System and Network Management

The Cisco ONS 15540 ESP is fully manageable through any of the following two mechanisms: the OSC and a direct Ethernet connection to the NME (network management Ethernet) on the processor card. While all shelves will be equipped with at least one processor card, provisioning the OSC is optional.

All three mechanisms can be deployed within a single network. Each mechanism is associated with an interface that can be assigned an IP address. Management information will be routed between these interfaces.

Different levels of availability exist for each of these management mechanisms. High availability for the direct NME connection can be achieved with redundant processor cards. The OSC becomes highly available when it is provisioned on both the working and protection trunk fibers.

NME

The NME is a 10/100 Ethernet port on the processor card. You can connect this port to a router and configure the interface to route messages using established routing protocols. The NME can be used to carry traffic to a network management system.

Note The NME provides little in the way of topology management or fault isolation. We recommend using the OSC to manage and troubleshoot your network topology.

NME Considerations

The following considerations apply to the NME:

- To remotely manage nodes in the network topology using the NME, each system must be accessible through an IP network.
- The NME port is present on every processor card and does not require extra equipment or a slot in the shelf.

Comparison of the OSC and SONET

Table 1-7 compares the features provided by the OSC and SONET.

Table 1-7 Comparison of the ISONET, and OSC

Feature	OSC	SONET[1]
Management reach	Per fiber section	Per wavelength
Fault isolation and topology discovery	Hop-by-hop fiber (physical topology)	End-to-end wavelength (logical topology)
Payload	Separate out-of-band channel	SONET (OC-n)
Management channel	Per fibre via a 33rd wavelength (channel 0)	Per wavelength via section DCC
Performance monitoring	OSC protocol	Section BIP[2]

1. SONET based management is not supported on the Cisco ONS 15540 ESP.
2. BIP = bit interleaved parity