



SONET Topologies and Upgrades



Note

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

This chapter explains Cisco ONS 15600 SONET topologies and upgrades. To provision topologies, refer to the *Cisco ONS 15600 Procedure Guide*.

Chapter topics include:

- [8.1 Overview, page 8-1](#)
- [8.2 Point-to-Point and Linear ADM Configurations, page 8-1](#)
- [8.3 Bidirectional Line Switched Rings, page 8-2](#)
- [8.4 Path-Protected Mesh Networks, page 8-11](#)
- [8.5 In-Service Topology Upgrades, page 8-13](#)

8.1 Overview

The ONS 15600 usually operates as a hub node in networks that include ONS 15454s, ONS 15327s, and ONS 15310-CLs. Single nodes are installed at geographic locations where several ONS SONET topologies converge. A single ONS 15600 node might be a part of several ONS SONET rings/networks.

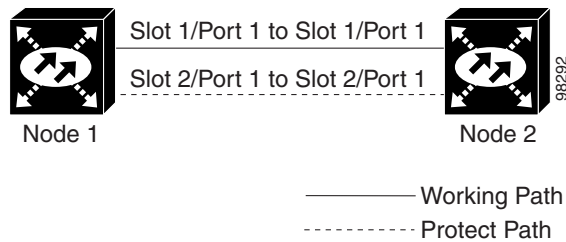
To avoid errors during network configuration, Cisco recommends that you draw the complete ONS SONET network topology on paper (or electronically) before you begin the physical implementation. A sketch ensures that you have adequate slots, cards, and fibers to complete the topology.

8.2 Point-to-Point and Linear ADM Configurations

You can configure ONS 15600s as a line of add/drop multiplexers (ADMs) by configuring one OC-N port as the working path and a second port as the protect path. Unlike rings, point-to-point (two node configurations) and linear (three node configurations) ADMs require that the OC-N ports at each node be in 1+1 protection to ensure that a break to the working line is automatically routed to the protect line.

Figure 8-1 shows two ONS 15600 nodes in a point-to-point ADM configuration. Working traffic flows from Slot 1/Port 1 at Node 1 to Slot 1/Port 1 at Node 2. You create the protect path by creating a 1+1 configuration with Slot 1/Port 1 and Slot 2/Port 1 at Nodes 1 and 2.

Figure 8-1 Point-to-Point ADM Configuration



8.3 Bidirectional Line Switched Rings

The ONS 15600 can support up to 32 bidirectional line switched rings (BLSRs). Eight four-fiber BLSR rings can be supported if all ports are OC-192. Because the working and protect bandwidths must be equal, you can create only OC-48 or OC-192 BLSRs. For information about BLSR protection channels, see the “7.7 Protection Channel Access Circuits” section on page 7-15.



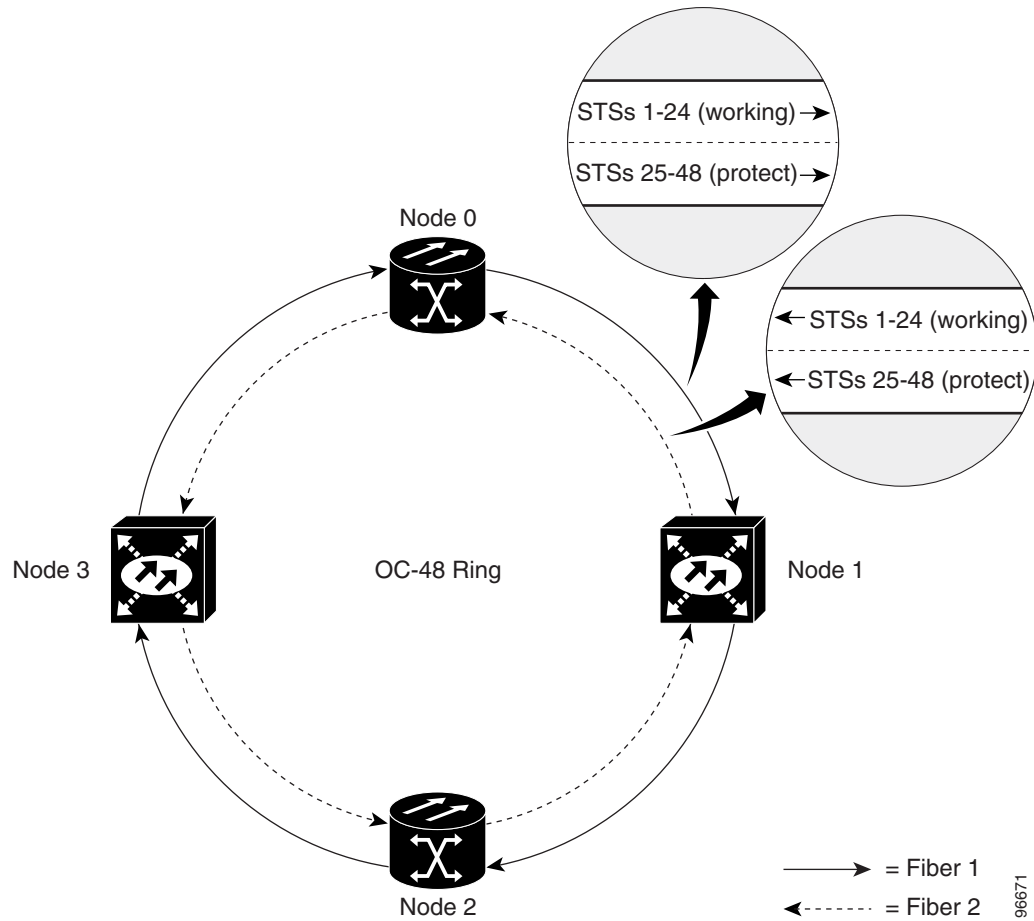
Note

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

8.3.1 Two-Fiber BLSRs

In two-fiber BLSRs, each fiber is divided into working and protect bandwidths. For example, in an OC-48 BLSR, STSs 1 to 24 carry the working traffic, and STSs 25 to 48 are reserved for protection (Figure 8-2). Working traffic (STSs 1 to 24) travels in one direction on one fiber and in the opposite direction on the second fiber. Cisco Transport Controller (CTC) circuit routing routines calculate the shortest path for circuits based on many factors, including user requirements, traffic patterns, and distance. For example, in Figure 8-2, circuits going from Node 0 to Node 1 will typically travel on Fiber 1, unless that fiber is full, in which case circuits will be routed to Fiber 2 through Node 3 and Node 2. Traffic from Node 0 to Node 2 (or Node 1 to Node 3) can be routed on either fiber, depending on circuit provisioning requirements and traffic loads.

Figure 8-2 Four-Node, Two-Fiber BLSR



The SONET K1, K2, and K3 bytes carry the information that governs BLSR protection switches. Each BLSR node monitors the K bytes to determine when to switch the SONET signal to an alternate physical path. The K bytes communicate failure conditions and actions taken between nodes in the ring.

If a break occurs on one fiber, working traffic targeted for a node beyond the break switches to the protect bandwidth on the second fiber. The traffic travels in a reverse direction on the protect bandwidth until it reaches its destination node. At that point, traffic is switched back to the working bandwidth.

Figure 8-3 shows a traffic pattern sample on a four-node, two-fiber BLSR.

Figure 8-3 Four-Node, Two-Fiber BLSR Traffic Pattern Sample

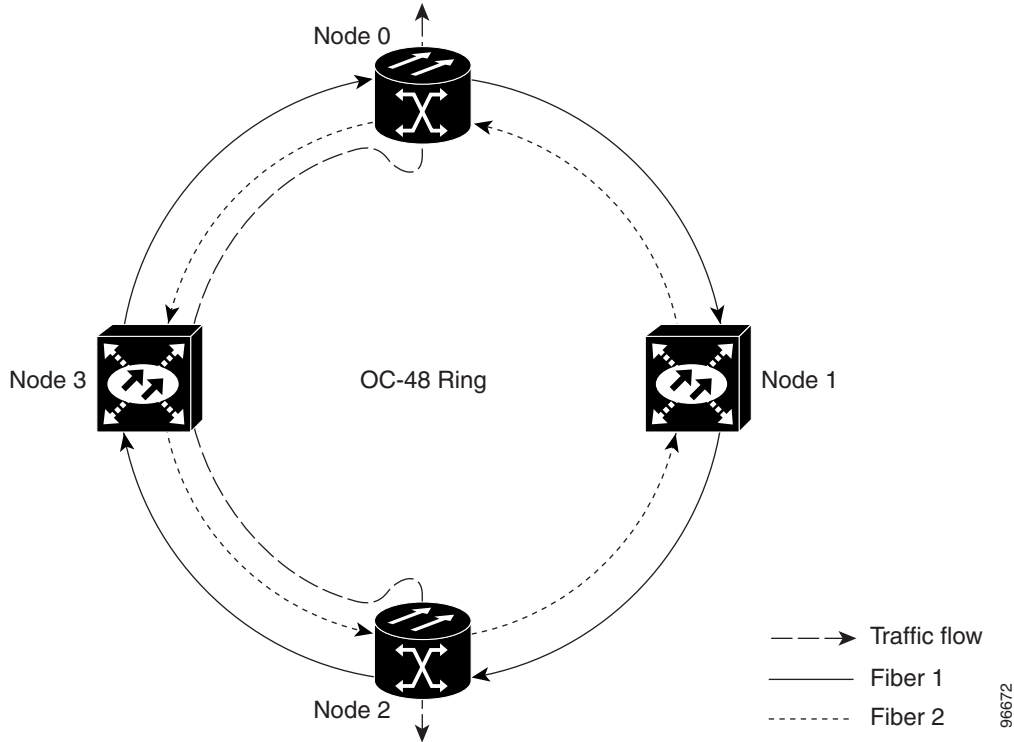
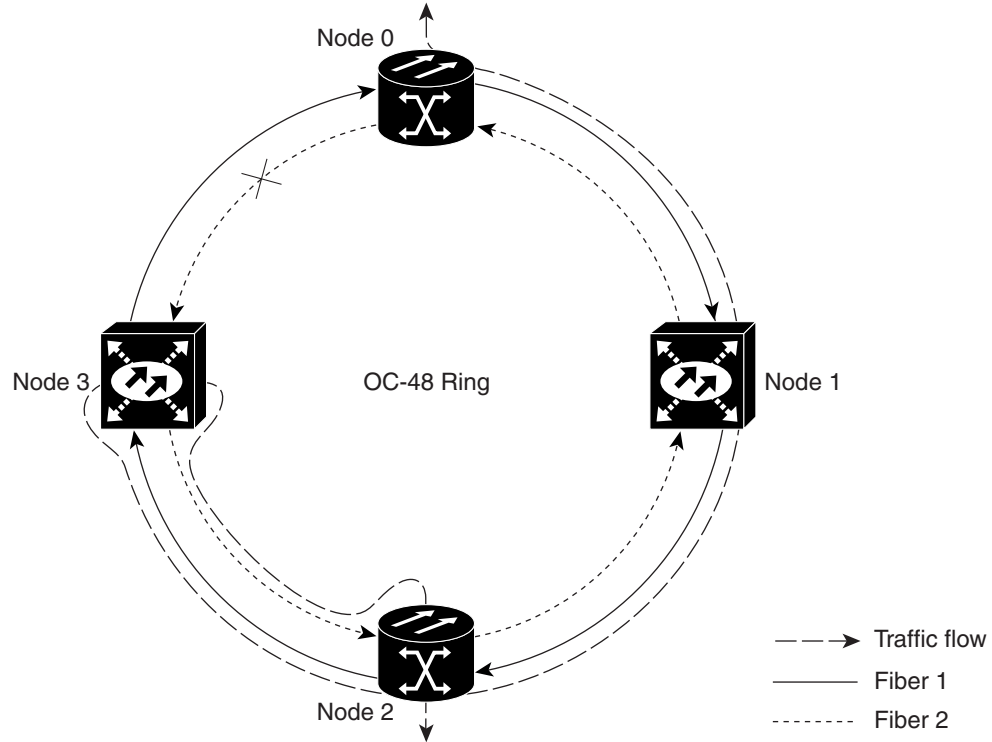


Figure 8-4 shows how traffic is rerouted following a line break between Node 0 and Node 3.

- All circuits originating on Node 0 that carried traffic to Node 2 on Fiber 2 are switched to the protect bandwidth of Fiber 1. For example, a circuit carrying traffic on STS-1 on Fiber 2 is switched to STS-25 on Fiber 1. A circuit carried on STS-2 on Fiber 2 is switched to STS-26 on Fiber 1. Fiber 1 carries the circuit to Node 3 (the original routing destination). Node 3 switches the circuit back to STS-1 on Fiber 2 where it is routed to Node 2 on STS-1.
- Circuits originating on Node 2 that normally carry traffic to Node 0 on Fiber 1 switch to the protect bandwidth of Fiber 2 at Node 3. For example, a circuit carrying traffic on STS-2 on Fiber 1 switches to STS-26 on Fiber 2. Fiber 2 carries the circuit to Node 0 where the circuit switches back to STS-2 on Fiber 1 and is then dropped to its destination.

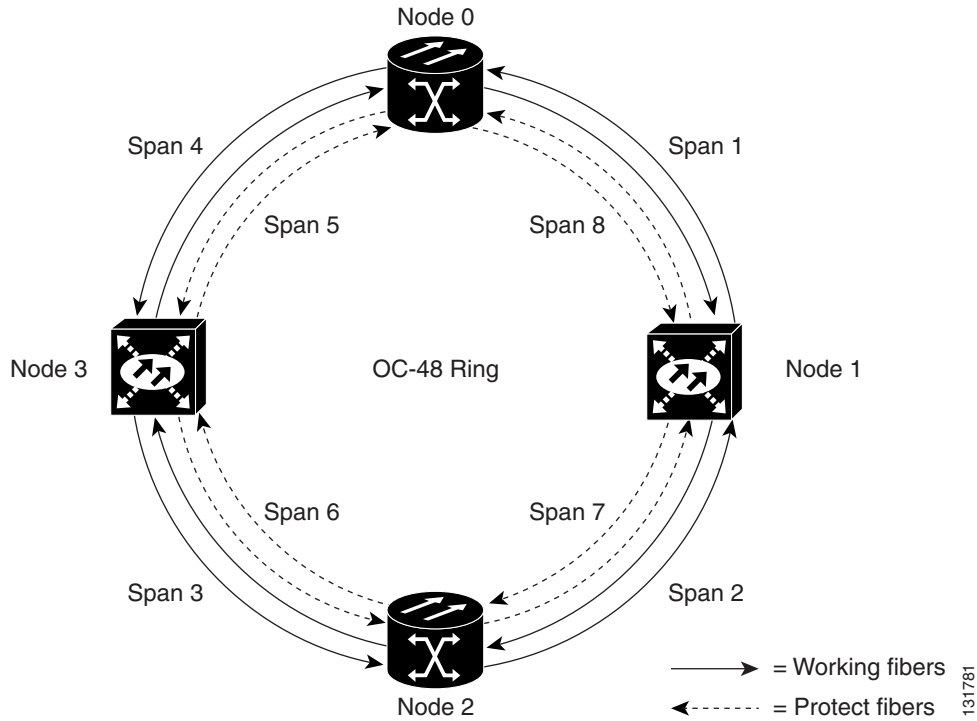
Figure 8-4 Four-Node, Two-Fiber BLSR Traffic Pattern Following Line Break



8.3.2 Four-Fiber BLSRs

Four-fiber BLSRs double the bandwidth of two-fiber BLSRs. Because they allow span switching as well as ring switching, four-fiber BLSRs increase the reliability and flexibility of traffic protection. Two fibers are allocated for working traffic and two fibers for protection, as shown in [Figure 8-5](#). To implement a four-fiber BLSR, you can install either two or four OC-48 or OC-192 cards at each BLSR node, or a single ASAP card at each node. (Each ASAP card provides up to sixteen OC-48 ports or four OC-192 ports. Refer to the [“2.8 ASAP Card”](#) section on page 2-19 for more information.)

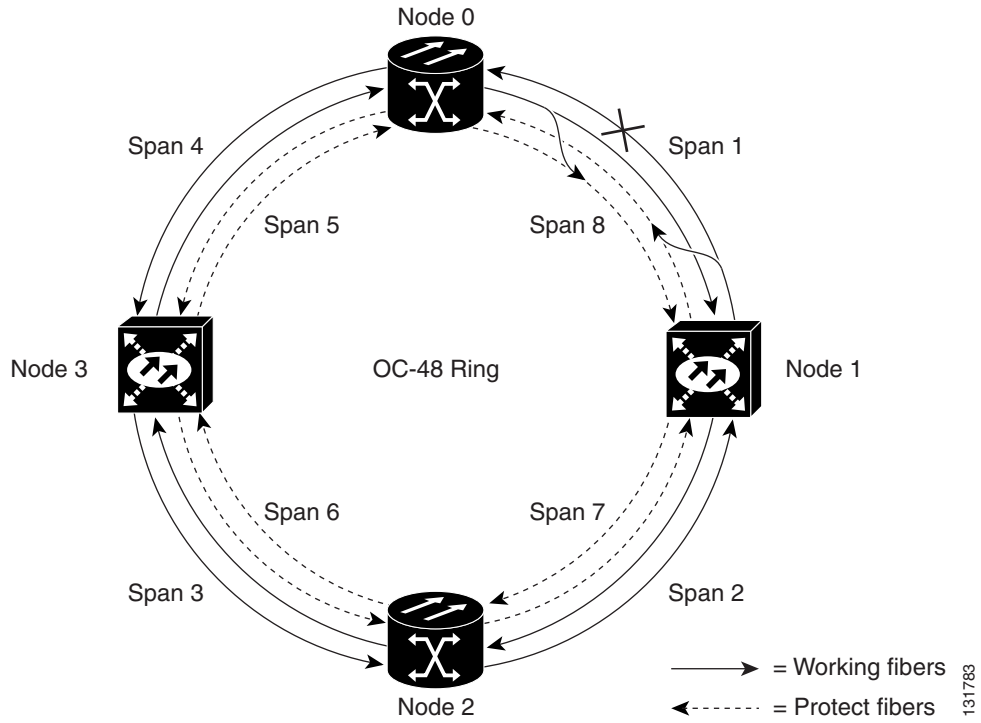
Figure 8-5 Four-Node, Four-Fiber BLSR



Four-fiber BLSRs provide span and ring switching:

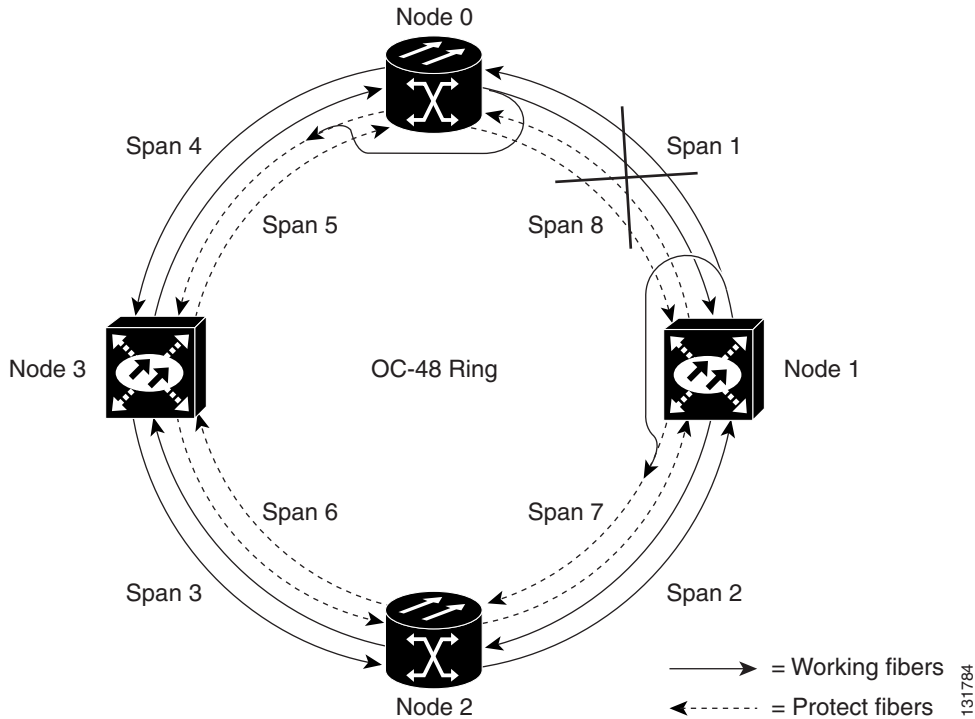
- Span switching (Figure 8-6 on page 8-7) occurs when a working span fails. Traffic switches to the protect fibers between the nodes (Node 0 and Node 1 in the example in Figure 8-6) and then returns to the working fibers. Multiple span switches can occur at the same time.

Figure 8-6 Four-Fiber BLSR Span Switch



- Ring switching (Figure 8-7) occurs when a span switch cannot recover traffic, such as when both the working and protect fibers fail on the same span. In a ring switch, traffic is routed to the protect fibers throughout the full ring.

Figure 8-7 Four-Fiber BLSR Ring Switch



8.3.3 BLSR Bandwidth

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

BLSRs allow bandwidth to be reused around the ring and can carry more traffic than a network with traffic flowing through one central hub. BLSRs can also carry more traffic than a unidirectional path switched ring path protection operating at the same OC-N rate. Table 8-1 shows the bidirectional bandwidth capacities of two-fiber BLSRs. The capacity is the OC-N rate divided by two, multiplied by the number of nodes in the ring minus the number of pass-through STS-1 circuits.

Table 8-1 Two-Fiber BLSR Capacity

OC Rate	Working Bandwidth	Protection Bandwidth	Ring Capacity
OC-48	STS 1-24	STS 25-48	$24 \times N^1 - PT^2$
OC-192	STS 1-96	STS 97-192	$96 \times N - PT$

1. N equals the number of ONS 15xxx nodes configured as BLSR nodes.
2. PT equals the number of STS-1 circuits passed through ONS 15xxx nodes in the ring (capacity can vary depending on the traffic pattern).

Table 8-2 shows the bidirectional bandwidth capacities of four-fiber BLSRs.

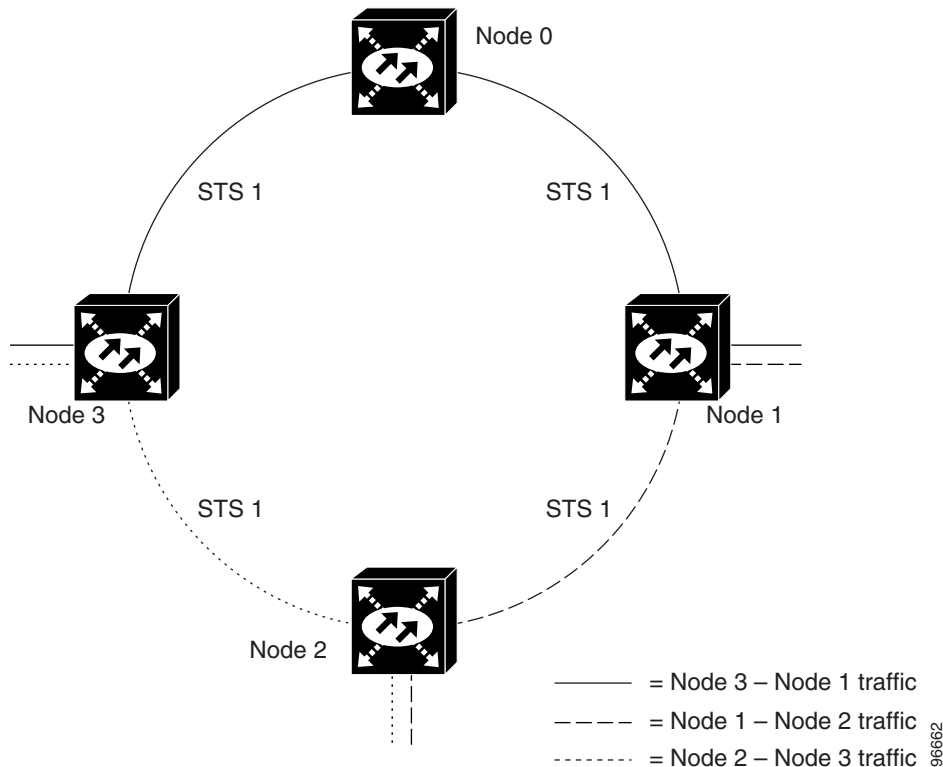
Table 8-2 Four-Fiber BLSR Capacity

OC Rate	Working Bandwidth	Protection Bandwidth	Ring Capacity
OC-48	STS 1-48 (Fiber 1)	STS 1-48 (Fiber 2)	$48 \times N^1 - PT^2$
OC-192	STS 1-192 (Fiber 1)	STS 1-192 (Fiber 2)	$192 \times N - PT$

1. N equals the number of ONS 15600 nodes configured as BLSR nodes.
2. PT equals the number of STS-1 circuits passed through ONS 15600 nodes in the ring (capacity can vary depending on the traffic pattern).

Figure 8-8 shows an example of BLSR bandwidth reuse. The same STS carries three different traffic sets simultaneously on different spans around the ring: one set from Node 3 to Node 1, another set from Node 1 to Node 2, and another set from Node 2 to Node 3.

Figure 8-8 BLSR Bandwidth Reuse



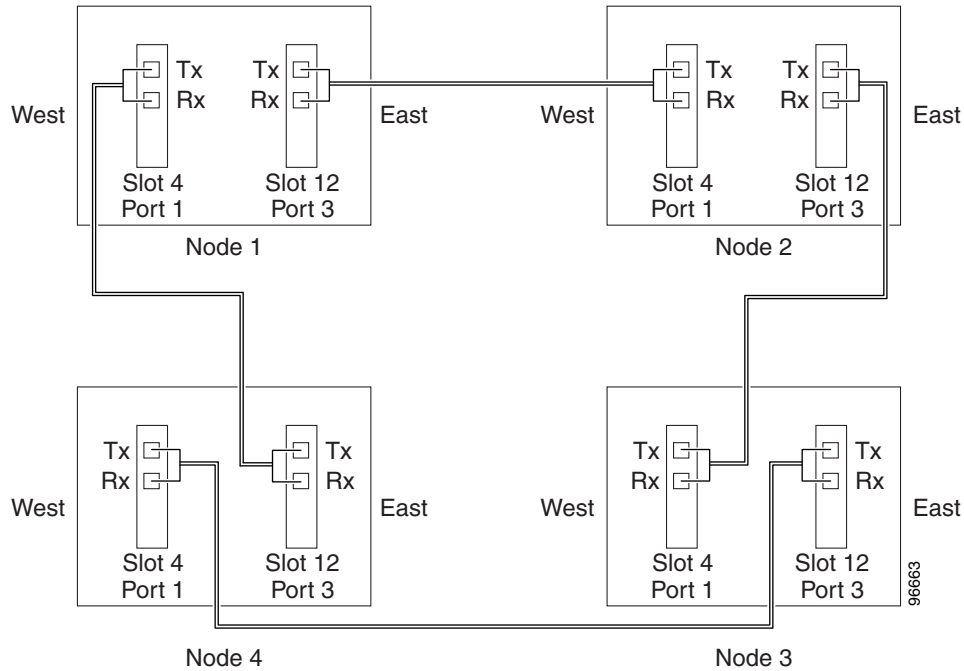
8.3.4 BLSR Fiber Connections

Plan your fiber connections and use the same plan for all BLSR nodes. For example, make the east port the farthest slot to the right and the west port the farthest slot to the left. Plug fiber connected to an east port at one node into the west port on an adjacent node. Figure 8-9 shows fiber connections for a two-fiber BLSR with trunk (span) ports in Slot 4 (west) and Slot 12 (east). Refer to the *Cisco ONS 15600 Procedure Guide* for fiber connection procedures.

**Note**

Always plug the transmit (Tx) connector of an OC-N port at one node into the receive (Rx) connector of an OC-N port at the adjacent node. Cards display an SF LED when Tx and Rx connections are mismatched.

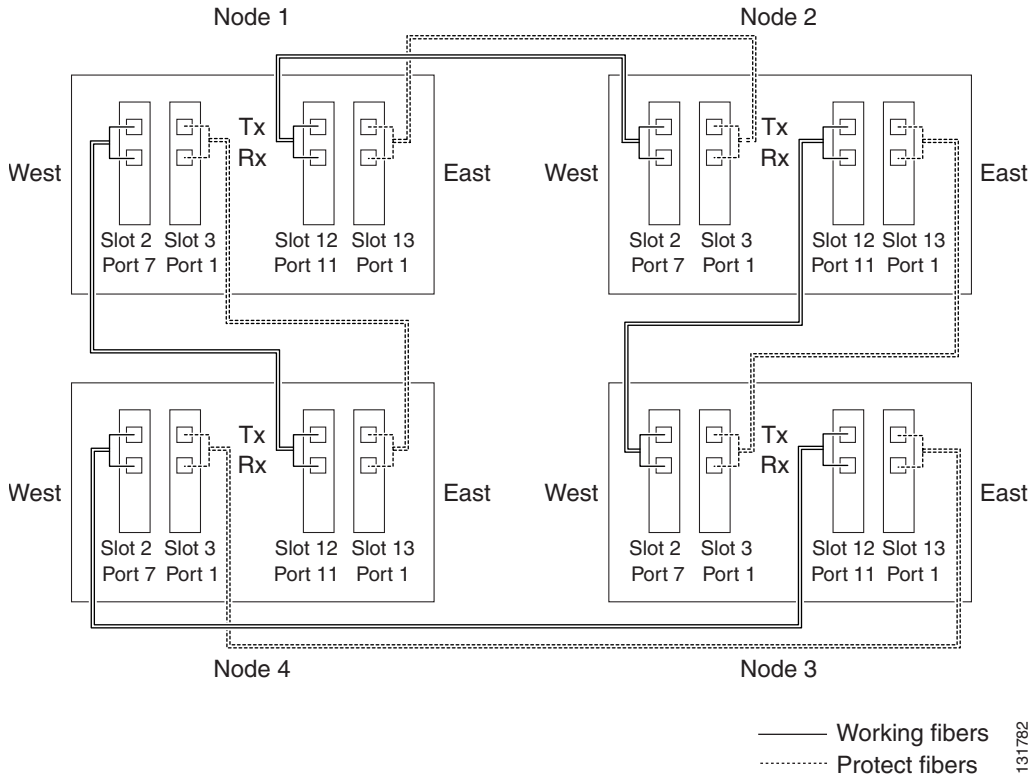
Figure 8-9 Connecting Fiber to a Four-Node, Two-Fiber BLSR



For four-fiber BLSRs, use the same east-west connection pattern for the working and protect fibers. Do not mix working and protect port connections. The BLSR does not function if working and protect ports are interconnected.

Figure 8-10 shows fiber connections for a four-fiber BLSR. Slot 2/Port 7 (west) and Slot 12/Port 11 (east) carry the working traffic. Slot 3/Port 1 (west) and Slot 13/Port 1 (east) carry the protect traffic.

Figure 8-10 Connecting Fiber to a Four-Node, Four-Fiber BLSR

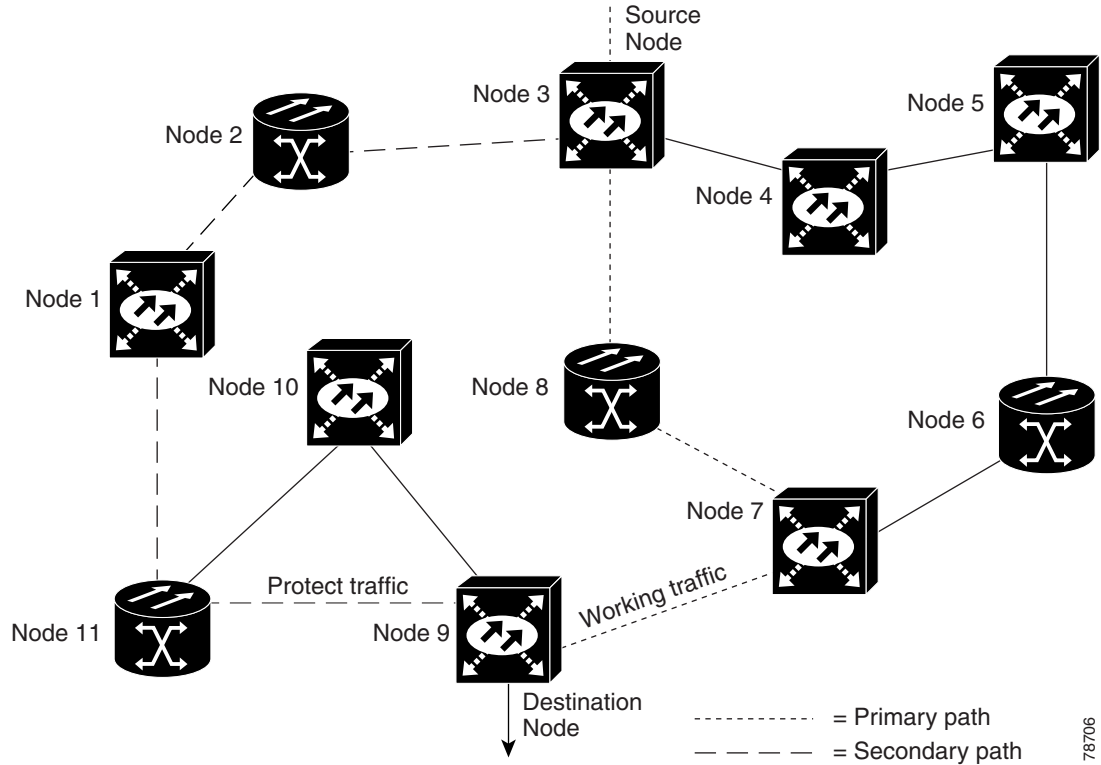


8.4 Path-Protected Mesh Networks

In addition to single BLSRs, path protection configurations, and ADMs, you can extend ONS 15600 traffic protection by creating path-protected mesh networks (PPMNs). PPMNs include multiple ONS 15600 SONET topologies and extend the protection provided by a single path protection to the meshed architecture of several interconnecting rings. In a PPMN, circuits travel diverse paths through a network of single or multiple meshed rings. When you create circuits, CTC automatically routes circuits across the PPMN, or you can manually route them. You can also choose levels of circuit protection. For example, if you choose full protection, CTC creates an alternate route for the circuit in addition to the main route. The second route follows a unique path through the network between the source and destination and sets up a second set of cross-connections.

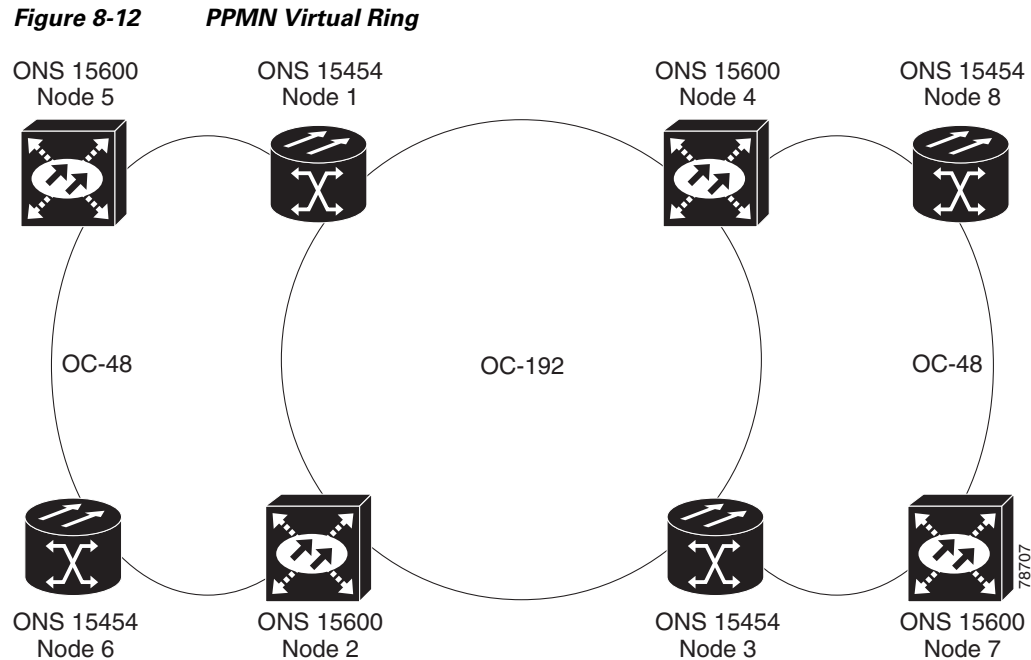
For example, in Figure 8-11, a circuit is created from Node 3 to Node 9. CTC determines that the shortest route between the two nodes passes through Node 8 and Node 7, shown by the dotted line, and automatically creates cross-connections at Nodes 3, 8, 7, and 9 to provide the primary circuit path.

Figure 8-11 Path-Protected Mesh Network



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

PPMN also allows spans of different SONET line rates to be mixed together in virtual rings. Figure 8-12 shows Nodes 1, 2, 3, and 4 in an OC-192 ring.



8.5 In-Service Topology Upgrades

Topology upgrades can be performed in-service to convert a live network to a different topology. An in-service topology upgrade is potentially service-affecting, and generally allows a traffic hit of 50 ms or less. Traffic might not be protected during the upgrade. The following in-service topology upgrades are supported:

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

You can perform in-service topology upgrades irrespective of the service state of the involved cross-connects or circuits, however all circuits must have a DISCOVERED status.

ONS 15600 circuit types supported for in-service topology upgrades are:

- Synchronous transport signal (STS)
- Unidirectional and bidirectional
- Automatically routed and manually routed
- CTC-created and TL1-created
- Ethernet (unstitched)
- Multiple source and destination (both sources should be on one node and both drops on one node)

You cannot upgrade stitched Ethernet circuits during topology conversions. For in-service topology upgrade procedures, refer to the “Convert Network Configurations” chapter in the *Cisco ONS 15600 Procedure Guide*. For procedures to add or remove a node, refer to the “Add and Remove Nodes” chapter of the *Cisco ONS 15600 Procedure Guide*.

**Note**

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

**Note**

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

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

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

8.5.2 Two-Fiber BLSR to Four-Fiber BLSR

CTC provides a wizard to convert two-fiber OC-48 or OC-192 BLSRs to four-fiber BLSRs. To convert the BLSR, you must install two OC-48 or OC-192 ports at each two-fiber BLSR node, then log into CTC and convert each node from two-fiber to four-fiber. The fibers that were divided into working and protect bandwidths for the two-fiber BLSR are now fully allocated for working BLSR traffic.

8.5.3 Add or Remove a Node from a Topology

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