SDH Topologies and Upgrades

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

Chapter topics include:

8.1 Overview

The ONS 15600 SDH usually operates as a hub node in networks that include ONS 15454 SDHs. Single nodes are installed at geographic locations where several ONS SDH topologies converge. A single ONS 15600 SDH node might be a part of several ONS SDH rings/networks.

To avoid errors during network configuration, Cisco recommends that you draw the complete ONS SDH 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 15600 SDHs as a line of add/drop multiplexers (ADMs) by configuring one STM-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 STM-N ports at each node be in 1+1 protection to ensure that a break to the working line automatically routes traffic to the protect line.

Figure 8-1 shows two ONS 15600 SDH 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 2/Port 1 and Slot 2/Port 1 at Nodes 1 and 2.

Figure 8-1   ***Point-to-Point ADM Configuration***
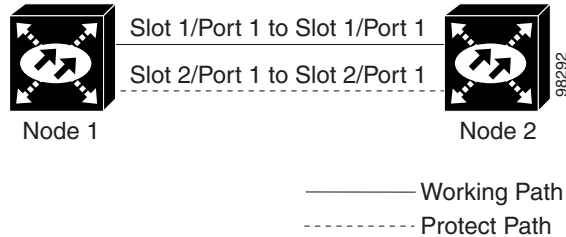
8.3 Multiplex-Section Shared Protection Rings

The ONS 15600 SDH can support up to 32 multiplex section-shared protection rings (MS-SPRings). Because the working and protect bandwidths must be equal, you can create only STM-16 or STM-64 MS-SPRings (that is, you cannot create an MS-SPRing with a mixture of STM-16 and STM-64 line rates). For information about MS-SPRing protection channels, see the "7.7 Protection Channel Access Circuits" section on page 7-14.

> **Note**   For best performance, MS-SPRings should have one LAN connection for every ten nodes in the MS-SPRing.

8.3.1 Two-Fiber MS-SPRings

In two-fiber MS-SPRings, each fiber is divided into working and protect bandwidths. For example, in an STM-16 MS-SPRing, VC4s 1 to 8 carry the working traffic, and VC4s 9 to 16 are reserved for protection (Figure 8-2). Working traffic (VC4s 1 to 8) 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 MS-SPRing
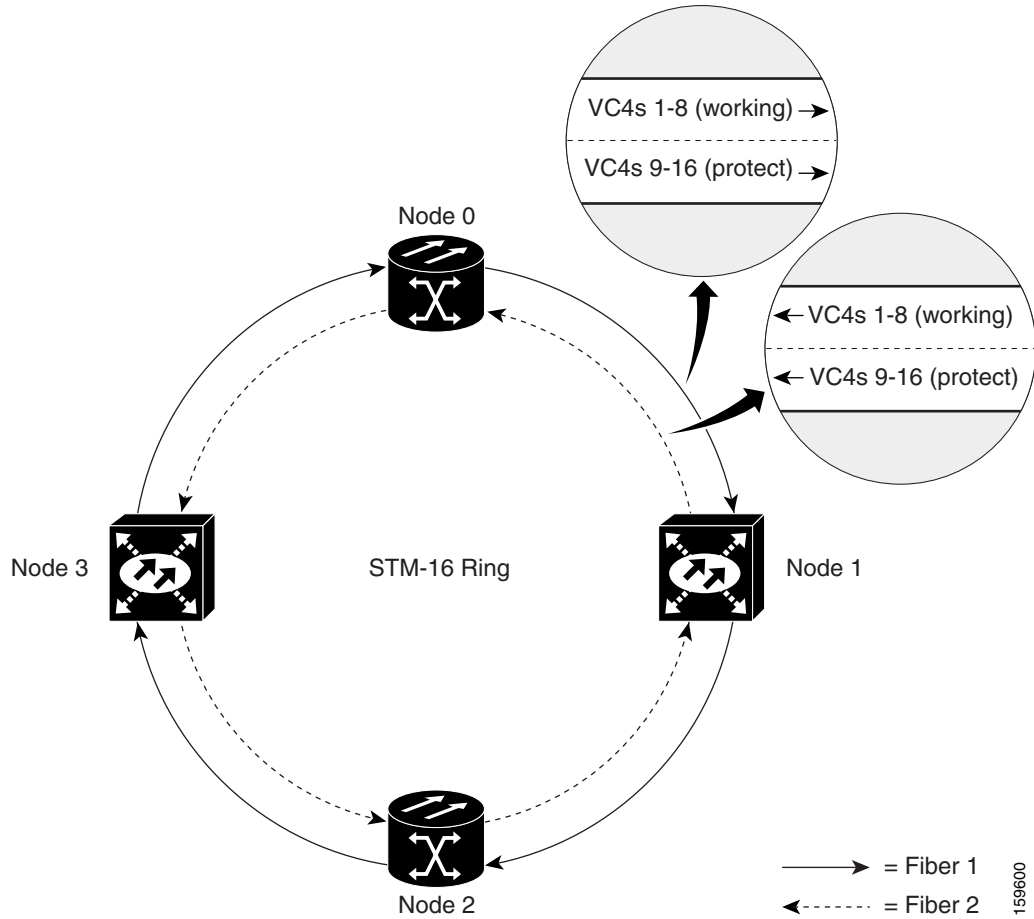
The SDH K1, K2, and K3 bytes carry the information that governs MS-SPRing protection switches. Each MS-SPRing node monitors the K bytes to determine when to switch the SDH signal to an alternate physical path. The K bytes communicate failure conditions and actions taken between nodes in the ring.

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 MS-SPRing.

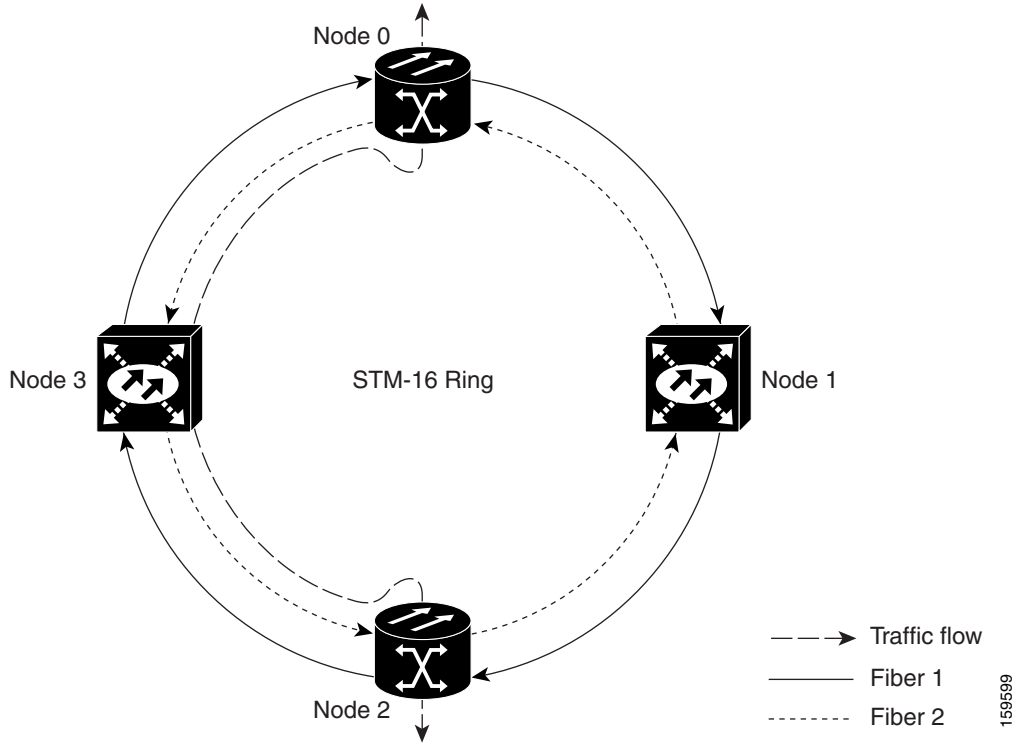*Figure 8-3*   *Four-Node, Two-Fiber MS-SPRing Traffic Pattern Sample*

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 carried on VC4-1 on Fiber 2 is switched to VC4-9 on Fiber 1. A circuit carried on VC4-2 on Fiber 2 is switched to VC4-10 on Fiber 1. Fiber 1 carries the circuit to Node 3 (the original routing destination). Node 3 switches the circuit back to VC4-1 on Fiber 2 where it is routed to Node 2 on VC4-1.

- 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 carried on VC4-2 on Fiber 1 is switched to VC4-10 on Fiber 2. Fiber 2 carries the circuit to Node 0 where the circuit is switched back to VC4-2 on Fiber 1 and then dropped to its destination.

Figure 8-4   Four-Node, Two-Fiber MS-SPRing Traffic Pattern Following Line Break
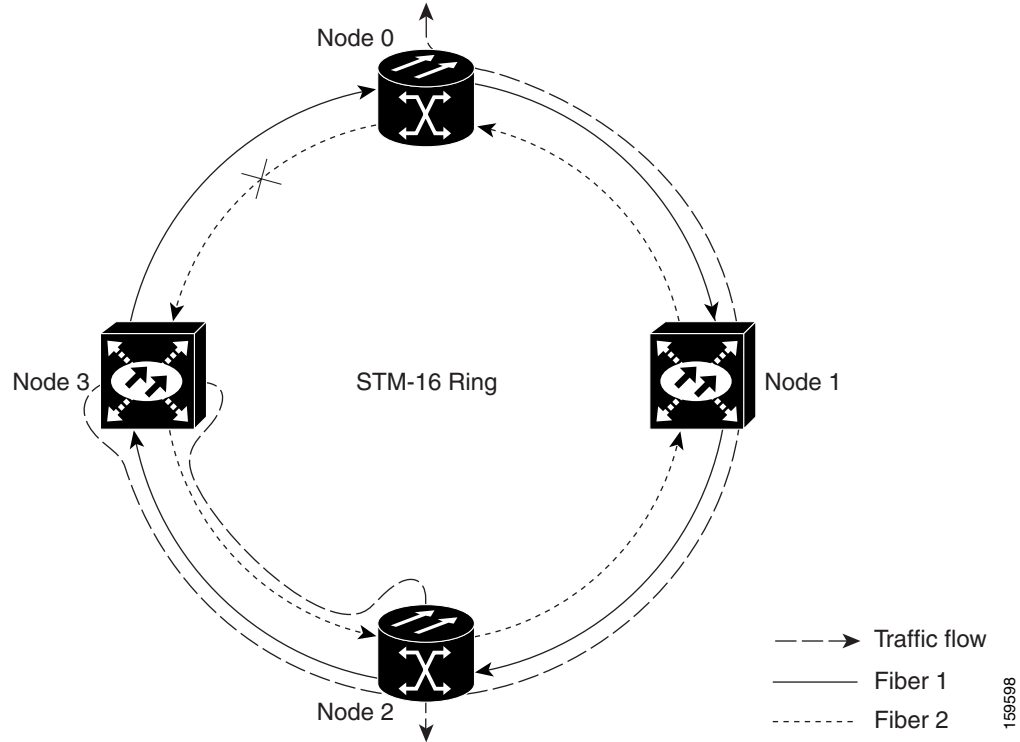
8.3.2 MS-SPRing Bandwidth

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

MS-SPRings allow bandwidth to be reused around the ring and can carry more traffic than a network with traffic flowing through one central hub. MS-SPRings can also carry more traffic than a subnetwork connection protection (SNCP) ring operating at the same STM-N rate. Table 8-1 shows the bidirectional bandwidth capacities of two-fiber MS-SPRings. The capacity is the STM-N rate divided by two, multiplied by the number of nodes in the ring minus the number of pass-through VC circuits.
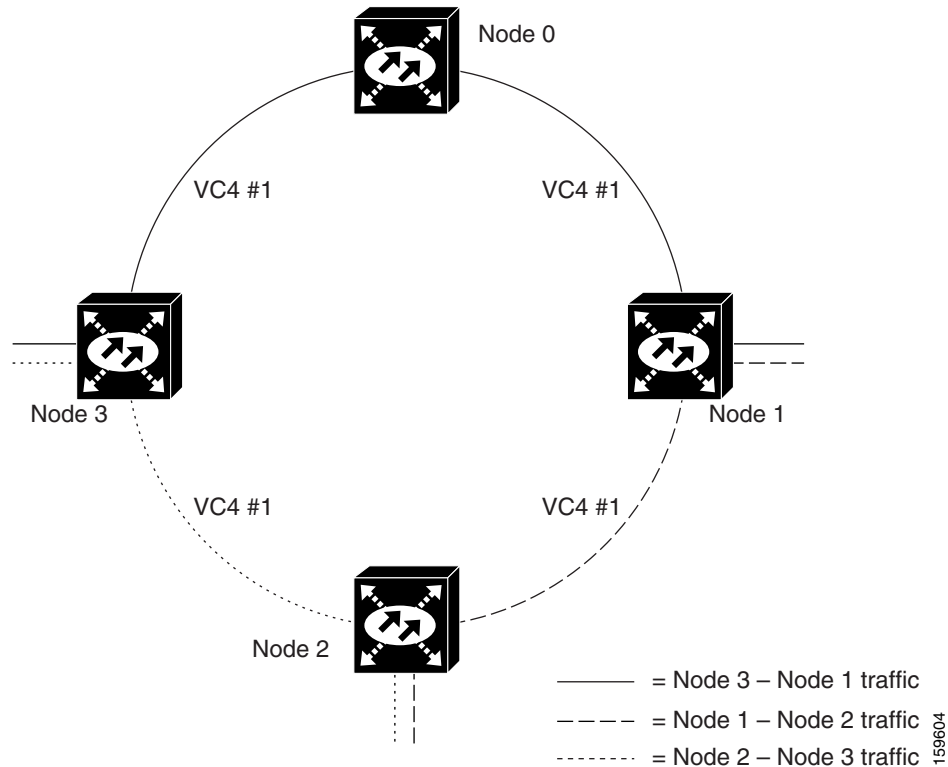
Table 8-1   Two-Fiber MS-SPRing Capacity

OC Rate	Working Bandwidth	Protection Bandwidth	Ring Capacity
STM-16	VC4 1-8	VC4 9-16	$8 \times N^1 - PT^2$
STM-64	VC4 1-32	VC4 33-64	$32 \times N - PT$

1. N equals the number of ONS 15xxx SDH nodes in the ring. Nodes can be configured as MS-SPRing nodes but be in another MS-SPRing.

2. PT equals the number of VC-4 circuits passed through ONS 15xxx SDH nodes in the ring (capacity varies depending on the traffic pattern).

Figure 8-5 shows an example of MS-SPRing bandwidth reuse. The same VC4 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 8-5　　　*MS-SPRing Bandwidth Reuse*

Node 0

VC4 #1　　　　VC4 #1

Node 3　　　　　　　　　　　　Node 1

VC4 #1　　　　VC4 #1

Node 2

───── = Node 3 – Node 1 traffic

– – – – = Node 1 – Node 2 traffic

- - - - - - - = Node 2 – Node 3 traffic

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8.3.3 MS-SPRing Fiber Connections

Plan your fiber connections and use the same plan for all MS-SPRing 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 8-6 shows fiber connections for a two-fiber MS-SPRing with trunk (span) ports in Slot 4 (west) and Slot 12 (east). Refer to the *Cisco ONS 15600 SDH Procedure Guide* for fiber connection procedures.

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

Figure 8-6   *Connecting Fiber to a Four-Node, Two-Fiber MS-SPRing*
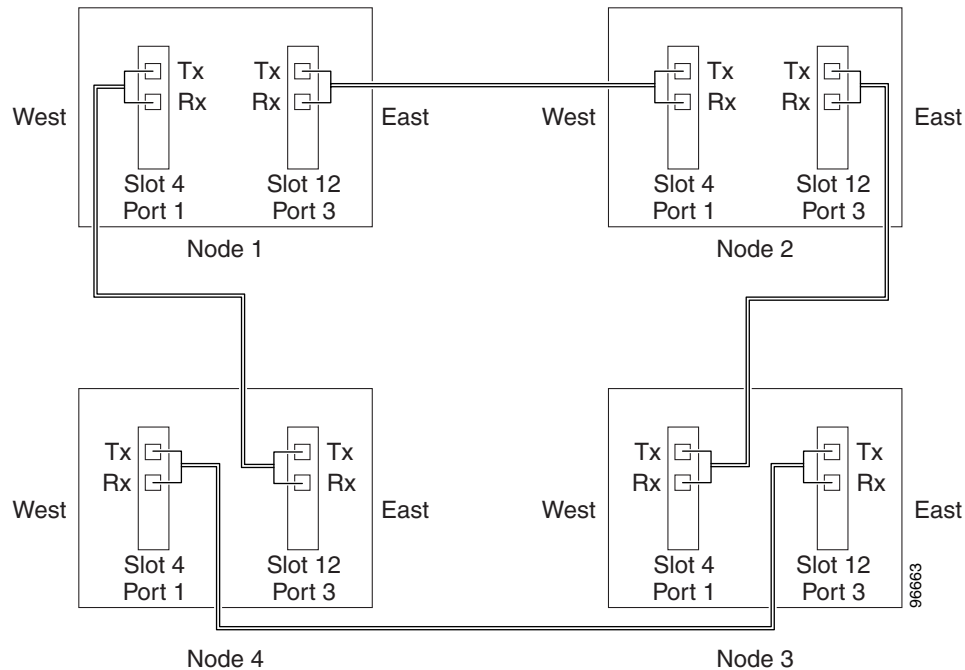
8.4 Subnetwork Connection Protection Rings

SNCP rings provide duplicate fiber paths around the ring. Working traffic flows in one direction and protection traffic flows in the opposite direction. If a problem occurs in the working traffic path, the receiving node switches to the path coming from the opposite direction.

CTC automates ring configuration. SNCP traffic is defined within the ONS 15600 SDH on a circuit-by-circuit basis. If a path-protected circuit is not defined within a 1+1 or MS-SPRing line protection scheme and path protection is available and specified, CTC uses SNCP as the default. You can set up a maximum of 64 STM-1/4/16 SNCPs or 16 STM-64 SNCPs for each ONS 15600 SDH node.

An SNCP circuit requires two data communications channel (DCC)-provisioned optical spans per node. SNCP circuits can be created across these spans until their bandwidth is consumed.

Note   If an SNCP circuit is created manually by Transaction Language One (TL1), DCCs are not needed; therefore, SNCP circuits are limited by the cross-connection bandwidth or the span bandwidth, but not by the number of DCCs.

The span bandwidth consumed by an SNCP circuit is two times the circuit bandwidth, since the circuit is duplicated. The cross-connection bandwidth consumed by an SNCP circuit is three times the circuit bandwidth at the source and destination nodes only. The cross-connection bandwidth consumed by an intermediate node has a factor of one.

Figure 8-7 shows a basic SNCP configuration. If Node 0 sends a signal to Node 2, the working signal travels on the working traffic path through Node 1. The same signal is also sent on the protect traffic path through Node 3.

Figure 8-7   Basic Four-Node SNCP
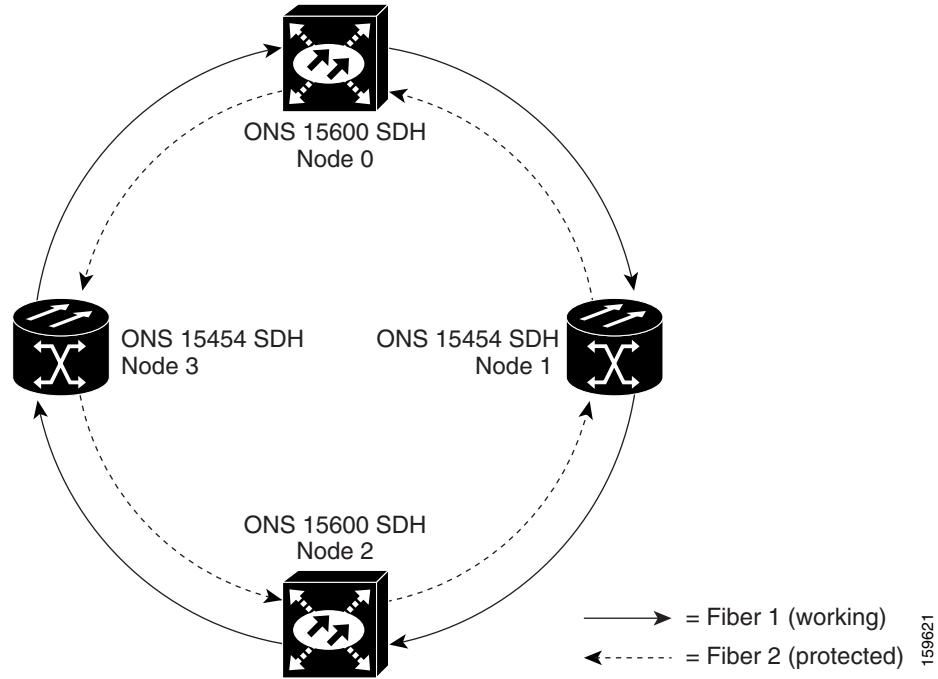
If a fiber break occurs, Node 2 switches its active receiver to the protect signal coming through Node 3 (Figure 8-8).

Figure 8-8   *SNCP with a Fiber Break*
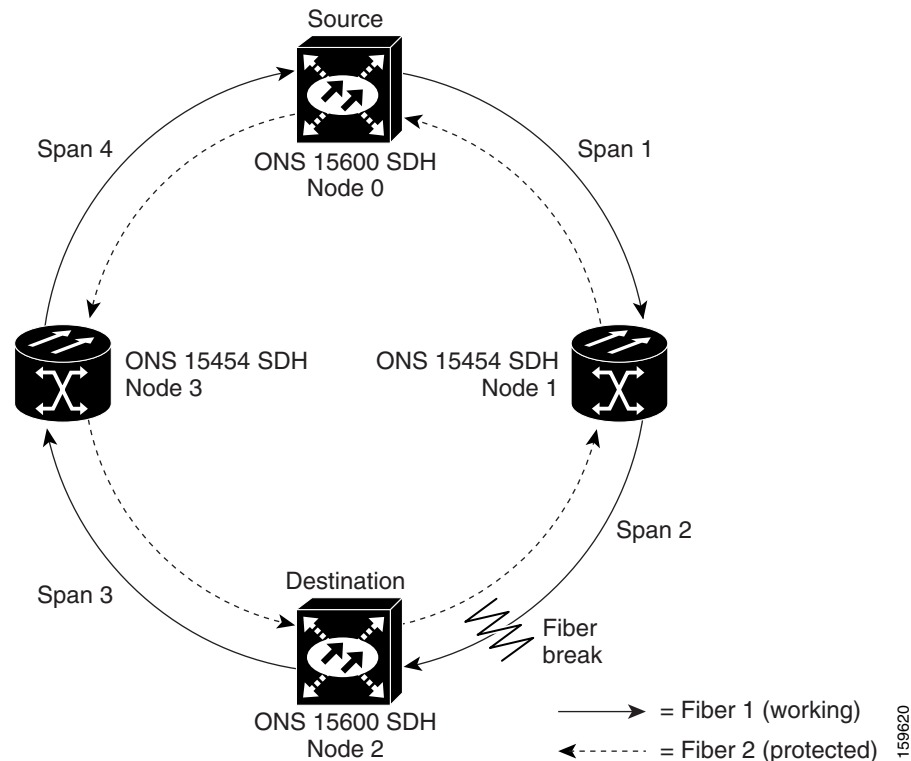
Because each traffic path is transported around the entire ring, SNCP rings are best suited for networks where traffic concentrates at one or two locations and is not widely distributed. SNCP capacity is equal to its bit rate. Services can originate and terminate on the same SNCP, or they can be passed to an adjacent access or interoffice ring for transport to the service-terminating location.

8.5 Dual-Ring Interconnect

Dual-ring interconnect (DRI) topology provides an extra level of path protection for circuits on interconnected rings. DRI allows users to interconnect MS-SPRings, SNCP rings, or an SNCP ring with an MS-SPRing, with additional protection provided at the transition nodes. In a DRI topology, ring interconnections occur at two or four nodes.

The drop-and-continue DRI method is used for all ONS 15600 SDH DRIs. In drop-and-continue DRI, a primary node drops the traffic to the connected ring and routes traffic to a secondary node within the same ring. The secondary node also routes the traffic to the connected ring; that is, the traffic is dropped at two different interconnection nodes to eliminate single points of failure. To route circuits on DRI, you must choose the Dual Ring Interconnect option during circuit provisioning. Dual transmit is not supported.

Two DRI topologies can be implemented on the ONS 15600 SDH:

- A traditional DRI requires two pairs of nodes to interconnect two networks. Each pair of user-defined primary and a secondary nodes drop traffic over a pair of interconnection links to the other network.

- An integrated DRI requires one pair of nodes to interconnect two networks. The two interconnected nodes replace the interconnection ring.

For DRI topologies, a hold-off timer sets the amount of time before a selector switch occurs. It reduces the likelihood of multiple switches, such as:

- Both a service selector and a path selector
- Both a line switch and a path switch of a service selector

For example, if an SNCP DRI service selector switch does not restore traffic, then the path selector switches after the hold-off time. The SNCP DRI hold-off timer default is 100 ms. You can change this setting in the SNCP Selectors tab of the Edit Circuits window. For an MS-SPRing DRI, if line switching does not restore traffic, then the service selector switches. The hold-off time delays the recovery provided by the service selector. The MS-SPRing DRI default hold-off time is 100 ms and cannot be changed.

8.5.1 MS-SPRing DRI

Unlike MS-SPRing automatic protection switching (APS) protocol, MS-SPRing DRI is a path-level protection protocol at the circuit level. Drop-and-continue MS-SPRing DRI requires a service selector in the primary node for each circuit routing to the other ring. Service selectors monitor signal conditions from dual feed sources and select the one that has the best signal quality. Same-side routing drops the traffic at primary nodes set up on the same side of the connected rings, and opposite-side routing drops the traffic at primary nodes set up on the opposite sides of the connected rings. For MS-SPRing DRI, primary and secondary nodes cannot be the circuit source or destination.

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

Figure 8-9 shows ONS 15600 SDHs in a traditional MS-SPRing DRI topology with same-side routing. In Ring 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 8 and 9. Duplicate signals are sent from Node 4 (Ring 1) to Node 9 (Ring 2), and from Node 3 (Ring 1) to Node 8 (Ring 2). The primary nodes (Nodes 4 and 9) are on the same side, and the secondary nodes (Nodes 3 and 8) provide an alternative route. In Ring 1, traffic at Node 4 is dropped (to Node 9) and continued (to Node 3). Similarly, at Node 9, traffic is dropped (to Node 4) and continued (to Node 8).

Figure 8-9   ONS 15600 SDH Traditional MS-SPRing Dual-Ring Interconnect (Same-Side Routing)
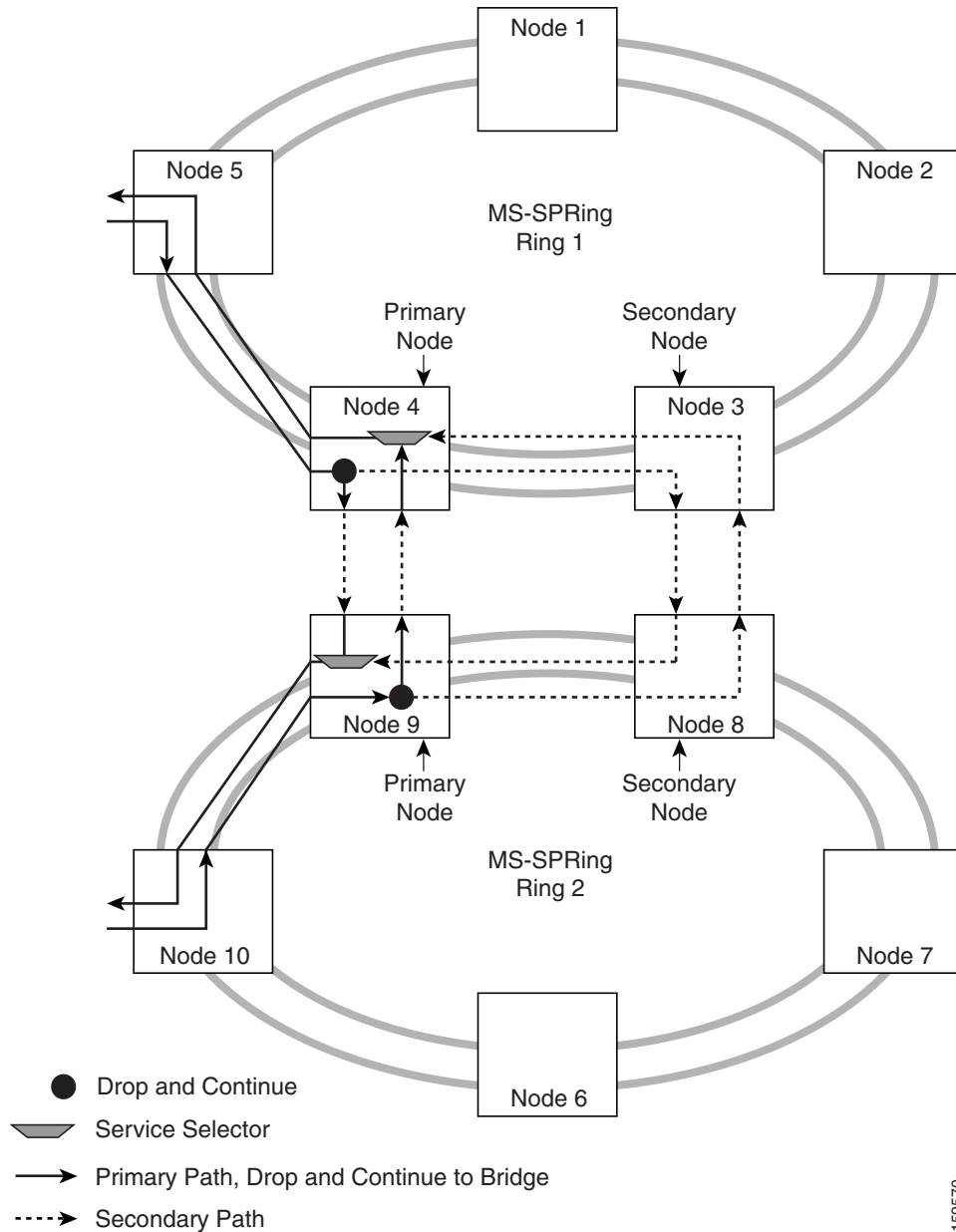

Figure 8-10 shows ONS 15600 SDHs in a traditional MS-SPRing DRI topology with opposite-side routing. In Ring 1, Nodes 3 and 4 are the interconnect nodes, and in Ring 2, Nodes 8 and 9. Duplicate signals are sent from Node 4 (Ring 1) to Node 8 (Ring 2), and from Node 3 (Ring 1) to Node 9 (Ring 2). In Ring 1, traffic at Node 4 is dropped (to Node 9) and continued (to Node 3). Similarly, at Node 8, traffic is dropped (to Node 3) and continued (to Node 9).

Figure 8-10   ONS 15600 SDH Traditional MS-SPRing Dual-Ring Interconnect (Opposite-Side Routing)
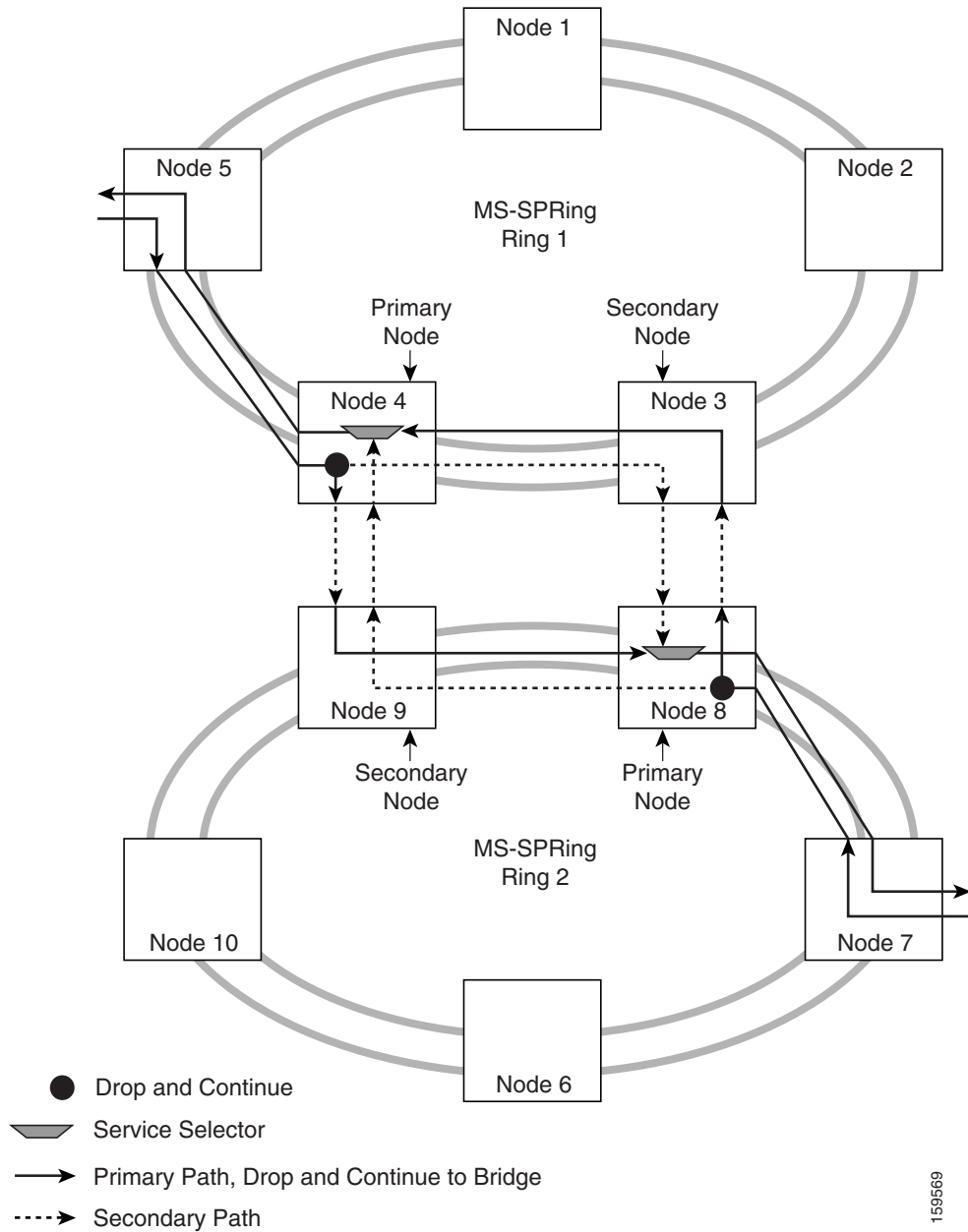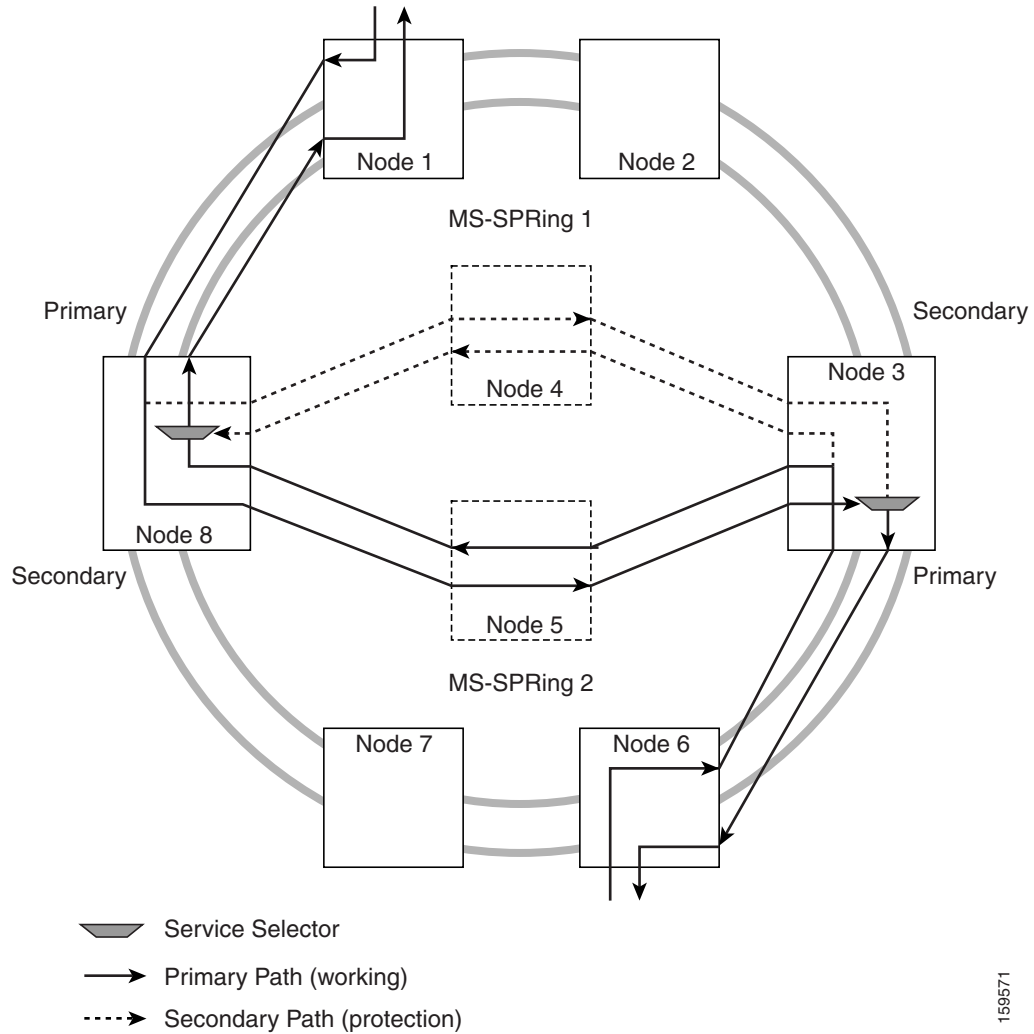

Figure 8-11 shows ONS 15600 SDHs in an integrated MS-SPRing DRI topology. The same drop-and-continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an additional STM-N trunk at the two interconnect nodes. Nodes 3 and 8 are the interconnect nodes.

Figure 8-11   *ONS 15600 SDH Integrated MS-SPRing Dual-Ring Interconnect*

8.5.2 SNCP DRI

Figure 8-12 shows ONS 15600 SDHs in a traditional drop-and-continue SNCP DRI topology. In Ring 1, Nodes 4 and 5 are the interconnect nodes, and in Ring 2, Nodes 6 and 7 are the interconnect nodes. Duplicate signals are sent from Node 4 (Ring 1) to Node 6 (Ring 2), and from Node 5 (Ring 1) to Node 7 (Ring 2). In Ring 1, traffic at Node 4 is dropped (to Node 6) and continued (to Node 5). Similarly, at Node 5, traffic is dropped (to Node 7) and continued (to Node 4).

Figure 8-12   *ONS 15600 SDH Traditional SNCP Dual-Ring Interconnect*
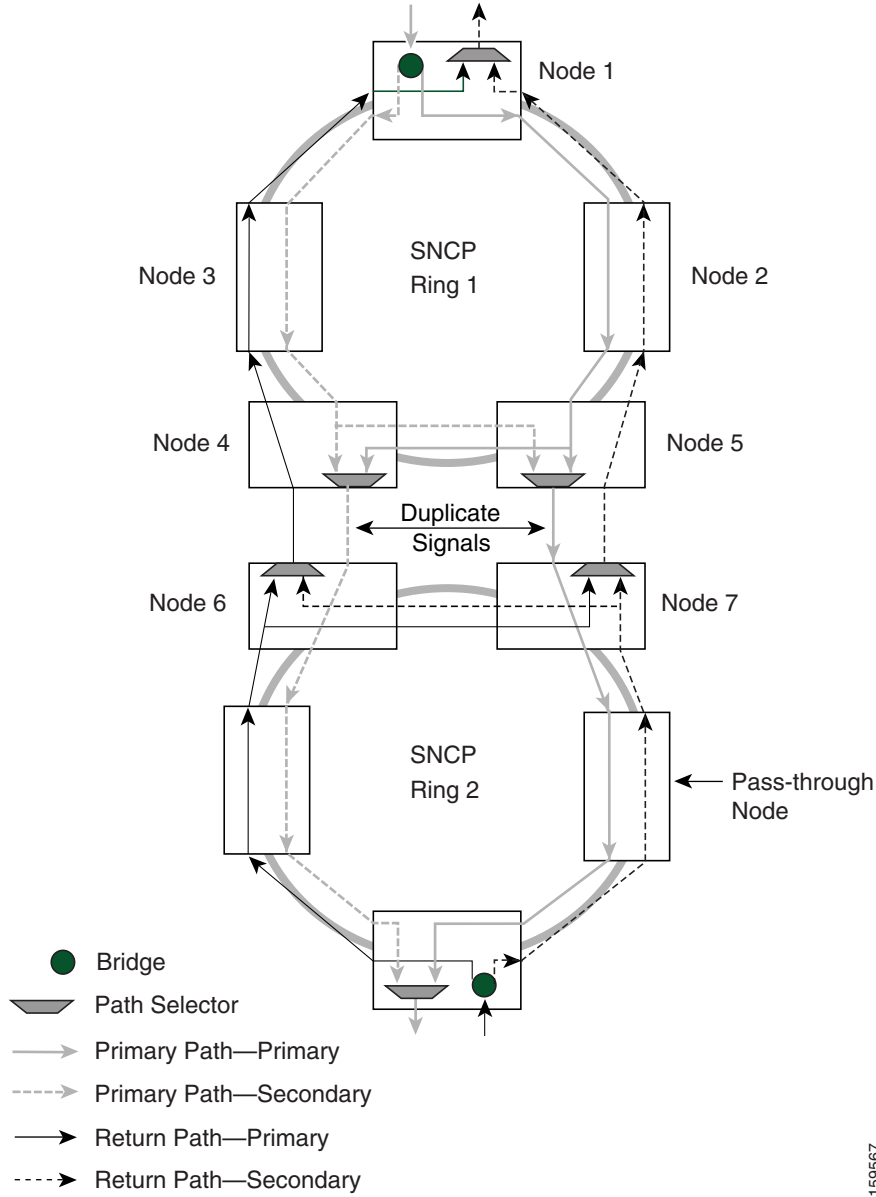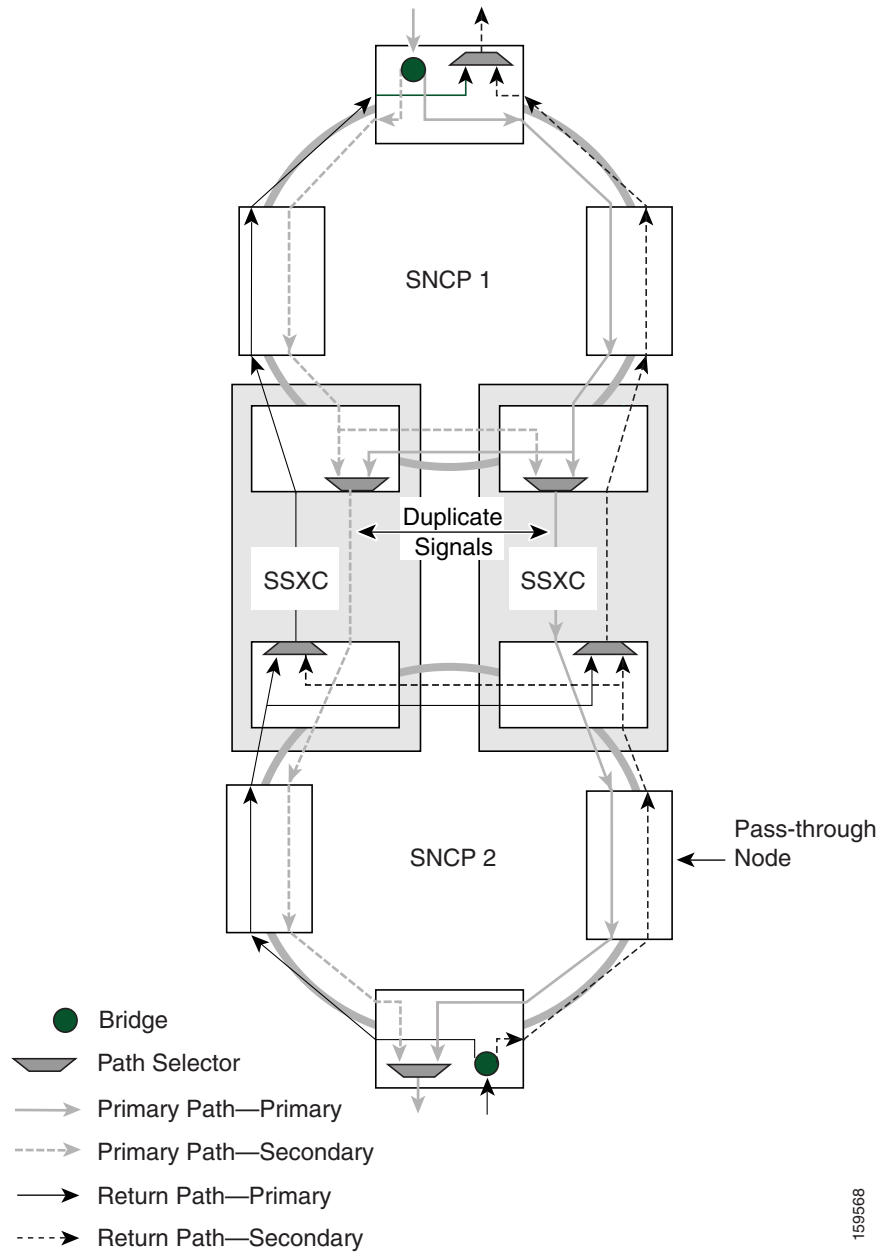

Figure 8-13 shows ONS 15600 SDHs in an integrated DRI topology. The same drop-and-continue traffic routing occurs at two nodes, rather than four. This is achieved by installing an addition STM-N trunk at the two interconnect nodes.

Figure 8-13   ONS 15600 SDH Integrated SNCP Dual-Ring Interconnect

8.5.3 SNCP/MS-SPRing DRI Handoff Configurations

SNCP rings and MS-SPRings can also be interconnected. In MS-SPRing/SNCP DRI handoff configurations, primary and secondary nodes can be the circuit source or destination, which is useful when non-DCC optical interconnecting links are present. Figure 8-14 shows an example of an SNCP ring to MS-SPRing traditional DRI handoff.

Figure 8-14   ONS 15600 SDH SNCP to MS-SPRing Traditional DRI Handoff
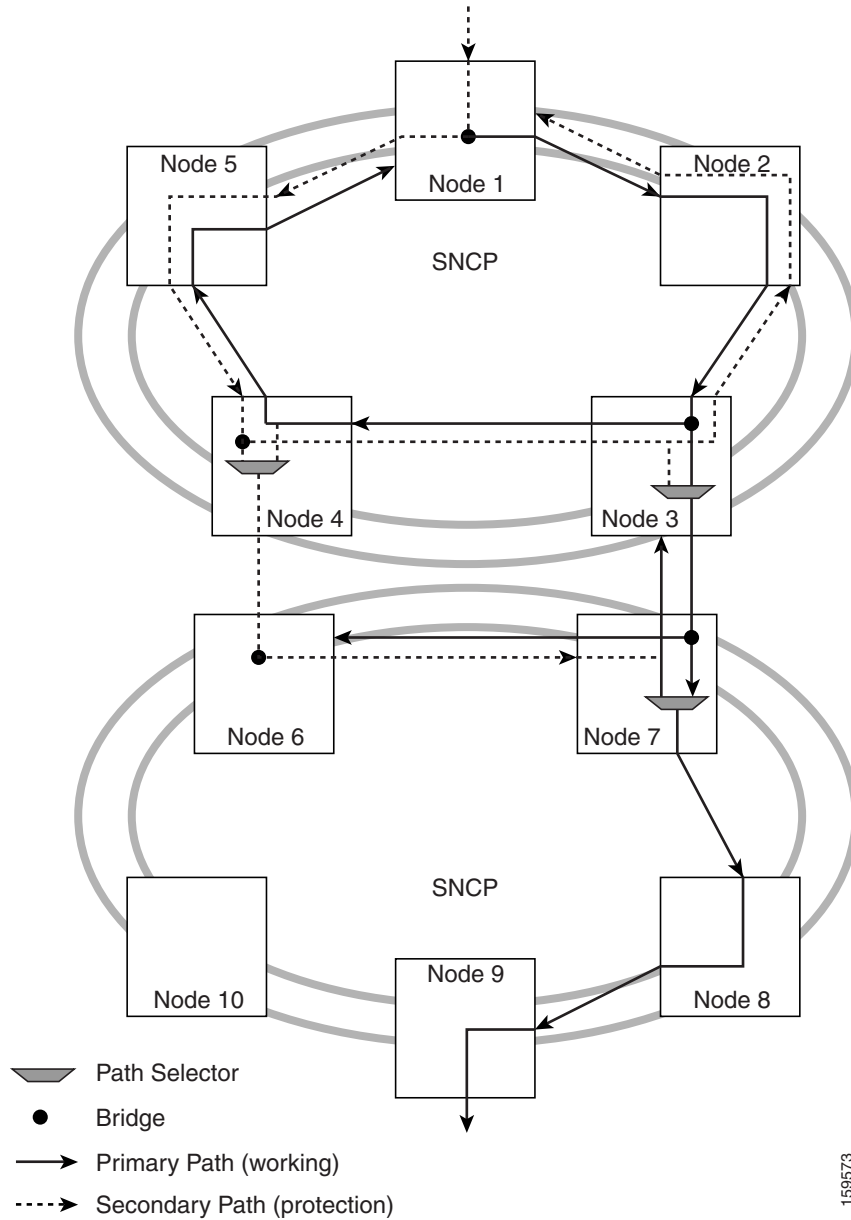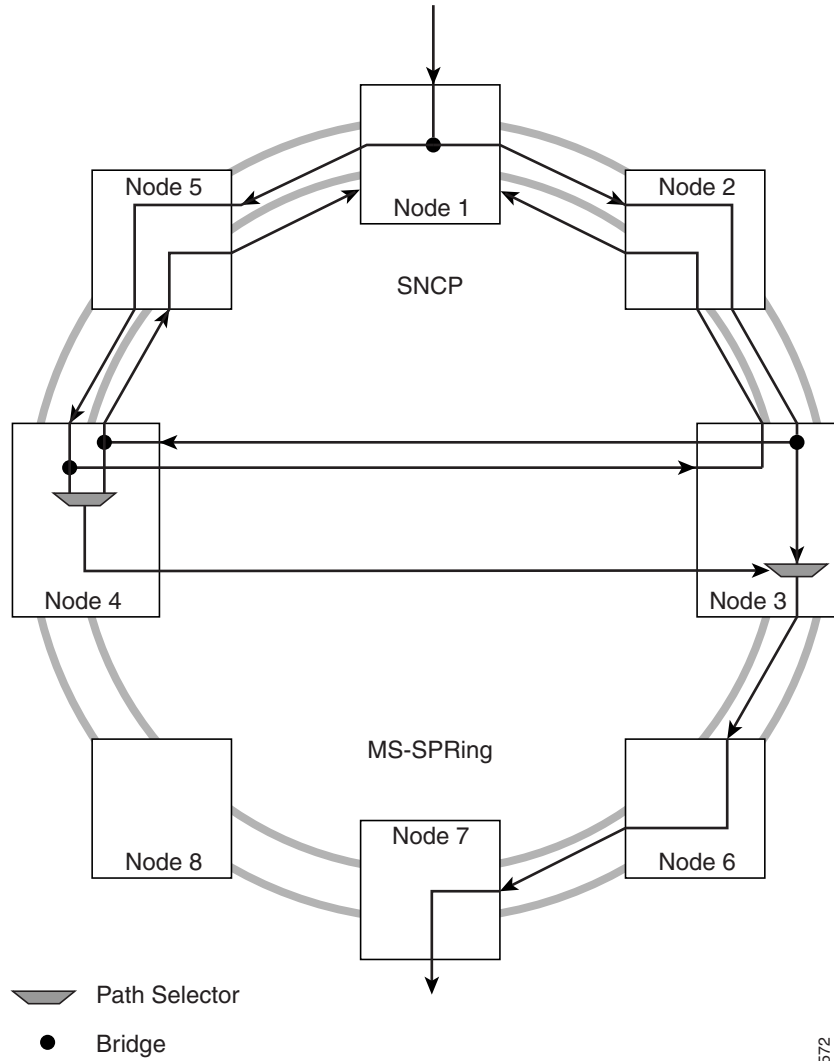

Figure 8-15 shows an example of an SNCP ring to MS-SPRing integrated DRI handoff.

Figure 8-15   ONS 15600 SDH SNCP Ring to MS-SPRing Integrated DRI Handoff

8.6 Subtending Rings

Subtending rings reduce the number of nodes and cards required and reduce external shelf-to-shelf cabling. The ONS 15600 SDH supports a maximum of 32 two-fiber MS-SPRings. If all rings have an STM-64 line rate, the maximum is 16 two-fiber MS-SPRings. Figure 8-16 shows an ONS 15600 SDH with multiple subtending rings.

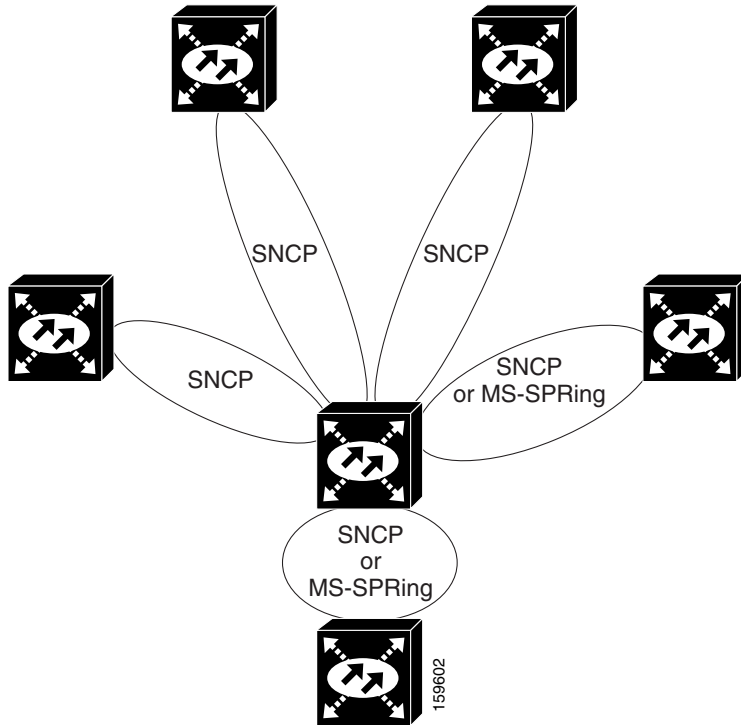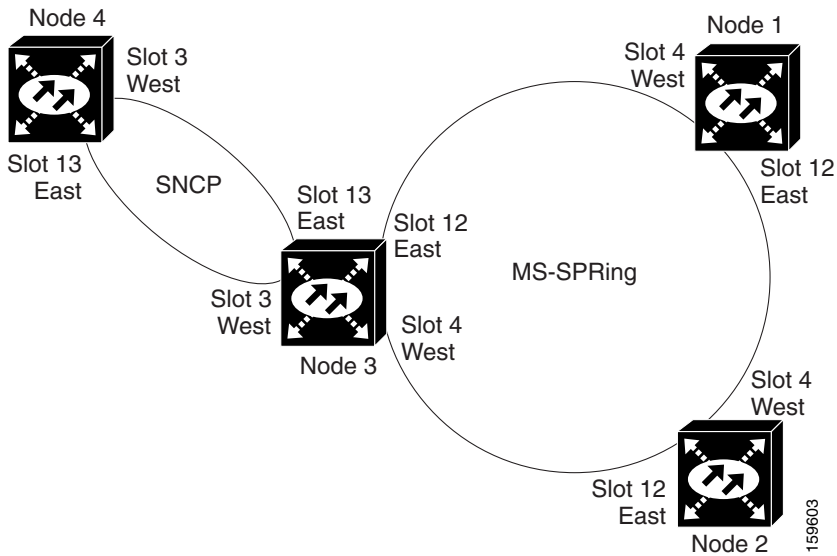*Figure 8-16   ONS 15600 SDH with Multiple Subtending Rings*

Figure 8-17 shows an SNCP ring subtending from an MS-SPRing. In this example, Node 3 is the only node serving both the MS-SPRing and SNCP ring. STM-N cards in Slots 4 and 12 serve the MS-SPRing, and STM-N cards in Slots 3 and 13 serve the SNCP ring.

Figure 8-17   SNCP Ring Subtending from an MS-SPRing

The ONS 15600 SDH can support 32 MS-SPRings on the same node. This capability allows you to deploy an ONS 15600 SDH in applications requiring SDH digital cross-connect systems (DCSs) or multiple SDH ADMs.
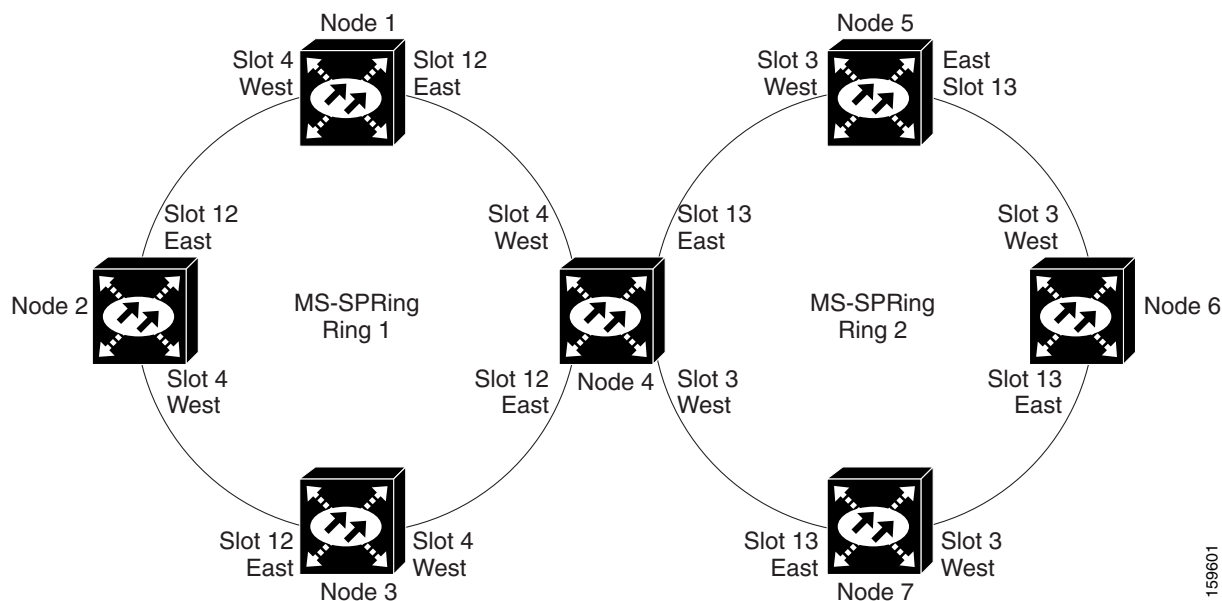
Figure 8-18 shows two MS-SPRings shared by one ONS 15600 SDH. Ring 1 runs on Nodes 1, 2, 3, and 4. Ring 2 runs on Nodes 4, 5, 6, and 7. Two MS-SPRings, Ring 1 and Ring 2, are provisioned on Node 4. Ring 1 uses cards in Slots 4 and 12, and Ring 2 uses cards in Slots 3 and 13.

Note Nodes in different MS-SPRings can have the same or different node IDs.

Figure 8-18 MS-SPRing Subtending from an MS-SPRing

After subtending two MS-SPRings, you can route circuits from nodes in one ring to nodes in the second ring. For example, in Figure 8-18 you can route a circuit from Node 1 to Node 7. The circuit would normally travel from Node 1 to Node 4 to Node 7. If fiber breaks occur, for example between Nodes 1 and 4 and Nodes 4 and 7, traffic is rerouted around each ring: in this example, Nodes 2 and 3 in Ring 1 and Nodes 5 and 6 in Ring 2.

8.7 Extended Subnetwork Connection Protection Networks

In addition to single MS-SPRings, SNCP rings, and ADM configurations, you can extend ONS 15600 SDH traffic protection by creating extended SNCP networks. On SONET platforms, this is referred to as path-protected mesh networks (PPMNs). Extended SNCP rings include multiple ONS 15600 SDH topologies and extend the protection provided by a single SNCP ring to the meshed architecture of several interconnecting rings. In an extended SNCP ring, circuits travel diverse paths through a network of single or multiple meshed rings. When you create circuits, CTC automatically routes circuits across the extended SNCP ring, 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 8-19, 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 8-19   Extended SNCP Network
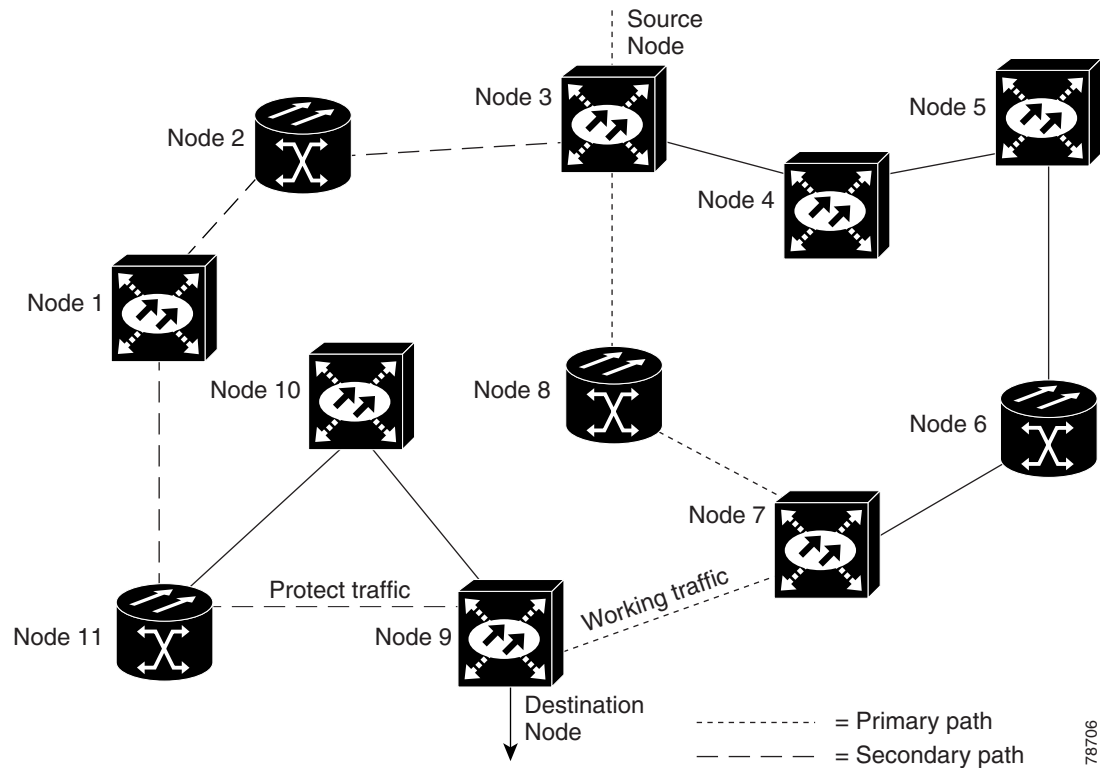
If full protection is selected, CTC creates a second unique route between Nodes 3 and 9 that passes through Nodes 2, 1, and 11. Cross-connections are automatically created at Nodes, 3, 2, 1, 11, and 9, shown by the dashed line. If a failure occurs on the primary path, traffic switches to the second circuit 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.

Extended SNCP also allows spans of different SDH line rates to be mixed together in virtual rings. Figure 8-20 shows Nodes 1, 2, 3, and 4 in an STM-64 ring.

Figure 8-20   Extended SNCP Virtual Ring
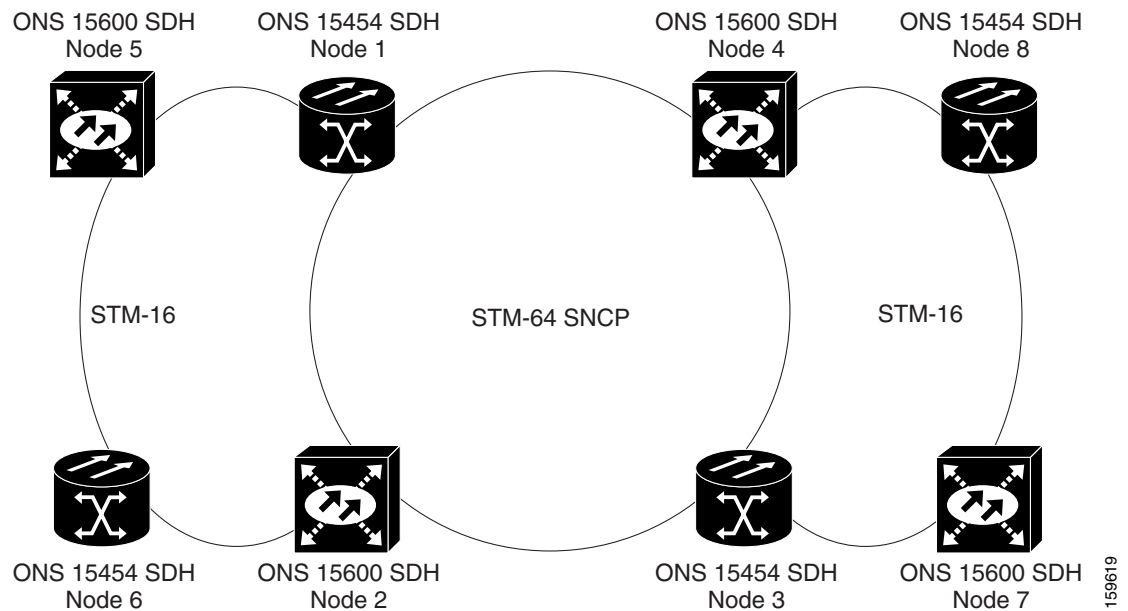
8.8 In-Service Topology Upgrades
8.8 In-Service Topology Upgrades

Topology upgrades can be performed while the network is 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 MS-SPRing
- 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 SDH circuit types supported for in-service topology upgrades are:

- Virtual containers (VC)
- 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.

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

✎

Note Open-ended SNCP and DRI configurations do not support in-service topology upgrades.

8.8.1 Point-to-Point or Linear ADM to Two-Fiber MS-SPRing

A 1+1 point-to-point or linear ADM to two-fiber MS-SPRing 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 MS-SPRing (for example, circuits in VC4s 9 and higher on an STM-16 MS-SPRing) and recreate them in the appropriate bandwidth. Finally, you must provision the nodes as MS-SPRing nodes. For in-service topology upgrade procedures, refer to the "Convert Network Configurations" chapter in the *Cisco ONS 15600 SDH Procedure Guide*.

8.8.2 Add or Remove a Node from a Topology

You can add or remove a node from a linear ADM, MS-SPRing, or SNCP configuration. Adding or removing nodes from MS-SPRings is potentially service affecting, however adding and removing nodes from an existing 1+1 linear ADM or SNCP 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. For procedures to add or remove a node, refer to the "Add and Remove Nodes" chapter in the *Cisco ONS 15600 SDH Procedure Guide*.