Circuits and Tunnels

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 15327 synchronous transport signal (STS) and virtual tributary (VT) circuits and VT and data communications channel (DCC) tunnels. To provision circuits and tunnels, refer to the *Cisco ONS 15327 Procedure Guide*.

Chapter topics include:

6.1 Circuit Properties

On the ONS 15327 you can create unidirectional and bidirectional circuits. For path protection circuits, you can create revertive or nonrevertive circuits. Circuits are routed automatically or you can manually route them. With the autorange feature, you do not need to build multiple circuits of the same type individually; the Cisco Transport Controller (CTC) can create additional sequential circuits if you specify the number of circuits you need and build the first circuit.

You can provision circuits either before or after cards are installed if the ONS 15327 slots are provisioned for the card that carries the circuit. However, circuits do not carry traffic until the cards are installed and the ports are In-Service and Normal (IS-NR); Out-of-Service and Autonomous, Automatic In-Service (OOS-AU,AINS); or Out-of-Service and Management, Maintenance (OOS-MA,MT).

The ONS 15327 Circuits window, which appears in network, node, and card view, is where you can view information about circuits. The Circuits window shows the following information:

- Name—The name of the circuit. The circuit name can be manually assigned or automatically generated.
- Type—The circuit types are: STS (STS circuit), VT (VT circuit), VTT (VT tunnel), or VAP (VT aggregation point).
- Size—The circuit size. VT circuits are 1.5. ONS 15327 STS circuit sizes are 1, 3c, 6c, 9c, 12c, 24c, or 48c.
- Protection—The type of circuit protection. See the "6.1.3 Circuit Protection Types" section on page 6-5.
- Direction—The circuit direction, either two-way or one-way.
- Status—The circuit status. See the "6.1.1 Circuit Status" section on page 6-2.
- Source—The circuit source in the format: *node/slot/port "port name"/STS/VT.* (Port name appears in quotes.) Node and slot always appear; *port "port name"/STS/VT* might appear, depending on the source card, circuit type, and whether a name is assigned to the port. If the circuit size is a concatenated size (3c, 6c, 12c, etc.), STSs used in the circuit are indicated by an ellipsis, for example, S7..9, (STSs 7, 8, and 9) or S10..12 (STSs 10, 11, and 12). If the source is located on an XTC card, *port* specifies DS1 or DS3; each STS on the XTC card is numbered 1.
- Destination—The circuit destination in same format (*node/slot/port "port name"/STS/VT*) as the circuit source.
- # of VLANS—The number of VLANS used by an Ethernet circuit.
- # of Spans—The number of inter-node links that constitute the circuit. Right-clicking the column opens a shortcut menu from which you can choose to show or hide circuit span detail.
- State—The circuit state. See the "6.1.2 Circuit States" section on page 6-3.

6.1.1 Circuit Status

The circuit statuses that appear in the Circuit window Status column are generated by CTC based on conditions along the circuit path. Table 6-1 shows the statuses that can appear in the Status column.

Table 6-1 ONS 15327 Circuit Status

Status	Definition/Activity
CREATING	CTC is creating a circuit.
DISCOVERED	CTC created a circuit. All components are in place and a complete path exists from circuit source to destination.
DELETING	CTC is deleting a circuit.

Table 6-1 ONS 15327 Circuit Status (continued)

Status	Definition/Activity
PARTIAL	A CTC-created circuit is missing a cross-connect or network span or a complete path from source to destinations does not exist. In CTC, circuits are represented using cross-connects and network spans. If a network span is missing from a circuit, the circuit status is PARTIAL. However, a PARTIAL status does not necessarily mean a circuit traffic failure has occurred, because traffic may flow on a protect path. Network spans are in one of two states: up or down. On CTC circuit and network maps, up spans appear as green lines, and down spans appear as gray lines. If a failure occurs on a network span during a CTC session, the span remains on the network map but its color changes to gray to indicate that the span is down. If you restart your CTC session while the failure is active, the new CTC session cannot discover the span and its span line does not appear on the network map. Subsequently, circuits routed on a network span that goes down appear as DISCOVERED during the current CTC session, but appear as PARTIAL to users who log in after the span failure.
DISCOVERED_TL1	A TL1-created circuit or a TL1-like, CTC-created circuit is complete. A complete path from source to destinations exists.
PARTIAL_TL1	A TL1-created circuit or a TL1-like, CTC-created circuit is missing a cross-connect or circuit span (network link), and a complete path from source to destinations does not exist.
CONVERSION_PENDING	An existing circuit in a topology upgrade is set to this state. The circuit returns to the DISCOVERED status once the topology upgrade is complete. For more information about topology upgrades, see Chapter 7, "SONET Topologies and Upgrades."
PENDING_MERGE	Any new circuits created to represent an alternate path in a topology upgrade are set to this status to indicate that it is a temporary circuit. These circuits can be deleted if a topology upgrade fails. For more information about topology upgrades, see Chapter 7, "SONET Topologies and Upgrades."

6.1.2 Circuit States

The circuit service state is an aggregate of the cross-connect service states within the circuit.

- If all cross-connects in a circuit are in the IS-NR service state, the circuit service state is In-Service (IS).

- If all cross-connects in a circuit are in the OOS-MA,MT, OOS-AU,AINS, or Out-of-Service and Management, Disabled (OOS-MA,DSBLD) service state, the circuit service state is Out-of-Service (OOS).
- PARTIAL is appended to the OOS circuit service state when circuit cross-connects state are mixed and not all in IS-NR. The OOS-PARTIAL state can occur during automatic or manual transitions between states. OOS-PARTIAL can appear during a manual transition caused by an abnormal event such as a CTC crash or communication error, or if one of the cross-connects could not be changed. Refer to the *Cisco ONS 15327 Troubleshooting Guide* for troubleshooting procedures.

You can assign a service state to circuit cross-connects at two points:

- During circuit creation, you can set the state on the Create Circuit wizard.
- After circuit creation, you can change a circuit state on the Edit Circuit window State tab or from the Tools > Circuits > Set Circuit State menu.

During circuit creation, you can apply a service state to the drop ports in a circuit; however, CTC does not apply a requested state other than IS-NR to drop ports if:

- The port is a timing source.
- The port is provisioned for orderwire or tunnel orderwire.
- The port is provisioned as a DCC or DCC tunnel.
- The port supports 1+1 or BLSR.

Circuits do not use the soak timer, but ports do. The soak period is the amount of time that the port remains in the OOS-AU,AINS service state after a signal is continuously received. When the cross-connects in a circuit are in the OOS-AU,AINS service state, the ONS 15327 monitors the cross-connects for an error-free signal. It changes the state of the circuit from OOS to IS or to OOS-PARTIAL as each cross-connect assigned to the circuit path is completed. This allows you to provision a circuit using TL1, verify its path continuity, and prepare the port to go into service when it receives an error-free signal for the time specified in the port soak timer. Two common examples of state changes you see when provisioning circuits using CTC are:

- When assigning the IS,AINS administrative state to cross-connects in VT1.5 circuits and VT tunnels, the source and destination ports on the VT1.5 circuits remain in the OOS-AU,AINS service state until an alarm-free signal is received for the duration of the soak timer. When the soak timer expires and an alarm-free signal is found, the VT1.5 source port and destination port service states change to IS-NR and the circuit service state becomes IS.
- When assigning the IS,AINS administrative state to cross-connects in STS circuits, the circuit source and destination ports transition to the OOS-AU,AINS service state. When an alarm-free signal is received, the source and destination ports remain OOS-AU,AINS for the duration of the soak timer. After the port soak timer expires, STS source and destination ports change to IS-NR and the circuit service state to IS.

To find the remaining port soak time, choose the Maintenance > AINS Soak tabs in card view and click the Retrieve button. If the port is in the OOS-AU,AINS service state and has a good signal, the Time Until IS column shows the soak count down status. If the port is OOS-AU,AINS and has a bad signal, the Time Until IS column indicates that the signal is bad. You must click the Retrieve button to obtain the latest time value.

For more information about port and cross-connect service states, see Appendix B, "Administrative and Service States."

6.1.3 Circuit Protection Types

The Protection column on the Circuit window shows the card (line) and SONET topology (path) protection used for the entire circuit path. Table 6-2 shows the protection type indicators that you see in this column.

Table 6-2 Circuit Protection Types

Protection Type	Description
1+1	The circuit is protected by a 1+1 protection group.
2F BLSR	The circuit is protected by a two-fiber bidirectional line switched ring (BLSR).
2F-PCA	The circuit is routed on a protection channel access (PCA) path on a two-fiber BLSR. PCA circuits are unprotected.
DRI	The circuit is protected by a dual-ring interconnect (DRI).
PCA	The circuit is routed on a PCA path on two-fiber BLSRs. PCA circuits are unprotected.
Protected	The circuit is protected by diverse SONET topologies, for example, a BLSR and a path protection, or a path protection and 1+1.
N/A	A circuit with connections on the same node is not protected.
Unknown	A circuit has a source and destination on different nodes and communication is down between the nodes. This protection type appears if not all circuit components are known.
Unprot (black)	A circuit with a source and destination on different nodes is not protected.
Unprot (red)	A circuit created as a fully protected circuit is no longer protected due to a system change, such as removal of a BLSR or 1+1 protection group.
Path protection	The circuit is protected by a path protection.

6.1.4 Edit Circuits Window

Use the Edit Circuits window to view general circuit information, create monitor circuits, change a circuit state, and merge circuits. For path protection circuits, use the Edit Circuits window to change path protection selectors and switch protection paths.

In the UPSR Selectors subtab on the Edit Circuits window, you can:

- View the path protection circuit's working and protection paths.
- Edit the reversion time.
- Set the hold-off timer.
- Edit the Signal Fail (SF)/Signal Degrade (SD) bit error rate (BER) thresholds.
- Change PDI-P settings.

Note In the UPSR Selectors tab, the SF Ber Level and SD Ber Level columns display "N/A" for those nodes that do not support VT signal BER monitoring. In Software Release 5.0, only the Cisco ONS 15310-CL supports VT signal BER monitoring.

In the UPSR Switch Counts subtab, you can:

- Perform maintenance switches on the circuit selector.
- View switch counts for the selectors.

Using the Edit Circuits window you can view a detailed circuit map by checking Show Detailed Map. The detailed map allows you to view information about ONS 15327 circuits graphically. Routing information that appears includes:

- Circuit direction (unidirectional/bidirectional)
- The nodes, STSs, and VTs through which circuit passes including slots and port numbers
- The circuit source and destination points
- OSPF area IDs
- Link protection (path protection, unprotected, BLSR, 1+1) and bandwidth (OC-N)

For BLSRs, the detailed map shows the number of BLSR fibers and the BLSR ring ID. For path protection configurations, the map shows the active and standby paths from circuit source to destination, and it also shows the working and protect paths.

Alarms and states can also be viewed on the circuit map, including:

- Alarm states of nodes on the circuit route
- Number of alarms on each node organized by severity
- Port service states on the circuit route
- Alarm state/color of most severe alarm on port
- Loopbacks
- Path trace states
- Path selectors states

By default, the working path on the detailed circuit map is indicated by a green bidirectional arrow, and the protect path is indicated by a purple bidirectional arrow. Source and destination ports are shown as circles with an S and D. Port states are indicated by colors, shown in Table 6-3.

Table 6-3 Port State Color Indicators

Port Color	State
Green	IS-NR
Gray	OOS-MA,DSBLD
Purple	OOS-AU,AINS
Light blue	OOS-MA,MT

Notation within or by the squares on each node indicate switches and other conditions. For example:

- F = Force switch
- M = Manual switch
- L = Lockout switch
- T = Terminal loopback
- Arrow = Facility loopback

Move the mouse cursor over nodes, ports, and spans to see tooltips with information including the number of alarms on a node (organized by severity), a port's service state, and the protection topology.

Right-click a node, port, or span on the detailed circuit map to initiate certain circuit actions:

- Right-click a unidirectional circuit destination node to add a drop to the circuit.
- Right-click a port containing a path trace capable card to initiate the path trace.
- Right-click a path protection span to change the state of the path selectors in the path protection circuit.

6.2 VT1.5 Bandwidth

The ONS 15327 XTC card performs port-to-port, time-division multiplexing (TDM). Because VT1.5 multiplexing is STS-based, understanding how VT1.5 circuits use the XTC VT matrix resources is necessary to avoid unexpected depletion of the VT matrix capacity. The key VT matrix principles are as follows:

- The VT matrix has 24 logical STS ports. All VT1.5 multiplexing is achieved through these logical STS ports.
- Each VT matrix STS port has capacity for 28 VT1.5s. Therefore, the VT matrix has a capacity for 672 VT1.5 terminations.
- Because each logical STS termination on the VT matrix can carry 28 VT1.5s, the VT matrix capacity is 672 VT 1.5s (24 times 28).

The XTC card can map up to 24 STSs for VT1.5 traffic. Because one STS can carry 28 VT1.5s, the XTC card can terminate up to 672 VT1.5s or 336 VT1.5 cross-connects. However, to terminate 336 VT1.5 cross-connects:

- Each STS mapped for VT1.5 traffic must carry 28 VT1.5 circuits. If you assign each VT1.5 circuit to a different STS, the XTC card VT1.5 cross-connect capacity is reached after you create 12 VT1.5 circuits.
- ONS 15327s must be in a BLSR. Source and drop nodes in path protection or 1+1 (linear) protection have capacity for only 224 VT1.5 cross-connects because an additional STS is used for the protect path.

6.3 VT Tunnels and Aggregation Points

To maximize XTC VT1.5 cross-connect resources, you can tunnel VT1.5 circuits through ONS 15327 nodes. VT1.5 tunnels do not use VT matrix capacity at ONS 15327 pass-through nodes, thereby freeing the XTC card cross-connect resources for other VT1.5 circuits.

VAPs allow you to provision BLSR circuits from multiple VT1.5 sources to a single STS destination. Like circuits, a VAP has a source and a destination. The source is the STS grooming end, the node where the VT1.5 circuits are aggregated into a single STS. The VAP STS must be a port on an OC-N card. VT matrix resources are not used on the VAP source node, which is the key advantage of VAPs. The VAP destination is the node where the VT1.5 circuits originate. Circuits can originate on any ONS 15327 card.

6.4 DCC Tunnels

SONET provides four DCCs for network element operations, administration, maintenance, and provisioning: one on the SONET Section layer (DCC1) and three on the SONET Line layer (DCC2, DCC3, DCC4). The ONS 15327 uses the section DCC for ONS 15327 management and provisioning. When multiple DCC channels exist between two neighboring nodes, the ONS 15327 balances traffic over the existing DCC channels using a load balancing algorithm. This algorithm chooses a DCC for packet transport by considering packet size and DCC utilization.

You can use the three Line DCCs (LDCCs) and the Section DCC (SDCC), when not used for ONS 15327 DCC terminations, to tunnel third-party SONET equipment across ONS 15327 networks. A DCC tunnel end-point is defined by Slot, Port, and DCC, where DCC can be either the SDCC or one of the LDCCs. You can link an SDCC to an LDCC and an LDCC to an SDCC. You can also link LDCCs to LDCCs and link SDCCs to SDCCs. To create a DCC tunnel, you connect the tunnel endpoints from one ONS 15327 optical port to another.

Table 6-4 shows the DCC tunnels that you can create.

Table 6-4 DCC Tunnels

DCC	SONET Layer	SONET Bytes	OC-3, OC-12, OC-48
DCC1	Section	D1 to D3	Yes
DCC2	Line	D4 to D6	Yes
DCC3	Line	D7 to D9	Yes
DCC4	Line	D10 to D12	Yes

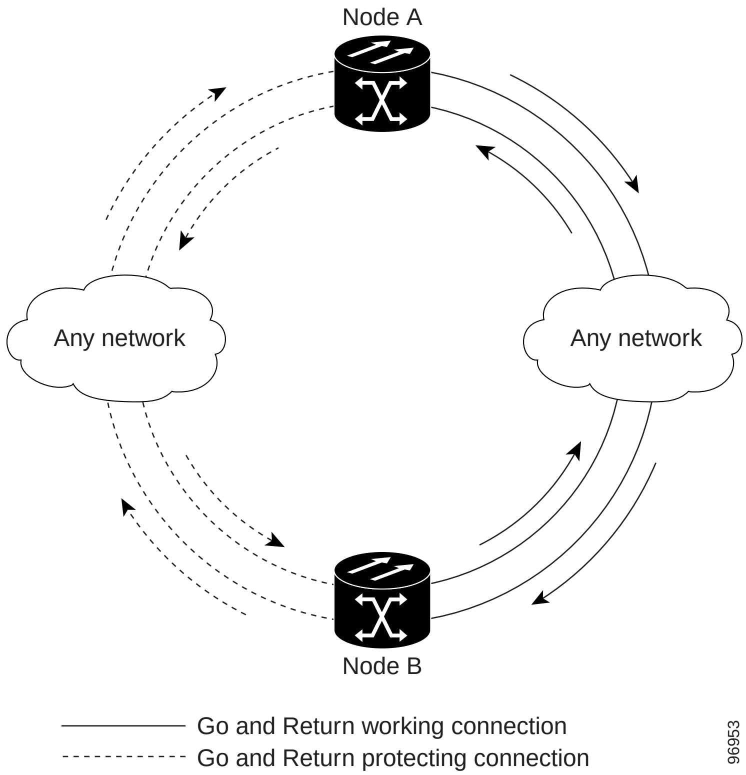
When you create DCC tunnels, keep the following guidelines in mind:

- Each ONS 15327 can have up to 32 DCC tunnel connections.
- Each ONS 15327 can have up to 10 SDCC terminations.
- An SDCC that is terminated cannot be used as a DCC tunnel endpoint, and an SDCC that is used as a DCC tunnel endpoint cannot be terminated.
- All DCC tunnel connections are bidirectional.

6.5 Go-and-Return Path Protection Routing

The go-and-return path protection routing option allows you to route the path protection working path on one fiber pair and the protect path on a separate fiber pair (Figure 6-1). The working path will always be the shortest path. If a fault occurs, both the working and protection fibers are not affected. This feature only applies to bidirectional path protection circuits. The go-and-return routing option appears on the Circuit Attributes panel of the Circuit Creation wizard.

Figure 6-1 Path Protection Go-and-Return Routing



6.6 BLSR Protection Channel Access Circuits

You can provision circuits to carry traffic on BLSR PCA circuits when conditions are fault-free. Traffic routed on BLSR PCA circuits, called extra traffic, has lower priority than the traffic on the working channels and is unprotected. During ring or span switches, PCA circuits are preempted and squelched. For example, in an OC-48 BLSR, STSs 25-48 can carry extra traffic when no ring switches are active, but PCA circuits on these STSs are preempted when a ring switch occurs. When the conditions that caused the ring switch are remedied and the ring switch is removed, PCA circuits are restored. If the BLSR is provisioned as revertive, this occurs automatically after the fault conditions are cleared and the reversion timer has expired.

Traffic provisioning on BLSR PCA circuits is performed during circuit provisioning. The Protection Channel Access check box appears whenever Fully Protected Path is unchecked on the Circuit Creation wizard. Refer to the *Cisco ONS 15327 Procedure Guide* for more information.

6.7 Path Trace

The SONET J1 Path Trace is a repeated, fixed-length string comprised of 64 consecutive J1 bytes. You can use the string to monitor interruptions or changes to circuit traffic. Table 6-5 shows the ONS 15327 cards that support path trace.

Table 6-5 ONS 15327 Cards Capable of Path Trace

J1 Function	Cards
Transmit and receive	XTC (DS-1)
	G1000-2
Receive only	OC3 IR 4 1310
	OC12 IR 1310
	OC12 LR 1550
	OC48-1-IR
	OC48 LR 1550

The J1 path trace transmits a repeated, fixed-length string. If the string received at a circuit drop port does not match the string the port expects to receive, an alarm is raised. Two path trace modes are available:

- Automatic—The receiving port assumes that the first J1 string it receives is the baseline J1 string.
- Manual—The receiving port uses a string that you manually enter as the baseline J1 string.

6.8 Merge Circuits

A circuit merge combines a single selected circuit with one or more circuits. You can merge tunnels, VAP circuits, VLAN-assigned circuits, CTC-created circuits, and TL1-created circuits. To merge circuits, you choose a circuit on the CTC Circuits window and the circuits that you want to merge with the chosen (master) circuit on the Merge tab in the Edit Circuits window. The Merge tab shows only the circuits that are available for merging with the master circuit:

- Circuit cross-connects must create a single, contiguous path.
- Circuits types must be a compatible. For example, you can combine an STS circuit with a VAP circuit to create a longer VAP circuit, but you cannot combine a VT circuit with an STS circuit.
- Circuit directions must be compatible. You can merge a one-way and a two-way circuit, but not two one-way circuits in opposing directions.
- Circuit sizes must be identical.
- VLAN assignments must be identical.
- Circuit end points must send or receive the same framing format.
- The merged circuits must become a DISCOVERED circuit.

If all connections from the master circuit and all connections from the merged circuits align to form one complete circuit, the merge is successful. If all connections from the master circuit and some, but not all, connections from the other circuits align to form a single complete circuit, CTC notifies you and gives you the chance to cancel the merge process. If you choose to continue, the aligned connections merge successfully into the master circuit, and un-aligned connections remain in the original circuits.

All connections from the master circuit and at least one connection from the other selected circuits must be used in the resulting circuit for the merge to succeed. If a merge fails, the master circuit and all other circuits remain unchanged. When the circuit merge completes successfully, the resulting circuit retains the name of the master circuit.

6.9 Reconfigure Circuits

You can reconfigure multiple circuits, which is typically necessary when a large number of circuits are in the PARTIAL status. When reconfiguring multiple circuits, the selected circuits can be any combination of DISCOVERED, PARTIAL, DISCOVERED_TL1, or PARTIAL_TL1 circuits. You can reconfigure tunnels, VAP circuits, VLAN-assigned circuits, CTC-created circuits, and TL1-created circuits.

Use the CTC Tools > Circuits > Reconfigure Circuits command to reconfigure selected circuits. During reconfiguration, CTC reassembles all connections of the selected circuits into circuits based on path size, direction, and alignment. Some circuits may merge and others may split into multiple circuits. If the resulting circuit is a valid circuit, it appears as a DISCOVERED circuit. Otherwise, the circuit appears as a PARTIAL or PARTIAL_TL1 circuit.

Note PARTIAL tunnel and PARTIAL VLAN-capable circuits do not split into multiple circuits during reconfiguration.