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MPLS Guide

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1 Preface

1.1 About This Guide

This guide describes the services and protocol support provided by the 7705 SAR and presents examples to configure and implement MPLS (RSVP-TE and LDP) protocols.

This guide is organized into functional chapters and provides concepts and descriptions of the implementation flow, as well as Command Line Interface (CLI) syntax and command usage.

Note: This manual generically covers Release 20.x content and may contain some content that will be released in later maintenance loads. Please refer to the 7705 SAR 20.x.Rx Software Release Notes, part number 3HE16192000xTQZZA, for information on features supported in each load of the Release 20.x software.

1.1.1 Audience

This guide is intended for network administrators who are responsible for configuring the 7705 SAR routers. It is assumed that the network administrators have an understanding of networking principles and configurations. Concepts described in this guide include the following:

- Multiprotocol Label Switching (MPLS)
- Resource Reservation Protocol for Traffic Engineering (RSVP-TE)
- Label Distribution Protocol (LDP)

1.1.2 Technical Support

If you purchased a service agreement for your 7705 SAR router and related products from a distributor or authorized reseller, contact the technical support staff for that distributor or reseller for assistance. If you purchased a Nokia service agreement, follow this link to contact a Nokia support representative and to access product manuals and documentation updates:

Product Support Portal

2 7705 SAR MPLS Configuration Process

Table 1 lists the tasks that are required to configure MPLS, RSVP-TE, and LDP protocols.

This guide is presented in an overall logical configuration flow. Each section describes a software area and provides CLI syntax and command usage to configure parameters for a functional area.

Table 1 **Configuration Process**

Area	Task/Description	Chapter
Protocol configuration	Configure MPLS parameters	MPLS
	Configure RSVP-TE parameters	RSVP and RSVP-TE
	Configure PCEP parameters	PCEP
	Configure LDP parameters	Label Distribution Protocol
Reference	List of IEEE, IETF, and other proprietary entities	Standards and Protocol Support

3 MPLS and RSVP-TE

This chapter provides information required to configure Multiprotocol Label Switching (MPLS) and Resource Reservation Protocol for Traffic Engineering (RSVP-TE) for the 7705 SAR. For information on dynamic LSPs with LDP, refer to the chapter Label Distribution Protocol.

Topics in this chapter include:

3.1 Overview

The 7705 SAR provides MPLS technology using static LSPs, RSVP-TE for traffic-engineered signaled routing of LSPs and LDP for non-traffic-engineered signaled routing of LSPs. A network operator may choose to use any combination of static LSPs, RSVP-TE, and LDP to establish paths for services. RSVP-TE and LDP are considered to be Layer 2.5 protocols.

The 7705 SAR can be used as an ingress and egress Label Edge Router (iLER and eLER), and as a transit router. A transit router is also referred to as a Label Switch Router (LSR).

OSPF and IS-IS are the interior gateway protocols with traffic engineering extensions (IGP-TE) available to the 7705 SAR. These are the Layer 3 protocols. Typically, one or the other of these gateway protocols will be in use in the network. Whichever protocol is the chosen gateway protocol, it must be working in order for LDP or RSVP-TE to function. These Layer 3 protocols identify the next hop, which is information needed by the Layer 2.5 protocols (LDP or RSVP-TE) in order to assign labels.

In addition, the 7705 SAR provides link and node redundancy protection through LSP redundancy and Fast Reroute (FRR) features.

The LSP redundancy and FRR features have the ability to take shared risk link groups (SRLGs) into consideration when the Constrained Shortest Path First (CSPF) algorithm is used to determine an alternate LSP. The selection of a route is determined by the IGP-TE protocol. The added constraints imposed by SRLGs and CSPF will ensure that the redundant route selected will be unique from the principal route (route being protected); that is, it will use physical equipment that is different from the equipment that carries the principal route. CSPF will constrain the alternate route to be the shortest possible alternative route. There may be more than one alternative route.

3.2 MPLS

Multiprotocol Label Switching (MPLS) is a label switching technology that provides the ability to set up connection-oriented paths over a connectionless IP network. MPLS facilitates network traffic flow and provides a mechanism to engineer network traffic patterns independently from routing tables. MPLS sets up a specific path for a sequence of packets. The packets are identified by a label inserted into each packet.

MPLS is independent of any routing protocol but is considered multiprotocol because it works with protocols such as IP, ATM, Ethernet, and circuit emulation.

This section contains the following topics:

3.2.1 Traffic Engineering for MPLS

Without traffic engineering (TE), routers route traffic according to the Shortest Path First (SPF) algorithm, disregarding congestion or packet types.

With traffic engineering, network traffic is routed efficiently to maximize throughput and minimize delay. Traffic engineering facilitates traffic flows to be mapped to the destination through a less-congested path than the one selected by the SPF algorithm.

MPLS directs a flow of IP packets along a label switched path (LSP). LSPs are simplex, meaning that the traffic flows in one direction (unidirectional) from an ingress router to an egress router. Two LSPs are required for duplex (bidirectional) traffic. Each LSP carries traffic in a specific direction, forwarding packets from one router to the next across the MPLS domain.

When an ingress router receives a packet, it adds an MPLS header to the packet and forwards it to the next hop in the LSP. The labeled packet is forwarded along the LSP path (from next hop to next hop) until it reaches the destination point. The MPLS header is removed and the packet is forwarded based on Layer 3 information such as the IP destination address. The physical path of the LSP is not constrained to the shortest path that the IGP would choose using SPF to reach the destination IP address.

3.2.1.1 TE Metric and IGP Metric

When the TE metric is selected for an LSP, the shortest path computation will select an LSP path based on the TE metric constraints instead of the IGP metric (for OSPF and IS-IS), which is the default metric. The user configures the TE metric under the **router>mpls>interface** context and the IGP metric under the **router>ospf>area>interface** context (for OSPF) and the **router>isis>if>level** context (for IS-IS). Both the TE and IGP metrics are advertised by OSPF and IS-IS for each link in the network.

The TE metric is part of the traffic engineering extensions of the IGP protocols. For more information on the OSPF and IS-IS routing protocols, refer to the 7705 SAR Routing Protocols Guide.

Typically, the TE metric is used to allow Constrained Shortest Path First (CSPF) to represent a dual TE topology for the purpose of computing LSP paths, where one TE topology is based on the RSVP-TE database and the other is based on the IGP-TE database.

An LSP dedicated to real-time and delay-sensitive user and control traffic has its path computed by CSPF using the TE metric. The user configures the TE metric to represent the amount of delay, or combined delay and jitter, of the link. In this case, the shortest path satisfying the constraints of the LSP path will effectively represent the shortest-delay path.

An LSP dedicated to non-delay-sensitive user and control traffic has its path computed by CSPF using the IGP metric. The IGP metric could represent the link bandwidth or some other value as required.

When the use of the TE metric is enabled for an LSP, the CSPF process will first eliminate all links in the network topology that do not meet the constraints specified for the LSP path; the constraints include bandwidth, admin-groups, and hop limit. CSPF will then run the SPF algorithm on the remaining links. The shortest path among all the SPF paths will be selected based on the TE metric instead of the IGP metric. The TE metric is only used in CSPF computations for MPLS paths and not in the regular SPF computation for IP reachability.

Operational metrics of LSPs that use the TE metric in CSPF path calculations can be overridden with the user-configured administrative LSP metric.

3.2.2 MPLS Label Stack

Routers that support MPLS are known as Label Edge Routers (LERs) and Label Switch Routers (LSRs). MPLS requires a set of procedures to enhance network layer packets with label stacks, which turns them into labeled packets. In order to initiate, transmit, or terminate a labeled packet on a particular data link, an LER or LSR must support the encoding technique which, when given a label stack and a network layer packet, produces a labeled packet.

In MPLS, packets can carry not just one label, but a set of labels in a stack. An LSR can swap the label at the top of the stack, pop the stack (that is, remove the top label), or swap the label and push one or more labels onto the stack. The processing of a labeled packet is completely independent of the level of hierarchy. The processing is always based on the top label, without regard for the possibility that other labels may have been above it in the past or that other labels may be below it at present.

As described in RFC 3032, *MPLS Label Stack Encoding*, the label stack is represented as a sequence of “label stack entries”. Each label stack entry is represented by 4 octets. Figure 1 shows the structure of a label and Table 2 describes the fields. Figure 2 shows the label placement in a packet.

Figure 1 **Label Structure**

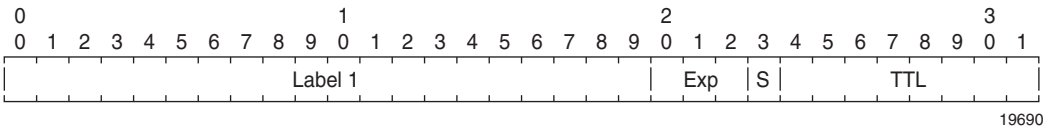
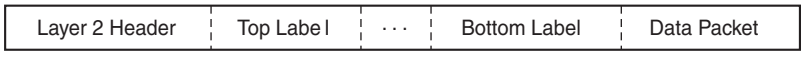


Table 2 **Packet/Label Field Description**

Field	Description
Label	This 20-bit field carries the actual value (unstructured) of the label.
Exp	This 3-bit field is reserved for experimental use. It is currently used for Class of Service (CoS).
S	This bit is set to 1 for the last entry (bottom) in the label stack and 0 for all other label stack entries.
TTL	This 8-bit field is used to encode a time-to-live value.

A stack can carry several labels, organized in a last in/first out order. The top of the label stack appears first in the packet and the bottom of the stack appears last (Figure 2).

Figure 2 **Label Packet Placement**



The label value at the top of the stack is looked up when a labeled packet is received. A successful lookup reveals:

- the next hop where the packet is to be forwarded
- the operation to be performed on the label stack before forwarding

In addition, the lookup may reveal outgoing data link encapsulation and other information needed to properly forward the packet.

An empty label stack can be thought of as an unlabeled packet. An empty label stack has zero (0) depth. The label at the bottom of the stack is referred to as the Level 1 label. The label above it (if it exists) is the Level 2 label, and so on. The label at the top of the stack is referred to as the Level *m* label.

3.2.2.1 Label Values

The 7705 SAR uses RSVP-TE and LDP protocols for label forwarding, For packet-based services such as VLL, the 7705 SAR uses T-LDP for signaling PW labels between peer nodes.

Packets traveling along an LSP are identified by the packet label, which is the 20-bit, unsigned integer (see Label Edge and Label Switch Routers). The range is 0 through 1 048 575. Label values 0 to 15 are reserved and are defined below:

- A value of 0 represents the IPv4 Explicit NULL label. This label value is legal only at the bottom of the label stack if the label stack is immediately followed by an IPv4 header, in which case the packet forwarding is based on the IPv4 header. If the IPv4 Explicit NULL label is not at the bottom of the label stack, then the packet forwarding is based on the subsequent label.

- A value of 1 represents the router alert label. This label value is legal anywhere in the label stack except at the bottom. When a received packet contains this label value at the top of the label stack, it is delivered to a local software module for processing. The actual packet forwarding is determined by the label beneath it in the stack. However, if the packet is further forwarded, the router alert label should be pushed back onto the label stack before forwarding. The use of this label is analogous to the use of the router alert option in IP packets. Since this label cannot be at the bottom of the stack, it is not associated with a particular network layer protocol.
- A value of 3 represents the Implicit NULL label. An LER advertises this when it is requesting penultimate hop popping (PHP) and expecting unlabeled packets. The label value 3 should never appear in the label stack.
- A value of 7 represents the entropy label indicator (ELI). The ELI is a special-purpose MPLS label that indicates that the entropy label (EL) follows it in the stack.
- Values 4 through 6 and 8 through 15 are reserved for future use.

Table 3 lists the label ranges available for use by ingress labels (pop labels).

Table 3 **Ingress Label Values (Pop Labels)**

Label Values	Description
16 through 31	Reserved for future use
32 through 1023	Available for static outer LSP tunnel label assignment
1024 through 2047	Reserved for future use
2048 through 18 431 [1]	Statically assigned for services (inner pseudowire label)
32 768 through 131 071	Dynamically assigned for both MPLS and services
131 072 through 1 048 575	Reserved for future use

Note:

1. In addition, users can define part of the dynamic label range from 18 432 to 131 071 to be the range of labels for the segment routing global block (SRGB).

Table 4 lists the label ranges available for use by egress labels (push labels).

Table 4 **Egress Label Values (Push Labels)**

Label Values	Description
16 through 1 048 575	Can be used for static LSP tunnel and static PW labels
16 through 1 048 575	Can be dynamically assigned for both MPLS tunnel labels and PW labels

3.2.3 MPLS Entropy Labels

This section contains information on the following topics:

- Overview of Entropy Labels
- Inserting and Processing the Entropy Label
- Entropy Label on OAM Packets
- Segment Routing Entropy Label and IPSec, ESPI Hashing, and NGE
- Entropy Label Configuration

3.2.3.1 Overview of Entropy Labels

The 7705 SAR supports MPLS entropy labels on RSVP-TE and SR-TE LSPs, as per RFC 6790. The entropy label provides greater granularity for load balancing on an LSR where load balancing is typically based on the MPLS label stack.

The ability of a node to receive and process an entropy label for an LSP is signaled using capability signaling (referred to as entropy label capability (ELC)). Entropy labels are supported on RSVP-TE and SR-TE tunnels.

Inserting an entropy label adds two labels in the MPLS label stack: the entropy label itself and the entropy label indicator (ELI).

The entropy label is inserted directly below the tunnel label and closest to the service payload that has advertised entropy label capability (which may be above the bottom of the stack). The value of the entropy label is calculated at the iLER and is based on a hash of the packet payload header content and other system parameters at ingress. For more information on hashing inputs, see the “Per-Flow Hashing” section in the 7705 SAR Interface Configuration Guide.

The ELI is inserted by the iLER. The ELI is a special-purpose MPLS label (value = 7) that indicates that the entropy label is the next label in the stack.

Entropy label capability is advertised at the tunnel level by the far-end node (eLER). This capability can be advertised for an RSVP-TE FEC or an SR-TE tunnel on IS-IS or OSPF. Capability signaling is not supported for point-to-multipoint LSPs, BGP tunnels, or LDP FECs. An LSR used for RSVP-TE and SR-TE tunnels will pass the entropy label capability signal from the downstream LSP segment to upstream peers. However, earlier releases that do not support entropy label functionality will pass the capability flag transparently, without altering the value.

The insertion of an entropy label by the upstream LER on a tunnel enabled for entropy label capability is enabled on a per-service basis. The entropy label is only inserted if the downstream peer has signaled entropy label support. The upstream LER only inserts a single entropy label, even if multiple LSP labels exist in a label stack.

The 7705 SAR supports the entropy label feature for the following services:

- Cpipe, Epipe, and Ipipe access to spoke SDP
- Cpipe, Epipe, and Ipipe spoke SDP to spoke SDP (vc-switching)
- VPLS SAP to VPLS spoke SDP or mesh SDP
- VPLS spoke SDP to VPLS spoke SDP
- VPRN for RSVP-TE
- R-VPLS
- IGP shortcut
- IS-IS for SR-TE
- OSPF for SR-TE

Entropy label capability on RSVP-TE LSPs is enabled on the eLER using the **config>router>rsvp>entropy-label-capability** command.

At the iLER, the insertion of the entropy label into the label stack is enabled using the **entropy-label** command under the service, mesh SDP, or spoke SDP context or under the **config>router>isis (or ospf)>segment-routing** context for SR-TE LSPs.

The entropy label requires the insertion of two additional labels in the label stack. In some cases, this may result in an unsupported label stack depth or large changes in the label stack depth during the lifetime of an LSP (for example, due to switching from a primary path with entropy label capability enabled to a secondary path for which the far end has not signaled entropy label capability).

The **entropy-label** command under the **config>router>mpls** and **config>router>mpls>lsp** contexts provides local control at the head end of an LSP over whether the entropy label is inserted on an LSP by overriding the entropy label capability signaled from the far-end LER, and control over how the additional label stack depth is accounted for. This allows the user to avoid entropy label insertion where there is a risk of the label stack depth becoming too great.

For entropy labels that are supported on LDP tunnels with remote-LFA protection (that is, for **rsvp-shortcut**), only loop-free alternate protect (**lfa-protect**) and LFA (**lfa-only**) are allowed.

Support of entropy labels over RSVP-TE and SR-TE tunnels are the only valid options, except when the 7705 SAR is the LER node with BGP labeled unicast (BGP-LU) tunnels. A 7705 SAR in an LER role can push and pop an entropy label for Epipe and VPLS services with a BGP-LU tunnel riding over an RSVP-TE LSP. Conversely, a 7705 SAR does not support being in an ABR or ASBR role with BGP-LU. Table 5 lists entropy label support on the 7705 SAR.

Table 5 **Summary of Entropy Label Support**

Service	RSVP-TE	SR-TE
Epipe	Yes	Yes
Ipipe	Yes	Yes
Cpipe	Yes	Yes
Apipe, Fpipe, Hpipe	No	No
VPRN (MP-BGP)	Yes	Yes
VPRN (Layer 3 spoke SDP)	Yes	Yes
IES (Layer 3 spoke SDP)	Yes	Yes
VPLS SDP (spoke/mesh SDP)	Yes	Yes
LDP over IGP shortcut (RSVP)	Yes	N/A
IGP shortcut (SR)	N/A	No
LDP FRR over RSVP	Yes	N/A
LDP stitching over SR (SR to LDP)	N/A	Yes [1]
LDP stitching over SR (LDP to SR)	No	No
BGP LU	Yes [2]	Yes [2]
SR	No	Yes

Table 5 **Summary of Entropy Label Support (Continued)**

Service	RSVP-TE	SR-TE
EVPN VPLS	Yes	Yes
EVPN Epipe	Yes	Yes
R-VPLS	Yes	Yes
IGP shortcut	Yes	No
SR FRR over TI-LFA or R-LFA	N/A	Yes
Static route with tunnel next hop	Yes	Yes

Notes:

1. On the SR segment because the SR head end injects the entropy label.
2. For services that support entropy label.

3.2.3.2 Inserting and Processing the Entropy Label

This section contains inserting and processing information on the following node types:

- Ingress LER
- LSR
- Egress LER

3.2.3.2.1 Ingress LER

The procedures at the iLER are as specified in section 4.2 of RFC 6790. In general, the router inserts an entropy label into the label stack if the downstream node for the LSP tunnel has signaled support for entropy label and the entropy label is enabled for the particular service.

RFC 6790 specifies that the iLER can insert several entropy labels in the label stack where the LSP hierarchy exists, one for each LSP in the hierarchy. However, this could result in unreasonably large label stacks. Therefore, when there are multiple LSPs in a hierarchy (for example, LDP over RSVP-TE), the router only inserts a single EL/ELI pair within the innermost LSP label closest to the service payload that has advertised entropy label capability.

The entropy label functionality is not available on first generation (Gen-1) adapter cards.

The router inserts an entropy label on a tunnel that is entropy label-capable when the service has entropy label enabled, even if an implicit or explicit NULL label has been signaled by the downstream LSR or LER. This ensures consistent behavior and ensures that the entropy label value as determined by the iLER is maintained where a tunnel with an implicit NULL label is stitched at a downstream LSR.

3.2.3.2.2 LSR

If an LSR is configured for load balancing and an entropy label is found in the label stack, the LSR will take the entropy label into account in the hashing algorithm as follows:

- **label-only**: the entropy label is used as input to the hash routine and the rest of the label stack is ignored.
- **label-ip**: the entropy label and the IP packet are used as input to the hash routine and the rest of the label stack is ignored.

The entropy label functionality is not available on first generation (Gen-1) adapter cards.

If penultimate hop popping (PHP) has been requested by a next-hop LER, the LSR will retain any entropy label found immediately below the tunnel label that is to be popped. The system will retain and use the entropy label information as input to the local hash routine if an applicable LSR load-balancing mode has been configured.

For more information on LSR load balancing, see the “LSR Hashing” section in the 7705 SAR Interface Configuration Guide.

3.2.3.2.3 Egress LER

At an eLER, if an ELI and entropy label are detected in the label stack, both the ELI and entropy label are popped and the packet processed as normal. This occurs whether or not the system has signaled entropy label capability.

If an ELI is popped that has the bottom of stack (BoS) bit set, the system will discard the packet.

3.2.3.3 Entropy Label on OAM Packets

Service OAM packets also include an entropy label and ELI if entropy label capability is signaled for the corresponding tunnel and entropy label is enabled for the service. The EL/ELI pair is inserted at the same level in the label stack as it is in user data packets; that is, within the innermost LSP label context closest to the service payload that has advertised entropy label capability. The EL/ELI pair will therefore always reside at a different level in the label stack from special-purpose labels related to the service payload (for example, the router alert label).

OAM packets at the LSP level, such as LSP ping and LSP trace, do not have the EL/ELI pair inserted.

3.2.3.4 Segment Routing Entropy Label and IPSec, ESPI Hashing, and NGE

Segment routing with entropy label can be used with IPSec and NGE services and with ESPI hashing, as listed below:

- IPSec and segment routing entropy label
  - IPSec over BGP 3107 over segment routing with entropy label
  - IPSec over static route over segment routing with entropy label
  - VLL over GRE over IPSec over BGP 3107 over segment routing with entropy label
  - VLL over GRE over IPSec over static route over segment routing with entropy label
- ESPI hashing GRT/VPRN
- NGE
  - VLL, VPLS, and VPRN NGE interaction with entropy label

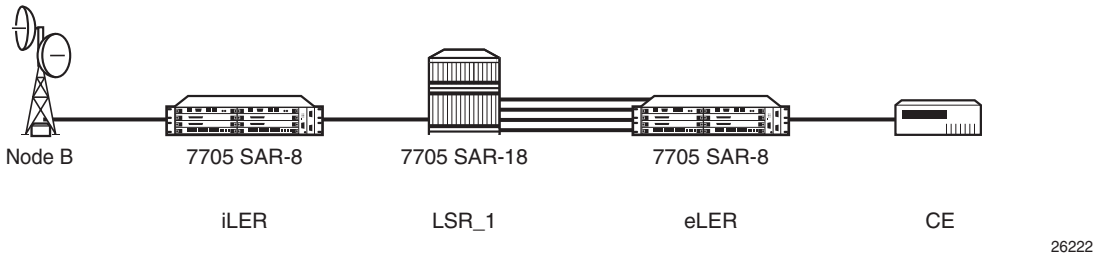
3.2.3.5 Entropy Label Configuration

Figure 3 illustrates the use of entropy labels at the service level.

The iLER has entropy label enabled under an applicable service context and the eLER has entropy label capability enabled. The iLER inserts the ELI and the EL into the label stack. The entropy label value is based on the service ID for point-to-point Layer 2 services.

At the LSR, if hashing is enabled, the LSR recognizes the ELI and uses the entropy label value as the hash result. If the **entropy-label** command had been disabled at the iLER, the LSR would not find the ELI and would default to hashing based on the label stack, if applicable.

Figure 3 **Entropy Label and Load Balancing**



At the ingress LER:

config>service>cpipe>spoke-sdp>entropy-label

config>service>epipe>spoke-sdp>entropy-label

config>service>ipipe>spoke-sdp>entropy-label

config>service>vpls>spoke-sdp>entropy-label

config>service>vpls>mesh-sdp>entropy-label

config>service>vprn>entropy-label

config>service>vprn>interface>spoke-sdp>entropy-label

config>router>isis>segment-routing>entropy-label

config>router>ospf>segment-routing>entropy-label

At the egress LER:

config>router>entropy-label

config>router>rsvp>entropy-label-capability

config>router>mpls>lsp>entropy-label

config>router>isis>entropy-label>override-tunnel-elc

config>router>ospf>entropy-label>override-tunnel-elc

The **per-service-hashing** command and the **l4-load-balancing**, **teid-load-balancing**, and **spi-load-balancing** commands are mutually exclusive.

For IP traffic, use the **l4-load-balancing** command. For IP traffic with mobile payload, use the **teid-load-balancing** and/or the **spi-load-balancing** command.

3.2.4 Label Edge and Label Switch Routers

A 7705 SAR performs different functions based on its position in an LSP—ingress, egress, or transit—as described in the following list:

- ingress Label Edge Router (iLER) — The router at the beginning of an LSP is the iLER. The ingress router encapsulates packets with an MPLS header and forwards the packets to the next router along the path. An LSP can only have one ingress router.
- Label Switching Router (LSR) — An LSR can be any intermediate router in the LSP between the ingress and egress routers, swapping the incoming label with the outgoing MPLS label and forwarding the MPLS packets it receives to the next router in the LSP. An LSP can have 0 to 253 transit routers.
- egress Label Edge Router (eLER) — The router at the end of an LSP is the eLER. The egress router strips the MPLS encapsulation, which changes it from an MPLS packet to a data packet, and then forwards the packet to its final destination using information in the forwarding table. An LSP can have only one egress router. The ingress and egress routers in an LSP cannot be the same router.

A router in a network can act as an ingress, egress, or transit router for one or more LSPs, depending on the network design.

Constrained-path LSPs are signaled and are confined to one Interior Gateway Protocol (IGP) area. These LSPs cannot cross an autonomous system (AS) boundary.

Static LSPs can cross AS boundaries. The intermediate hops are manually configured so that the LSP has no dependence on the IGP topology or a local forwarding table.

3.2.5 LSP Types

The following LSP types are supported:

- static LSPs — a static LSP specifies a static path. All routers that the LSP traverses must be configured manually with labels. No RSVP-TE or LDP signaling is required. Static LSPs are discussed in this chapter.
- signaled LSPs — LSPs are set up using the RSVP-TE or LDP signaling protocol. The signaling protocol allows labels to be assigned from an ingress router to the egress router. Signaling is triggered by the ingress routers. Configuration is required only on the ingress router and is not required on intermediate routers. Signaling also facilitates path selection. RSVP-TE is discussed in this chapter, and LDP is discussed in Label Distribution Protocol.

  There are two types of signaled LSP:

  - explicit-path LSPs — MPLS uses RSVP-TE to set up explicit-path LSPs. The hops within the LSP are configured manually. The intermediate hops must be configured as either strict or loose, meaning that the LSP must take either a direct path from the previous hop router to this router (strict) or can traverse other routers (loose). Thus, you can control how the path is set up. Explicit-path LSPs are similar to static LSPs but require less configuration. See RSVP and RSVP-TE. An explicit path that has not specified any hops will follow the IGP route.
  - constrained-path LSPs — for constrained-path LSPs, the intermediate hops of the LSP are dynamically assigned. A constrained-path LSP relies on the Constrained Shortest Path First (CSPF) routing algorithm to find a path that satisfies the constraints for the LSP. In turn, CSPF relies on the topology database provided by an extended IGP such as OSPF or IS-IS.

    Once the path is found by CSPF, RSVP-TE uses the path to request the LSP setup. CSPF calculates the shortest path based on the constraints provided, such as bandwidth, class of service, and specified hops.

If Fast Reroute (FRR) is configured, the ingress router signals the downstream routers so that each downstream router can preconfigure a detour route for the LSP that will be used if there is a failure on the original LSP. If a downstream router does not support FRR, the request is ignored and the router continues to support the original LSP. This can cause some of the detour routes to fail, but the original LSP is not impacted. For more information on FRR, see RSVP-TE Fast Reroute (FRR).

No bandwidth is reserved for the reroute path. If the user enters a value in the bandwidth parameter in the **config>router>mpls>lsp>fast-reroute** context, it will have no effect on establishing the backup LSP. The following warning message is displayed:

“The fast reroute bandwidth command is not supported in this release.”

3.3 RSVP and RSVP-TE

The Resource Reservation Protocol (RSVP) is a network control protocol used by a host to request specific qualities of service from the network for particular application data streams or flows. RSVP is also used by routers to deliver quality of service (QoS) requests to all nodes along the paths of the flows and to establish and maintain operational state to provide the requested service. In general, RSVP requests result in resources reserved in each node along the data path.

The Resource Reservation Protocol for Traffic Engineering (RSVP-TE) is an extended version of RSVP for MPLS. RSVP-TE uses traffic engineering extensions to support automatic signaling of LSPs. MPLS uses RSVP-TE to set up traffic-engineered LSPs. See RSVP-TE Extensions for MPLS for more information.

3.3.1 RSVP-TE Overview

RSVP-TE requests resources for simplex (unidirectional) flows. Therefore, RSVP-TE treats a sender as logically distinct from a receiver, although the same application process may act as both a sender and a receiver at the same time. Duplex flows require two LSPs, to carry traffic in each direction.

RSVP-TE is a signaling protocol, not a routing protocol. RSVP-TE operates with unicast and multicast routing protocols. Routing protocols determine where packets are forwarded. RSVP-TE consults local routing tables to relay RSVP-TE messages.

RSVP-TE uses two message types to set up LSPs, PATH and RESV. Figure 4 depicts the process to establish an LSP.

- The sender (the ingress LER (iLER)) sends PATH messages toward the receiver, (the egress LER (eLER)) to indicate the forwarding equivalence class (FEC) for which label bindings are desired. PATH messages are used to signal and request the label bindings required to establish the LSP from ingress to egress. Each router along the path observes the traffic type.
- PATH messages facilitate the routers along the path to make the necessary bandwidth reservations and distribute the label binding to the router upstream.
- The eLER sends label binding information in the RESV messages in response to PATH messages received.
- The LSP is considered operational when the iLER receives the label binding information.

Figure 4 **Establishing LSPs**

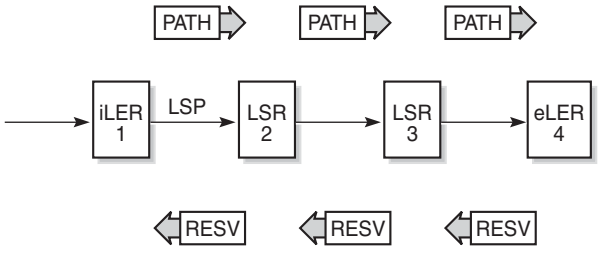
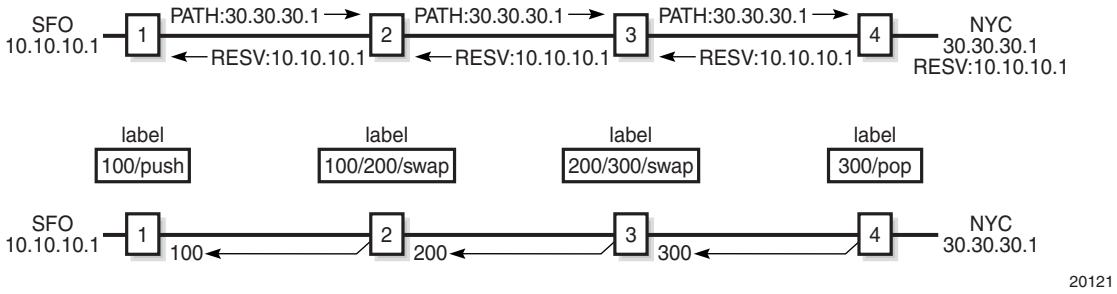


Figure 5 displays an example of an LSP path set up using RSVP-TE. The ingress label edge router (iLER 1) transmits an RSVP-TE PATH message (path: 30.30.30.1) downstream to the egress label edge router (eLER 4). The PATH message contains a label request object that requests intermediate LSRs and the eLER to provide a label binding for this path.

Figure 5 **LSP Using RSVP-TE Path Setup**



In addition to the label request object, an RSVP-TE PATH message can also contain a number of optional objects:

- explicit route object (ERO) — when the ERO is present, the RSVP-TE PATH message is forced to follow the path specified by the ERO (independent of the IGP shortest path)
- record route object (RRO) — allows the iLER to receive a listing of the LSRs that the LSP tunnel actually traverses
- session attribute object — controls the path setup priority, holding priority, and local rerouting features

Upon receiving a PATH message containing a label request object, the eLER transmits an RESV message that contains a label object. The label object contains the label binding that the downstream LSR communicates to its upstream neighbor. The RESV message is sent upstream towards the iLER, in a direction opposite to that followed by the PATH message. Each LSR that processes the RESV message carrying a label object uses the received label for outgoing traffic associated with the specific LSP. When the RESV message arrives at the ingress LSR, the LSP is established.

3.3.1.1 Using RSVP-TE for MPLS

Hosts and routers that support both MPLS and RSVP-TE can associate labels with RSVP-TE flows. When MPLS and RSVP-TE are combined, the definition of a flow can be made more flexible. Once an LSP is established, the traffic through the path is defined by the label applied at the ingress node of the LSP. The mapping of label to traffic can be accomplished using a variety of criteria. The set of packets that are assigned the same label value by a specific node are considered to belong to the same Forwarding Equivalence Class (FEC) that defines the RSVP-TE flow.

For use with MPLS, RSVP-TE already has the resource reservation component built in, making it ideal to reserve resources for LSPs.

3.3.1.2 RSVP-TE Extensions for MPLS

The RSVP-TE extensions enable MPLS to support the creation of explicitly routed LSPs, with or without resource reservation. Several of the features enabled by these extensions were implemented to meet the requirements for traffic engineering over MPLS, which enables the creation of traffic trunks with specific characteristics. None of the TE extensions result in backward compatibility problems with traditional RSVP implementations.

To run properly, the traffic engineering capabilities of RSVP-TE require an underlying TE-enabled IGP routing protocol. The 7705 SAR supports OSPF and IS-IS with TE extensions.

Routing protocols make it possible to advertise the constraints imposed over various links in the network. For example, in order for the nodes in a network to choose the best link for signaling a tunnel, the capacity of a particular link and the amount of reservable capacity must be advertised by the IGP. RSVP-TE makes use of these constraints to request the setup of a path or LSP that traverses only those links that are part of an administrative group (admin groups are described in the following list).

Thus, both RSVP-TE and the IGP-TE (that is, OSPF-TE or IS-IS-TE for the 7705 SAR) must be enabled and running simultaneously.

The following TE capabilities are supported:

- hop limit — the hop limit is the maximum number of LSRs that a given LSP can traverse, including the ingress and the egress LERs. Typically, the hop limit is used to control the maximum delay time for mission-critical traffic such as voice traffic.

  The hop limit applies to the primary LSP, any backup LSPs, and LSPs configured to be used in Fast Reroute (FRR) situations.
- admin groups — administrative groups provide a way to define which LSR nodes should be included or excluded while signaling an LSP. For example, it might be desirable to avoid some nodes or links that are known to be used heavily from being included in the path of an LSP, or to include a specific LSR node to ensure that a newly signaled RSVP-TE tunnel traverses that LSR node.

  Administrative groups apply to both primary and secondary LSPs. They are defined under the **config>router>if-attribute** context, and are applied at the MPLS interface level, as well as at the LSP and the primary and secondary LSP levels through **include** and **exclude** commands.
- bandwidth — the bandwidth capability (supported by RSVP-TE), is similar to the Connection Admission Control (CAC) function in ATM. During the establishment phase of RSVP-TE, the LSP PATH message contains the bandwidth reservation request. If the requested capacity is available, the RESV message confirms the reservation request. The amount of reserved bandwidth stated in the request is deducted from the amount of reservable bandwidth for each link over which the LSP traverses.

  The bandwidth capability applies to both primary and secondary LSPs, and LSPs configured to be used in Fast Reroute (FRR) situations.

3.3.1.3 Hello Protocol

The Hello protocol detects the loss of a neighbor node (node failure detection) or the reset of a neighbor’s RSVP-TE state information. In standard RSVP, neighbor monitoring occurs as part of the RSVP soft-state model. The reservation state is maintained as cached information that is first installed and then periodically refreshed by the ingress and egress LERs. If the state is not refreshed within a specified time interval, the LSR discards the state because it assumes that either the neighbor node has been lost or its RSVP-TE state information has been reset.

The Hello protocol extension is composed of a Hello message, a Hello request object and a Hello ACK object. Hello processing between two neighbors supports independent selection of failure detection intervals. Each neighbor can automatically issue Hello request objects. Each Hello request object is answered by a Hello ACK object.

3.3.1.4 Authentication

Protocol authentication protects against malicious attacks on the communications between routing protocol neighbors. These attacks could either disrupt communications or inject incorrect routing information into the systems routing table. The use of authentication keys can help to protect routing protocols from these types of attacks.

All RSVP-TE protocol exchanges can be authenticated. This guarantees that only trusted routers can participate in autonomous system routing.

Authentication must be explicitly configured and can be done using two separate mechanisms:

- configuration of an explicit authentication key and algorithm using the **authentication-key** command
- configuration of an authentication keychain using the **auth-keychain** command

Either the **authentication-key** command or the **auth-keychain** command can be used by RSVP-TE, but both cannot be supported at the same time. If both commands are configured, the **auth-keychain** configuration will be applied and the **authentication-key** command will be ignored.

By default, authentication is not enabled on an interface.

3.3.1.4.1 Authentication Key

When enabled on an RSVP-TE interface with the **authentication-key** command, authentication of RSVP messages operates in both directions of the interface. A node maintains a security association with its neighbors for each authentication key. The following items are stored in the context of this security association:

- the HMAC-MD5 authentication algorithm
- the key used with the authentication algorithm

- the lifetime of the key. A key is a user-generated key using third-party software or hardware. The value is entered as a static string into the CLI configuration of the RSVP interface. The key will continue to be valid until it is removed from that RSVP interface.
- the source address of the sending system
- the latest sending sequence number used with this key identifier

The RSVP sender transmits an authenticating digest of the RSVP message, computed using the shared authentication key and a keyed hash algorithm. The message digest is included in an Integrity object that also contains a Flags field, a Key Identifier field, and a Sequence Number field. The RSVP sender complies with the procedures for RSVP message generation in RFC 2747, *RSVP Cryptographic Authentication*.

An RSVP receiver uses the key together with the authentication algorithm to process received RSVP messages.

If a point of local repair (PLR) node switches the path of the LSP to a bypass LSP, it does not send the integrity object in the RSVP messages over the bypass tunnel. If an integrity object is received from the merge point (MP) node, then the message is discarded since there is no security association with the next-next-hop MP node.

The 7705 SAR MD5 implementation does not support the authentication challenge procedures in RFC 2747.

3.3.1.4.2 Authentication Keychains

The keychain mechanism allows for the creation of keys used to authenticate RSVP-TE communications. Each keychain entry defines the authentication attributes to be used in authenticating RSVP-TE messages from remote peers or neighbors; the entry must include at least one key entry to be valid. The keychain mechanism also allows authentication keys to be changed without affecting the state of the RSVP-TE adjacencies and supports stronger authentication algorithms than plain text and MD5.

Keychains are configured in the **config>system>security>keychain** context. For more information about configuring keychains, refer to the 7705 SAR System Management Guide, “TCP Enhanced Authentication and Keychain Authentication”.

The keychain is then associated with an RSVP-TE interface with the **auth-keychain** command.

For a key entry to be valid, it must include a valid key, the current system clock value must be within the begin and end time of the key entry, and the algorithm specified must be supported by RSVP-TE.

RSVP-TE supports the following authentication algorithms:

- HMAC-MD5
- HMAC-SHA-1-96
- HMAC-SHA-1
- HMAC-SHA-256

Keychain errors are handled as follows.

- If a keychain exists but there are no active key entries with an authentication type that matches the type supported by RSVP-TE, inbound RSVP-TE packets will not be authenticated and will be discarded and no outbound RSVP-TE packets will be sent.
- If a keychain exists but the last key entry has expired, a log entry will be raised indicating that all keychain entries have expired.

  RSVP-TE requires that the protocol continue to authenticate inbound and outbound traffic using the last valid authentication key.

3.3.1.5 Non-Router ID Addresses as Destinations and Hops

The address of a configured loopback interface, other than the router ID, can be used as the destination of an RSVP LSP. For a constrained-path LSP, CSPF searches for the best path that matches the constraints across all areas or levels of the IGP where this address is reachable. If the address is the router ID of the destination node, then CSPF selects the best path across all areas or levels of the IGP for that router ID, regardless of which area or level the router ID is reachable for as an interface.

The address of a loopback interface other than the router ID can also be configured as a hop in the LSP path hop definition. If the hop is “strict” and corresponds to the router ID of the node, the CSPF path may use any TE-enabled link to the downstream node based on best cost. If the hop is “strict” and does not correspond to the router ID of the node, CSPF will fail.

3.3.2 RSVP LSP and LDP FEC Statistics

RSVP LSP and LDP FEC statistics allow operators to monitor traffic being forwarded between any two PE routers and for all services using an RSVP or LDP SDP. If the LSP is used as a shortcut to transport BGP LU, VPRN traffic over MP-BGP or IGP prefixes, statistics are collected for these IP packets being forwarded.

The following statistics are collected for each RSVP LSP or LDP FEC:

- per forwarding class forwarded in-profile packet count
- per forwarding class forwarded in-profile byte count
- per forwarding class forwarded out-of-profile packet count
- per forwarding class forwarded out-of-profile byte count

For an RSVP LSP, these counters are available for the egress data path at the ingress LER and for the ingress data path at the egress LER.

For an LDP FEC, these counters are available for the egress data path at the ingress LER and LSR. Because an ingress LER is also potentially an LSR for an LDP FEC, combined egress data path statistics are provided whenever applicable.

OAM packets that are forwarded using LSP encapsulation, such as LSP ping and LSP trace, are also included in the above counters.

Dropped packets and bytes for an RSVP LSP or LDP FEC are not counted on the ingress LER.

Octet counters are for the entire frame and include the label stack and Layer 2 header and padding, similar to existing MPLS interface counters. For that reason, ingress and egress octet counters for an RSVP LSP may differ slightly if the type of interface or encapsulation is different (POS, Ethernet null, or Ethernet dot1q).

RSVP LSP and LDP FEC statistics counters can be retrieved by:

- using the CLI **show** command for the RSVP LSP or the LDP FEC
- using the CLI **monitor** command applied to a specific RSVP LSP or LDP FEC
- using an SNMPv3 interface to query the MIB
- accessing an accounting file if statistics collection is enabled with the default or a user-specified accounting policy for the RSVP LSP or LDP FEC

RSVP LSP and LDP FEC statistics counters are not saved to an accounting file unless statistics collection is enabled and the specific RSVP LSP or LDP FEC statistics collection record is included in the default accounting policy or in a user-defined accounting policy using the following commands:

- RSVP LSP ingress data path counters
  config>router>mpls>ingress-statistics>lsp>collect-stats
  config>router>mpls>ingress-statistics>lsp>accounting-policy *policy-id*
- RSVP LSP egress data path counters
  config>router>mpls>lsp>egress-statistics>collect-stats
  config>router>mpls>lsp>egress-statistics>accounting-policy *policy-id*
- LDP FEC egress data path counters
  config>router>ldp>egress-statistics>fec-prefix>collect-stats
  config>router>ldp>egress-statistics>fec-prefix>accounting-policy *policy-id*

3.3.2.1 Configuring RSVP LSP Statistics at Ingress LER

At the ingress LER, statistics are configured in the egress data path of an originating LSP with the **config>router>mpls>lsp>egress-statistics** command in the LSP configuration at the head-end node. Statistics collection in the egress data path is enabled after the user executes the **no shutdown** command in the **egress-statistics** context. By default, this function is in a shutdown state.

Statistics cannot be configured if the LSP name contains a colon (:), which is used as a field separator by the ingress LER for encoding the LSP and path names into the RSVP Session Name field in the Session_Attribute object.

The **no** form of the **egress-statistics** command disables statistics collection in the egress data path and removes the accounting policy association from the RSVP LSP. Users can choose to disable statistics in the egress data path while keeping the accounting policy association of the RSVP LSP with the **config>router>mpls>lsp>egress-statistics shutdown** command.

The same set of counters are updated for packets forwarded over any path of the LSP. In the steady state, counters are updated for packets forwarded over the active path of the LSP. The active path can be the primary path, one of the secondary paths, the FRR detour path, or the FRR bypass path when the head-end node is also the PLR.

The LSP counters are maintained over the lifetime of the LSP as long as statistics are enabled. The user can clear the counters with the **clear>router>mpls>lsp-egress-stats [***lsp-name***]** command.

LSP statistics are not collected on a dynamic or static bypass tunnel. LSP egress statistics are also not collected if the head-end node is also the penultimate-popping hop (PHP) node for a single-hop LSP using an implicit null label. However, if any label is pushed onto the label stack, for example, the Layer 2 or Layer 3 service label, the egress statistics are counted for the LSP even if the transport MPLS label is not present.

When a hierarchy of LSPs is in use, statistics collection on the outermost label corresponding to the tunneling LSP and on the inner labels, corresponding to the tunneled LSPs, are mutually exclusive. The outermost label takes precedence. Consequently, when the user enables statistics collection on an RSVP LSP that is also used for tunneling LDP FECs with the LDP over RSVP shortcut, statistics will be collected on the RSVP LSP only. No statistics are collected for an LDP FEC tunneled over this RSVP LSP even if the user enabled statistics collection on the FEC. When the user disables statistics collection on the RSVP LSP, statistics collection, if enabled, will be performed on the tunneled LDP FEC.

LSP statistics are not collected on static LSPs. Auto-LSP templates do not support LSP statistics collection.

3.3.2.2 Configuring RSVP LSP Statistics at Egress LER

At the egress LER, statistics are configured in the ingress data path of a terminating LSP by entering the LSP name, along with the ingress LER system interface address, with the **config>router>mpls>ingress-statistics>lsp** *lsp-name* **sender** *ip-address* command. Statistics collection is enabled in the ingress data path after the user executes the **no shutdown** command in the **ingress-statistics** context. By default, this function is in a shutdown state.

The LSP name must correspond to the name configured by the user at the ingress LER. Statistics cannot be configured if the LSP name contains a colon (:), which is used as a field separator by the ingress LER for encoding the LSP and path names into the RSVP Session Name field in the Session_Attribute object.

The **no** form of the **ingress-statistics** command disables statistics collection in the ingress data path and removes the accounting policy association from the RSVP LSP. Users can choose to disable statistics in the ingress data path while keeping the accounting policy association of the RSVP LSP with the **config>router>mpls>ingress-statistics>lsp>shutdown** command.

The same set of counters are updated for packets received over any path of the LSP. In the steady state, the counters are updated for packets received over the active path of the LSP. The active path can be the primary path, one of the secondary paths, the FRR detour path, or the FRR bypass path when the tail-end node is also the MP.

The LSP counters are maintained over the lifetime of the LSP as long as statistics are enabled. The user can clear the counters with the **clear>router>mpls>lsp-ingress-stats** *ip-address* **lsp** *lsp-name* command.

When a hierarchy of LSPs is in use, statistics collection on the outermost label corresponding to the tunneling LSP and on the inner labels, corresponding to the tunneled LSPs, are mutually exclusive. The outermost label takes precedence.

Because ingress data path statistics are not supported for an LDP FEC, there are no statistics collected for an LDP FEC, however if the LDP FEC is tunneled over an RSVP shortcut LSP that has LSP ingress statistics configured, the statistics are collected for the RSVP LSP

The user can enable statistics collection on a manual bypass LSP terminating on the egress LER. However, all LSPs whose primary path is protected by the manual bypass will not collect statistics when they activate forwarding over the manual bypass. If the user disables statistics collection on the manual bypass LSP, statistics collection, if enabled, is continued on the protected LSP when the bypass LSP is activated.

A flag in the output of the **show** command for the LSP statistics will indicate if there were no path state blocks (PSBs) that matched the specified LSP name at any given point in time. This could be due to the absence of the RSVP session or to the presence of a session type that is not supported; for example, the LSP name matched a point-to-multipoint LSP. The counters will show all zero values, which could otherwise be confused with an LSP with a valid matched PSB that is not receiving packets.

3.3.2.3 Configuring LDP FEC Statistics

At the ingress LER and LSR, statistics collection is configured in the egress data path of an LDP FEC by specifying the FEC prefix with the **config>router>ldp>egress-statistics>fec-prefix** command. Statistics collection is enabled in the egress data path after the user executes the **no shutdown** command under the **egress-statistics** context. By default, this function is in a shutdown state.

The **no** form of the **egress-statistics** command disables statistics collection in the egress data path and removes the accounting policy association from the LDP FEC. Users can choose to disable statistics in the egress data path while keeping the accounting policy association of the LDP FEC with the **config>router>ldp>egress-statistics>fec-prefix>shutdown** command.

Statistics collection applies to prefix FECs imported from both LDP neighbors and T-LDP neighbors.

The egress data path counters are updated for both originating and transit packets. Originating packets may be service packets or IP user and control packets forwarded either as BGP LU over LDP FEC or as VPRN traffic (MP-BGP) over LDP FEC or simply over LDP FEC IGP shortcut. Transit packets of the FEC are label-switched on this node.

When ECMP is enabled and multiple paths exist for a FEC, the same set of counters is updated for each packet forwarded over any of the ECMP links for as long as this FEC is active.

The LDP FEC counters are maintained over the lifetime of the FEC as long as statistics are enabled. The user can clear the counters with the **clear>router>ldp>fec-egress-statistics** command.

For more information about LDP FEC statistics commands, see LDP Command Reference.

3.4 RSVP-TE Signaling

RSVP-TE-based signaling provides a means to establish tunnels dynamically.

RSVP-TE uses the Downstream on Demand (DOD) label distribution mode, sending PATH messages from the ingress LER node to the egress LER and RESV messages in the reverse direction. DOD label distribution is a router's response to an explicit request from another router for label binding information. The DOD mode is in contrast to LDP on the 7705 SAR, which uses the Downstream Unsolicited (DU) label distribution mode for both PWs and LSPs. A router in DU mode will distribute label bindings to another router that has not explicitly requested the label bindings.

RSVP-TE signaling is supported when the 7705 SAR is deployed as an LER and as an LSR. When used as an LER, the 7705 SAR uses RSVP-TE signaling to set up constrained paths because only the LER knows all the constraints imposed on the LSP. When used as an LSR, the 7705 SAR uses RSVP-TE to interpret the RSVP-TE messages (including all the constraints).

With RSVP-TE, users can choose which services and PWs may use a particular LSP. One-to-one or many-to-one scenarios for binding PWs to RSVP-TE LSPs is supported, which is similar to binding PWs to static LSPs. Furthermore, each RSVP-TE LSP can be configured with its own set of attributes and constraints.

3.4.1 General Attributes of RSVP-TE

The following general attributes of RSVP-TE on the 7705 SAR are supported:

- Bidirectional Forwarding Detection
- Timers
- LSP Resignal Limit
- RSVP-TE Message Pacing
- RSVP-TE Overhead Refresh Reduction
- RSVP-TE Reservation Styles
- Implicit Null Label
- RSVP-TE Entropy Labels

3.4.1.1 Bidirectional Forwarding Detection

Bidirectional Forwarding Detection (BFD) is supported on the 7705 SAR. In the case of BFD for RSVP-TE, an RSVP-TE enabled link is registered with the BFD state machine, and if a failure occurs the RSVP-TE interface is taken out of service. The BFD implementation on the 7705 SAR works on a hop-by-hop basis, and if BFD detects a link failure, only the two directly connected MPLS nodes are aware of that failure. If the node that detects the link failure is an LSR node, it generates PATH-ERR messages to the originators (the LER nodes) of the failing LSPs. If FRR is configured, the detecting node takes corrective action itself. See LSP Redundancy and RSVP-TE Fast Reroute (FRR) for more information on these topics.

3.4.1.1.1 RSVP-TE over Broadcast Interface with BFD

The 7705 SAR supports per-neighbor tracking when RSVP-TE is used over a broadcast interface in conjunction with BFD. Per-neighbor tracking enables RSVP-TE to distinguish neighbors from one another when the outgoing interface is a broadcast interface that is connected to multiple neighbors over a broadcast domain. If a BFD session toward a specific neighbor on the broadcast domain goes down, the session failure triggers consecutive actions (for example, an FRR switchover) only for the LSPs of the affected neighbor.

3.4.1.2 Timers

The following timers are implemented to ensure the successful operation of RSVP-TE:

- bypass-resignal-timer — the bypass resignal timer defines the time between the global reoptimization of all dynamic bypass RSVP-TE LSPs. For more information, see Bypass Resignal Timer.
- hold-timer — the hold timer defines the amount of time before an LSP is brought up and is in service, which provides protection against unreliable nodes and links
- resignal-timer — the resignal timer is used in conjunction with the route optimization process, especially after a reroute has occurred. If the newly computed path for an LSP has a better metric than the currently recorded hop list, an attempt is made to resignal that LSP, and if the attempt is successful, a make-before-break switchover occurs. If the attempt to resignal an LSP fails, the LSP continues to use the existing path and another resignal attempt is made the next time the timer expires.

  When the resignal timer expires, a trap and syslog message are generated.

- retry-timer — the retry timer defines a period of time before a resignal attempt is made after an LSP failure. This delay time protects network resources against excessive signaling overhead.

3.4.1.3 LSP Resignal Limit

When an LSP fails, an LER node tries to resignal it. The following limit can be configured:

- retry-limit — the retry limit defines the number of resignaling attempts in order to conserve the resources of the nodes in the network. There could be a serious loss of capacity due to a link failure where an infinite number of retries generate unnecessary message overhead.

3.4.1.4 RSVP-TE Message Pacing

RSVP-TE message pacing provides a means to limit the overwhelming number of RSVP-TE signaling messages that can occur in large MPLS networks during node failures. RSVP-TE message pacing allows the messages to be sent in timed intervals.

To protect nodes from receiving too many messages, the following message pacing parameters can be configured:

- msg-pacing — message pacing can be enabled or disabled
- max-burst — maximum burst defines the number of RSVP-TE messages that can be sent in the specified period of time
- period — period defines the interval of time used in conjunction with the max-burst parameter to send message pacing RSVP-TE messages

Message pacing needs to be enabled on all the nodes in a network to ensure the efficient operation of tier-1 nodes. Message pacing affects the number of RSVP-TE messages that a particular node can generate, not the number of messages it can receive. Thus, each node must be paced at a rate that allows the most loaded MPLS nodes to keep up with the number of messages they receive.

Note: Typically, a tier-1 node is an aggregator of tier-2 node transmissions, which is an aggregator of tier-3 node transmissions. Tier-1 nodes are often installed at an MTSO, while tier-3 nodes are often installed at cell sites.

3.4.1.5 RSVP-TE Overhead Refresh Reduction

RFC 2961, *RSVP Refresh Overhead Reduction Extensions*, defines enhancements to the RSVP-TE signaling protocol that reduce refresh overhead, which are in addition to the message pacing function.

These extensions are:

- RSVP-TE message bundling — RSVP-TE message bundling reduces the total number of RSVP-TE messages by aggregating the status information of multiple LSPs into a single RSVP-TE PDU. The 7705 SAR supports the receipt and processing of bundled RSVP-TE messages but not the transmission of bundled messages as specified in RFC 2961, section 3.3.
- reliable message delivery — reliable message delivery extends RSVP-TE to support MESSAGE_ACK. Each RSVP-TE PDU has a unique message-id for sequence tracking purposes. When an RSVP-TE message arrives, the recipient acknowledges the reception of the specific message-id (this is similar to TCP ACK messages). Lost PDUs can be detected and re-sent with this method, which helps reduce the refresh rate because there are two endpoints tracking the received/lost messages.
- summary refresh — the summary refresh capability uses a single message-id list to replace many individual refresh messages and sends negative ACKs (NACKs) for any message-id that cannot be matched (verified). The summary refresh capability reduces the number of message exchanges and message processing between peers. It does not reduce the amount of soft state stored in the node. The term soft state refers to the control state in hosts and routers that will expire if not refreshed within a specified amount of time (see RFC 2205 for information on soft state).

These capabilities can be enabled on a per-RSVP-TE interface basis and are referred to collectively as “refresh overhead reduction extensions”. When **refresh-reduction** is enabled on a 7705 SAR RSVP-TE interface, the node indicates this to its peer by setting a refresh-reduction-capable bit in the flags field of the common RSVP-TE header. If both peers of an RSVP-TE interface set this bit, all three of the capabilities listed above can be used. The node monitors the setting of this bit in received RSVP-TE messages from the peer on the interface. If the bit is cleared, the node stops sending summary refresh messages. If a peer did not set the refresh-reduction-capable bit, a 7705 SAR node does not attempt to send summary refresh messages.

Also, reliable delivery of RSVP-TE messages over the RSVP-TE interface can be enabled using the **reliable-delivery** option.

3.4.1.6 RSVP-TE Reservation Styles

LSPs can be signaled with explicit reservation styles for the reservation of resources, such as bandwidth. A reservation style describes a set of attributes for a reservation, including the sharing attributes and sender selection attributes. The style information is part of the LSP configuration. The 7705 SAR supports two reservation styles:

- fixed filter (FF) — the fixed filter (FF) reservation style specifies an explicit list of senders and a distinct reservation for each of them. Each sender has a dedicated reservation that is not shared with other senders. Each sender is identified by an IP address and a local identification number, the LSP ID. Because each sender has its own reservation, a unique label and a separate LSP can be constructed for each sender-receiver pair. For traditional RSVP applications, the FF reservation style is ideal for a video distribution application in which each channel (or source) requires a separate pipe for each of the individual video streams.
- shared explicit (SE) — the shared explicit (SE) reservation style creates a single reservation over a link that is shared by an explicit list of senders. Because each sender is explicitly listed in the RESV message, different labels can be assigned to different sender-receiver pairs, thereby creating separate LSPs.

If the FRR option is enabled for the LSP and the facility FRR method is selected at the head-end node, only the SE reservation style is allowed. If a 7705 SAR PLR node receives a PATH message with fast reroute requested with facility method and the FF reservation style, it will reject the reservation. The one-to-one backup method supports both FF and SE styles.

3.4.1.7 Implicit Null Label

The implicit null label option enables an eLER to receive MPLS packets from the previous-hop LSR without the outer LSP label.

The implicit null label is included in RESV messages sent by the eLER to the previous-hop LSR. When the implicit null label is signaled to the LSR, it pops the outer label before sending the MPLS packet to the eLER; this is known as penultimate hop popping.

The implicit null label option can be enabled for all RSVP-TE interfaces and for all RSVP-TE LSPs for which the router is the eLER by using the **implicit-null-label** command in the **config>router>rsvp** context.

RSVP-TE must be shut down before this command can be used.

The implicit null label option can also be enabled or disabled on a specific RSVP-TE interface, overriding the RSVP-TE level configuration, by using the **implicit-null-label** {**enable** | **disable**} command in the **config>router>rsvp>interface** context.

The implicit null label is enabled for all LSPs for which the router is the eLER and for which the PATH message is received from the previous-hop LSR over the RSVP-TE interface.

With facility backup, if the eLER is also the merge point (MP) node, the incoming interface for the PATH refresh message over the bypass tunnel dictates whether the packet will use the implicit null label. Similarly, with one-to-one backup, if the eLER is also the detour merge point (DMP) node, the incoming interface for the PATH refresh message over the detour LSP dictates whether the packet will use the implicit null label.

The RSVP-TE interface must be shut down before this command can be used.

3.4.1.8 RSVP-TE Entropy Labels

The 7705 SAR supports entropy labels as described in MPLS Entropy Labels.

3.5 LSP Redundancy

Each primary LSP can be protected by up to two secondary LSPs. When the LER detects a primary LSP failure, it signals its secondary LSPs, if any have been configured, and automatically switches to the first one that is available. LSP redundancy supports shared risk link groups (SRLG). See Shared Risk Link Groups for more information on SRLG.

LSP redundancy differs from the Fast Reroute (FRR) feature in that LSP redundancy is controlled by the LER that initiated the LSP, whereas FRR uses the node that detects the failure to take recovery action. This means that LSP redundancy takes longer to reroute traffic than FRR because failure messages need to traverse multiple hops to reach the LER and activate LSP redundancy, whereas an FRR-configured node responds immediately to bypass the failed node or link. See RSVP-TE Fast Reroute (FRR) for more information on FRR.

The following parameters can be configured for primary and secondary LSPs:

- bandwidth — the amount of bandwidth needed for the secondary LSP can be reserved and can be any value; it does not need to be identical to the value reserved by the primary LSP. Bandwidth reservation can be set to 0, which is equivalent to reserving no bandwidth.
- inclusion and exclusion of nodes — by including or excluding certain nodes, you can ensure that the primary and secondary LSPs do not traverse the same nodes and therefore ensure successful recovery. Each secondary LSP can have its own list of included and excluded nodes.
- hop limit — the hop limit is the maximum number of LSRs that a secondary LSP can traverse, including the ingress and egress LERs.
- standby (secondary LSPs only) — when a secondary LSP is configured for standby mode, it is signaled immediately and is ready to take over traffic the moment the LER learns of a primary LSP failure. This mode is also called hot-standby mode.

  When a secondary LSP is not in standby mode, then it is only signaled when the primary LSP fails. If there is more than one secondary LSP, they are all signaled at the same time (upon detection of a primary LSP failure) and the first one to come up is used.

  If a **path-preference** priority value is configured for standby secondary LSP paths, the standby secondary LSP configured with the highest path priority becomes the active LSP when the primary LSP fails.

3.5.1 Make-Before-Break (MBB) Procedures for LSP and Path Parameter Configuration Changes

The Make-Before-Break (MBB) procedure allows an LSP to switch from an existing working path to a new path without interrupting service. The MBB procedure does this by first signaling the new path when it is operationally up, having the ingress LER move the traffic to the new path, and then allowing the ingress LER to tear down the original path.

The MBB procedure is invoked during the following operations:

- timer-based and manual resignal of an LSP path
- Fast Reroute (FRR) global revertive procedures
- Traffic Engineering (TE) graceful shutdown procedures
- update of the secondary path due to an update to the primary path SRLG
- LSP primary or secondary path name change
- LSP or path configuration parameter change

MBB procedure coverage has been extended to most of the other LSP-level and path-level parameters as follows:

- including or excluding admin groups at the LSP and path levels
- enabling or disabling the LSP-level CSPF option
- enabling or disabling LSP-level **use-te-metric** parameters when the CSPF option is enabled
- enabling or disabling the LSP-level hop-limit option in the fast-reroute context
- enabling the LSP-level least-fill option
- enabling or disabling the LSP-level **adspec** option
- changing between node-protect and no node-protect (link-protect) values in the LSP-level fast-reroute option
- changing the LSP-level and path-level hop-limit parameter values
- enabling or disabling primary or secondary path record or record-label options

The MBB procedure is not supported on a manual bypass LSP.

3.5.2 Automatic Creation of RSVP-TE LSPs

Automatic creation of RSVP-TE LSPs enables the automated creation of point-to-point RSVP-TE LSPs within a single IGP IS-IS level or OSPF area that can subsequently be used by services and/or IGP shortcuts. The feature is divided into two modes: creation of an RSVP-TE LSP mesh, and creation of single-hop RSVP-TE LSPs.

When creating an RSVP-TE LSP mesh, the mesh can be full or partial, the extent of which is governed by a prefix list containing the system addresses of all nodes that should form part of the mesh. When using single-hop RSVP-TE LSPs, point-to-point LSPs are established to all directly connected neighbors.

The use of automatically created RSVP-TE LSPs avoids manual configuration of RSVP-TE LSP meshes. Even when provisioning tools are used to automatically provision these LSPs, automatic creation of a mesh still provides a benefit by avoiding increased configuration file sizes.

3.5.3 Automatic Creation of RSVP-TE LSP Mesh (Auto-LSP)

This feature enables the automatic creation of an RSVP-TE point-to-point LSP to a destination node whose router ID matches a prefix in the specified peer prefix policy. This LSP type is referred to as an auto-created LSP mesh. To start the process of automatically creating an RSVP-TE LSP mesh, the user must create a route policy referencing a prefix list. This prefix list contains the system addresses of all nodes that are required to be in the mesh, and can be entered as a series of /32 addresses, or simply as a range.

After the route policy is created, the user must create an LSP template containing the common parameters that are used to establish all point-to-point LSPs within the mesh. The template must be created with the keyword **mesh-p2p**:

config>router>mpls>lsp-template *template-name* **mesh-p2p**

Upon creation of the template, CSPF is automatically enabled and cannot be disabled. The template must also reference a default path before it can be placed in a **no shutdown** state.

Next, the user must associate the LSP template with the previously defined route policy, and this is accomplished using the **auto-lsp lsp-template** command:

config>router>mpls>auto-lsp lsp-template *template-name* **policy** *peer-prefix-policy*

Once the **auto-lsp lsp-template** command is entered, the system starts the process of establishing the point-to-point LSPs. The prefixes defined in the prefix list are checked, and if a prefix corresponds to a router ID that is present in the Traffic Engineering (TE) database, the system instantiates a CSPF-computed primary path to that prefix using the parameters specified in the LSP template.

Multiple templates can be associated with the same or different peer prefix policies. Each application of an LSP template with a given prefix in the prefix list results in the instantiation of a single CSPF-computed LSP primary path using the LSP template parameters, as long as the prefix corresponds to a router ID for a node in the TE database. Auto LSP does not support the automatic signaling of a secondary path for an LSP. If the signaling of multiple LSPs to the same destination node is required, a separate LSP template must be associated with a prefix list that contains the same destination node address. Each instantiated LSP will have a unique LSP ID and a unique tunnel ID.

The auto-created LSP is installed in the Tunnel Table Manager (TTM) and is available to applications such as resolution of BGP label routes, and resolution of BGP, IGP, and static routes. The auto-created LSP can also be used for auto-binding by a VPRN service. The auto-created LSP cannot be used as a provisioned SDP for explicit binding by services.

The auto-created LSP mesh can be signaled over both numbered and unnumbered RSVP-TE interfaces.

Up to five peer prefix policies can be associated with an LSP template. Every time the user executes the **auto-lsp** command with the same or different prefix policy associations or changes the prefix policy associated with an LSP template, the system re-evaluates the prefix policy. The outcome of the re-evaluation indicates to MPLS whether an existing LSP must be torn down or a new LSP must be signaled to a destination address that is already in the TE database.

If a /32 prefix is added to or removed from a prefix list associated with an LSP template, or if a prefix range is expanded or narrowed, the prefix policy re-evaluation is performed. Whether the prefix list contains one or more specific /32 addresses or a range of addresses, MPLS requires an external trigger to instantiate an LSP to a node whose address matches an entry in the prefix list. The external trigger is when the router with a router ID matching an address in the prefix list appears in the TE database. The TE database provides the trigger to MPLS.

The user must perform a **no shutdown** of the template before it takes effect. When a template is in use, the user must shut down the template before changing any parameters except for those LSP parameters for which the change can be handled with the Make-Before-Break (MBB) procedures (see Make-Before-Break (MBB) Procedures for LSP and Path Parameter Configuration Changes). When the template is shut down and parameters are added, removed, or modified, the existing instances of the LSP using this template are torn down and resignaled.

MBB procedures for manual and timer-based resignaling of the LSP, and for TE graceful shutdown, are supported.

The **tools**>**perform**>**router**>**mpls**>**update-path** command is not supported for mesh LSPs.

The **one-to-one** option under the **fast-reroute** command is also not supported.

If the TE database loses the router ID while the LSP is up, it will perform an update to the MPLS that states that the router ID is no longer in the TE database. This occurs whether the bypass backup path is activated or not. This will cause MPLS to tear down all mesh LSPs to this router ID. However, if the destination router is not a neighbor of the ingress LER and the user shuts down the IGP instance on the destination router, the router ID corresponding to the IGP instance will only be deleted from the TE database on the ingress LER after the LSA/LSP times out. If the user brings the IGP instance back up before the LSA/LSP times out, the ingress LER will delete and reinstall the same router ID at the receipt of the updated LSA/LSP. The RSVP-TE LSPs destined for this router ID will be deleted and re-established. All other failure conditions will cause the LSP to activate the bypass backup LSP or to go down without being deleted.

3.5.3.1 Multi-Area and Multi-Instance Support

A router that does not have TE links within a given IGP area or level will not have its router ID discovered in the TE database by other routers in this area or level. In other words, an auto-created LSP mesh cannot be signaled to a router that does not participate in the area or level of the ingress LER.

A mesh LSP can be signaled using TE links that belong to the same IGP area even if the router ID of the ingress and egress routers are interfaces reachable in a different area. In this case, the LSP is considered to be an intra-area LSP.

If multiple instances of IS-IS are configured on a router, each with its own router ID, the TE database on other routers will be able to discover TE links advertised by each instance. In this case, an instance of an LSP can be signaled to each router ID with a CSPF path computed using TE links within each instance.

If multiple instances of IS-IS are configured on a destination router, each with the same router ID, a single instance of LSP will be signaled from other routers. If the user shuts down one IGP instance, this will have no impact as long as the other IGP instances remain up. The LSP will remain up and will forward traffic using the same TE links. The same behavior exists with a provisioned LSP.

3.5.3.2 Mesh LSP Name Encoding

When the ingress LER signals the path of an auto-created mesh LSP, it includes the name of the LSP and the path name in the Session Name field of the Session Attribute object in the PATH message. The encoding is as follows:

Session Name: <*lsp-name::path-name*>, where the *lsp-name* component is encoded as follows:

TemplateName-DestIpv4Address-TunnelId

where **DestIpv4Address** is the address of the destination of the auto-created LSP.

3.5.4 Automatic Creation of an RSVP-TE Single-Hop LSP

If the one-hop option is specified instead of a prefix policy, the **auto-lsp** command enables the automatic signaling of single-hop, point-to-point LSPs using the specified template to all directly connected neighbors. This LSP type is referred to as auto-created single-hop LSPs of type one-hop. Unlike the automatically created RSVP-TE LSP mesh, the automatically created single-hop RSVP-TE LSPs have no requirement for a prefix list to be referenced.

The first requirement is to create an LSP template containing the common parameters used to establish each single-hop LSP. The template must be created with the keyword **one-hop-p2p**:

config>router>mpls>lsp-template *template-name* **one-hop-p2p**

Upon creation of the template, CSPF is automatically enabled (and cannot be disabled), and the **hop-limit** is set to a value of two. The **hop-limit** defines the number of nodes the LSP may traverse, and since these are single-hop LSPs to adjacent neighbors, a limit of two is sufficient. The template must also reference a default path before it can be placed in the **no shutdown** state.

The next requirement is to trigger the creation of single-hop LSPs using the **auto-lsp lsp-template** command:

config>router>mpls>auto-lsp lsp-template *template-name* **one-hop**

The LSP and path parameters and options supported in an LSP template of type **one-hop-p2p** are the same as those in the LSP template of type **mesh-p2p**. The show command for **auto-lsp** will display the actual outgoing interface address in the “from” field.

The auto-created single-hop LSP can be signaled over both numbered and unnumbered RSVP-TE interfaces.

When the **one-hop** command is executed, the TE database keeps track of each TE link to a directly connected IGP neighbor whose router ID is discovered. MPLS then signals an LSP with a destination address matching the router ID of the neighbor and with a strict hop consisting of the address of the interface used by the TE link. The **auto-lsp** command with the **one-hop** option results in one or more LSPs signaled to the IGP neighbor.

Only the router ID of the first IGP instance of the neighbor that advertises a TE link causes the LSP to be signaled. If another IGP instance with a different router ID advertises the same TE link, no action is taken and the existing LSP is kept up. If the router ID originally used disappears from the TE database, the LSP is kept up and is now associated with the other router ID.

The state of a single-hop LSP that is signaled displays the following behavior.

- If the interface used by the TE link goes down or BFD times out and the RSVP-TE interface is registered with BFD, the LSP path moves to the bypass backup LSP if the primary path is associated with one.
- If the association of the TE link with a router ID is removed from the TE database while the single-hop LSP is up, the single-hop LSP is torn down whether the bypass backup path is activated or not. This occurs if the interface used by the TE link is deleted or if the interface is shut down in the context of RSVP-TE.
- If the TE database loses the router ID while the LSP is up, it will perform two separate updates to MPLS, whether the bypass backup path is activated or not. The first one updates the loss of the TE link association, which will cause the single-hop LSP to be torn down. The other update states that the router ID is no longer in the TE database, which will cause MPLS to tear down all mesh LSPs to this router ID. A shutdown at the neighbor of the IGP instance that advertised the router ID will cause the router ID to be removed from the ingress LER node immediately after the last IGP adjacency is lost and not be subject to time-out as it is for a non-directly connected destination router.

All other feature behavior and limitations are the same as for an auto-created LSP mesh.

3.5.5 Automatic ABR Selection for Inter-area LSPs

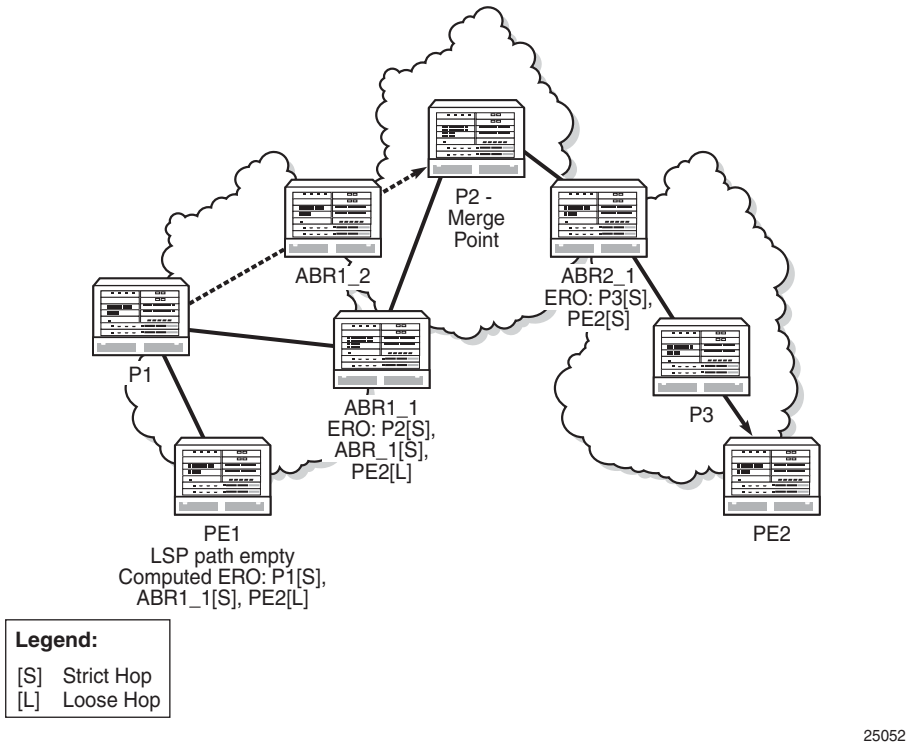
Inter-area RSVP point-to-point LSPs support automatic area border router (ABR) selection at the ingress LER. The ABR does not need to be included as a loose hop in the LSP path definition.

CSPF can now compute all segments of a multi-segment, inter-area LSP path in one operation. Previously, MPLS made separate requests to CSPF for each segment.

For LSP path establishment, the explicit route object (ERO) in the PATH message is expanded on ABRs where the next hop is a loose hop in the LSP path definition. For ERO expansion to operate, the **cspf-on-loose-hop** command must be enabled under the **mpls** context on the ABR to allow the ABR to perform a CSPF calculation. If CSPF calculations are not performed, CSPF for the LSP path fails at the head-end node as TE information for links in another area are not available.

Figure 6 illustrates the role of each node in the signaling of an inter-area LSP with automatic ABR selection.

Figure 6 **Automatic ABR Selection for Inter-Area LSP**



CSPF for an inter-area LSP operates as follows:

1. CSPF in the ingress LER node determines that an LSP is inter-area by performing a route lookup with the destination address of a point-to-point LSP, such as the address in the “to” field of the LSP configuration. If there is no intra-area route to the destination address, the LSP is considered to be inter-area.
2. When the path of the LSP is empty, CPSF computes a single-segment, intra-area path to an ABR that advertised a prefix matching the destination address of the LSP.
3. If the path of the LSP contains one or more hops, CSPF computes a multi-segment, intra-area path including the hops that are in the area of the ingress LER node.
4. If all hops are in the area of the ingress LER, the calculated path ends on an ABR that advertised a prefix matching the destination address of the LSP.
5. When there are one or more hops that are not in the area of the ingress LER, the calculated path ends on an ABR that advertised a prefix matching the first-hop address that is not in the area of the ingress LER.

6. Note the following special case of a multi-segment, inter-area LSP. If CSPF hits a hop that can be reached via an intra-area path but that resides on an ABR, CSPF only calculates a path up to that ABR. This is because there is a better chance to reach the destination of the LSP by first signaling the LSP up to that ABR and continuing the path calculation from there on by having the ABR expand the remaining hops in the ERO.
7. If there is more than one ABR that advertised a prefix, CSPF calculates a path for all ABRs. Only the shortest path is withheld. If more than one path is the shortest path, CSPF picks a path randomly or based on the least-fill criterion if least-fill is enabled. If more than one ABR satisfies the least-fill criterion, CSPF also picks one path randomly.
8. The path for an intra-area LSP cannot exit and re-enter the local area of the ingress LER. This behavior was possible in prior implementations when the user specified a loose hop outside the local area or when the only available path was via TE links outside the local area.

3.5.5.1 Rerouting of Inter-area LSPs

In prior implementations, an inter-area LSP path would have been rerouted if a failure or a topology change occurred in the local area or in a remote area while the ABR loose hop in the path definition was still up. If the transit/inter-area (exit) ABR failed or was put into node TE graceful shutdown, or if IS-IS went into overload mode, the LSP path would remain down at the ingress LER.

With automatic ABR selection, the ingress LER can reroute an inter-area LSP primary path via a different ABR in the following situations:

- When the local exit ABR fails, there are two cases to consider:
  - If the primary path is not protected at the ABR, and is therefore torn down by the previous hop in the path, then the ingress LER retries the LSP primary path via the ABR that currently has the best path for the destination prefix of the LSP.
  - If the primary path is protected at the ABR with a manual or dynamic bypass LSP, the ingress LER will receive a PathErr message with a notification of protection becoming active downstream and a RESV message with a Local-Protection-In-Use flag set. At the receipt of the first of these two messages, the ingress LER performs a Global Revertive MBB procedure to optimize the LSP primary path via the ABR that currently has the best path for the destination prefix of the LSP.

- When the local exit ABR node goes into IS-IS overload or is put into node TE graceful shutdown, the ingress LER performs an MBB procedure to optimize the LSP primary path via the ABR that currently has the best path for the destination prefix of the LSP. The MBB is performed at the receipt of the PathErr message for the node TE shutdown, or at the next timer or manual optimization of the LSP path if the IS-IS overload bit is received.

3.5.5.2 Behavior of MPLS Options in Inter-area LSPs

The automatic ABR selection for an inter-area LSP does not change the prior implementation of inter-area LSP behavior for many of the LSP-level and path-level options. However, there are a number of enhancements introduced by the automatic ABR selection feature.

- Features such as path bandwidth reservation and admin-groups continue to operate within the scope of all areas since they rely on propagating the parameter information in the PATH message across the area boundary.
- The TE graceful shutdown feature continues to support MBB of the LSP path to avoid the link or node that originated the PathErr message as long as the link or node is in the local area of the ingress LER. If the PathErr originated in a remote area, the ingress LER is not able to avoid the link or node when it performs the MBB since it computes the path to the local exit ABR only. However, there is an exception to this. An enhancement has been added to cause the upstream ABRs in the current path of the LSP to record the link or node to avoid and use the record in subsequent ERO expansions. This means that if the ingress LER computes a new MBB path that goes through the same exit ABR as the current path, and all ABRs upstream of the node or link that originated the PathErr message are also selected in the new MBB path when the ERO is expanded, then the new path will also avoid this link or node.
- MBB support has been expanded to avoid the ABR when the node is put into TE graceful shutdown.
- The **use-te-metric** option in CSPF cannot be propagated across the area boundary and thus operates within the scope of the local area of the ingress LER. This is a new behavior.
- The **srlg** option on the bypass LSP continues to operate locally at each PLR within each area. The PLR protecting the ABR checks the SRLG constraint for the path of the bypass within the local area.
- The **srlg** option on the secondary path is allowed to operate within the scope of the local area of the ingress LER with the automatic ABR selection feature.
- The **least-fill** option support with an inter-area LSP is introduced with the automatic ABR selection feature. When this option is enabled, CSPF applies the least-fill criterion to select the path segment to the exit ABR in the local area.

- The PLR must indicate to CSPF that a request to a one-to-one detour LSP path must remain within the local area. If the destination for the detour, which is the same as that of the LSP, is outside of the area, CSPF must return no path.
- With the automatic ABR selection feature, timer-based resignaling of the inter-area LSP path is supported and the path is resignaled if the cost of the path segment to the local exit ABR changes. The cost shown for the inter-area LSP at the ingress LER is the cost of the path segments to the ABR.

3.5.5.3 Inter-area LSP Support of OSPF Virtual Links

The OSPF virtual link extends area 0 for a router that is not connected to area 0 (OSPF backbone area). All prefixes in area 0 appear to be reachable via an intra-area path. However, the prefixes are not reachable since the path crosses the transit area through which the virtual link is set up to reach the area 0 remote nodes.

The TE database in a router learns all of the remote TE links in area 0 from the ABR connected to the transit area, but an intra-area LSP path using these TE links cannot be signaled within area 0 since none of these links are directly connected to this node.

The inter-area LSP feature can identify when the destination of an LSP is reachable via a virtual link. In that case, CSPF automatically computes and signals an inter-area LSP via the ABRs that are connected to the transit area.

However, when the ingress LER for the LSP is the ABR connected to the transit area, and the destination of the LSP is the address corresponding to another ABR **router-id** in that same transit area, CSPF computes and signals an intra-area LSP using the transit area TE links, even when the destination **router-id** is only part of area 0.

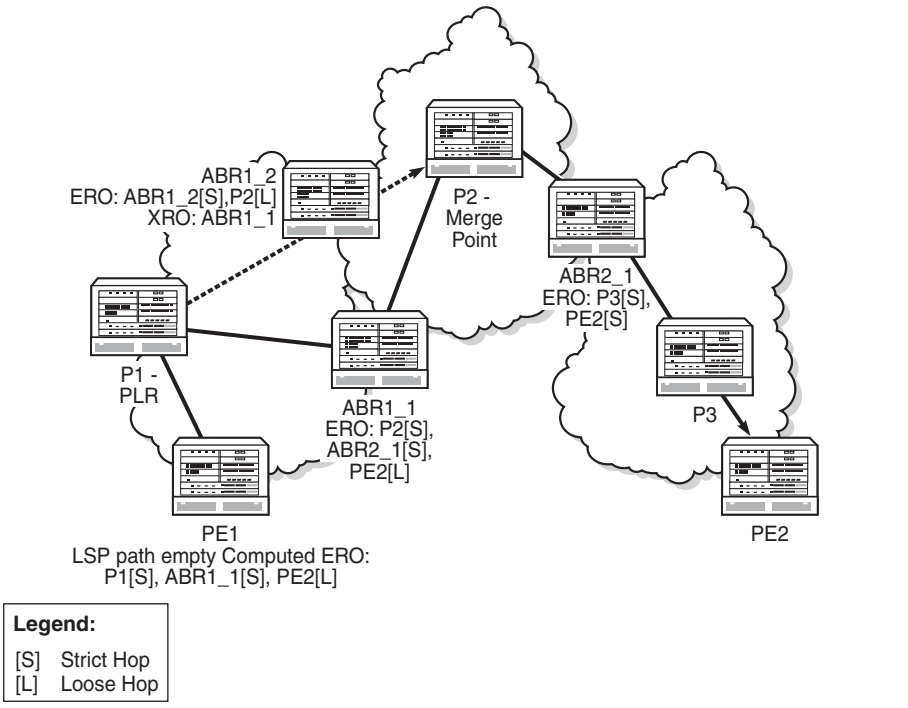
3.5.6 ABR FRR Protection for Inter-area LSP

For protection of the ABR, the upstream node of the ABR acts as a PLR, and the next-hop node to the protected domain border router is the merge point (MP). Both manual and dynamic bypass are available to protect the ABR.

Manual bypass protection only works when a proper completely strict path is provisioned that avoids the ABR.

Dynamic bypass protection provides for the automatic computation, signaling, and association with the primary path of an inter-area point-to-point LSP to provide ABR protection. Figure 7 illustrates the role of each node in ABR protection using a dynamic bypass LSP.

Figure 7 **ABR Protection Using Dynamic Bypass LSP**



In order for a PLR within the local area of the ingress LER to provide ABR protection, it must dynamically signal a bypass LSP and associate it with the primary path of the inter-area LSP using the following procedures.

- The PLR must inspect the RRO node-id of the LSP primary path to determine the address of the node immediately downstream of the ABR in the other area.
- The PLR signals an inter-area bypass LSP with a destination address set to the address downstream of the ABR and with the exclude route object (XRO) set to exclude the node-id of the protected ABR.
- The request to CSPF is for a path to the merge point (that is, the next-next-hop in the RRO received in the RESV message for the primary path) along with the constraint to exclude the protected ABR and the include/exclude admin groups of the primary path. If CSPF returns a path that can only go to an intermediate hop, then the PLR signals the dynamic bypass and automatically includes the XRO with the address of the protected ABR and propagates the admin-group constraints of the primary path into the Session Attribute object of the bypass LSP. Otherwise, the PLR signals the dynamic bypass directly to the merge point node with no XRO in the PATH message.

- If a node-protect dynamic bypass cannot be found or signaled, the PLR attempts a link-protect dynamic bypass LSP. As with the existing implementation of dynamic bypass within the same area, the PLR attempts in the background to signal a node-protect bypass at the receipt of every third RESV refresh message for the primary path.
- Refresh reduction over dynamic bypass only works if the RRO node-id also contains the interface address. Otherwise, the neighbor is not created once the bypass is activated by the PLR. The Path state then times out after three refreshes following the activation of the bypass backup LSP.

A one-to-one detour backup LSP cannot be used at the PLR for the protection of the ABR. As a result, a 7705 SAR, acting as a PLR, will not signal a one-to-one detour LSP for ABR protection. In addition, an ABR will reject a PATH message, received from a third party implementation, with a detour object and with the ERO having the next hop loose. This is performed whether the **cspf-on-loose** option is enabled or not on the 7705 SAR. In other words, the 7705 SAR, working as a transit ABR for the detour path, rejects the signaling of an inter-area detour backup LSP.

3.6 Preference Option for Standby Secondary LSP Paths

The **path-preferenc**e command allows priority values to be assigned to standby secondary LSP paths. This command can only be used for secondary LSP paths that have been configured in standby mode.

When the primary LSP becomes inactive, the standby secondary LSP with the highest path priority (lowest **path-preference** value) is chosen from the qualifying standby secondary LSPs to become the active LSP. This functionality allows a user to choose a path for one of the standby secondary LSPs that may, for example, be over a more reliable link or over a link with a lower latency.

If multiple standby secondary LSP paths have the same priority value, the system selects the path with the lowest uptime.

3.7 RSVP-TE Fast Reroute (FRR)

FRR is a mechanism to protect against RSVP-TE signaled LSP failures by reacting to these failures as soon as possible. FRR is set up from the iLER, which signals the transit routers to precompute their backup LSPs. FRR creates a precomputed backup LSP from each node in the LSP path. If a link or LSP between two routers fails, traffic is rerouted immediately onto the precomputed backup LSP.

Note: In order for FRR to work, CSPF must be enabled.

The 7705 SAR supports FRR facility backup and one-to-one backup.

Facility backup mode allows FRR to be enabled on an aggregate basis and protects a whole node or a whole link, regardless of the number of LSPs using that link. In other words, facility backup mode creates a common bypass tunnel to protect all LSP-paths traversing a common facility path. It provides flexibility, faster provisioning, and faster convergence times compared with one-to-one backup or LSP redundancy. One-to-one backup allows FRR to be enabled on a per-LSP basis.

With both methods, MPLS switches build many possible detour routes on the nodes between the ingress and egress nodes of an LSP. The facility backup method creates a detour route between two nodes, called a bypass tunnel, which is a single tunnel that follows the primary LSP path except where the link or node has failed. Traffic then switches to the bypass tunnel. The bypass tunnel merges with the original LSP path at the merge point (MP) as soon as possible. The one-to-one backup method creates a detour route, called a detour LSP, for each LSP that needs to be rerouted. Unlike the bypass tunnel, the detour LSP takes the best path to the termination point, and does not merge with the original LSP as soon as possible. The detour LSPs of a one-to-one backup LSP can merge at a detour merge point (DMP), which can either be at the termination point or at a point along the primary LSP.

One of the major differences between facility and one-to-one backup is the scalability offered by the protection method. In facility backup mode, all LSPs of the same type are rerouted over the bypass tunnel. Hence they are all protected against the failure of a node or link in the network. In facility backup mode, each LSR along the path verifies that it has a bypass tunnel available to meet its requirements; otherwise, if it can, it signals a new bypass tunnel based on the requirements. If a new LSP is configured for FRR facility backup, the existing backup tunnels are scanned and if any one of them can be used for recovery, it is preferred. If there are no common links, then a new bypass tunnel will be signaled, assuming that the LSP requirements can be met. One-to-one backup mode uses similar reroute and protection methods except a detour route is applied on a per-LSP basis.

The 7705 SAR uses CSPF to calculate the explicit route and dynamically signal the FRR LSP.

With facility backup mode, routers check the contents of the Record Route Object (RRO) in the received RESV message to determine the bypass tunnel endpoint in the FRR facility. For link protection, the router uses the RRO to check the IP address of the next-hop router attached to the far end of the link along with the label allocation information and to build the bypass tunnel. This label is preserved until the LSP is merged at the MP. For node protection, the router uses the RRO to determine the next-next-hop router and the label it is expecting. The collection of RRO information is enabled through the **record** and **record-label** options.

If, after this process, another LSP requests FRR using the facility backup method, the router checks and compares its session object to the existing session objects and if there is a match, the router binds that LSP to the same bypass tunnel. If there is no match, another bypass is created.

3.7.1 FRR Terminology

Table 6 provides definitions of terms used for FRR.

Table 6 **FRR Terminology**

Term	Definition
Backup path	The LSP that is responsible for backing up a protected LSP. A backup path can be a backup tunnel (facility backup) or a detour LSP (one-to-one backup).
Backup tunnel	The LSP that is used to back up one of the many LSPs in FRR facility (many-to-one) backup
Bypass tunnel	An LSP that is used to protect a set of LSPs passing over a common facility in FRR facility backup. A bypass tunnel can be configured manually or dynamically (see Dynamic and Manual Bypass LSPs).
CSPF	Constraint-based shortest path first
Detour route	Any alternate route that protects the primary path, such as a secondary path, FRR bypass tunnel, or FRR detour LSP. The term “detour route” should not be confused with the term “detour LSP”. Detour route is a general term that refers to any alternate route, while detour LSP is a specific term that applies to one-to-one backup.

Table 6 **FRR Terminology (Continued)**

Term	Definition
Detour LSP	The LSP that is used to reroute traffic around a failure in FRR one-to-one backup. The term “detour LSP” should not be confused with the term “detour route”. Detour route is a general term that refers to any alternate route, while detour LSP is a specific term that applies to one-to-one backup.
DMP	Detour merge point In the case of one-to-one backup, this is an LSR where multiple detours converge. Only one detour is signaled beyond that LSR.
Disjoint	See SRLG disjoint
Facility backup	A local repair method in which a single bypass tunnel is used to protect one or more LSPs that traverse the PLR, the resource being protected, and the Merge Point (in that order). Facility backup is distinct from a one-to-one backup tunnel, which has one backup path per protected path.
MP	Merge point The LSR where one or more backup tunnels rejoin the path of the protected LSP downstream of the potential failure. The same LSR may be both an MP and a PLR simultaneously.
NHOP bypass tunnel	Next-hop bypass tunnel A backup tunnel that bypasses a single link of the protected LSP
NNHOP bypass tunnel	Next-next-hop bypass tunnel A backup tunnel that bypasses a single node of the protected LSP
One-to-one backup	A local repair method in which a backup LSP is separately created for each protected LSP at a PLR
PLR	Point of local repair The head-end router of a backup tunnel or a detour LSP, where the term local repair refers to techniques used to repair an LSP tunnel quickly when a node or link along an LSP path fails
Primary path	An LSP that uses the routers specified by the path defined by the **primary** *path-name* command
Protected LSP	An LSP is protected at a given hop if it has one or more associated backup tunnels originating at that hop
Reroutable LSP	Any LSP for which the head-end router requests local protection
Secondary path	An LSP that protects a primary path that uses LSP redundancy protection rather than FRR protection

Table 6 **FRR Terminology (Continued)**

Term	Definition
SRLG disjoint	A path is considered to be SRLG disjoint from a given link or node if the path does not use any links or nodes that belong to the same SRLG as the given link or node

3.7.2 Bypass Resignal Timer

When the bypass resignal timer is enabled, MPLS makes a request to CSPF for the best path for each dynamic bypass LSP originated on the node. The constraints of the first associated LSP primary path that originally triggered the signaling of the bypass LSP must be satisfied. In order to do this, MPLS saves the original Path State Block (PSB) of the LSP primary path, even if the path is torn down.

If CSPF returns no path or returns a new path that is equal in cost to the current path, the PSB associations are not updated. If CSPF returns a new path with a different cost from the current one, MPLS signals it.

When the new path is successfully signaled, MPLS evaluates each PSB of each PLR (that is, each unique avoid-node or avoid-link constraint) associated with the older bypass LSP path to check whether the corresponding LSP primary path constraints are still satisfied by the new bypass LSP path. If the constraints are satisfied, the PSB association is moved to the new bypass LSP.

If the constraints are not satisfied, the PSB remains associated with the older bypass LSP and will be checked at the next background PSB re-evaluation or at the next timed or manual bypass reoptimization. Additionally, if the older bypass LSP is SRLG disjoint with a primary path that has the non-strict SRLG condition and the new bypass LSP is not SRLG disjoint, the PSB association is not moved.

If a PLR associated with a bypass LSP is active, the corresponding PSBs remain associated with the older bypass LSP until the global revertive make-before-break (MBB) operation tears down all corresponding primary paths, which also causes the older bypass LSP to be torn down.

When the **bypass resignal timer** is configured, a PSB re-evaluation task is initiated that runs in the background of each RSVP-TE session to determine whether an existing manual or dynamic bypass is more optimal for that session. If the PSB re-evaluation task finds a more optimal bypass, it moves the PSB association to it. If the PLR for this session is active, no action is taken and the PSB is re-examined at the next re-evaluation.

The periodic bypass reoptimization feature evaluates only the PSBs of the PLRs associated with that bypass LSP and only against the new bypass LSP path. The background re-evaluation task will, however, audit all PSBs on the system against all existing manual and dynamic bypass LSPs. PSBs that have not been moved by the dynamic or manual re-optimization of a bypass LSP, due to the PSB constraints not being met by the new signaled bypass LSP path, will be re-evaluated by the background task against all existing manual and dynamic bypass LSPs.

The background re-evaluation task also checks for PSBs that have requested a node-protect bypass LSP but are currently associated with a link-protect bypass LSP, as well as PSBs that have requested FRR protection and have no association. The background task is in addition to the attempt made when an RESV message is received on the protected LSP path, which ensures the association is completed faster.

This feature is not supported with inter-area dynamic bypass LSPs.

3.7.3 FRR Behavior

The FRR MPLS facility backup method and one-to-one backup method are configured on the ingress LER (iLER) by using the **fast-reroute** command.

The behavior of an LSP at an iLER with both FRR and a standby LSP path configured is as follows.

- When a downstream detour route (alternative path) becomes active at a Point of Local Repair (PLR):

  The iLER switches to the standby LSP path as soon as it is notified of the reroute. If the primary LSP path is subsequently repaired at the PLR, the LSP switches back to the primary path. If the standby path goes down, the LSP is switched back to the primary path, even though the primary path is still on the detour route at the PLR.
- If the primary path goes down at the iLER while the LSP is on the standby path, the detour route at the iLER is torn down and, for one-to-one backup detour routes, a “path tear” is sent for the detour route. In other words, the detour route at the iLER does not protect the standby LSP. If and when the primary LSP is again successfully resignaled, the iLER detour route will be restarted.
- When the primary LSP fails at the iLER:

  The LSP switches to the detour route. If the primary path undergoes a global revertive recovery, the LSP switches back to the primary path. If the LSP is on the detour route and the detour route fails, the LSP is switched to the standby path.

- Administrative groups are not taken into account when creating the detour routes for LSPs.

3.7.4 Dynamic and Manual Bypass LSPs

Users can disable dynamic bypass creation on a per-node basis using the **config>router>mpls>dynamic-bypass** command. Disabling dynamic bypass means that manual bypass is enabled. Dynamic bypass is enabled by default.

Dynamic bypass tunnels are implemented as per RFC 4090, *Fast Reroute Extensions to RSVP-TE for LSP Tunnels*. When an LSP is signaled and the Local Protection flag in the Session_attribute object is set, or the FRR object in the PATH message indicates that facility backup is desired, the PLR establishes a bypass tunnel to provide node and link protection. If there exists a bypass LSP that merges with the protected LSP at a downstream node, and if this LSP satisfies the constraints in the FRR object, then this bypass tunnel is selected and used. The **frr-object** command specifies whether facility backup is signaled in the FRR object.

The manual bypass feature allows an LSP to be preconfigured from a Point of Local Repair (PLR) that will be used exclusively for bypass protection. When a PATH message for a new LSP requests bypass protection, the node first checks for a manual bypass tunnel that satisfies the path constraints. If one is found, it is selected and used. If no manual bypass tunnel is found, the 7705 SAR dynamically signals a bypass LSP in the default behavior. To configure a manual bypass LSP, use the **bypass-only** option in the **config>router>mpls>lsp** *lsp-name* **[bypass-only]** command.

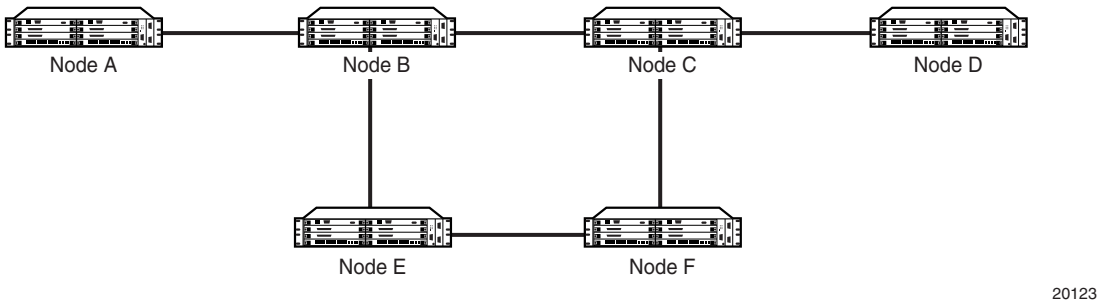
When a PLR activates a bypass backup LSP and subsequently receives a RESV refresh message for the original primary LSP path reservation over the restored interface, the PLR does not generate a ResvErr packet downstream. In addition, the MP node, once it becomes active, does not propagate a downstream ResvErr message received packet for the original primary LSP path reservation.

Refer to Configuring Manual Bypass Tunnels for configuration information.

3.7.4.1 Bypass LSP Selection Rules for the PLR

Figure 8 shows an example of a network used to illustrate the LSP selection rules for a PLR bypass scenario.

Figure 8 **Bypass Tunnel Node Example**



The PLR uses the following rules to select a bypass LSP from among multiple bypass LSPs (manually and dynamically created) when establishing the primary LSP path or when searching for a bypass for a protected LSP that does not have an association with a bypass tunnel.

1. The MPLS/RSVP-TE task in the PLR node checks for an existing manual bypass tunnel that satisfies the constraints. If the PATH message for the primary LSP path indicated that node protection is desired, which is the default LSP FRR setting at the head-end node, then the MPLS/RSVP-TE task searches for a node-protect bypass LSP. If the PATH message for the primary LSP path indicated that link protection is desired, then it searches for a link-protect bypass LSP.
2. If multiple manual bypass LSPs satisfying the path constraints exist, the PLR will prefer a manual bypass LSP terminating closer to the PLR over a manual bypass LSP terminating further away. If multiple manual bypass LSPs satisfying the path constraints terminate on the same downstream node, the PLR selects the one with the lowest IGP path cost, or if there is a tie, it picks the first one available.
3. If none of the manual bypass LSPs satisfy the constraints and dynamic bypass tunnels have not been disabled on the PLR node, then the MPLS/RSVP-TE task in the PLR node checks to determine if any of the already established dynamic bypass LSPs of the requested type satisfy the constraints.
4. If none of the dynamic bypass LSPs satisfy the constraints, then the MPLS/RSVP-TE task will ask CSPF to check if a new dynamic bypass of the requested type, node-protect or link-protect, can be established.
5. If the PATH message for the primary LSP path indicated node protection is desired, and no manual bypass was found after Step 1, and/or no dynamic bypass LSP was found after three attempts to perform Step 3, the MPLS/RSVP-TE task will repeat Steps 1 to 3 looking for a suitable link-protect bypass LSP. If none are found, the primary LSP will have no protection and the PLR node must clear the Local Protection Available flag in the IPv4 address sub-object of the RRO, starting in the next RESV refresh message it sends upstream.

6. If the PATH message for the primary LSP path indicated link protection is desired, and no manual bypass was found after Step 1, and/or no dynamic bypass LSP was found after performing Step 3, the primary LSP will have no protection and the PLR node must clear the Local Protection Available flag in the IPv4 address sub-object of the RRO, starting in the next RESV refresh message it sends upstream. The PLR will not search for a node-protect bypass LSP in this case.
7. If the PLR node successfully makes an association, it must set the Local Protection Available flag in the IPv4 address sub-object of the RRO, starting in the next RESV refresh message it sends upstream.
8. For all primary LSPs that requested FRR protection but are not currently associated with a bypass tunnel, the PLR node—upon reception of an RESV refresh message on the primary LSP path—repeats Steps 1 to 7.

If the user disables dynamic bypass tunnels on a node while dynamic bypass tunnels are activated and passing traffic, traffic loss will occur on the protected LSP. Furthermore, if no manual bypass tunnel exists that satisfies the constraints of the protected LSP, the LSP will remain without protection.

If the user configures a bypass tunnel on Node B (Figure 8) and dynamic bypass tunnels have been disabled, LSPs that had been previously signaled and that were not associated with any manual bypass tunnel (for example, none existed) will be associated with the manual bypass tunnel, if it is suitable. The node checks for the availability of a suitable bypass tunnel for each of the outstanding LSPs every time an RESV message is received for these LSPs.

If the user configures a bypass tunnel on Node B and dynamic bypass tunnels have not been disabled, LSPs that had been previously signaled over dynamic bypass tunnels will not automatically be switched to the manual bypass tunnel, even if the manual bypass tunnel is a more optimized path. The user must perform a make-before-break switchover at the head end of these LSPs. The make-before-break process is enabled using the **adaptive** option.

If the manual bypass tunnel goes into the down state on Node B and dynamic bypass tunnels have been disabled, Node B (PLR) will clear the “protection available” flag in the RRO IPv4 sub-object in the next RESV refresh message for each affected LSP. It will then try to associate each of these LSPs with one of the manual bypass tunnels that are still up. If it finds one, it will make the association and set the “protection available” flag in the next RESV refresh message for each of these LSPs. If it cannot find one, it will keep checking for one every time an RESV message is received for each of the remaining LSPs. When the manual bypass tunnel is back up, the LSPs that did not find a match are associated back with this tunnel and the protection available flag is set starting in the next RESV refresh message.

If the manual bypass tunnel goes into the down state on Node B and dynamic bypass tunnels have not been disabled, Node B will automatically signal a dynamic bypass tunnel to protect the LSPs if a suitable one does not exist. Similarly, if an LSP is signaled while the manual bypass tunnel is in the down state, the node will only signal a dynamic bypass tunnel if the user has not disabled dynamic tunnels. When the manual bypass tunnel is back up, the node will not switch the protected LSPs from the dynamic bypass tunnel to the manual bypass tunnel.

3.7.4.2 FRR Node Protection (Facility Backup)

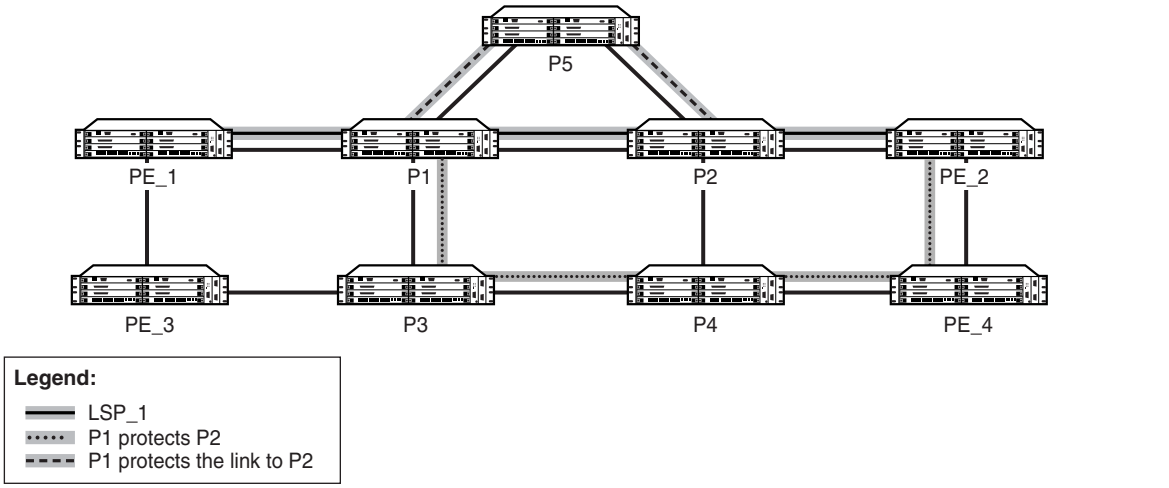
The MPLS Fast Reroute (FRR) functionality enables PLRs to be aware of the lack of node protection and lets them regularly probe for a node bypass via the **node-protect** command.

When enabled, the **node-protect** command provides node protection for the specified LSP. If node protection cannot be provided, link protection is attempted. If link protection cannot be provided, no protection is provided. When disabled via the **no** form of the command, link protection is attempted, and if link protection cannot be provided, no protection is provided.

For example, assume the following for the LSP scenario in Figure 9.

1. LSP_1 is between PE_1 and PE_2 (via P1 and P2), and has CSPF, FRR facility backup, and FRR node protection enabled.
2. P1 protects P2 with bypass nodes P1 - P3 - P4 - PE_4 - PE_3.
3. If P4 fails, P1 tries to establish the bypass node three times.
4. When the bypass node creation fails (there is no bypass route), P1 will protect link P1-P2.
5. P1 protects the link to P2 through P1 - P5 - P2.
6. P4 returns online.

Figure 9 **FRR Node-Protection Example**



LSP_1 had requested node protection, but due to lack of an available path it could only obtain link protection. Therefore, every 60 s, the PLR for LSP_1 will search for a new path that might be able to provide node protection. When P4 is back online and such a path is available, a new bypass tunnel will be signaled and LSP_1 will be associated with this new bypass tunnel.

3.7.5 Admin Group Support on Facility Bypass Backup LSPs

Admin group support on facility bypass backup LSPs provides for the inclusion of the LSP primary path admin-group constraints in the computation of an FRR facility bypass backup LSP to protect the primary LSP path. Admin group constraints are honored by all nodes in the LSP path both for primary and FRR backup LSPs.

This feature is supported on primary paths of an RSVP point-to-point LSP in both intra-area and inter-area TE where applicable.

This feature is not supported on one-to-one detour backup LSPs.

3.7.6 FRR Over Unnumbered Interfaces

When the PLR is the ingress LER node and the outgoing interface of the bypass LSP is unnumbered, the user must assign a borrowed IP address to the interface that is different from the system interface; otherwise, the bypass LSP will not come up.

In addition, the PLR node includes the IF_ID RSVP_HOP object (C-Type = 3) in the PATH message if the outgoing interface of the bypass LSP is unnumbered. If the outgoing interface of the bypass LSP is numbered, the PLR node includes the IPv4 RSVP_HOP object (C-Type = 1).

When the MP node receives the PATH message over the bypass LSP, it creates the merge-point context for the protected LSP and associates it with the existing state if any of the following is satisfied:

- the C-Type value of the RSVP_HOP object has changed
- the C-Type is the value for the IF_ID RSVP_HOP object (C-Type = 3) and it has not changed, but the IF_ID TLV is different
- the IPv4 Next/Previous Hop Address field in the RSVP_HOP object has changed, regardless of the C-Type value

This behavior at the PLR and MP nodes is the same for both link protection and node protection FRR.

Note: If node protection FRR is enabled but the MP does not support an unnumbered interface, the PATH message is rejected at the MP and the path is torn down.

See RSVP-TE Support for Unnumbered Interfaces for information on unnumbered interfaces.

3.8 Shared Risk Link Groups

A shared risk link group (SRLG) represents a set of interfaces (or links) that share the same risk of failing because they may be subjected to the same resource failures or defects. Two examples where the same risk of failure exists are fiber links that share the same conduit, and multiple wavelengths that share the same fiber.

SRLGs are supported by both LSP redundancy protection and FRR protection. SRLGs allow the user to prepare a detour route that is disjoint from the primary LSP path. See Disjoint and Non-disjoint Paths.

The SRLG feature ensures that a primary and secondary LSP path, or a bypass tunnel or detour LSP path, do not share SRLGs. That is, they do not share the same sets of links that are considered to have a similar (or identical) chance of failure.

To use SRLGs, the user first creates an SRLG by assigning one or more routers to the SRLG. Then, the user links the SRLG to an MPLS interface and enables the SRLG feature on the LSP path. SRLGs cannot be assigned to the system interface.

3.8.1 SRLGs for Secondary LSP Paths

SRLGs for secondary LSP paths apply when LSP redundancy protection is used.

When setting up the secondary path, enable the **srlg** option on the secondary path to ensure that CSPF includes the SRLG constraint in its route calculation. To make an accurate computation, CSPF requires that the primary LSP be established and in the up state (because the head-end LER needs the most current explicit route object (ERO) for the primary path, and the most current ERO is built during primary path CSPF computation). The ERO includes the list of SRLGs.

At the establishment of a secondary path with the SRLG constraint, the MPLS/RSVP-TE task queries CSPF again, which provides the list of SRLGs to be avoided. CSPF prunes all links having interfaces that belong to the same SRLGs as the interfaces included in the ERO of the primary path. If CSPF finds an eligible path, the secondary path is set up. If CSPF does not find an eligible path, MPLS/RSVP-TE keeps retrying the requests to CSPF.

3.8.2 SRLGs for FRR LSP Paths

When setting up the FRR bypass or detour LSP, enable the **srlg-frr** option on FRR to ensure that CSPF includes the SRLG constraint in its route calculation. CSPF prunes all links that are in the SRLG being used by the primary LSP during the calculation of the FRR path. If one or more paths are found, CSPF sets up the FRR bypass or detour LSP based on the best cost and signals the FRR LSP.

If there is no path found based on the above calculation and the **srlg-frr** command has the **strict** option set, then the FRR LSP is not set up and the MPLS/RSVP-TE task keeps trying to set up a path. If the **strict** option is not set, then the FRR LSP is set up based on the other TE constraints (that is, excluding the SRLG constraint).

3.8.3 Disjoint and Non-disjoint Paths

A path is considered to be SRLG disjoint from a given link (or node) if the path does not use any links (or nodes) that belong to the same SRLG as the given link (or node). Eligible disjoint paths are found by CSPF when the SRLG constraint is included in the CSPF route calculation (referred to as the strict SRLG condition).

When LSP redundancy is used, the secondary LSP is always signaled with a strict SRLG condition.

When FRR is used, the FRR bypass or detour LSP may have a strict or non-strict SRLG condition. If the **strict** option is used with the **srlg-frr** command, then the bypass LSP must be on the list of eligible paths found by the CSPF calculation that included the SRLG constraint. If the **strict** option is not used, then it is possible for the bypass or detour LSP to be non-disjoint. The non-disjoint case is supported only if the SRLG is not strict.

At the PLR, if an FRR tunnel is needed to protect a primary LSP, the priority order for selecting that FRR tunnel is as follows:

1. Manual bypass disjoint
2. Manual bypass non-disjoint (eligible only if **srlg-frr** is non-strict)
3. Dynamic bypass disjoint
4. Dynamic bypass non-disjoint (eligible only if **srlg-frr** is non-strict)

A bypass or a detour LSP path is not guaranteed to be SRLG disjoint from the primary path. This is because only the SRLG constraint of the outgoing interface at the PLR that the primary path is using is considered in the CSPF calculation.

3.8.4 Enabling Disjoint Backup Paths

A typical application of the SRLG feature is to provide automatic setup of secondary LSPs or FRR bypass or detour LSPs, in order to minimize the probability that they share the same failure risks with the primary LSP path (see Figure 10 and Figure 11).

Figure 10 illustrates SRLG when LSP redundancy is used, where SRLG_1 contains the interfaces that define links A-B, B-C, and C-D. The primary path uses these links to connect node A to node D. In the event of a failure along the primary path, the secondary path cannot use any of the links in SRLG_1 and takes the path from node A to nodes E, F, G, H, J, and D.

Figure 11 illustrates SRLG when FRR bypass is used, where SRLG_1 is the same as in Figure 10. Since FRR bypass is used, the following possible reroutes may occur, depending on where the failure occurs:

- if node B fails, the bypass is from node A to nodes E, F, G, H, and C
- if node C fails, the bypass is from node B to nodes F, G, H, J, and D
- if link C-D fails, the bypass is from node C to nodes H, J, and D

The SRLG feature is supported on OSPF and IS-IS interfaces for which RSVP-TE is enabled.

The following steps describe how to enable SRLG disjoint backup paths for LSP redundancy and FRR.

LSP Redundancy for Primary/Secondary (standby) SRLG Disjoint Configuration

- Create an SRLG-group (similar to creating an admin group).
- Link the SRLG-group to MPLS interfaces.
- Configure primary and secondary LSP paths, and enable SRLG on the secondary LSP path. The SRLG secondary LSP paths will always perform a strict CSPF query.

  The setting of the **srlg-frr** command is irrelevant in this case (see the srlg-frr command).

FRR Bypass Tunnel or Detour LSP SRLG Disjoint Configuration

- Create an SRLG-group (similar to creating an admin group).
- Link the SRLG-group to MPLS interfaces.
- Enable the **strict** option on the **srlg-frr** command, which is a system-wide command that forces the CSPF calculation for every LSP path to take any configured SRLG memberships into account.
- Configure primary FRR (facility backup or one-to-one backup) LSP paths. Each PLR will create a bypass or detour LSP that will only avoid the SRLG memberships configured on the primary LSP path egress interface. For one-to-one backup, detour-detour merging is out of the control of the PLR. The PLR will not ensure that the FRR detour will be prohibited from merging with a colliding detour LSP. For facility backup, given that there are several bypass types to bind to, the priority rules shown in Disjoint and Non-disjoint Paths are used.

Manually configured bypasses that do not use CSPF are not considered as possible backup paths.

Figure 10 **Disjoint Primary and Secondary LSPs**

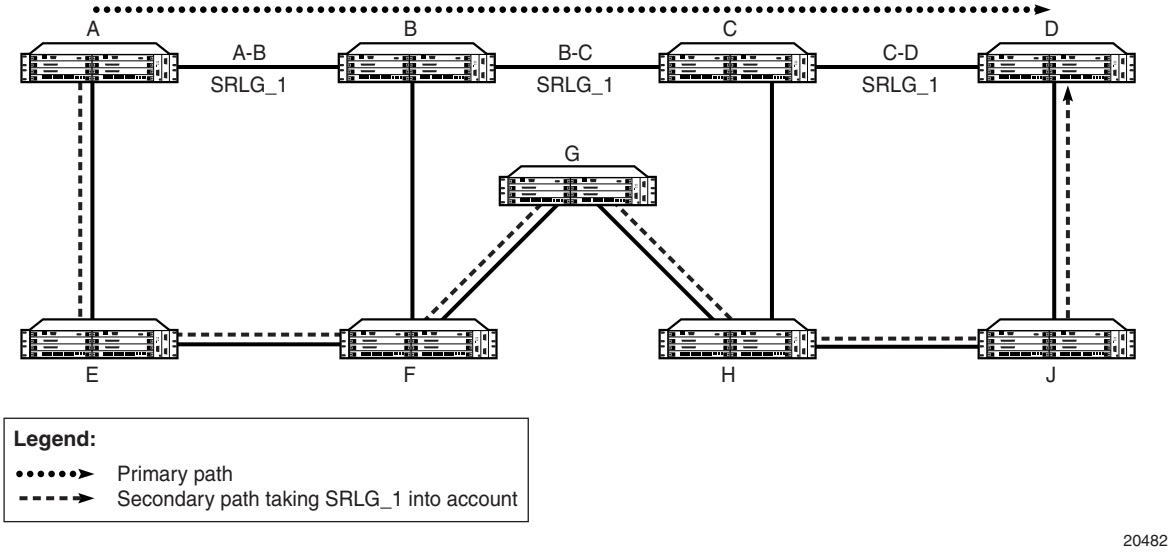
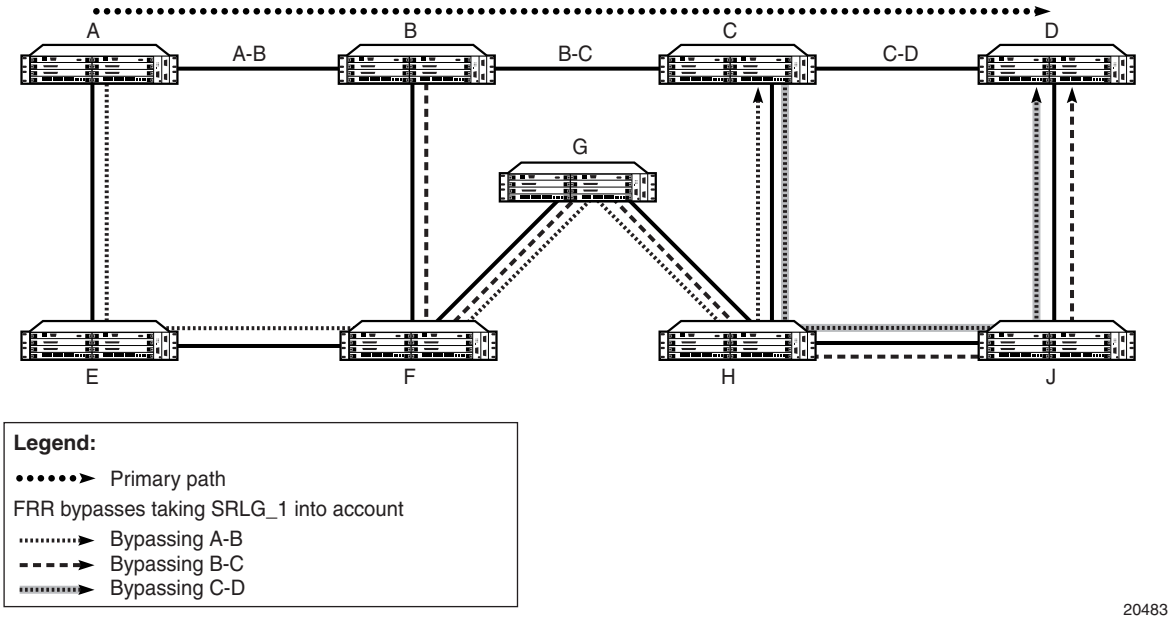


Figure 11 **Disjoint FRR Bypass LSPs**



3.9 RSVP-TE Graceful Shutdown

RSVP-TE graceful shutdown provides a method to reroute transit LSPs in a bulk fashion away from a node prior to maintenance of that node. A PathErr message with the error code “Local Maintenance on TE Link required Flag” (if the affected network element is a link) or the error code “Local node maintenance required” (if the affected network element is the node) is sent before the links or node are taken out of service.

When an LER receives the message, it performs a make-before-break on the LSP path to move the LSPs away from the links/nodes whose IP addresses are indicated in the PathErr message and reroute them. Affected link/node resources are flagged in the TE database so that other routers will signal LSPs using the affected resources only as a last resort.

Graceful shutdown can be enabled on a per-interface basis or on all interfaces on the node if the whole node must be taken out of service.

3.10 RSVP-TE Support for Unnumbered Interfaces

Unnumbered interfaces are point-to-point interfaces that are not explicitly configured with a dedicated IP address and subnet; instead, they borrow (or link to) an IP address from another interface on the system (the system IP address, another loopback interface, or any other numbered interface) and use it as the source IP address for packets originating from the interface. For more information on support for unnumbered interfaces, refer to the 7705 SAR Router Configuration Guide, “Unnumbered Interfaces”.

Unnumbered IP interfaces can be used via RSVP-TE for signaling traffic engineering (TE) LSPs.

Supporting RSVP-TE over unnumbered interfaces requires the ability to:

- carry TE information over unnumbered links in IS-IS-TE or OSPF-TE extensions
- specify unnumbered interfaces in RSVP-TE signaling

An unnumbered IP interface is identified uniquely on a router in the network by the tuple (router ID, ifindex). An LSR at each end of the link assigns a system-wide unique interface index to the unnumbered interface. IS-IS, OSPF, MPLS (RSVP-TE, LDP), and OAM use this tuple to advertise the link information, signal LSPs over the interface, or send and respond to an MPLS echo request message over an unnumbered interface.

The borrowed IP address for an unnumbered interface is configured using the following CLI command, with the default value set to the system interface address: **config>router>interface>unnumbered** {*ip-int-name* **|** *ip-address*}.

Note: The borrowed IP address is used exclusively as the source address for IP packets that originate from the interface. For FRR, this address must be configured to an address different from the system interface in order for the FRR bypass LSP to come up at the ingress LER. See RSVP-TE Fast Reroute (FRR) for information on FRR.

To support unnumbered TE links in IS-IS, a new sub-TLV of the extended IS reachability TLV is added, which encodes the link local identifiers and link remote identifiers as defined in RFC 5307, *IS-IS Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)*.

To support unnumbered TE links in OSPF, a new sub-TLV of the Link TLV is added, which encodes the link local identifiers and link remote identifiers as defined in RFC 4203, *OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)*.

To support unnumbered TE links in RSVP-TE, a new sub-object of the Explicit Route Object (ERO) is added to specify unnumbered links and a new sub-object of the Route Record Object (RRO) is added to record that the LSP traversed an unnumbered link, as per RFC 3477, *Signalling Unnumbered Links in Resource ReSerVation Protocol - Traffic Engineering (RSVP-TE)*. As well, a new IF_ID RSVP_HOP object with a C-Type of 3 is added as per section 8.1.1 of RFC 3473, *Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) Extensions*. The IPv4 Next/ Previous Hop Address field in the object is set to the borrowed IP interface address.

The unnumbered IP interface address is advertised by IS-IS-TE or OSPF-TE, and CSPF can include it in the computation of a path for a point-to-point LSP. However, this feature does not support defining an unnumbered interface as a hop in the path definition of an LSP.

A router creates an RSVP neighbor over an unnumbered interface using the tuple (router ID, ifindex). The router ID of the router that advertised an unnumbered interface index is obtained from the TE database. Therefore, if traffic engineering is disabled in IS-IS or OSPF, a non-CSPF LSP that has its next hop over an unnumbered interface will not come up at the ingress LER because the router ID of the neighbor that has the next hop of the PATH message cannot be looked up. The LSP path will remain operationally down with the error “noRouteToDestination”. If a PATH message is received at the LSR for which traffic engineering was disabled and the next hop for the LSP is over an unnumbered interface, a PathErr message is sent back to the ingress LER with the error code of 24 “Routing Problem” and an error value of 5 “No route available toward destination”.

All MPLS (RSVP-TE and LDP) features supported for numbered IP interfaces are supported for unnumbered interfaces, with the following exceptions:

- configuration of a router ID with a value other than system interface
- signaling of an LSP with an ERO based on a loose or strict hop using an unnumbered TE link in the path hop definition
- signaling of a one-to-one detour LSP over an unnumbered interface
- RSVP Hello messages and all Hello-related capabilities, such as Graceful-Restart Helper
- RSVP refresh reduction on an unnumbered interface

The unnumbered interface feature also extends the support of LSP ping and LSP traceroute to point-to-point LSPs that have unnumbered TE links in their path.

3.11 PCEP Support for RSVP-TE LSPs

The Path Computation Element Communication Protocol (PCEP) is one of several protocols used for communication between a wide area network (WAN) software-defined network (SDN) controller and network elements.

The 7705 SAR operates as a PCE Client (PCC) only, supporting PCC capabilities for RSVP-TE LSPs.

The following MPLS-level and LSP-level CLI commands are used to configure RSVP-TE LSPs in a router acting as a PCC. See MPLS and RSVP-TE Command Reference for command descriptions. See the PCEP Support for RSVP-TE LSPs section in the PCEP chapter for information on using these commands.

- **config>router>mpls>**
  pce-report rsvp-te {**enable** | **disable**}
- **config>router>mpls>lsp>**
  path-profile *profile-id* [**path-group** *group-id*]
  pce-computation
  pce-control
  pce-report {**enable** | **disable** | **inherit**}
- **config>router>mpls>lsp-template>**
  pce-report {**enable** | **disable** | **inherit**}

3.12 Segment Routing with Traffic Engineering (SR-TE)

Segment routing adds the ability to perform shortest path routing and source routing using the concept of abstract segments to IS-IS and OSPF routing protocols. A segment can represent a local prefix of a node, a specific adjacency of the node (interface/next hop), a service context, or a specific explicit path over the network. For each segment, the IGP advertises an identifier referred to as a Segment ID (SID).

When segment routing is used together with the MPLS data plane, the SID is a standard MPLS label. A router forwarding a packet using segment routing will therefore push one or more MPLS labels.

Segment routing using MPLS labels can be used in both shortest path routing applications (refer to the 7705 SAR Routing Protocols Guide for information) and in traffic engineering (TE) applications, as described in this section.

The following are the objectives and applications of segment routing:

- ability for a node to specify a unicast shortest-route or source-routed forwarding path with the same mechanism; IGP can be reused to minimize the number of control plane protocols
- ability to use IGP-based MPLS tunnels without the addition of any other signaling protocol
- ability to tunnel services from ingress PE to egress PE with or without an explicit path and without requiring forwarding plane or control plane state in intermediate nodes
- ability to use Layer 3 spoke SDP interfaces to support multicast for segment routing. Refer to the 7705 SAR Routing Protocols Guide, “Multicast for Segment Routing”.
- FRR: ability to expand coverage of basic LFA to any topology with the use of a source-routed backup path; precomputation and setup of backup path without additional signaling
- support for LFA policies with shared-risk constraints, admin-groups, and link/node protection
- support for SR-TE entropy labels
- support for TE that includes loose/strict options, distributed and centralized TE, path disjointness, ECMP awareness, and limited or no per-service state on midpoint and tail-end routers
- support for fine-grained flow steering and service chaining via a centralized stateful Path Computation Element (PCE) such as the one provided by the Nokia Network Services Platform (NSP)

3.12.1 SR-TE Support

The following MPLS commands and modes are supported:

- global [router] MPLS-level commands and modes:

  interface, **lsp**, **path**, **shutdown**
- LSP-level commands and modes:

  bgp-transport-tunnel, **exclude**, **hop-limit**, **include**, **metric**, **primary**, **retry-limit**, **retry-timer**, **shutdown**, **to**, **from**, **vprn-auto-bind**
- primary path-level commands and modes (only primary paths are supported with SR-TE LSPs):

  bandwidth, **exclude**, **hop-limit**, **include**, **priority**, **shutdown**

The following MPLS commands and modes are not supported:

- global MPLS-level commands and modes not applicable to SR-TE LSPs (configuration is ignored):

  admin-group-frr, **auto-lsp**, **bypass-resignal-timer, cspf-on-loose-hop**, **dynamic-bypass**, **frr-object**, **hold-timer**, **least-fill-min-thd**, **least-fill-reoptim-thd**, **logger-event-bundling**, **lsp-template**, **srlg-frr**, **static-lsp**, **static-lsp-fast-retry**
- LSP-level commands and modes not supported with SR-TE LSPs (configuration is blocked):

  adaptive, **adspec**, **fast-reroute**, **least-fill**, **propagate-admin-group**, **rsvp-resv-style**, **secondary**
- LSP-level commands and modes not supported with SR-TE LSP (configuration is ignored):

  igp-shortcut, **cspf**
- primary path-level commands and modes not supported with SR-TE LSPs (configuration is blocked):

  adaptive, **record**, **record-label**
- secondary path is not supported

The user can associate an empty path or a path with strict or loose explicit hops with the primary paths of the SR-TE LSP using the **hop** and **primary** CLI commands.

A hop that corresponds to an adjacency SID must be identified with its far-end host IP address (next hop) on the subnet. If the local-end host IP address is provided, this hop is ignored because this router can have multiple adjacencies (next hops) on the same subnet.

A hop that corresponds to a node SID is identified by the prefix address.

Details of processing the user-configured path hops are provided in SR-TE LSP Instantiation.

3.12.2 SR-TE LSP Instantiation

When an SR-TE LSP is configured on the router, its path can be computed by the router or by an external TE controller referred to as a PCE. This feature works with the Nokia stateful PCE that is part of the Network Services Platform (NSP).

The 7705 SAR supports three different modes of operation configurable on a per-SR-TE LSP basis.

- When the path of the LSP is computed by the router acting as a PCE client (PCC), the LSP is referred to as PCC-initiated and PCC-controlled.

  A PCC-initiated and controlled SR-TE LSP has the following characteristics:

  - can contain strict or loose hops, or a combination of both
  - does not support CSPF, and local path computation takes the form of hop-to-label translation
  - has the capability to report an SR-TE LSP to synchronize the LSP database of a stateful PCE server using the **pce-report** option, but the LSP path cannot be updated by the PCE. The control of the LSP is maintained by the PCC.

- When the path of the LSP is computed by the PCE at the request of the PCC, it is referred to as PCC-initiated and PCE-computed.

  A PCC-initiated and PCE-computed SR-TE LSP supports the passive stateful mode, which enables the **pce-computation** option for the SR-TE LSP so that the PCE can perform path computation at the request of the PCC only. The PCC retains control.

  The capability exists to report an SR-TE LSP to synchronize the LSP database of a stateful PCE server using the **pce-report** option.

- When the path of the LSP is computed and updated by the PCE following a delegation from the PCC, it is referred to as PCC-initiated and PCE-controlled.

  A PCC-initiated and PCE-controlled SR-TE LSP allows active stateful mode, which enables the **pce-control** option for the SR-TE LSP so that the PCE can perform path computation and updates following a network event without the explicit request from the PCC. The PCC delegates full control.

The user can configure the path computation requests only (PCE-computed) or both path computation requests and path updates (PCE-controlled) to the PCE for a specific LSP using the **pce-computation** and **pce-control** commands.

The **pce-computation** option sends the path computation request to the PCE instead of the local CSPF. When this option is enabled, the PCE acts in passive stateful mode for this LSP. In other words, the PCE can perform path computations for the LSP only at the request of the router. This is used in cases where the operator wants to use the PCE specific path computation algorithm instead of the local router CSPF algorithm.

The default value is **no pce-computation**. Enabling **pce-computation** requires that the **cspf** option also be enabled; otherwise, the command is rejected. If the **cspf** option is disabled for an LSP, the **pce-computation** option will also be automatically disabled.

Enabling **cspf** without enabling **pce-computation** for an SR-TE LSP means that, internally, the router still performs label translation as if **cspf** was disabled, because there is no support of CSPF for an SR-TE LSP on the router.

The **pce-control** option allows the router to delegate full control of the LSP to the PCE (PCE-controlled). Enabling this option means that the PCE is acting in active stateful mode for this LSP and the PCE can reroute the path following a failure or to reoptimize the path and update the router without requiring a request from the router.

Note:

- The user can delegate CSPF and non-CSPF LSPs.
- The user can delegate LSPs that have the **pce-computation** option enabled or disabled. The LSP maintains its latest active path computed by the PCE or the router at the time it was delegated. The PCE will only make an update to the path at the next network event or reoptimization. The default value is **no pce-control**.

In all cases, the PCC LSP database is synchronized with the PCE LSP database using the PCEP path computation state report (PCRpt) message for LSPs that have the **pce-report** command enabled.

The global MPLS- level **pce-report** command can be used to enable or disable PCE reporting for all SR-TE LSPs for the purpose of LSP database synchronization. This configuration is inherited by all LSPs of a particular type. The PCE reports both CSPF and non-CSPF LSPs. The default value is disabled (**no pce-report**). This default value controls the introduction of the PCE into an existing network and allows the operator to decide if all LSP types need to be reported.

The LSP-level **pce-report** command overrides the global configuration for PCE reporting for an LSP. The default value is to inherit the global MPLS-level value. The **inherit** value reconfigures the LSP to inherit the global configuration for that LSP type.

Note: If PCE reporting is disabled for the LSP, either due to inheritance or due to LSP-level configuration, enabling the **pce-control** option for the LSP has no effect. To help troubleshoot this situation, operational values of both the **pce-report** and **pce-control** are added to the output of the LSP **show** commands.

For more information about configuring PCC-initiated and PCC-controlled LSPs, see Configuring PCC-controlled, PCE-computed, and PCE-controlled SR-TE LSPs.

3.12.2.1 PCC-initiated and PCC-controlled LSP

In the PCC-initiated and PCC-controlled LSP mode of operation, the user configures the LSP name and the primary path name with the path information in the referenced path name, entering a full or partial explicit path with all or some hops to the destination of the LSP. Each hop is specified as an address of a node or an address of the next hop of a TE link.

To configure the primary path to always use a specific link whenever it is up, the strict hop must be entered as an address corresponding to the next hop of an adjacency SID. If the strict hop corresponds to a loopback address, it is translated to an adjacency SID as explained below and therefore there is no guarantee that the same TE link is picked.

To use an SR-TE path that consists of unprotected adjacency SIDs, each hop of the path must be configured as a strict hop with the address matching the next hop of the adjacency SID and protection on each of these adjacencies must be disabled as explained in SR-TE LSP Path Computation.

MPLS assigns a tunnel ID to the SR-TE LSP and a path ID to each new instantiation of the primary path, as for an RSVP-TE LSP. These IDs represent the MBB path of the same SR-TE LSP, which must coexist during the update of the primary path.

Note: The concept of MBB is not exactly accurate in the context of an SR-TE LSP because there is no signaling involved and therefore the new path information immediately overrides the older one.

The router retains full control of the path of the LSP. CSPF is not supported; therefore, the full or partially explicit path is instantiated as-is and no other constraint (such as SRLG, admin-group, hop-count, or bandwidth) is checked. Only the LSP path label stack size is checked by MPLS against the maximum value configured for the LSP after the TE database (TE-DB) hop-to-label translation returns the label stack. See SR-TE LSP Path Computation for more information about this check.

The ingress LER performs the following steps to resolve the user-entered path before programming it in the data path:

1. MPLS passes the path information to the TE-DB, which converts the list of hops into a label stack by scanning the TE-DB for adjacency and node SID information that belongs to the router or link identified by each hop address. If the conversion is successful, the TE-DB will return the actual selected hop SIDs plus labels as well as the configured path hop addresses that were used as the input for this conversion.

   Details of this step are as follows:

   - A loose hop with an address matching any interface (loopback or not) of a router (identified by router ID) is always translated to a node SID. If the prefix matching the hop address has a node SID in the TE-DB, it will be selected by preference. If not, the node SID of any loopback interface of the same router that owns the hop address is selected. In the latter case, the lowest IP address of that router that has a /32 prefix-SID is selected.
   - A strict hop with an address matching any interface (loopback or not) of a router (identified by router ID) is always translated to an adjacency SID. If the hop address matches the host address reachable in a local subnet from the previous hop, the adjacency SID of that adjacency is selected. If the hop address matches a loopback interface, it is translated to the adjacency SID of any link from the previous hop that terminates on the router owning the loopback. The adjacency SID label of the selected link is used.

     In both cases, it is possible to have multiple matching previous hops if the interface is a LAN interface. If there are multiple hops, the adjacency SID with the lowest interface address is selected.
   - All IGP instances are scanned from the lowest to the highest instance ID, beginning with IS-IS instances and then the OSPF instance; not only the IGP instance that resolved the prefix of the destination address of the LSP in the RTM is used. For the first instance where all specified path hop addresses can be translated, the label stack is selected. The hop-to-SID/label translation tool does not support paths that cross area boundaries. All SID/labels of a given path are therefore taken from the same IGP area and instance.

Note: For the hop-to-label translation to operate, the user must enable TE on the network links by adding the network interfaces to MPLS and RSVP. In addition, the user must enable the **traffic-engineering** option on all participating router IGP instances. If a router has the **database-export** option enabled in the participating IGP instances to populate the TE-DB with the learned IGP link-state information, then enabling of the **traffic-engineering** option is not required. For consistency, it is recommended that the **traffic-engineering** option always be enabled.

2. The ingress LER validates the first hop of the path to determine the outgoing interface and next hop to forward the packet to, and programs the data path according to the following conditions.
   - If the first hop corresponds to an adjacency SID (host address of next hop on the link's subnet), the adjacency SID label is not pushed. In other words, the ingress LER treats forwarding to a local interface as a push of an implicit null label.
   - If the first hop is a node SID of a downstream router, the node SID label is pushed.

   In both cases, the SR-TE LSP tracks and uses the SR shortest path tunnel of the SID of the first hop.
3. If the router is configured as a PCC and has a PCEP session to a PCE, the router sends a PCRpt message to update the PCE with the Up state and the RRO object for each LSP that has the **pce-report** option enabled. The PE router does not set the delegation control flag to keep LSP control. The state of the LSP is now synchronized between the router and the PCE.

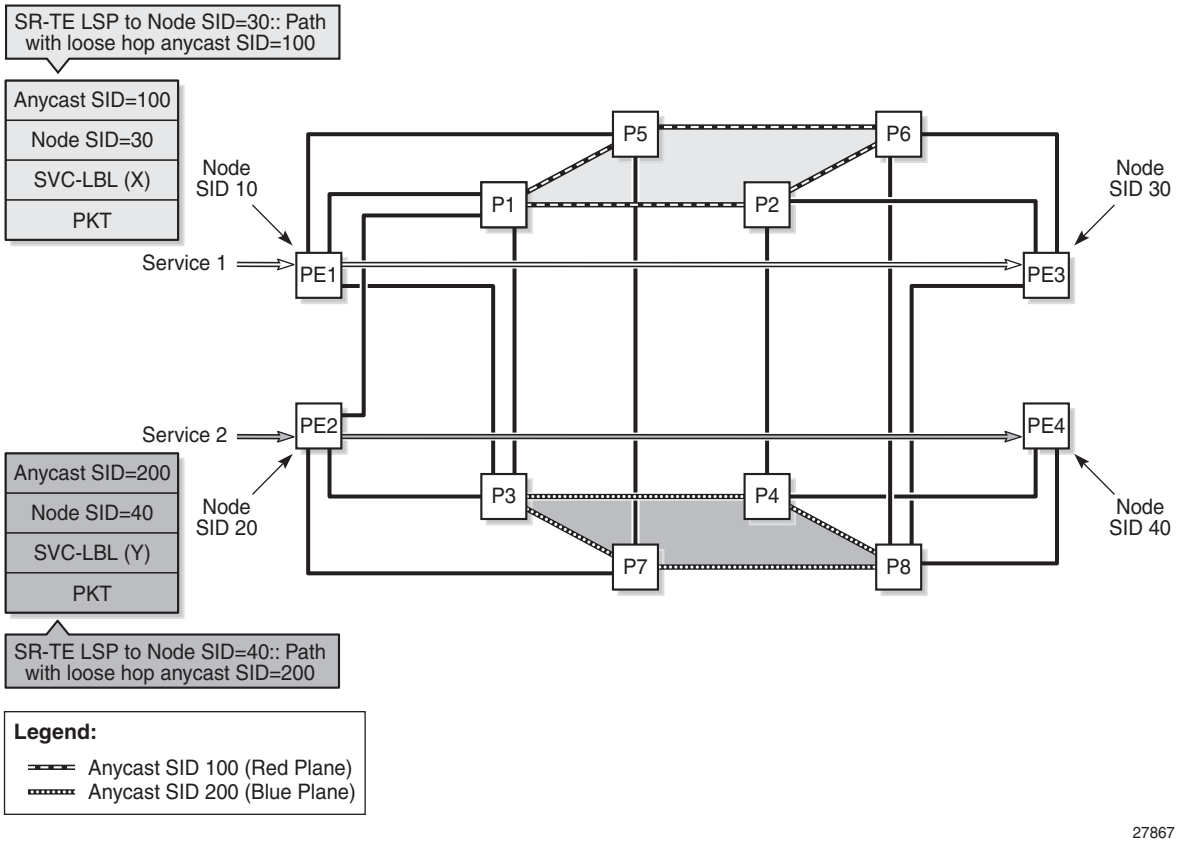
3.12.2.1.1 Guidelines for Using PCC-initiated and PCC-controlled LSPs

The 7705 SAR does not support CSPF path computation for an SR-TE LSP and uses the hop-to-label translation to compute the path. The ingress LER does not monitor network events that affect the reachability of the adjacency SID or node SID used in the label stack of the LSP; therefore, the label stack is not updated to reflect changes in the path. As a result, it is recommended that this type of SR-TE LSP be used in the following configurations only:

- empty path
- path with a single node SID loose hop
- path of an LSP to a directly connected router (single-hop LSP) with an adjacency SID or a node SID loose or strict hop

In addition, the user can configure an SR-TE LSP with a single loose hop, using the anycast SID concept to provide LSR node protection within a particular plane of the network TE topology. This is illustrated in Figure 12. The user configures all LSRs in a plane with the same loopback interface address, which must be different from that of the system interface and the router ID of the router, and assigns them the same node SID index value. All routers must use the same SRGB.

Figure 12 **Multi-plane TE with Node Protection**



The user then configures an SR-TE LSP on an LER to a destination and adds to its path a loose hop matching the anycast loopback address. The SR-TE LSP to any destination will hop over the closest of the LSRs owning the anycast SID because the resolution of the node SID for that anycast loopback address uses the closest router. If that router fails, the resolution is updated to the next closest router owning the anycast SID without changing the label stack of the SR-TE LSP.

3.12.2.2 PCC-initiated and PCE-computed/controlled LSP

In the PCC-initiated and PCE-computed/controlled LSP mode of operation, the ingress LER uses PCEP to communicate with a PCE-based external TE controller (also referred to as the PCE). The router instantiates a PCEP session to the PCE. The router is referred to as the PCE client (PCC).

When the user enables the **pce-computation** option for one or more SR-TE LSPs, the PCE performs path computations at the request of the PCC, which is referred to as passive stateful mode. If the user enables the **pce-control** option for an LSP, the PCE can also perform both path computation and periodic reoptimization of the LSP path without an explicit request from the PCC. This is referred to as active stateful mode.

For the PCC to communicate with a PCE about the management of the path of an SR-TE LSP, the router implements the extensions to PCEP in support of segment routing (see PCEP for more information).This feature works with the Nokia stateful PCE, which is part of the network services platform (NSP).

The following steps describe configuring a PCC-initiated SR-TE LSP when passive or active control is given to the PCE.

1. The SR-TE LSP configuration is created on the PE router using the CLI or NSP NFM-P.

   The configuration dictates which PCE stateful mode is desired: active (**pce-control** option enabled) or passive (**pce-computation** enabled and **pce-control** disabled).
2. The PCC assigns a unique PLSP-ID to the LSP. The PLSP-ID uniquely identifies the LSP on a PCEP session and must remain constant during its lifetime. The PCC on the router tracks the association of {PLSP-ID, SRP-ID} to {tunnel-ID, path-ID} and uses the latter to communicate with MPLS about a specific path of the LSP.
3. The PE router does not validate the entered path. While the PCC can include the IRO objects for any loose or strict hop in the configured LSP path in the path computation request (PCReq) message to the PCE, the PCE ignores the IRO objects and computes the path with the other constraints.
4. The PE router sends a PCReq message to the PCE to request a path for the LSP and includes the LSP parameters in the METRIC object, the LSPA object, and the BANDWIDTH object. It also includes the LSP object with the assigned PLSP-ID. At this point, the PCC does not delegate control of the LSP to the PCE.
5. The PCE computes a new path, reserves the bandwidth, and returns the path in a path computation reply (PCRep) message with the computed ERO in the ERO object. It also includes the LSP object with the unique PLSP-ID, the METRIC object with the computed metric value if any, and the BANDWIDTH object.

Note: In order for the PCE to use the SRLG path diversity and admin-group constraints in the path computation, the user must configure the SRLG and admin-group membership against the MPLS interface and verify that the traffic-engineering option is enabled in the IGP. This causes the IGP to flood the link SRLG and admin-group membership in its participating area and for the PCE to learn it in its TE database.

6. The PE router updates the CSM and the data path with the new path.

   Up to this step, the PCC and PCE are using passive stateful PCE procedures. The next steps synchronize the LSP database of the PCC and PCE for both PCE-computed and PCE-controlled LSPs. They also initiate the active PCE stateful procedures for the PCE-controlled LSP only.
7. The PE router sends a PCRpt message to update the PCE with the Up state and the RRO as confirmation, including the LSP object with the unique PLSP-ID. For a PCE-controlled LSP, the PE router also sets a delegation control flag to delegate control to the PCE. The state of the LSP is now synchronized between the router and the PCE.
8. Following a network event or reoptimization, the PCE computes a new path for a PCE-controlled LSP and returns it in a path computation update (PCUpd) message with the new ERO. It includes the LSP object with the same unique PLSP-ID assigned by the PCC and the stateful request parameter (SRP) object with a unique SRP-ID number to track error and state messages specific to this new path.
9. The PE router updates the CSM and the data path with the new path.
10. The PE router sends a new PCRpt message to update the PCE with the Up state and the RRO as confirmation. The state of the LSP is now synchronized between the router and the PCE.
11. If the user makes any configuration change to the PCE-computed or PCE-controlled LSP, MPLS requests the PCC to revoke delegation in a PCRpt message (PCE-controlled only), and then MPLS and the PCC follow the above steps to convey the changed constraint to the PCE, which will result in a new path programmed into the data path, the LSP databases of the PCC and PCE to be synchronized, and the delegation to be returned to the PCE.

    For SR-TE LSPs, MBB is not supported. Therefore, the PCC first tears down the LSP and sends a PCRpt message to the PCE with the remove flag set to 1 before following this configuration change procedure.

Note: The above procedures are followed when the user performs a **no shutdown** on a PCE-controlled or PCE-computed LSP. The starting point is an administratively down LSP with no active paths.

The following steps are for an LSP with an active path.

- If the user enabled the **pce-computation** option on a PCC-controlled LSP that has an active path, no action is performed until the next time the router needs a path for the LSP following a network event or an LSP parameter change. At that point, the procedures above are followed.
- If the user enabled the **pce-control** option on a PCC-controlled or PCE-computed LSP that has an active path, the PCC will issue a PCRpt message to the PCE with the Up state and the RRO of the active path. The PCC will set the delegation control flag to delegate control to the PCE. The PCE will keep the active path of the LSP and will not update until the next network event or reoptimization. At that point, the procedures above are followed.

The PCE supports the computation of disjoint paths for two different LSPs originating or terminating on the same or different PE routers. To indicate this constraint to the PCE, the user must configure the PCE path profile ID and path group ID that the LSP belongs to. These parameters are passed transparently by the PCC to the PCE and are therefore opaque data to the router. The user can configure the path profile and path group using the **path-profile** *profile-id* [**path-group** *group-id*] command.

The association of the optional path group ID is to allow the PCE to determine which profile ID this path group ID must be used with. One path group ID is allowed per profile ID. The user can, however, enter the same path group ID with multiple profile IDs by executing this command multiple times. A maximum of five entries of **path-profile** [*path-group*] can be associated with the same LSP. More details of the operation of the PCE path profile are provided in the PCEP chapter.

3.12.3 SR-TE LSP Path Computation

For PCC-controlled SR-TE LSPs, CSPF is not supported on the router. Whether the **cspf** option is enabled or disabled for an SR-TE LSP, MPLS makes a request to the TE-DB to get the label corresponding to each hop entered by the user in the primary path of the SR-TE LSP. See PCC-initiated and PCC-controlled LSP for details of the hop-to-label translation.

The user can configure the path computation request of a CSPF-enabled SR-TE LSP to be forwarded to a PCE instead of the local router CSPF by enabling the **pce-computation** option, as explained in SR-TE LSP Instantiation. The user can further delegate the reoptimization of the LSP to the PCE by enabling the **pce-control** option. In both cases, the PCE is responsible for determining the label required for each returned explicit hop and includes this in the SR-ERO.

In all cases, the user can configure the maximum number of labels that the ingress LER can push for a particular SR-TE LSP by using the **max-sr-labels** command.

This command is used to set a limit on the maximum label stack size of the SR-TE LSP primary path to allow room to insert additional transport, service, and other labels when packets are forwarded in a particular context.

CLI Syntax: `config>router>mpls>lsp>max-sr-labels` *`label-stack-size`*
`[additional-frr-labels` *`labels`*`]`

The **max-sr-labels** *label-stack-size* value should be set to account for the desired maximum label stack of the primary path of the SR-TE LSP. Its range is 1 to 11 and the default value is 6.

The value in **additional-frr-labels** *labels* should be set to account for additional labels inserted by remote LFA or Topology Independent LFA (TI-LFA) for the backup next hop of the SR-TE LSP. Its range is 0 to 4 labels with a default value of 1.

The sum of both label values represents the worst-case transport of SR label stack size for this SR-TE LSP and is populated by MPLS in the TTM such that services and shortcut applications can check it to decide if a service can be bound or a route can be resolved to this SR-TE LSP. More details of the label stack size check and requirements in various services and shortcut applications are provided in Service and Shortcut Application SR-TE Label Stack Check.

The maximum label stack supported by the router is discussed in Data Path Support. The maximum label stack is always signaled by the PCC in the PCEP Open object as part of the SR-PCE-CAPABILITY TLV. It is referred to as the Maximum Stack Depth (MSD).

In addition, the per-LSP value for the **max-sr-labels** *label-stack-size* option, if configured, is signaled by the PCC to the PCE in the SID Depth value in a METRIC object for both a PCE-computed LSP and a PCE-controlled LSP. The PCE will compute and provide the full explicit path with TE links specified. If there is no path with the number of hops lower than the MSD value or the SID Depth value (if signaled), a reply with no path will be returned to the PCC.

For a PCC-controlled LSP, if the label stack returned by the TE-DB hop-to-label translation exceeds the per-LSP maximum SR label stack size, the LSP is brought down.

3.12.3.1 Service and Shortcut Application SR-TE Label Stack Check

Each service and shortcut application on the router performs a check of the resulting net label stack after pushing all the labels required for forwarding the packet in that context. The MPLS module populates each SR-TE LSP in the TTM with the maximum transport label stack size, which consists of the sum of the values in **max-sr-labels** *label-stack-size* and **additional-frr-labels** *labels*.

Each service or shortcut application then adds the additional, context-specific labels, such as service label and NGE label, required to forward the packet in that context, and checks that the resulting net label stack size does not exceed the maximum label stack supported by the router.

If the check succeeds, the service is bound or the prefix is resolved to the SR-TE LSP. If the check fails, the service will not bind to this SR-TE LSP. Instead, the service will either find another SR-TE LSP or another tunnel of a different type to bind to, if the user configured the use of other tunnel types. Otherwise, the service will go down.

When the service uses an SDP with one or more SR-TE LSPs (up to eight), the spoke SDP bound to this SDP will remain operationally down as long as at least one SR-TE LSP fails the check. In this case, the spoke SDP flag "labelStackLimitExceeded" will be displayed in the **show** output of the service. As well, the prefix will not get resolved to the SR-TE LSP and will either be resolved to another SR-TE LSP or another tunnel type or become unresolved.

The value of **additional-frr-labels** *labels* is checked against the maximum value across all IGP instances of the parameter *frr-overhead*. The *frr-overhead* parameter value is computed within an IGP instance as shown in Table 7. For more information on FRR overhead, refer to the "Segment Routing in Shortest Path Forwarding" section in the 7705 SAR Routing Protocols Guide.

Table 7 **Parameter Values for frr-overhead**

Condition	Parameter Value
segment-routing is disabled in the IGP instance	0
segment-routing is enabled but **remote-lfa** is disabled and **ti-lfa** is disabled	0
segment-routing is enabled and **remote-lfa** is enabled but **ti-lfa** is disabled	1
segment-routing is enabled and **ti-lfa** is enabled, regardless of whether **remote-lfa** is enabled or disabled	**ti-lfa max-sr-frr-labels** *label*

When the user configures or changes the configuration of **additional-frr-labels**, MPLS ensures that the new value accommodates the *frr-overhead* parameter value across all IGP instances.

For example:

- The user configures the **config>router>isis**>**loopfree-alternate remote-lfa** command.
- The user creates a new SR-TE LSP or changes the configuration of an existing SR-TE LSP as follows: **mpls**>**lsp**>**max-sr-labels** *10* **additional-frr-labels** *0*.
- Performing a **no shutdown** of the new LSP or changing the existing LSP configuration will be blocked because the IS-IS instance enabled remote LFA, which requires one additional label on top of the 10 SR labels of the primary path of the SR-TE LSP.

If the check is successful, MPLS adds **max-sr-labels** and **additional-frr-labels** and checks that the sum is lower than or equal to the maximum label stack supported by the router. MPLS then populates the value of {**max-sr-labels** + **additional-frr-labels**}, along with tunnel information in the TTM, and also passes **max-sr-labels** to the PCEP module.

Conversely, if the user tries a configuration change that results in a change to the computed *frr-overhead*, the IGP will check that all SR-TE LSPs can properly account for the overhead; otherwise, the change is rejected. On the IGP, enabling **remote-lfa** may cause the *frr-overhead* value to change.

For example:

- An MPLS LSP is administratively enabled and has **mpls**>**lsp**>**max-sr-labels** *10* **additional-frr-overhead** *0* configured.
- The current configuration in IS-IS or OSPFv2 has the **loopfree-alternate** command disabled.
- The user attempts to configure **loopfree-alternate remote-lfa** for IS-IS or OSPFv2. This changes *frr-overhead* to 1.

  This configuration change would be blocked.

When the user configures the **ti-lfa** command, the **max-sr-frr-labels** *value* parameter is used to limit the search for the LFA backup next hop, as follows:

- 0 — the IGP LFA SPF restricts the search to the TI-LFA backup next hop that does not require a repair tunnel, meaning that the P node and Q node are the same and match a neighbor. This is also the case when both P and Q nodes match the advertising router for a prefix. For information on P nodes and Q nodes, refer to *draft-francois-rtgwg-segment-routing-ti-lfa-04* (*Topology Independent Fast Reroute using Segment Routing*).
- 1 to 3 — the IGP LFA SPF widens the search to include a repair tunnel to a P node that is connected to the Q nodes with zero to two hops for a total of three labels maximum: one node SID-to-P node and two adjacency SIDs from the P node to the Q node. If the P node is a neighbor of the computing node, its node SID is compressed, meaning that up to three adjacency SIDs can separate the P and Q nodes.
- 2 (default) — this corresponds to a repair tunnel to a non-adjacent P node that is adjacent to the Q node. If the P node is a neighbor of the computing node, the node SID of the P node is compressed and the default value of two labels corresponds to two adjacency SIDs between the P and Q nodes.

When the user attempts to change the **max-sr-frr-labels** parameter to a value that results in a change to the computed FRR overhead, the IGP checks that all SR-TE LSPs can properly account for the overhead based on the configuration of the LSP **max-sr-labels** and **additional-frr-labels** values; otherwise, the change is rejected.

The FRR overhead is computed by the IGP and its value is shown in Table 7.

The above LFA commands allow the user to enable the base LFA feature with the **loopfree-alternate** command, and to optionally add remote LFA with the **remote-lfa** option and TI-LFA with the **ti-lfa** option. For more information, refer to the “Segment Routing in Shortest Path Forwarding” section in the 7705 SAR Routing Protocols Guide.

3.12.4 SR-TE LSP Protection

Each path is locally protected along the network using LFA or remote-LFA next hop whenever possible. The protection of a node SID reuses the LFA and remote LFA features introduced with segment routing shortest path tunnels; the protection of an adjacency SID has been added to the 7705 SAR in the specific context of an SR-TE LSP to augment the protection level. The user must enable the **loopfree-alternate** [**remote-lfa**] option in IS-IS or OSPF.

An SR-TE LSP has state at the ingress LER only. The LSR has state for the node SID and adjacency SID, whose labels are programmed in the label stack of the received packet and which represent the part of the ERO of the SR-TE LSP on this router and downstream of this router. In order to provide protection for an SR-TE LSP, each LSR node must attempt to program a link-protect or node-protect LFA next hop in the ILM record of a node SID or an adjacency SID, and the LER node must do the same in the LTN record of the SR-TE LSP. The following are details of the behavior.

- If the ILM record is for a node SID of a downstream router that is not directly connected, the ILM of this node SID points to the backup NHLFE computed by the LFA SPF and programmed by the SR module for this node SID. Depending on the topology and LFA policy used, this can be a link-protect or node-protect LFA next hop.

  This behavior is already supported in the SR shortest path tunnel feature at both the LER and LSR. Therefore, an SR-TE LSP that transits at an LSR and that matches the ILM of a downstream node SID automatically takes advantage of this protection when enabled. If required, node SID protection can be disabled under the IGP instance by excluding the prefix of the node SID from the LFA.
- If the ILM is for a node SID of a directly connected router, the LFA SPF only provides link protection. The ILM or LTN record of this node SID points to the backup NHLFE of this LFA next hop. An SR-TE LSP that transits at an LSR and that matches the ILM of a neighboring node SID automatically takes advantage of this protection when enabled.

Note: Only link protection is possible in this case because packets matching this ILM record can either terminate on the neighboring router owning the node SID or can be forwarded to different next hops of the neighboring router, that is, to different next next-hops of the LSR providing the protection. The LSR providing the connection does not have context to distinguish among all possible SR-TE LSPs and therefore can only protect the link to the neighboring router.

- If the ILM or LTN record is for an adjacency SID, it is treated as in the case of a node SID of a directly connected router.

  When protecting an adjacency SID, the PLR first tries to select a parallel link to the node SID of the directly connected neighbor. That is the case when the node SID is reachable over parallel links. The selection is based on lowest interface ID. If no parallel links exist, regular LFA/remote LFA algorithms are applied to find a loopfree path to reach the node SID of the neighbor via other neighbors.

  The ILM or LTN for the adjacency SID must point to this backup NHLFE and will benefit from FRR link protection. As a result, an SR-TE LSP that transits at an LSR and matches the ILM of a local adjacency SID automatically takes advantage of this protection when enabled.
- At the ingress LER, the LTN record points to the SR-TE LSP NHLFE, which points to the NHLFE of the SR shortest path tunnel to the node SID or adjacency SID of the first hop in the ERO of the SR-TE LSP.The FRR link or node protection at the ingress LER is inherited directly from the SR shortest path tunnel.

If an adjacency to a neighbor fails, the IGP withdraws the advertisement of the link TLV information as well as its adjacency SID sub-TLV. However, the LTN or ILM record of the adjacency SID must be kept in the data path for a sufficient period of time to allow the ingress LER to compute a new path after the IGP converges. If the adjacency is restored before the timer expires, the timer is aborted as soon as the new ILM or LTN records are updated with the new primary and backup NHLFE information. By default, the ILM/LTN and NHLFE information is kept for a period of 15 seconds.

The adjacency SID hold timer is configured using the **adj-sid-hold** command and activated when the adjacency to the neighbor fails due to the following conditions:

- the network IP interface went down due to a link or port failure or due to the user performing a shutdown of the port
- the user shuts down the network IP interface in the **config**>**router** or **config**>**router**>**ospf**/**isis** context

The adjacency SID hold timer is not activated if the user deletes an interface in the **config**>**router**>**ospf**/**isis** context.

Note:

- The adjacency SID hold timer does not apply to the ILM or LTN of a node SID, because NHLFE information is updated in the data path as soon as the IGP is converged locally and a new primary and LFA backup next hops have been computed.
- The label information of the primary path of the adjacency SID is maintained and reprogrammed if the adjacency is restored before the timer expires. However, the backup NHLFE may change when a new LFA SPF is run while the adjacency ILM is being held by the timer running. An update to the backup NHLFE is performed immediately following the LFA SPF and may cause packets to drop.
- A new protect group ID (PG-ID) is assigned each time an adjacency comes back up. This PG-ID is used by the ILM of the adjacency SID and the ILMs of all downstream node SIDs that resolve to the same next hop.

While protection is enabled globally for all node SIDs and local adjacency SIDs when the user enables the **loopfree-alternate** option in IS-IS or OSPF at the LER and LSR, there are applications where the user wants traffic to never divert from the strict hop computed by CSPF for an SR-TE LSP. In that case, the user can disable protection for all adjacency SIDs formed over a particular network IP interface using the **sid-protection** command.

The protection state of an adjacency SID is advertised in the B-FLAG of the IS-IS or OSPF Adjacency SID sub-TLV. No mechanism exists in PCEP for the PCC to signal to the PCE the constraint to use only adjacency SIDs, which are not protected. The path profile ID is configured in the PCE with the no-protection constraint.

3.12.5 Static Route Resolution Using SR-TE LSPs

Static route packets can be forwarded to an indirect next hop over an SR-TE LSP programmed in the TTM with the following static route tunnel binding command:

CLI Syntax:

```
config>router>static-route-entry ip-prefix/prefix-
 length [mcast]
  indirect ip-address
    tunnel-next-hop
      resolution {any | disabled | filter}
      resolution-filter
        [no] sr-te
          [no] lsp lsp-name
        exit
      exit
    exit
  exit
```

3.12.6 BGP Label Route Resolution Using SR-TE LSPs

An SR-TE LSP programmed in the TTM can be used for resolving the next hop of a BGP IPv4 label route with the following BGP transport tunnel command:

CLI Syntax:
```
config>router>bgp>next-hop-res>
   label-route-transport-tunnel
      [no] family {label-ipv4 | vpn}
        resolution {any | disabled | filter}
        resolution-filter
           [no] sr-te
        exit
      exit
   exit
```

3.12.7 Service Packet Forwarding Using SR-TE LSPs

An SDP sub-type of the MPLS encapsulation type allows service binding of up to eight SR-TE LSPs programmed in the TTM by MPLS. The following example shows how to bind an SR-TE LSP to an MPLS SDP:

Example:
```
configure service sdp 100 mpls create
config>service>sdp$ sr-te-lsp lsp-name
```

The destination address of all LSPs must match the SDP far-end address. Service data packets are sprayed over the set of LSPs in the SDP using the same procedures as for tunnel selection in ECMP. In all cases, the SDP can only spray packets over a maximum of eight next hops. Each SR-TE LSP can, however, have up to eight next hops at the ingress LER when the first segment is a node SID-based SR tunnel. The SDP selects one next hop from each SR-TE LSP until the maximum number of eight next hops for the SDP is reached.

The **tunnel-far-end** option is not supported. In addition, the **mixed-lsp-mode** option does not support the **sr-te** tunnel type.

The signaling protocol for the service labels for an SDP using an SR-TE LSP can be configured to static (**off**), T-LDP (**tldp**), or BGP (**bgp**).

An SR-TE LSP can be used in VPRN auto-bind with the following commands:

CLI Syntax:
```
config>service>vprn>
   auto-bind-tunnel
      resolution {any | disabled | filter}
      resolution-filter
```

```
            [no] sr-te
          exit
        exit
```

Both VPN-IPv4 and VPN-IPv6 (6VPE) are supported in a VPRN service using segment routing transport tunnels with the **auto-bind-tunnel** command.

This **auto-bind-tunnel** command is also supported with BGP EVPN service, as shown below:

CLI Syntax:

```
config>service>vpls>bgp-evpn>mpls>
  auto-bind-tunnel
    resolution {any | disabled | filter}
    resolution-filter
      [no] sr-te
    exit
  exit
```

The following service contexts are supported with SR-TE LSPs:

- VLL, VPLS, IES/VPRN spoke-SDP and interface, and R-VPLS
- Epipe and VPLS services under BGP EVPN
- intra-AS BGP VPRN for VPN-IPv4 and VPN-IPv6 prefixes with both auto-bind and explicit SDP
- inter-AS option C for VPN-IPv4 and VPN-IPv6 VPRN prefix resolution
- multicast over IES/VPRN spoke interface with spoke-SDP over an SR-TE LSP

3.12.8 Data Path Support

The support of SR-TE in the data path requires that the ingress LER push a label stack where each label represents a hop, a TE link, or a node, in the ERO for the LSP path computed by the router or the PCE. However, only the label and the outgoing interface to the first strict or loose hop in the ERO factor into the forwarding decision of the ingress LER. In other words, the SR-TE LSP only needs to track the reachability of the first strict or loose hop.

The first strict or loose hop of the SR-TE LSP is represented as an NHFLE to the SR shortest path tunnel. The rest of the SR-TE label stack can have a larger size and is modeled as another NHLFE referred to as a “super NHLFE”.

Therefore, an SR-TE LSP is modeled in the ingress LER data path as a hierarchical LSP with the super NHLFE tunneled over the NHLFE of the SR shortest path tunnel to the first strict or loose hop in the SR-TE LSP path ERO.

Some characteristics of this design are as follows.

- The design saves on NHLFE usage. When many SR TE LSPs are going to the same first hop, they will be using the same SR shortest path tunnel and will consume one super NHLFE each, but they will be pointing to a single NHLFE, or set of NHLFEs, when ECMP exists for the first strict or loose hop, of the first-hop SR tunnel.

  The ingress LER does not need to program a separate backup super NHLFE. Instead, the single super NHLFE will automatically begin forwarding packets over the LFA backup path of the SR tunnel to the first hop as soon as it is activated.
- There is an exception to the above model in the case where the user configured an empty path SR-TE LSP that uses the router's hop-to-label translation. In this case, the SR-TE LSP will use the NHLFE of the node SID of the destination router. The super NHLFE is null in this case.
- If the first segment is a node SID tunnel and multiple next hops exist, ECMP spraying is supported at the ingress LER.
- If the first-hop SR tunnel, node SID, or adjacency SID goes down, the SR module informs MPLS that the outer tunnel is down and MPLS brings the SR-TE LSP down and requests the SR to delete the SR-TE LSP in the IOM.

The data path behavior at the LSR and egress LER for an SR-TE LSP is similar to that of the shortest path tunnel because there is no tunnel state in these nodes. The forwarding of the packet is based on processing the incoming label stack consisting of a node SID and/or adjacency SID label. If the ILM is for a node SID and multiple next hops exist, ECMP spraying is supported at the LSR.

The link-protect LFA backup next hop for an adjacency SID can be programmed at the ingress LER and LSR nodes (as explained in SR-TE LSP Protection).

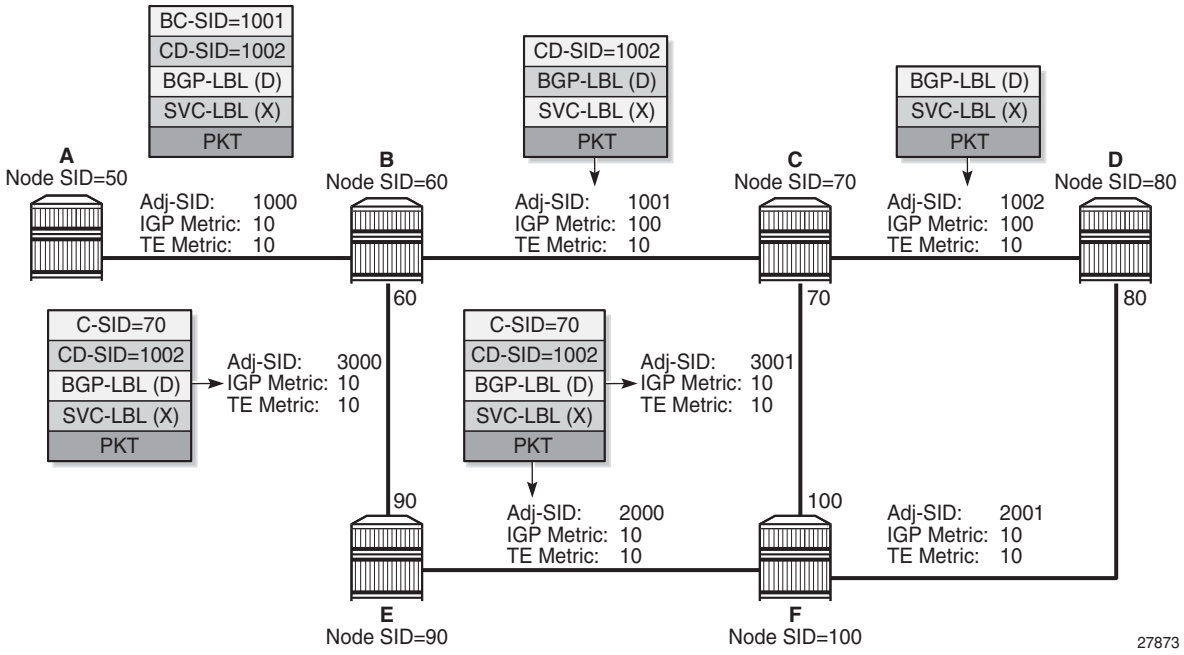
A maximum of 12 labels, including all transport (including entropy), service, NGE, and OAM labels, can be pushed. The label stack size for the SR-TE LSP can be 1 to 11 labels, with a default value of 6.

The label stack size manipulation includes the following LER and LSR roles:

- LER role:
  - push up to 12 labels depending on the service type
  - pop up to 8 labels
- LSR role:
  - pop up to 5 labels and swap 1 label for a total of 6 labels
  - LSR hash of a packet with up to 10 labels

An example of the label stack pushed by the ingress LER and by an LSR acting as a PLR is illustrated in Figure 13.

Figure 13 **SR-TE LSP Label Stack Programming**



On node A, the user configures an SR-TE LSP to node D with a list of explicit strict hops mapping to the adjacency SID of links A-B, B-C, and C-D.

Ingress LER A programs a super NHLFE consisting of the label for the adjacency over link C-D and points it to the already programmed NHLFE of the SR tunnel of its local adjacency over link A-B. The latter NHLFE has the top label and also the outgoing interface to send the packet to.

Note: The SR-TE LSP does not consume a separate backup super NHLFE; it only points the single super NHLFE to the NHLFE of the SR shortest path tunnel it is riding. When the latter activates its backup NHLFE, the SR-TE LSP will automatically forward over it.

LSR Node B already programmed the primary NHLFE for the adjacency SID over link C-D and has the ILM with label 1001 point to it. In addition, node B will preprogram the link-protect LFA backup next hop for link B-C and point the same ILM to it.

Note: There is no super NHLFE at node B because it only deals with the programming of the ILM and primary and backup NHLFE of its adjacency SIDs and its local and remote node SIDs.

VPRN service in node A forwards a packet to the VPN-IPv4 prefix X advertised by BGP peer D. Figure 13 shows the resulting data path at each node for the primary path and for the FRR backup path at LSR B.

3.12.8.1 SR-TE LSP Metric and MTU Settings

The MPLS module assigns an SR-TE LSP the maximum LSP metric value of 16 777 215 when the local router provides the hop-to-label translation for its path. For an SR-TE LSP that uses PCE for path computation (**pce-computation** option enabled) by the PCE and/or has its control delegated to the PCE (**pce-control** enabled), the latter will return the computed LSP IGP or TE metric in the PCReq and PCUpd messages. In both cases, the user can override the returned value by configuring an admin metric using the command **config**>**router**>**mpls**>**lsp**>**metric**.

The MTU setting of an SR-TE LSP is derived from the MTU of the outgoing SR shortest path tunnel it is using, adjusted with the size of the super NHLFE label stack size.

The following are the details of this calculation:

SR_Tunnel_MTU = MIN {Cfg_SR_MTU, IGP_Tunnel_MTU – (1+ *frr-overhead***)×4}**

where:

- **Cfg_SR_MTU** is the MTU configured by the user for all SR tunnels within a particular IGP instance using **config**>**router**>**ospf/isis**>**segment-routing**>**tunnel-mtu**. If no value was configured by the user, the SR tunnel MTU will be fully determined by the IGP interface calculation. This calculation is performed by the IGP and passed to the SR module each time it changes due to an updated resolution of the node SID.
- **IGP_Tunnel_MTU** is the minimum of the IS-IS or OSPF interface MTU among all the ECMP paths or among the primary and LFA backup paths of this SR tunnel.
- *frr-overhead* is set to 1 if **segment-routing** and **remote-lfa** options are enabled in the IGP instance; otherwise, it is set to 0.

This calculation is performed by the IGP and passed to the SR module each time it changes due to an updated resolution of the node SID.

The 7705 SAR also provides the MTU for the adjacency SID tunnel because it is needed in an SR-TE LSP if the first hop in the ERO is an adjacency SID. In that case, the calculation for **SR_Tunnel_MTU**, initially introduced for a node SID tunnel, is applied to get the MTU of the adjacency SID tunnel.

The MTU of the SR-TE LSP is derived as follows:

SRTE_LSP_MTU = SR_Tunnel_MTU – numLabels×4

where:

- **SR_Tunnel_MTU** is the MTU SR tunnel shortest path that the SR-TE LSP is using. The 7705 SAR also provides the MTU for the adjacency SID tunnel because it is needed in an SR-TE LSP if the first hop in the ERO is an adjacency SID. In that case, the calculation for **SR_Tunnel_MTU** (given above), initially introduced for a node SID tunnel, is applied to get the MTU of the adjacency SID tunnel.
- **numLabels** is the number of labels found in the super NHLFE of the SR-TE LSP. At LER, the super NHLFE is pointing to the SR tunnel NHLFE, which has a primary and a backup NHLFE.

This calculation is performed by the SR module and is updated each time the SR-TE LSP path changes or the SR tunnel it is using is updated.

3.12.9 SR-TE Entropy Labels

The 7705 SAR supports SR-TE entropy labels as described in MPLS Entropy Labels.

3.13 MPLS Service Usage

The 7705 SAR routers enable service providers to deliver virtual private networks (VPNs) and Internet access using Generic Routing Encapsulation (GRE), IP, and/or MPLS tunnels, with Ethernet and/or SONET/SDH interfaces.

3.13.1 Service Destination Points

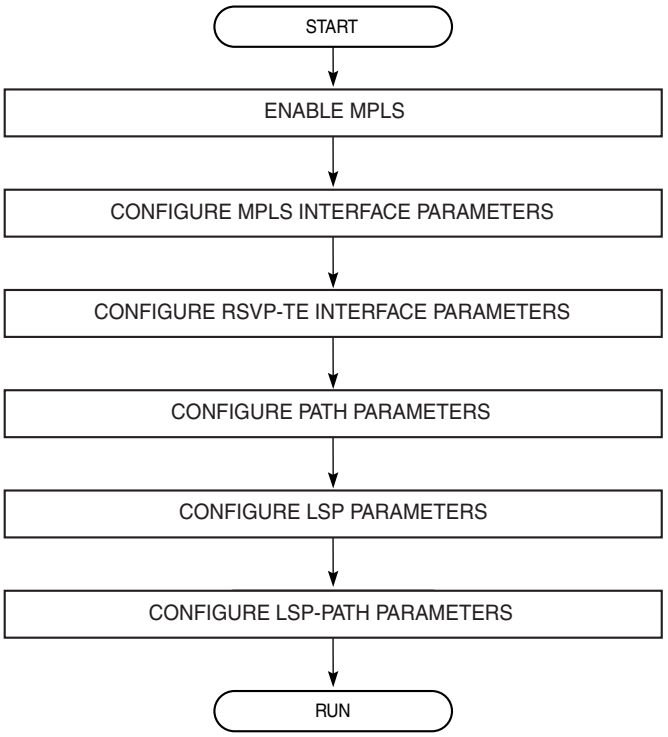
A service destination point (SDP) acts as a logical way of directing traffic from one 7705 SAR router to another through a unidirectional (one-way) service tunnel. The SDP terminates at the far-end 7705 SAR router, which directs packets to the correct service egress service access point (SAP) on that device. All services mapped to an SDP use the GRE, IP, or MPLS transport encapsulation type.

For information about service transport tunnels, refer to the 7705 SAR Services Guide. Service transport tunnels can support up to eight forwarding classes and can be used by multiple services.

3.14 MPLS and RSVP-TE Configuration Process Overview

Figure 14 displays the process to configure MPLS and RSVP-TE parameters.

Figure 14 **MPLS and RSVP-TE Configuration and Implementation Flow**



3.15 Configuration Notes

Network and system interfaces must be configured in the **config>router>interface** context before they can be specified in MPLS. Refer to the 7705 SAR Router Configuration Guide for interface configuration information.

This section describes MPLS and RSVP-TE guidelines and caveats.

- Interfaces must already be configured in the **config>router>interface** context before they can be specified in MPLS and RSVP.
- A router interface must be specified in the **config>router>mpls** context in order to apply it or modify parameters in the **config>router>rsvp** context.
- A system interface must be configured and specified in the **config>router>mpls** context.
- Paths must be created before they can be applied to an LSP.
- CSPF must be enabled in order for administrative groups and SRLGs to be relevant.

3.15.1 Reference Sources

For information on supported IETF drafts and standards, as well as standard and proprietary MIBs, refer to Standards and Protocol Support.

3.16 Configuring MPLS and RSVP-TE with CLI

This section provides information to configure MPLS and RSVP-TE using the CLI.

Topics in this section include:

3.17 MPLS Configuration Overview

MPLS enables routers to forward traffic based on a label embedded in the packet header. A router examines the label to determine the next hop for the packet, instead of router address lookups to the next node when forwarding packets.

To implement MPLS on an LSP for outer tunnel and pseudowire assignment, the following entities must be configured:

- Router Interface
- Paths
- LSPs
- Pseudowires
- Signaling Protocol (for RSVP-TE or LDP)

3.17.1 Router Interface

At least one router interface and one system interface must be defined in the **config>router>interface** context in order to configure MPLS on an interface.

3.17.1.1 E-LSP for Differentiated Services

An EXP-inferred LSP (E-LSP) is an LSP that can support a variety of VLLs or traffic types. Up to eight types of traffic can be multiplexed over an E-LSP.

The prioritization of mission-critical traffic is handled by the settings of the three EXP bits. The EXP bits designate the importance of a particular packet. The classification and queuing at the Provider (P) or Provider Edge (PE) nodes typically take place based on the value of the EXP bits. Refer to the 7705 SAR Quality of Service Guide for more information on the use of EXP bits and differentiated services on the 7705 SAR.

3.17.2 Paths

To configure signaled LSPs, you must first create one or more named paths on the ingress router using the **config>router>mpls>path** command. For each path, the transit routers (hops) in the path are specified.

3.17.3 LSPs

The 7705 SAR supports static and dynamic LSPs.

To configure MPLS-signaled (dynamic) LSPs, the LSP must run from an ingress LER to an egress LER. Configure the dynamic LSP only at the ingress router, and either configure the LSP to allow the router software to make the forwarding decisions or configure some or all routers in the LSP path statically. The LSP is set up by RSVP-TE signaling messages. The 7705 SAR automatically manages label values. Labels that are automatically assigned have values ranging from 1024 through 1 048 575 (see Label Values).

A static LSP is a manually configured LSP where the next hop IP address and the outgoing label are explicitly specified.

To establish a static LSP, an LSP must be configured from an ingress LER to an egress LER. Labels must be manually assigned and the label values must be within the range of 32 to 1023 (see Label Values).

3.17.4 Pseudowires

To configure PW/VLL labels, the PW/VLL service must be configured. PW/VLL labels can be configured manually as statically allocated labels using any unused label within the static label range. Pseudowire/VLL labels can also be dynamically assigned by targeted LDP. Statically allocated labels and dynamically allocated labels are designated differently in the label information base.

PW/VLL labels are uniquely identified against a 7705 SAR, not against an interface or module.

As defined in RFC 3036, *LDP Specification,* and RFC 4447 *Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP)*, label distribution is handled in the Downstream Unsolicited (DU) mode. Generic Label TLV is used for all setup and maintenance operations.

3.17.5 Signaling Protocol

For static LSPs, the path and the label mappings and actions configured at each hop must be specified manually. RSVP-TE or LDP is not required for static LSPs.

For dynamic LSPs, RSVP-TE or LDP must be turned on. See RSVP and RSVP-TE or Label Distribution Protocol.

To implement dynamic pseudowire/VLL labels, entities must be enabled as follows:

- MPLS must be enabled on all routers that are part of a static LSP
- LDP must be enabled on the ingress and egress LERs

When MPLS is enabled and either RSVP-TE or LDP is also enabled, MPLS uses RSVP-TE or LDP to set up the configured LSPs. For example, when you configure an LSP with both MPLS and RSVP-TE running, RSVP-TE initiates a session to create the LSP. RSVP-TE uses the local router as the RSVP-TE session sender and the LSP destination as the RSVP-TE session receiver. Once the RSVP-TE session is created, the LSP is set up on the path created by the session. If the session is not successfully created, RSVP-TE notifies MPLS; MPLS can then either initiate backup paths or retry the initial path.

3.18 Basic MPLS Configuration

This section provides information to configure MPLS and gives configuration examples of common configuration tasks. To enable MPLS on a 7705 SAR router, you must configure at least one MPLS interface. The MPLS interface is configured in the **config>router> mpls** context. The other MPLS configuration parameters are optional.

The following example displays an MPLS configuration output. The **admin-group** is configured in the **config>router>if-attribute** context and associated with the MPLS interface in the **config>router>mpls>interface** context.

```
A:ALU-1>config>router>if-attr# info
----------------------------------------
            admin-group "green" 15
            admin-group "yellow" 20
            admin-group "red" 25
----------------------------------------


A:ALU-1>config>router>mpls# info
----------------------------------------
            interface "system"
            exit
            interface "StaticLabelPop"
                admin-group "green"
                label-map 50
                    pop
                    no shutdown
                exit
            exit
            interface "StaticLabelPop"
                label-map 35
                    swap 36 nexthop 10.10.10.91
                    no shutdown
                exit
            exit
            path "to-NYC"
                hop 1 10.10.10.104 strict
                no shutdown
            exit
            path "secondary-path"
                no shutdown
            exit
            lsp "lsp-to-eastcoast"
                to 10.10.10.104
                from 10.10.10.103
                fast-reroute one-to-one
                exit
                primary "to-NYC"
                exit
                secondary "secondary-path"
                exit
                no shutdown
            exit
```

```
            static-lsp "StaticLabelPush"
                to 10.10.11.105
                push 60 nexthop 10.10.11.105
                no shutdown
            exit
            no shutdown
-------------------------------------------
A:ALU-1>config>router>mpls#
```

3.19 Common Configuration Tasks

This section provides a brief overview of the tasks to configure MPLS and provides the CLI commands.

The following protocols must be enabled on each participating router:

- MPLS
- RSVP-TE (for RSVP-TE-signaled MPLS only)
- LDP

In order for MPLS to run, you must configure at least one MPLS interface in the **config>router>mpls** context.

- An interface must be created in the **config>router>interface** context before it can be applied to MPLS.
- In the **config>router>mpls** context, configure the path parameters. A path specifies some or all hops from ingress to egress. A path can be used by multiple LSPs.
- When an LSP is created, the egress router must be specified in the to command and at least one primary or secondary path must be specified. All other settings under the LSP hierarchy are optional.

3.19.1 Configuring MPLS Components

Use the MPLS and RSVP-TE CLI syntax shown in the following information for:

- Configuring Global MPLS Parameters
- Configuring an MPLS Interface
- Configuring MPLS Paths
- Configuring an MPLS LSP
- Configuring a Static LSP
- Configuring Manual Bypass Tunnels
- Configuring RSVP-TE Parameters and Interfaces
- Configuring RSVP-TE Message Pacing Parameters

3.19.2 Configuring Global MPLS Parameters

Admin groups can signify link colors, such as red, yellow, or green, or some other link quality. Shared risk link groups (SRLGs) are lists of interfaces that share the same risk of failure due to shared resources. MPLS interfaces advertise the admin groups and SRLGs that they support. CSPF uses the information when paths are computed for constraint-based LSPs. CSPF must be enabled in order for admin groups and SRLGs to be relevant.

Admin groups and SRLGs are created in the **config>router>if-attribute** context. Other global parameters are created in the **config>router>mpls** context.

To configure global MPLS parameters, enter the following commands:

CLI Syntax:
```
config>router>if-attribute
   admin-group group-name value group-value
   srlg-group group-name value group-value
```

CLI Syntax:
```
config>router>mpls
   bypass-resignal-timer minutes
   dynamic-bypass [enable | disable]
   frr-object
   hold-timer seconds
   resignal-timer minutes
   srlg-frr [strict]
```

Example:
```
config>router# if-attribute
config>router>if-attr# admin-group "green" value 15
config>router>if-attr# admin-group "red" value 25
config>router>if-attr# admin-group "yellow" value 20
config>router>if-attr# srlg-group "SRLG_fiber_1" value
 50
config>router>if-attr# exit
config>router# mpls
config>router>mpls# frr-object
config>router>mpls# bypass-resignal-timer 120
config>router>mpls# hold-timer 3
config>router>mpls# resignal-timer 500
config>router>mpls# srlg-frr strict
```

The following example displays a global MPLS configuration output.

```
A:ALU-1>config>router>if-attr# info
----------------------------------------------
            admin-group "green" 15
            admin-group "red" 25
            admin-group "yellow" 20
            srlg-group "SRLG_fiber_1" 50
----------------------------------------------

A:ALU-1>config>router>mpls# info
----------------------------------------------
            frr-object
            bypass-resignal-timer 120
            hold-timer 3
            resignal-timer 500
            srlg-frr strict
----------------------------------------------
A:ALU-1>config>router>mpls# info
```

3.19.3 Configuring an MPLS Interface

The interface must exist in the system before it can be configured as an MPLS interface; refer to the 7705 SAR Router Configuration Guide for more information.

Once the MPLS protocol instance is created, the **no shutdown** command is not required since MPLS is administratively enabled upon creation. Configure the **label-map** parameters if the interface is used in a static LSP.

Use the following CLI syntax to configure an MPLS interface on a router:

CLI Syntax:

```
config>router>mpls
   interface ip-int-name
      admin-group group-name [group-name...(up to 5 max)]
      label-map in-label
         pop
         swap out-label next-hop ip-address
         no shutdown
      srlg-group group-name [group-name...(up to 5 max)]
      te-metric value
      no shutdown
```

Example:

```
config>router# mpls
config>router>mpls# interface to-104
config>router>mpls>if# label-map 35
config>router>mpls>if>label-map# swap 36 next-hop
 10.10.10.91
config>router>mpls>if>label-map# no shutdown
config>router>mpls>if>label-map# exit
```

```
config>router>mpls>if# srlg-group "SRLG_fiber_1"
config>router>mpls>if# no shutdown
config>router>mpls# exit
```

The following example displays the interface configuration output.

```
A:ALU-1>config>router>mpls# info
----------------------------------------------
            interface "to-104"
                admin-group "green"
                admin-group "red"
                admin-group "yellow"
                label-map 35
                    swap 36 nexthop 10.10.10.91
                    no shutdown
                srlg-group "SRLG_fiber_1"
                exit
            exit
            no shutdown
```

3.19.4 Configuring MPLS Paths

When configuring an MPLS path for LSPs, the IP address of each hop that the LSP should traverse on its way to the egress router must be specified. The intermediate hops must be configured as either **strict** or **loose**, meaning that the LSP must take either a direct path from the previous hop router to this router (strict) or can traverse other routers (loose).

Use the following CLI syntax to configure a path:

CLI Syntax:

```
config>router>mpls
   path path-name
      hop hop-index ip-address {strict|loose}
      no shutdown
```

The following example displays a path configuration output.

```
A:ALU-1>config>router>mpls# info
----------------------------------------
            interface "system"
            exit
            path "to-NYC"
                hop 1 10.10.10.103 strict
                hop 2 10.10.0.210 strict
                hop 3 10.10.0.215 loose
            exit
            path "secondary-path"
                hop 1 10.10.0.121 strict
                hop 2 10.10.0.145 strict
                hop 3 10.10.0.1 strict
```

```
                no shutdown
            exit
-----------------------------------------
A:ALU-1>config>router>mpls#
```

3.19.5 Configuring an MPLS LSP

When configuring an LSP, you must specify the IP address of the egress router in the **to** statement. You must also specify the primary path to be used. Secondary paths can be explicitly configured or signaled upon the failure of the primary path. All other statements are optional.

The following displays an MPLS LSP configuration.

```
A:ALU-1>config>router>mplp# info
----------------------------------------------
...
            lsp "lsp-to-eastcoast"
                to 192.0.2.41
                rsvp-resv-style ff
                cspf
                include "red"
                exclude "green"
                adspec
                fast-reroute one-to-one
                exit
                primary "to-NYC"
                    hop-limit 10
                exit
                secondary "secondary-path"
                    bandwidth 50000
                exit
                no shutdown
            exit
            no shutdown
----------------------------------------------
A:ALU-1>config>router>mpls#
```

3.19.6 Configuring a Static LSP

An LSP can be explicitly (manually) configured. The reserved range of static LSP labels is 32 to 1023. Static LSPs are configured on every node along the LSP path. The label's forwarding information includes the address of the next hop router.

Use the following CLI syntax to configure a static LSP:

CLI Syntax:
```
config>router>mpls
   static-lsp lsp-name
      to ip-address
      push label nexthop ip-address
      no shutdown
```

Example:
```
config>router# mpls
config>router>mpls# static-lsp static-LSP
config>router>mpls>static-lsp$ to 10.10.10.124
config>router>mpls>static-lsp# push 60 nexthop
 10.10.42.3
config>router>mpls>static-lsp# no shutdown
config>router>mpls>static-lsp# exit
```

The following example displays the static LSP configuration output.

```
ALU-1>config>router>mpls# info
----------------------------------------------
...
            static-lsp "static-LSP"
                to 10.10.10.124
                push 60 nexthop 10.10.42.3
                no shutdown
            exit
----------------------------------------------
```

3.19.6.1 Configuring a Fast-Retry Timer for Static LSPs

A fast-retry timer can be configured for static LSPs. When a static LSP is trying to come up, MPLS tries to resolve the ARP entry for the next hop of the LSP. This request may fail because the next hop might still be down or unavailable. In that case, MPLS starts a retry timer before making the next request. The fast-retry command allows the user to configure the retry timer so that the LSP comes up shortly after the next hop is available.

Use the following CLI syntax to configure a fast-retry timer for static LSPs:

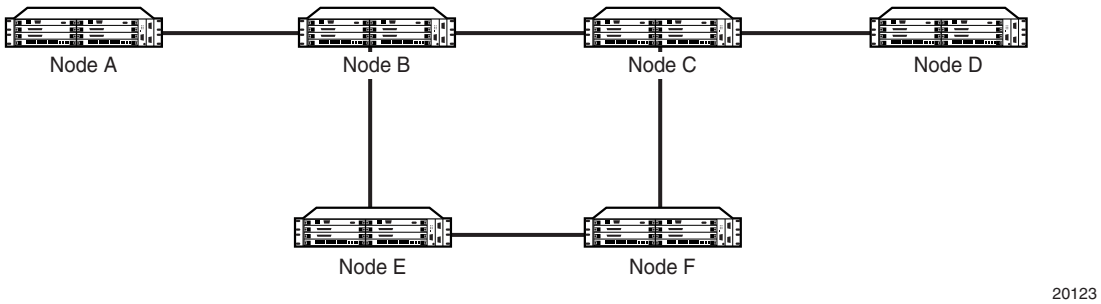
CLI Syntax:
```
config>router>mpls
   static-lsp-fast-retry seconds
```

Example:
```
config>router# mpls
config>router>mpls# static-lsp-fast-retry 15
```

3.19.7 Configuring Manual Bypass Tunnels

Consider the following network setup in Figure 15. Assume that a manual bypass tunnel must be configured on Node B.

Figure 15 **Manual Bypass Tunnels**



Step 1. Disable dynamic bypass tunnels on Node B.

The CLI syntax for this configuration is:

config>router>mpls>dynamic-bypass [disable | enable]

By default, dynamic bypass tunnels are enabled.

Step 2. Configure an LSP on Node B, such as B-E-F-C, which will be used only as a bypass. Specify each hop in the path and assign its **strict** or **loose** option; in this case, the bypass LSP will have a strict path. Designate the LSP as a primary LSP.

The CLI syntax for this configuration is:

config>router>mpls>path *path-name*>**hop** *hop-index ip-address* **[strict | loose]**

config>router>mpls>lsp *lsp-name* **bypass-only**

(see also the configuration example below)

Including the **bypass-only** keyword disables some options under the LSP configuration. See Table 8.

Table 8 **Disabled and Enabled Options for Bypass-Only**

Disabled Options	Enabled Options
• bandwidth • fast-reroute • secondary	• adaptive • adspec • cspf • exclude • hop-limit • include • metric

Step 3. Configure an LSP from A to D and indicate fast-reroute bypass protection by selecting facility as the FRR method.

The CLI syntax for this configuration is:

config>router>mpls>lsp *lsp-name***>fast-reroute facility**

If the LSP from A to D goes through Node B and bypass is requested, the next hop is Node C, and there is a manually configured bypass-only tunnel from B to C that excludes link BC (that is, path BEFC), then Node B uses the bypass-only tunnel.

The following example displays a bypass tunnel configuration output.

```
A:ALU-48>config>router>mpls># info
----------------------------------------
...
            path "BEFC"
                hop 10 10.10.10.11 strict
                hop 10 10.10.10.12 strict
                hop 10 10.10.10.13 strict
                no shutdown
            exit
            lsp "bypass-BC" bypass-only
                to 10.10.10.15
                primary "BEFC"
                exit
                no shutdown
...
----------------------------------------
```

3.19.8 Configuring RSVP-TE Parameters and Interfaces

RSVP-TE is used to set up LSPs. RSVP-TE must be enabled on the router interfaces that are participating in signaled LSPs. The default values can be modified in the **config>router>rsvp** context.

Initially, interfaces are configured in the **config>router>mpls>interface** context. Only these existing (MPLS) interfaces are available to be modified in the **config>router>rsvp** context. Interfaces cannot be directly added in the **rsvp** context.

The following example displays an RSVP-TE configuration output.

```
A:ALU-1>config>router>rsvp# info
----------------------------------------------
          keep-multiplier 3
          refresh-time 30
          no msg-pacing
          rapid-retransmit-time 5
          rapid-retry-limit 3
          refresh-reduction-over-bypass disable
          no graceful-shutdown
          no entropy-label-capability
          node-id-in-rro exclude
          interface "system"
             no shutdown
          exit
          interface to-104
             hello-interval 4000
             no shutdown
          exit
          no shutdown
----------------------------------------------
A:ALU-1>config>router>rsvp#
```

3.19.9 Configuring RSVP-TE Message Pacing Parameters

RSVP-TE message pacing maintains a count of the messages that were dropped because the output queue for the egress interface was full.

Use the following CLI syntax to configure RSVP-TE message pacing parameters:

CLI Syntax:

```
config>router>rsvp
   no shutdown
   msg-pacing
      period milli-seconds
      max-burst number
```

The following example displays an RSVP-TE message pacing configuration output.

```
A:ALU-1>config>router>rsvp# info
----------------------------------------------
            keep-multiplier 5
            refresh-time 60
            msg-pacing
                period 400
                max-burst 400
            exit
            interface "system"
                no shutdown
            exit
            interface to-104
                hello-interval 4000
                no shutdown
            exit
            no shutdown
----------------------------------------------
A:ALU-1>config>router>rsvp#
```

3.20 MPLS Configuration Management Tasks

This section discusses the following MPLS configuration management tasks:

- Deleting MPLS
- Modifying MPLS Parameters
- Modifying an MPLS LSP
- Modifying MPLS Path Parameters
- Modifying MPLS Static LSP Parameters
- Deleting an MPLS Interface

3.20.1 Deleting MPLS

The **no** form of the **mpls** command typically removes an MPLS instance and all associated information. However, MPLS must be disabled (shut down) and all SDP bindings to LSPs removed before an MPLS instance can be deleted. Once MPLS is shut down, the **no mpls** command deletes the protocol instance and removes all configuration parameters for the MPLS instance.

If MPLS is not shut down first, when the **no mpls** command is executed, a warning message on the console indicates that MPLS is still administratively up.

To delete the MPLS instance:

1. Disable the MPLS instance using the **shutdown** command.
2. Remove the MPLS instance from the router using the **no mpls** command.

CLI Syntax: `config>router# no mpls`

3.20.2 Modifying MPLS Parameters

Note: You must shut down MPLS entities in order to modify parameters. Re-enable (no shutdown) the entity for the change to take effect.

3.20.3 Modifying an MPLS LSP

Some MPLS LSP parameters (such as primary and secondary), must be shut down before they can be edited or deleted from the configuration.

The following example displays an MPLS LSP configuration output. Refer to Configuring an MPLS Interface.

```
A:ALU-1>>config>router>mpls>lsp# info
----------------------------------------------
                shutdown
                to 10.10.10.104
                from 10.10.10.103
                rsvp-resv-style ff
                include "red"
                exclude "green"
                fast-reroute one-to-one
                exit
                primary "to-NYC"
                    hop-limit 50
                exit
                secondary "secondary-path"
                exit
----------------------------------------------
A:ALU-1>config>router>mpls#
```

3.20.4 Modifying MPLS Path Parameters

In order to modify path parameters, the **config>router>mpls>path** context must be shut down first.

The following example displays an MPLS path configuration output. Refer to Configuring MPLS Paths.

```
A:ALU-1>config>router>mpls# info
#----------------------------------------
echo "MPLS"
#----------------------------------------
...
            path "secondary-path"
                hop 1 10.10.0.111 strict
                hop 2 10.10.0.222 strict
                hop 3 10.10.0.123 strict
                no shutdown
            exit
            path "to-NYC"
                hop 1 10.10.10.104 strict
                hop 2 10.10.0.210 strict
                no shutdown
            exit
----------------------------------------------
```

3.20.5 Modifying MPLS Static LSP Parameters

Use the **show>service>router>static-lsp** command to display a list of LSPs.

In order to modify static LSP parameters, the **config>router>mpls>static-lsp** *lsp-name* context must be shut down.

To modify an LSP:

1. Access the specific LSP by specifying the LSP name, and then shut it down.
2. Enter the parameter to modify and then enter the new information.

Example:

```
config>router# mpls
config>router>mpls# static-lsp "static-LSP"
config>router>mpls>static-lsp# shutdown
config>router>mpls>static-lsp# to 10.10.0.234
config>router>mpls>static-lsp# push 1023 nexthop
 10.10.8.114
config>router>mpls>static-lsp# no shutdown
config>router>mpls>static-lsp# exit
```

The following example displays the static LSP configuration output.

```
ALU-1>config>router>mpls# info
----------------------------------------------
...
            static-lsp "static-LSP"
                to 10.10.10.234
                push 1023 nexthop 10.10.8.114
                no shutdown
            exit
            no shutdown
----------------------------------------------
ALU-1>config>router>mpls#
```

3.20.6 Deleting an MPLS Interface

To delete an interface from the MPLS configuration:

1. Administratively disable the interface using the **shutdown** command.
2. Delete the interface with the **no interface** command.

CLI Syntax:

```
mpls
   interface ip-int-name
      shutdown
      exit
   no interface ip-int-name
```

Example:

```
config>router# mpls
config>router>mpls# interface to-104
config>router>mpls>if# shutdown
config>router>mpls>if# exit
config>router>mpls# no interface to-104
```

The following example displays the configuration output when interface “to-104” has been deleted.

```
A:ALU-1>config>router>mpls# info
----------------------------------------------
...
admin-group "green" 15
            admin-group "red" 25
            admin-group "yellow" 20
            interface "system"
            exit
            no shutdown
----------------------------------------------
A:ALU-1>config>router>mpls#
```

3.21 RSVP-TE Configuration Management Tasks

This section discusses the following RSVP-TE configuration management tasks:

- Modifying RSVP-TE Parameters
- Modifying RSVP-TE Message Pacing Parameters
- Deleting an Interface from RSVP-TE

3.21.1 Modifying RSVP-TE Parameters

Only interfaces configured in the MPLS context can be modified in the **rsvp** context.

The **no rsvp** command deletes this RSVP-TE protocol instance and removes all configuration parameters for this RSVP-TE instance. The **shutdown** command suspends the execution and maintains the existing configuration.

The following example displays a modified RSVP-TE configuration output.

```
A:ALU-1>config>router>rsvp# info
----------------------------------------------
            keep-multiplier 5
            refresh-time 60
            msg-pacing
                period 400
                max-burst 400
            exit
            rapid-retransmit-time 5
            rapid-retry-limit 3
            refresh-reduction-over-bypass disable
            no graceful-shutdown
            no entropy-label-capability
            no implicit-null-label
            node-id-in-rro exclude
            interface "system"
            exit
            interface "test1"
                hello-interval 5000
            exit
            no shutdown
----------------------------------------------
A:ALU-1>config>router>rsvp#
```

3.21.2 Modifying RSVP-TE Message Pacing Parameters

RSVP-TE message pacing maintains a count of the messages that were dropped because the output queue for the egress interface was full.

The following example displays a modified RSVP-TE message pacing configuration output. Refer to Configuring RSVP-TE Message Pacing Parameters.

```
A:ALU-1>config>router>rsvp# info
----------------------------------------------
            keep-multiplier 5
            refresh-time 60
            msg-pacing
                period 200
                max-burst 200
            exit
            interface "system"
            exit
            interface "to-104"
            exit
            no shutdown
----------------------------------------------
A:ALU-1>config>router>rsvp#
```

3.21.3 Deleting an Interface from RSVP-TE

Interfaces cannot be deleted directly from the RSVP-TE configuration. Because an interface is created in the **mpls** context and then configured in the **rsvp** context, it can only be deleted in the mpls context This removes the association from RSVP-TE.

Refer to Deleting an MPLS Interface.

3.22 Configuring and Operating SR-TE

This section provides information on the configuration and operation of the Segment Routing with Traffic Engineering (SR-TE) LSP. It covers the following topics:

- SR-TE Configuration Prerequisites
- SR-TE LSP Configuration Overview
- Configuring Path Computation and Control for SR-TE LSPs
- Configuring SR-TE LSP Label Stack Size
- Configuring Adjacency SID Parameters
- Configuring PCC-controlled, PCE-computed, and PCE-controlled SR-TE LSPs

3.22.1 SR-TE Configuration Prerequisites

To configure SR-TE, the user must first configure the prerequisite parameters.

First, configure the label space partition for the Segment Routing Global Block (SRGB) for all participating routers in the segment routing domain by using the **mpls-labels**>**sr-labels** command.

Example:
```
configure>router>mpls-labels
   sr-labels start 200000 end 200400
exit
```

Enable segment routing, traffic engineering, and advertisement of router capability in all participating IGP instances in all participating routers by using the **traffic-engineering**, **advertise-router-capability**, and **segment-routing** commands.

Example:
```
ospf 0
   traffic-engineering
   advertise-router-capability area
   loopfree-alternate remote-lfa
   area 0.0.0.202
      stub
         no summaries
      exit
      interface "system"
         node-sid index 194
         no shutdown
      exit
      interface "toSim199"
         interface-type point-to-point
```

```
            no shutdown
          exit
          interface "toSim213"
            interface-type point-to-point
            no shutdown
          exit
          interface "toSim219"
            interface-type point-to-point
            metric 2000
            no shutdown
          exit
        exit
        segment-routing
          prefix-sid-range global
          entropy-label {force-disable | enable}
          no shutdown
        exit
        no shutdown
      exit
```

Configure a segment routing tunnel MTU for the IGP instance, if required, by using the **tunnel-mtu** command.

Example:
```
prefix-sid-range global
tunnel-mtu 1500
no shutdown
```

Assign a node SID to each loopback interface that a router would use as the destination of a segment routing tunnel by using the **node-sid** command.

Example:
```
ospf 0
  area 0.0.0.202
    interface "system"
      node-sid index 194
      no shutdown
    exit
```

3.22.2 SR-TE LSP Configuration Overview

An SR-TE LSP can be configured as an LSP using the existing CLI command hierarchy under the MPLS context and specifying the **sr-te** LSP type.

CLI Syntax: `config>router>mpls>lsp` *lsp-name* | `sr-te`

A primary path can be configured for the SR-TE LSP.

Use the following CLI syntax to associate an empty path or a path with strict or loose explicit hops with the primary paths of the SR-TE LSP:

CLI Syntax:
```
config>router>mpls>path>hop hop-index ip-address {strict
  | loose}
config>router>mpls>lsp>primary path-name
```

3.22.3 Configuring Path Computation and Control for SR-TE LSPs

Use the following syntax to configure the path computation requests only (PCE-computed) or both path computation requests and path updates (PCE-controlled) to the PCE for a specific LSP:

CLI Syntax:
```
config>router>mpls>lsp>pce-computation
config>router>mpls>lsp>pce-control
```

The PCC LSP database is synchronized with the PCE LSP database using the PCEP PCRpt (PCE Report) message for LSPs that have the following commands enabled:

CLI Syntax:
```
config>router>mpls>pce-report sr-te {enable | disable}
config>router>mpls>lsp>pce-report {enable | disable |
  inherit}
```

3.22.3.1 Configuring Path Profile and Group for PCC-initiated and PCE-computed/controlled LSPs

The PCE supports the computation of disjoint paths for two different LSPs originating or terminating on the same or different PE routers. To indicate this constraint to the PCE, the user must configure the PCE path profile ID and path group ID that the LSP belongs to. These parameters are passed transparently by the PCC to the PCE and are therefore opaque data to the router. Use the following syntax to configure the path profile and path group:

CLI Syntax:
```
config>router>mpls>lsp>path-profile profile-id [path-
  group group-id]
```

The association of the optional path group ID is to allow the PCE to determine which profile ID this path group ID must be used with. One path group ID is allowed per profile ID. The user can, however, enter the same path group ID with multiple profile IDs by executing this command multiple times. A maximum of five entries of **path-profile** [*path-group*] can be associated with the same LSP. More details of the operation of the PCE path profile are provided in the PCEP chapter.

3.22.4 Configuring SR-TE LSP Label Stack Size

Use the following syntax to configure the maximum number of labels that the ingress LER can push for a specific SR-TE LSP:

CLI Syntax: `config>router>mpls>lsp>max-sr-labels` *`label-stack-size`*

This command allows the user to reduce the SR-TE LSP label stack size by accounting for additional transport (including entropy), service, and other labels when packets are forwarded in a particular context. See Data Path Support for more information about label stack size requirements in various forwarding contexts. If the CSPF on the PCE or the router's hop-to-label translation cannot find a path that meets the maximum SR label stack, the SR-TE LSP will remain on its current path or will remain down if it has no path. The range is 1 to 11 labels with a default value of 6.

3.22.5 Configuring Adjacency SID Parameters

Configure the adjacency hold timer for the LFA or remote LFA backup next hop of an adjacency SID.

Use the following syntax to configure the length time that LTN or ILM records of an adjacency SID are kept:

CLI Syntax:
```
config>router>ospf>segment-routing>adj-sid-hold
 seconds[1..300, default 15]
config>router>isis>segment-routing>adj-sid-hold
 seconds[1..300, default 15]
```

Example:
```
adj-sid-hold 15
prefix-sid-range global
no tunnel-table-pref
no tunnel-mtu
no backup-node-sid
no shutdown
```

While protection is enabled globally for all node SIDs and local adjacency SIDs when the user enables the **loopfree-alternate** option in IS-IS or OSPF at the LER and LSR, there are applications where the user wants traffic to never divert from the strict hop computed by CSPF for an SR-TE LSP. In that case, use the following syntax to disable protection for all adjacency SIDs formed over a particular network IP interface:

CLI Syntax:
```
config>router>ospf>area>if>no sid-protection
config>router>isis>if>no sid-protection
```

Example:
```
node-sid index 194
no sid-protection
no shutdown
```

3.22.6 Configuring PCC-controlled, PCE-computed, and PCE-controlled SR-TE LSPs

The following example shows the configuration of PCEP PCC parameters on LER routers that require peering with the PCE server:

Example:
```
keepalive 30
dead-timer 120
no local-address
unknown-message-rate 10
report-path-constraints
peer 192.0.0.226
   no shutdown
exit
no shutdown
```

The following example shows the configuration of a PCC-controlled SR-TE LSP that is not reported to the PCE:

Example:
```
lsp "to-SanFrancisco" sr-te
   to 192.0.2.211
   cspf
   pce-report disable
   metric 10
   primary "loose-anycast"
   exit
   no shutdown
exit
```

The following example shows the configuration of a PCC-controlled SR-TE LSP that is reported to the PCE:

Example:
```
lsp "to-SanFrancisco" sr-te
  to 192.0.2.211
  cspf
  pce-report enable
  metric 10
  primary "loose-anycast"
  exit
  no shutdown
exit
```

The following example shows the configuration of a PCE-computed SR-TE LSP that is reported to the PCE:

Example:
```
lsp "to-SanFrancisco" sr-te
  to 192.0.2.211
  cspf
  pce-computation
  pce-report enable
  metric 10
  primary "loose-anycast"
  exit
  no shutdown
exit
```

The following example shows the configuration of a PCE-controlled SR-TE LSP with no PCE path profile:

Example:
```
lsp "from Reno to Atlanta no Profile" sr-te
  to 192.0.2.224
  cspf
  pce-computation
  pce-report enable
  pce-control
  primary "empty"
  exit
  no shutdown
exit
```

The following example shows the configuration of a PCE-controlled SR-TE LSP with a PCE path profile and a maximum label stack set to a non-default value:

Example:
```
lsp "from Reno to Atlanta no Profile" sr-te
  to 192.0.2.224
  cspf
  max-sr-labels 8 additional-frr-labels 1
```

```
        pce-computation
        pce-report enable
        pce-control
        path-profile 10 path-group 2
        primary "empty"
          bandwidth 15
        exit
        no shutdown
      exit
```

3.23 MPLS and RSVP-TE Command Reference

3.23.1 Command Hierarchies

- MPLS Commands
- RSVP-TE Commands
- Show Commands
- Tools Commands (refer to Tools section of 7705 SAR OAM and Diagnostics Guide)
- Clear Commands
- Debug Commands

3.23.1.1 MPLS Commands

```
config
    — router [router-name]
        — [no] mpls
            — [no] admin-group-frr
            — auto-lsp lsp-template template-name {policy peer-prefix-policy [peer-prefix-
                policy...(up to 5 max)] | one-hop}
            — no auto-lsp lsp-template template-name
            — bypass-resignal-timer minutes
            — no bypass-resignal-timer
            — [no] cspf-on-loose-hop
            — dynamic-bypass [enable | disable]
            — entropy-label rsvp-te {force-disable | enable}
            — entropy-label sr-te {force-disable | enable}
            — [no] frr-object
            — hold-timer seconds
            — no hold-timer
            — ingress-statistics
                — [no] lsp lsp-name sender ip-address
                    — accounting-policy policy-id
                    — no accounting-policy
                    — [no] collect-stats
                    — [no] shutdown
            — [no] interface ip-int-name
                — [no] admin-group group-name [group-name...(up to 5 max)]
                — [no] label-map in-label
                    — [no] pop
                    — swap out-label nexthop ip-address
                    — no swap
                    — [no] shutdown
                — [no] shutdown
                — [no] srlg-group group-name [group-name...(up to 5 max)]
                — te-metric value
                — no te-metric
            — least-fill-min-thd percent
            — no least-fill-min-thd
            — least-fill-reoptim-thd percent
            — no least-fill-reoptim-thd
            — [no] logger-event-bundling
            — [no] lsp lsp-name [bypass-only] [sr-te]
                — [no] adaptive
                — [no] adspec
                —  bgp-transport-tunnel {include | exclude}
                — [no] cspf [use-te-metric]
                — [no] egress-statistics
                    — accounting-policy policy-id
                    — no accounting-policy
                    — [no] collect-stats
                    — [no] shutdown
                — entropy-label {force-disable | inherit | enable}
                — [no] exclude group-name [group-name...(up to 5 max)]
                — [no] fast-reroute [frr-method]
```

- **hop-limit** *limit*
- **no hop-limit**
- [**no**] **node-protect**
- [**no**] **propagate-admin-group**

- **from** *ip-address*
- **hop-limit** *number*
- **no hop-limit**
- **igp-shortcut** [**lfa-protect** | **lfa-only** | **relative-metric** [*offset*]]
- **no igp-shortcut**
- [**no**] **include** *group-name* [*group-name*...(up to 5 max)]
- [**no**] **least-fill**
- **max-sr-labels** *label-stack-size* [**additional-frr-labels** *labels*]
- **no max-sr-labels**
- **metric** *metric*
- **path-profile** *profile-id* [**path-group** *group-id*]
- **no path-profile** *profile-id*
- [**no**] **pce-computation**
- [**no**] **pce-control**
- **pce-report** {**enable** | **disable** | **inherit**}
- [**no**] **primary** *path-name*
  - [**no**] **adaptive**
  - **bandwidth** *rate-in-mpbs*
  - **no bandwidth**
  - [**no**] **exclude** *group-name* [*group-name*...(up to 5 max)]
  - **hop-limit** *number*
  - **no hop-limit**
  - [**no**] **include** *group-name* [*group-name*...(up to 5 max)]
  - [**no**] **record**
  - [**no**] **record-label**
  - [**no**] **shutdown**
- [**no**] **propagate-admin-group**
- **retry-limit** *number*
- **no retry-limit**
- **retry-timer** *seconds*
- **no retry-timer**
- **rsvp-resv-style** [**se** | **ff**]
- [**no**] **secondary** *path-name*
  - [**no**] **adaptive**
  - **bandwidth** *rate-in-mbps*
  - **no bandwidth**
  - [**no**] **exclude***group-name* [*group-name*...(up to 5 max)]
  - **hop-limit** *number*
  - **no hop-limit**
  - [**no**] **include** *group-name* [*group-name*...(up to 5 max)]
  - **path-preference** *preference-number*
  - **no path-preference**
  - [**no**] **record**
  - [**no**] **record-label**
  - [**no**] **shutdown**
  - [**no**] **srlg**
  - [**no**] **standby**
- [**no**] **shutdown**
- **to** *ip-address*
- **vprn-auto-bind** [**include** | **exclude**]

- **no vprn-auto-bind**
- **lsp-template** *template-name*
- **lsp-template** *template-name* **mesh-p2p**
- **lsp-template** *template-name* **one-hop-p2p**
- **no lsp-template** *template-name* [**one-hop-p2p** | **mesh-p2p**]
- [**no**] **adaptive**
- [**no**] **adspec**
- **bgp-transport-tunnel** {**include** | **exclude**}
- [**no**] **cspf** [**use-te-metric**]
- [**no**] **default-path** *path-name*
- [**no**] **exclude** *group-name* [*group-name*...(up to 5 max)]
- [**no**] **fast-reroute** [*frr-method*]
- **hop-limit** *limit*
- **no hop-limit**
- [**no**] **node-protect**
- [**no**] **propagate-admin-group**
- **from** *ip-address*
- **hop-limit** *number*
- **no hop-limit**
- **igp-shortcut** [**lfa-protect** | **lfa-only**] [**relative-metric** [*offset*]]
- **no igp-shortcut**
- [**no**] **include** *group-name* [*group-name*...(up to 5 max)]
- [**no**] **least-fill**
- **metric** *metric*
- **pce-report** {**enable** | **disable** | **inherit**}
- [**no**] **propagate-admin-group**
- **retry-limit** *number*
- **no retry-limit**
- **retry-timer** *seconds*
- **no retry-timer**
- [**no**] **shutdown**
- **vprn-auto-bind** [**include** | **exclude**]
- [**no**] **path** *path-name*
- **hop** *hop-index ip-address* {**strict** | **loose**}
- **no hop** *hop-index*
- [**no**] **shutdown**
- **pce-report rsvp-te** {**enable** | **disable**}
- **pce-report sr-te** {**enable** | **disable**}
- **resignal-timer** *minutes*
- **no resignal-timer**
- **srlg-frr** [**strict**]
- **no srlg-frr**
- [**no**] **shutdown**
- [**no**] **static-lsp** *lsp-name*
- **push** *label* **nexthop** *ip-address*
- **no push** *label*
- **to** *ip-address*
- [**no**] **shutdown**
- **static-lsp-fast-retry** *seconds*
- **no static-lsp-fast-retry**

3.23.1.2 RSVP-TE Commands

```
config
    — router
        — [no] rsvp
            — [no] entropy-label-capability
            — [no] graceful-shutdown
            — [no] implicit-null-label
            — [no] interface ip-int-name
                — auth-keychain name
                — no auth-keychain
                — authentication-key {authentication-key | hash-key} [hash | hash2]
                — no authentication-key
                — [no] bfd-enable
                — [no] graceful-shutdown
                — hello-interval milli-seconds
                — no hello-interval
                — implicit-null-label {enable | disable}
                — no implicit-null-label
                — [no] refresh-reduction
                    — [no] reliable-delivery
                — [no] shutdown
                — subscription percentage
                — no subscription
            — [no] keep-multiplier number
            — no keep-multiplier
            — [no] msg-pacing
                — max-burst number
                — no max-burst
                — period milli-seconds
                — no period
            — node-id-in-rro {include | exclude}
            — rapid-retransmit-time hundred-milliseconds
            — no rapid-retransmit-time
            — rapid-retry-limit number
            — no rapid-retry-limit
            — refresh-reduction-over-bypass [enable | disable]
            — refresh-time seconds
            — no refresh-time
            — [no] shutdown
```

3.23.1.3 Show Commands

show
— **router**
— **mpls**
— **admin-group** *group-name*
— **bypass-tunnel** [**to** *ip-address*] [**protected-lsp** [*lsp-name*]] [**dynamic** | **manual**] [**detail**]
— **interface** [*ip-int-name* | *ip-address*] [**label-map** [*label*]]
— **interface** [*ip-int-name* | *ip-address*] **statistics**
— **lsp** [*lsp-name*] [**status** {**up** | **down**}] [**from** *ip-address*| **to** *ip-address*] [**detail**] [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]
— **lsp** {**transit** | **terminate**} [**status** {**up** | **down**}] [**from** *ip-address* | **to** *ip-address* | **lsp-name** *name*] [**detail**]
— **lsp count**
— **lsp** [*lsp-name*] **activepath** [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]
— **lsp** [*lsp-name*] **path** [*path-name*] [**status** {**up** | **down**}] [**detail**] [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]
— **lsp** [*lsp-name*] **path** [*path-name*] **mbb** [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]
— **lsp-egress-stats** [**type** *lsp-type*] [**active**] [**template-match**]
— **lsp-egress-stats lsp** *lsp-name*
— **lsp-ingress-stats** [**type** *lsp-type*] [**active**] [**template-match** *SessionNameString* [**sender** *ip-address*]]
— **lsp-ingress-stats lsp** *lsp-name* **sender** *ip-address*
— **lsp-template** [*lsp-template-name*] **bindings**
— **lsp-template** [*lsp-template-name*] **detail**
— **path** [*path-name*] [**lsp-binding**]
— **sr-te-lsp** [*lsp-name*] [**status** {**up** | **down**}] [**detail**] **path** [*path-name*]
— **sr-te-lsp** [*lsp-name*] [**detail**]
— **sr-te-lsp** [*sp-name*] [**status** {**up** | **down**}] [**to** *ip-address*] [**detail**]
— **static-lsp** [*lsp-name*]
— **static-lsp** [*lsp-type*]
— **static-lsp count**
— **srlg-group** [*group-name*]
— **status**

show
— **router**
— **mpls-labels**
— **label** *start-label* [*end-label* | **in-use** | *label-owner*]
— **label-range**
— **summary**

show
— **router**
— **rsvp**
— **interface** [*ip-int-name* | *ip-address*] **statistics** [**detail**]
— **neighbor** [*ip-address*] [**detail**]
— **session** [*session-type*] [**from** *ip-address*| **to** *ip-address*| **lsp-name** *name*] [**status** {**up** | **down**}] [**detail**]
— **statistics**
— **status**

3.23.1.4 Clear Commands

```
clear
    — router
        — mpls
            — interface [ip-int-name] [statistics]
            — lsp [lsp-name]
            — lsp-egress-stats [lsp-name]
            — lsp-ingress-stats [ip-address lsp lsp-name]
        — rsvp
            — interface [ip-int-name] [statistics]
            — statistics
```

3.23.1.5 Debug Commands

```
debug
    — router
        — [no] mpls [lsp lsp-name] [sender source-address] [endpoint endpoint-address] [tunnel-id tunnel-id] [lsp-id lsp-id] [interface ip-int-name]
            — [no] event
                — all [detail]
                — no all
                — frr [detail]
                — no frr
                — iom [detail]
                — no iom
                — lsp-setup [detail]
                — no lsp-setup
                — mbb [detail]
                — no mbb
                — misc [detail]
                — no misc
                — xc [detail]
                — no xc
        — [no] rsvp [lsp lsp-name] [sender sender-address] [endpoint endpoint-address] [tunnel-id tunnel-id] [lsp-id lsp-id] [interface ip-int-name]
            — [no] event
                — all [detail]
                — no all
                — auth
                — no auth
                — misc [detail]
                — no misc
                — nbr [detail]
                — no nbr
                — path [detail]
                — no path
                — resv [detail]
                — no resv
```

— **rr**
— **no rr**
— [**no**] **packet**
— **ack** [**detail**]
— **no ack**
— **all** [**detail**]
— **no all**
— **bundle** [**detail**]
— **no bundle**
— **hello** [**detail**]
— **no hello**
— **path** [**detail**]
— **no path**
— **patherr** [**detail**]
— **no patherr**
— **pathtear** [**detail**]
— **no pathtear**
— **resv** [**detail**]
— **no resv**
— **resverr** [**detail**]
— **no resverr**
— **resvtear** [**detail**]
— **no resvtear**
— **srefresh** [**detail**]
— **no srefresh**

3.23.2 Command Descriptions

3.23.2.1 Configuration Commands (MPLS)

- Generic Commands
- MPLS Global Commands
- RSVP LSP Statistics Commands
- Interface Commands
- Interface Label-Map Commands
- LSP and LSP Template Commands
- Primary and Secondary Path Commands
- LSP Path Commands
- Static LSP Commands

3.23.2.1.1 Generic Commands

shutdown

Syntax [**no**] **shutdown**

Context config>router>mpls
config>router>mpls>ingress-statistics>lsp
config>router>mpls>interface
config>router>mpls>if>label-map
config>router>mpls>lsp>egress-statistics
config>router>mpls>path
config>router>mpls>static-lsp

Description The **shutdown** command administratively disables an entity. The operational state of the entity is disabled as well as the operational state of any entities contained within. When disabled, an entity does not change, reset, or remove any configuration settings or statistics. Many objects must be shut down before they can be deleted. Many entities must be explicitly enabled using the **no shutdown** command.

In the **label-map** context, all packets that match the specified *in-label* are dropped when the label map is shut down.

In the **path** context, this command disables the existing LSPs using this path. All services using these LSPs are affected. Binding information, however, is retained in those LSPs. Paths are created in the **shutdown** state.

The **no** form of this command places the entity into an administratively enabled state. In the **mpls** and **mpls>interface** contexts, this triggers any LSPs that were previously defined under the associated context to come back up. In the **path** context, the **no** form of this command administratively enables the path and all LSPs—where the path is defined as a primary or a standby secondary path—are (re)established.

Default mpls — no shutdown

interface — shutdown

label-map — no shutdown

path — shutdown

static-lsp — shutdown

3.23.2.1.2 MPLS Global Commands

mpls

Syntax [**no**] **mpls**

Context config>router

Description This command creates the MPLS protocol instance and enables MPLS configuration. The MPLS protocol instance is not created by default, but once it is created, a **no shutdown** command is not required since MPLS is enabled automatically. The **shutdown** command administratively disables MPLS.

The **no** form of this command deletes this MPLS protocol instance and all configuration parameters for this MPLS instance.

MPLS must be shut down and all SDP bindings to LSPs removed before the MPLS instance can be deleted. If MPLS is not shut down, when the **no mpls** command is executed, a warning message on the console indicates that MPLS is still administratively up.

admin-group-frr

Syntax [**no**] **admin-group-frr**

Context config>router>mpls

Description This command enables the use of admin-group constraints in the association of a manual or dynamic bypass LSP with the primary LSP path at a Point-of-Local Repair (PLR) node.

When this command is enabled, each PLR node reads the admin-group constraints in the FAST_REROUTE object in the PATH message of the LSP primary path. If the FAST_REROUTE object is not included in the PATH message, the PLR reads the admin-group constraints from the SESSION_ATTRIBUTE object in the PATH message.

If the PLR is also the ingress LER for the LSP primary path, it only uses the admin-group constraint from the LSP and/or path level configurations.

The PLR node then uses the admin-group constraints along with other constraints, such as hop-limit and SRLG, to select a manual or dynamic bypass LSP among those that are already in use.

If none of the manual or dynamic bypass LSPs satisfies the admin-group constraints and/or the other constraints, the PLR node will request CSPF for a path that merges the closest to the protected link or node and includes or excludes the specified admin-group IDs.

Changes to this command (enabling or disabling) will apply only to new attempts to find a valid bypass.

The **no** form of this command disables the use of administrative group constraints on a FRR backup LSP at a PLR node.

Default no admin-group-frr

auto-lsp

Syntax **auto-lsp lsp-template** *template-name* {**policy** *peer-prefix-policy* [*peer-prefix-policy*...(up to 5 max)] | **one-hop**}
no auto-lsp lsp-template *template-name*

Context config>router>mpls

Description This command enables the automatic creation of an RSVP-TE point-to-point LSP within a single IGP IS-IS level or OSPF area that can subsequently be used by services and/or IGP shortcuts. It can be used to create an RSVP-TE LSP mesh to a destination node whose router ID matches a prefix in a specified previously created peer prefix policy, or to create single-hop RSVP-TE LSPs. These LSP types are referred to as auto-LSP of type mesh or auto-LSP of type one-hop.

Multiple templates can be associated with the same or different peer prefix policies. Each application of an LSP template with a given prefix in the prefix list results in the instantiation of a single CSPF-computed LSP primary path using the LSP template parameters, as long as the prefix corresponds to a router ID for a node in the TE database. Auto LSP does not support the automatic signaling of a secondary path for an LSP. If the signaling of multiple LSPs to the same destination node is required, a separate LSP template must be associated with a prefix list that contains the same destination node address. Each instantiated LSP will have a unique LSP ID and a unique tunnel ID. Auto LSP also does not support the signaling of a non-CSPF LSP. The selection of the **no cspf** option in the LSP template is blocked.

Up to five peer prefix policies can be associated with an LSP template. Every time the user executes the above command with the same or different prefix policy associations or a prefix policy associated with the LSP template, the system re-evaluates the prefix policy. The outcome of the re-evaluation indicates to MPLS whether an existing LSP must be torn down or a new LSP must be signaled to a destination address that is already in the TE database.

If a /32 prefix is added to or removed from a prefix list associated with the template, or if a prefix range is expanded or narrowed, the prefix policy re-evaluation described above is performed.

A **no shutdown** of the template must be performed before it takes effect. When a template is in use, it must be shut down before the user can make any changes to the parameters except for LSP parameters for which the change can be handled with the Make-Before-Break (MBB) procedures. This includes **fast-reroute** with or without the **hop-limit** or **node-protect** options. When the template is shut down and parameters are added, removed or modified, the existing instances of the LSP using this template are torn down and resignaled.

The trigger to signal the LSP is when the router with a router ID matching a prefix in the prefix list appears in the TE database. The signaled LSP is installed in the Tunnel Table Manager (TTM) and is available to applications such as resolution of BGP label routes, and resolution of BGP, IGP, and static routes. It can also be used for auto-binding by a VPRN service but cannot be used as a provisioned SDP for explicit binding.

Except for the MBB limitations to the configuration parameter change in the LSP template, MBB procedures for manual and timer-based resignaling of the LSP, and for TE graceful shutdown, are supported.

The **one-to-one** option under fast-reroute is not supported.

If the **one-hop** option is specified instead of a prefix policy, this command enables the automatic signaling of single-hop, point-to-point LSPs using the specified template to all directly connected neighbors. This LSP type is referred to as auto LSP of type **one-hop**. When the above command is executed, the TE database keeps track of each TE link to a directly connected IGP neighbor whose router ID is discovered. It then instructs MPLS to signal an LSP with a destination address matching the router ID of the neighbor and with a strict hop consisting of the address of the interface used by the TE link. This results in one or more LSPs signaled to the neighboring router.

For an LSP mesh, the **no** form of this command deletes all LSPs signaled using the specified template and prefix policy. When the **one-hop** option is used, the **no** form of the command deletes all single-hop LSPs signaled using the specified template to all directly connected neighbors.

Default n/a

Parameters *template-name* — specifies an LSP template name

one-hop — specifies that the template type is one-hop LSP, rather than LSP mesh

peer-prefix-policy — specifies a peer prefix policy name. The prefix policy must already be defined.

bypass-resignal-timer

Syntax **bypass-resignal-timer** *minutes*
no bypass-resignal-timer

Context config>router>mpls

Description This command triggers the periodic global reoptimization of all dynamic bypass LSP paths associated with RSVP point-to-point LSPs. The operation is performed at each expiry of the timer.

The **no** form of this command disables the periodic global re-optimization of dynamic bypass LSP paths.

Default no bypass-resignal-timer

Parameters *minutes* — the time that MPLS waits before attempting to resignal dynamic bypass LSP paths originated on the system

Values 30 to 10080

cspf-on-loose-hop

Syntax [**no**] **cspf-on-loose-hop**

Context config>router>mpls

Description This command enables the option to perform CSPF calculations to the next loose hop or the final destination of the LSP on the LSR. On receiving a PATH message on the LSR and processing all local hops in the received ERO, if the next hop is loose, then the LSR does a CSPF calculation to the next loose hop (this is known as ERO expansion). On successful completion of the CSPF calculation, the ERO in the PATH message is modified to include the newly calculated intermediate hops and the message is propagated forward to the next hop. This allows for the setting up of inter-area LSPs based on the ERO expansion method.

The LSP may fail to set up if this option is enabled on an LSR that is not an ABR and that receives a PATH message without a proper next loose hop in the ERO. The **cspf-on-loose-hop** configuration can change dynamically and is applied to the new LSP setup after changes are made.

Default no cspf-on-loose-hop

dynamic-bypass

Syntax **dynamic-bypass** [**enable** | **disable**]

Context config>router>mpls

Description This command disables the creation of dynamic bypass LSPs in FRR. One or more manual bypass LSPs must be configured to protect the primary LSP path at the PLR nodes.

Default enable

entropy-label

Syntax **entropy-label rsvp-te** {**force-disable** | **enable**}
entropy-label sr-te {**force-disable** | **enable**}

Context config>router>mpls

Description This command enables or disables the use of entropy labels for MPLS RSVP-TE and SR-TE LSPs.

If **entropy-label** is enabled, the entropy label and entropy label indicator (ELI) are inserted in the label stack. In some cases, this may result in an unsupported label stack depth or large changes in the label stack depth during the lifetime of an LSP (for example, due to switching from a primary path with entropy label capability (ELC) enabled to a secondary path for which the far end has not signaled ELC).

This command provides local control at the head end of an RSVP-TE or SR-TE LSP over whether an entropy label is inserted on the LSP by overriding the ELC signaled from the far-end LER, and control over how the additional label stack depth is accounted for.

By default, the value of **entropy-label** is inherited from the MPLS level. This command overrides the default MPLS behavior on a per-LSP basis. For auto-LSPs, it can only be configured in LSP templates of type **one-hop-p2p** and **mesh-p2p**.

When the value of **entropy-label** changes at either the MPLS level or the LSP level, the new operational value does not take effect until the LSP is resignaled. A **shutdown/no shutdown** command must be performed on the LSP to enable the new value.

The user can use the **clear** command or bounce MPLS using the **shutdown/no shutdown** command to force the new value to take effect for a large numbers of LSPs.

Default entropy-label disable

Parameters **rsvp-te** — indicates that the **entropy-label** command applies to RSVP-TE LSPs

sr-te — indicates that the **entropy-label** command applies to SR-TE LSPs

force-disable — the ingress LER will not consider the entropy label or the ELI in the label stack while sending the information to the TTM and NHLFE. The system will mark the TTM and NHLFE as ELC not supported, and applications will not insert an entropy label or ELI in the label stack.

enable — the ingress LER will take into consideration what is signaled from the egress node for ELC for marking the NHLFE, while the TTM is always marked. Although applications will only insert the entropy label if the far end signals ELC, the additional two labels of the entropy label and ELI are always accounted for.

frr-object

Syntax [**no**] **frr-object**

Context config>router>mpls

Description This command specifies whether signaling the FAST_REROUTE object is on or off. The value is ignored if fast reroute is disabled for the LSP or if the LSP is using one-to-one backup.

Default frr-object — by default, the value is inherited by all LSPs

hold-timer

Syntax **hold-timer** *seconds*
no hold-timer

Context config>router>mpls

Description This command specifies the amount of time that the ingress node waits before programming its data plane and declaring to the service module that the LSP status is up.

The **no** form of the command disables the hold-timer.

Parameters *seconds* — specifies the hold time, in seconds

Values 0 to 10

least-fill-min-thd

Syntax **least-fill-min-thd** *percent*
no least-fill-min-thd

Context config>router>mpls

Description This parameter is used in the least-fill path selection process. See the description of the least-fill command for information on the least-fill path selection process. When comparing the percentages of least available link bandwidth across the available paths, whenever two percentages differ by less than the value configured as the least-fill minimum threshold, CSPF considers them to be equal and applies a random number generator to select the path.

The **no** form of the command resets this parameter to its default value.

Default 5

Parameters *percent* — specifies the least fill minimum threshold value as a percentage

Values 1 to 100

least-fill-reoptim-thd

Syntax **least-fill-reoptim-thd** *percent*
no least-fill-reoptim-thd

Context config>router>mpls

Description This parameter is used in the least-fill path selection process. See the description of the least-fill command for information on the least-fill path selection process.

During a timer-based resignaling of an LSP path that has the least-fill option enabled, CSPF first updates the least-available bandwidth value for the current path of this LSP. It then applies the least-fill path selection method to select a new path for this LSP. If the new computed path has the same cost as the current path, CSPF compares the least-available bandwidth values of the two paths and if the difference exceeds the user-configured optimization threshold, MPLS generates a trap to indicate that a better least-fill path is available for this LSP. This trap can be used by an external SNMP-based device to trigger a manual resignaling of the LSP path, since the timer-based resignaling will not resignal the path in this case. MPLS generates a path update trap at the first MBB event that results in the resignaling of the LSP path. This clears the eligibility status of the path at the SNMP device.

The **no** form of the command resets this parameter to its default value.

Default 10

Parameters *percent* — specifies the least fill reoptimization threshold value as a percentage

Values 1 to 100

logger-event-bundling

Syntax [**no**] **logger-event-bundling**

Context config>router>mpls

Description This command merges two of the most commonly generated MPLS traps, vRtrMplsXCCreate and vRtrMplsXCDelete, which can be generated at both the LER and LSR, into the new vRtrMplsSessionsModified trap. In addition, this command bundles traps of multiple RSVP sessions, such as LSPs, into this new trap.

This trap bundling allows the user to minimize trap generation in an MPLS network. MPLS trap throttling is not applied to the vRtrMplsSessionsModified trap.

The **no** version of the command disables the merging and bundling of the vRtrMplsXCCreate and vRtrMplsXCDelete traps.

pce-report

Syntax **pce-report rsvp-te** {**enable** | **disable**}
pce-report sr-te {**enable** | **disable**}

Context config>router>mpls

Description This command separately configures the reporting modes to a PCE for RSVP-TE or SR-TE LSPs.

The PCC LSP database is synchronized with the PCE LSP database using the PCEP PCRpt (PCE Report) message for PCC-controlled, PCE-computed, and PCE-controlled LSPs.

The global MPLS-level **pce-report** command can be used to enable or disable PCE reporting for all SR-TE LSPs or RSVP-TE LSPs during PCE LSP database synchronization. This configuration is inherited by all LSPs of a particular type (RSVP-TE LSPs or SR-TE LSPs). The PCC reports both CSPF and non-CSPF LSPs.

The LSP-level **pce-report** command overrides the global configuration for the reporting of an LSP to the PCE (see **config>router>mpls>lsp>**pce-report). The default configuration is to inherit the global MPLS-level configuration.

The default configuration is disabled. This default configuration is meant to control the introduction of a PCE into an existing network and let the operator decide whether all RSVP-TE LSPs or SR-TE LSPs need to be reported. If PCE reporting is disabled for an LSP, either due to inheritance of the global MPLS configuration or due to LSP-level configuration, enabling the **pce-control** option for the LSP has no effect.

Default pce-report rsvp-te disable

pce-report sr-te disable

Parameters **rsvp-te** {**enable** | **disable**} — specifies to enable or disable PCE reporting for all RSVP-TE LSPs

sr-te {**enable** | **disable**} — specifies to enable or disable PCE reporting for all SR-TE LSPs

resignal-timer

Syntax **resignal-timer** *minutes*
no resignal-timer

Context config>router>mpls

Description This command specifies the value for the LSP resignal timer. The resignal timer is the time, in minutes, that the 7705 SAR software waits before attempting to resignal the LSPs.

When the resignal timer expires, if the newly computed path for an LSP has a better metric than that for the currently recorded hop list, an attempt is made to resignal that LSP using the make-before-break (MBB) mechanism. If the attempt to resignal an LSP fails, the LSP will continue to use the existing path and a resignal will be attempted the next time the timer expires.

When the resignal timer expires, a trap and syslog message are generated.

The **no** form of the command disables timer-based LSP resignaling.

Default no resignal-timer

Parameters *minutes* — specifies the time the software waits before attempting to resignal the LSPs, in minutes

Values 30 to 10080

srlg-frr

Syntax **srlg-frr** [**strict**]
no srlg-frr

Context config>router>mpls

Description This system-wide command enables or disables the use of the shared risk link group (SRLG) constraint in the computation of an FRR bypass or detour LSP for any primary LSP path on the system. When **srlg-frr** is enabled, CSPF includes the SRLG constraint in the computation of an FRR bypass or detour LSP for protecting the primary LSP path.

The **strict** option is a system-wide option that forces the CSPF to consider any configured SRLG membership lists in its calculation of every LSP path.

CSPF and FRR

CSPF prunes all links with interfaces that belong to the same SRLG as the interface being protected, where the interface being protected is the outgoing interface at the PLR used by the primary path.

If one or more paths are found, the MPLS/RSVP-TE task selects one path based on best cost and signals the setup of the FRR bypass or detour LSP. If no path is found and the user included the **strict** option, the FRR bypass or detour LSP is not set up and the MPLS/RSVP-TE task keeps retrying the request to CSPF. If no path is found and the **strict** option is disabled, if a path exists that meets all the TE constraints except the SRLG constraint, then the FRR bypass or detour LSP is set up.

An FRR bypass or detour LSP is not guaranteed to be SRLG disjoint from the primary path. This is because only the SRLG constraint of the outgoing interface at the PLR that the primary path is using is checked.

When the MPLS/RSVP-TE task is searching for an SRLG bypass tunnel to associate with the primary path of the protected LSP, the task does the following steps.

- First, the task checks for any configured manual bypass LSP that has CSPF enabled and that satisfies the SRLG constraints.
- The task skips any non-CSPF bypass LSP since there is no ERO returned with which to check the SRLG constraint.
- If no path is found, the task checks for an existing dynamic bypass LSP that satisfies the SRLG and other primary path constraints.
- If no bypass path is found, then the task makes a request to CSPF to try to create one.

Primary Path and FRR Behavior

Once the primary path of the LSP is set up and is operationally up, any subsequent changes to the SRLG membership of an interface that the primary path is using will not be considered by the MPLS/RSVP-TE task at the PLR for FRR bypass or detour LSP association until the next opportunity that the primary path is resignaled. The path may be resignaled due to a failure or to a make-before-break (MBB) operation. A make-before-break operation occurs as a result of a global revertive operation, a reoptimization of the LSP path (timer-based or manual), or a change by the user to any of the path constraints.

Once the FRR bypass or detour LSP is set up and is operationally up, any subsequent change to the SRLG membership of an interface that the FRR bypass or detour LSP is using will not be considered by the MPLS/RSVP-TE task at the PLR until the next opportunity that the association with the primary LSP path is rechecked. The association is rechecked if the FRR bypass or detour LSP is reoptimized. Detour routes are not reoptimized and are resignaled if the primary path is down.

The user must first shut down MPLS before enabling or disabling the **srlg-frr** option in CLI.

An RSVP-TE interface can belong to a maximum of 64 SRLGs. The user creates SRLGs using the **config>router>mpls>srlg-group** command. The user associates the SRLGs with an RSVP-TE interface using the **srlg-group** command in the **config>router>mpls>interface** context.

The **no** form of the command reverts to the default value.

Default no srlg-frr

Parameters **strict** — specifies that the CSPF calculation for the FRR backup must include the SRLG constraint and the backup must be on the resulting list of eligible backup paths

Values non-strict:srlg-frr
strict:srlg-frr **strict**

3.23.2.1.3 RSVP LSP Statistics Commands

ingress-statistics

Syntax **ingress-statistics**

Context config>router>mpls

Description This command enters the context to configure LSP ingress statistics.

Default n/a

lsp

Syntax [**no**] **lsp** *lsp-name* **sender** *ip-address*

Context config>router>mpls>ingress-statistics

Description This command configures statistics in the ingress data path of a terminating RSVP LSP at an egress LER. The LSP name must correspond to the name configured by the user at the ingress LER. It must not contain a colon (:), which is used as a field separator by the ingress LER for encoding the LSP and path names into the RSVP Session Name field in the Session_Attribute object. The user must also execute the **no shutdown** command in this context to enable statistics collection.

The **no** form of this command disables statistics for this RSVP LSP in the ingress data path and removes the accounting policy association from the LSP.

Default n/a

Parameters *lsp-name* — the LSP name as configured at the ingress LER, up to 32 characters in length

ip-address — the IP address of the ingress LER for the LSP

accounting-policy

Syntax **accounting-policy** *policy-id*
no accounting-policy

Context config>router>mpls>ingr-stats>lsp
config>router>mpls>lsp>egress-statistics

Description This command associates an accounting policy with an RSVP LSP. Only one accounting policy at a time can be associated with an RSVP LSP on a particular node.

An accounting policy must first be configured in the **config>log>accounting-policy** context before it can be associated; otherwise an error message is generated.

The **no** form of this command removes the accounting policy association.

Default no accounting-policy

Parameters *policy-id* — the accounting policy ID

Values 1 to 99

collect-stats

Syntax [**no**] **collect-stats**

Context config>router>mpls>ingr-stats>lsp
config>router>mpls>lsp>egress-statistics

Description This command enables accounting and statistical data collection.

The collected statistic counters can be retrieved via **show** and **monitor** commands or with the SNMPv3 interface. The counters can be saved to an accounting file if the specific statistics collection record is included in the default accounting policy or in a user-defined accounting policy.

If the **no collect-stats** command is issued, the statistics are still accumulated by the forwarding engine. However, the CPU will not obtain the results and write them to the accounting file. If a subsequent **collect-stats** command is issued, then the counters written to the accounting file will include all the traffic that went through while the **no collect-stats** command was in effect.

Default no collect-stats

egress-statistics

Syntax [**no**] **egress-statistics**

Context config>router>mpls>lsp

Description This command configures statistics in the egress data path of an originating LSP at a head-end node. The user must also execute the **no shutdown** command in this context to enable statistics collection.

The **no** form of this command disables the statistics in the egress data path and removes the accounting policy association from the RSVP LSP.

Default no egress-statistics

3.23.2.1.4 Interface Commands

interface

Syntax [**no**] **interface** *ip-int-name*

Context config>router>mpls

Description This command enables MPLS protocol support on an IP interface. MPLS commands are not executed on an IP interface where MPLS is not enabled.

The **no** form of this command deletes all MPLS commands that are defined under the interface, such as **label-map**. The interface must be shut down before it can be deleted. If the interface is not shut down, the **no interface** *ip-int-name* command issues a warning message on the console indicating that the interface is administratively up.

Default shutdown

Parameters *ip-int-name* — identifies the network IP interface. The interface name character string cannot be in the form of an IP address. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

admin-group

Syntax [**no**] **admin-group** *group-name* [*group-name*...(up to 5 max)]

Context config>router>mpls>interface

Description This command associates admin groups with this interface. The admin group must already be defined in the **config>router>if-attribute** context (refer to the 7705 SAR Router Configuration Guide, “IP Router Command Reference”).

Up to five groups can be specified with one command. When an admin group is bound to one or more interfaces, its value cannot be changed until all bindings are removed.

When associated with MPLS interfaces, the interfaces can be included or excluded in the LSP path definition by matching on the admin-group name. CSPF will calculate a path that satisfies the admin-group include and exclude constraints.

The configured admin-group membership is applied in all levels or areas that the interface is participating in. The same interface cannot have different memberships in different levels or areas.

The admin groups bound to an MPLS interface are advertised area-wide in TE link TLVs and sub-TLVs when the traffic-engineering option is enabled in IS-IS or OSPF.

The **no** form of this command deletes the association of this interface with one or more of the admin groups.

Default no admin-group

Parameters *group-name* — specifies the name of the group. The group names should be the same across all routers in the MPLS domain.

srlg-group

Syntax [**no**] **srlg-group** *group-name* [*group-name*...(up to 5 max)]

Context config>router>mpls>interface

Description This command associates an MPLS interface with one or more SRLGs. The SRLG must already be defined in the **config>router>if-attribute** context (refer to the 7705 SAR Router Configuration Guide, “IP Router Command Reference”).

Up to five SRLGs can be specified with one command. When an SRLG is bound to one or more interfaces, its value cannot be changed until all bindings are removed.

When SRLGs are associated with MPLS interfaces, CSPF at an LER will exclude the SRLGs of interfaces used by the LSP primary path when calculating the route of the secondary path. CSPF at an LER or LSR will also exclude the SRLGs of the outgoing interface of the primary LSP path in the calculation of the path of the FRR backup LSP. This provides a path disjoint between the primary path and the secondary path or FRR backup path of an LSP.

The configured SRLG membership is applied in all levels or areas that the interface is participating in. The same interface cannot have different memberships in different levels or areas.

SRLGs bound to an MPLS interface are advertised area-wide in TE link TLVs and sub-TLVs when the traffic-engineering option is enabled in IS-IS or OSPF.

The **no** form of this command deletes the association of this interface with one or more of the SRLGs.

Default n/a

Parameters *group-name* — specifies the name of the SRLG. The group names should be the same across all routers in the MPLS domain.

te-metric

Syntax **te-metric** *value*
no te-metric

Context config>router>mpls>interface

Description This command configures the traffic engineering metric used on the interface. This metric is in addition to the interface metric used by IGP for the shortest path computation.

This metric is flooded as part of the TE parameters for the interface using an opaque LSA or an LSP. The OSPF-TE metric is encoded as a sub-TLV type 5 in the Link TLV. The metric value is encoded as a 32-bit unsigned integer. The IS-IS-TE metric is encoded as sub-TLV type 18 as part of the extended IS reachability TLV. The metric value is encoded as a 24-bit unsigned integer.

When the use of the TE metric is enabled for an LSP, CSPF will first prune all links in the network topology that do not meet the constraints specified for the LSP path. Such constraints include bandwidth, admin-groups, and hop limit. Then, CSPF will run an SPF on the remaining links. The shortest path among the all SPF paths will be selected based on the TE metric instead of the IGP metric, which is used by default.

The TE metric in CSPF LSP path computation can be configured by entering the command **config>router>mpls>lsp** *lsp-name*>**cspf use-te-metric**.

The TE metric is only used in CSPF computations for MPLS paths and not in the regular SPF computation for IP reachability.

The **no** form of the command reverts to the default value.

Default no te-metric

Parameters *value* — 1 to 16777215

3.23.2.1.5 Interface Label-Map Commands

label-map

Syntax [**no**] **label-map** *in-label*

Context config>router>mpls>interface

Description This command is used on either transit or egress LSP routers when a static LSP is defined. The static LSP on the ingress router is initiated using the **config>router>mpls>static-lsp** *lsp-name* command. The *in-label* is associated with a **pop** action or a **swap** action, but not both. If both actions are specified, the last action specified takes effect.

The **no** form of this command deletes the static LSP configuration associated with the *in-label*.

Parameters *in-label* — specifies the incoming MPLS label on which to match

Values 32 to 1023

pop

Syntax [**no**] **pop**

Context config>router>mpls>if>label-map

Description This command specifies that the incoming label must be popped (removed). No label stacking is supported for a static LSP. The service header follows the top label. Once the label is popped, the packet is forwarded based on the service header.

The **no** form of this command removes the **pop** action for the *in-label*.

Default n/a

swap

Syntax **swap** *out-label* **nexthop** *ip-address*
no swap

Context config>router>mpls>if>label-map

Description This command swaps the incoming label and specifies the outgoing label and next-hop IP address on an LSR for a static LSP.

The **no** form of this command removes the swap action associated with the *in-label*.

Default n/a

Parameters *out-label* — specifies the label value to be swapped with the *in-label*. Label values 16 through 1048575 are defined as follows:

Label values 16 through 31 are 7705 SAR reserved

Label values 32 through 1023 are available for static assignment

Label values 1024 through 2047 are reserved for future use

Label values 2048 through 18431 are statically assigned for services

Label values 28672 through 131071 are dynamically assigned for both MPLS and services

Label values 131072 through 1048575 are reserved for future use

Values 16 to 1048575

ip-address — specifies the IP address to forward to. If an ARP entry for the next hop exists, then the static LSP will be marked operational. If an ARP entry does not exist, software will set the operational status of the static LSP to down and continue to ARP for the configured next-hop at a fixed interval.

3.23.2.1.6 LSP and LSP Template Commands

lsp

Syntax [**no**] **lsp** *lsp-name* [**bypass-only** | **sr-te**]

Context config>router>mpls

Description This command creates an LSP that is signaled dynamically by the 7705 SAR.

When the LSP is created, the egress router must be specified using the **to** command and at least one **primary** or **secondary** path must be specified. All other statements under the LSP hierarchy are optional. For SR-TE, secondary paths are not supported.

LSPs are created in the administratively down (**shutdown**) state.

The **no** form of this command deletes the LSP. All configuration information associated with this LSP is lost. The LSP must be administratively shut down and unbound from all SDPs before it can be deleted.

Default n/a

Parameters *lsp-name* — specifies the name that identifies the LSP. The LSP name can be up to 32 characters long and must be unique.

bypass-only — defines an LSP as a manual bypass LSP exclusively. When a PATH message for a new LSP requests bypass protection, the PLR first checks if a manual bypass tunnel satisfying the path constraints exists. If one is found, the 7705 SAR selects it. If no manual bypass tunnel is found, the 7705 SAR dynamically signals a bypass LSP as the default behavior. The CLI for this feature includes a command that provides the user with the option to disable dynamic bypass creation on a per-node basis.

sr-te — defines an LSP as a segment routing LSP exclusively.

lsp-template

Syntax **lsp-template** *template-name*
lsp-template *template-name* **mesh-p2p**
lsp-template *template-name* **one-hop-p2p**
no lsp-template *template-name*

Context config>router>mpls

Description This command creates an LSP template that is referenced when dynamic LSP creation is required. The LSP template type, **mesh-p2p** or **one-hop-p2p**, must be specified when the template is first created.

The **no** form of this command deletes the LSP template. The LSP template cannot be deleted if a client application is using it.

Parameters *template-name* — specifies an LSP template name up to 32 characters in length. The LSP template name and the LSP name cannot be the same.

mesh-p2p | **one-hop-p2p** — This command specifies the type of LSP the template signals

adaptive

Syntax [**no**] **adaptive**

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command enables the make-before-break (MBB) functionality for an LSP, LSP path, or LSP instance created using an LSP template. When enabled for the LSP, a make-before-break operation will be performed for the primary path and all the secondary paths of the LSP.

Default adaptive

adspec

Syntax [**no**] **adspec**

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description When enabled, the advertised data (ADSPEC) object will be included in RSVP-TE messages.

Default no adspec

bgp-transport-tunnel

Syntax **bgp-transport-tunnel** {**include** | **exclude**}

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command allows an RSVP-TE LSP to be used as a transport LSP for BGP tunnel routes or blocks it from being used.

Default include

Parameters **include** — allows an RSVP-TE LSP to be used as a transport LSP from the ASBR to a local PE router, from an ingress PE to the ASBR in the local AS or between multihop EBGP peers with ASBR-to-ASBR adjacency

exclude — blocks an RSVP-TE LSP from being used as a transport LSP from the ASBR to a local PE router, from an ingress PE to the ASBR in the local AS or between multihop EBGP peers with ASBR-to-ASBR adjacency

cspf

Syntax [**no**] **cspf** [**use-te-metric**]

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command enables Constrained Shortest Path First (CSPF) computation for constrained-path LSPs. Constrained-path LSPs are the LSPs that take configuration constraints into account. CSPF is also used to calculate the FRR bypass or detour LSP routes when fast reroute is enabled.

Explicitly configured LSPs where each hop from ingress to egress is specified do not use CSPF. The LSP is set up using RSVP-TE signaling from ingress to egress.

If an LSP is configured with **fast-reroute** specified but does not enable CSPF, neither global revertive nor local revertive will be available for the LSP to recover.

When an LSP template is created, CSPF is automatically enabled and cannot be disabled.

Default no cspf

Parameters **use-te-metric** — specifies to use the TE metric for the purpose of the LSP path computation by CSPF

default-path

Syntax **default-path** *path-name*

Context config>router>mpls>lsp-template

Description This command specifies the default path to be used for signaling an LSP created using the LSP template. You must reference a default path before the template is put in a **no shutdown** state.

Parameters *path-name* — specifies the default path name to be used

entropy-label

Syntax **entropy-label** {**force-disable** | **inherit** | **enable**}

Context config>router>mpls>lsp

Description This command configures the use of entropy labels for an LSP.

If **entropy-label** is enabled, the entropy label and entropy label indicator (ELI) are inserted in the label stack. In some cases, this may result in an unsupported label stack depth or large changes in the label stack depth during the lifetime of an LSP (for example, due to switching from a primary path with ELC enabled to a secondary path for which the far end has not signaled ELC).

This command provides local control at the head end of an RSVP LSP over whether an entropy label is inserted on an LSP by overriding the ELC signaled from the far-end LER, and control over how the additional label stack depth is accounted for.

By default, the value of **entropy-label** is inherited from the MPLS level. This command overrides the default MPLS behavior on a per-LSP basis. For auto-LSPs, it can only be configured in LSP templates of type one-hop-p2p and mesh-p2p.

Under the LSP context, when the value of **entropy-label** is set to **enable**, the ingress LER considers what is signaled from the egress node for ELC when marking the NHLFE as entropy-label-capable. When the value of **entropy-label** is set to **enable** at the LSP level, the system always marks the LSP as entropy label-capable regardless of the signaled value, in order to ensure that the potential additional label stack depth is accounted for. In this scenario, the TTM and NHLFE can be out of synchronization based on what is configured at the egress node. That is, the application will always account for the entropy label and ELI in the label stack without taking into consideration the signaled value of the ELC.

When the value of **entropy-label** changes at either the MPLS level or the LSP level, the new operational value does not take effect until the LSP is resignaled. A **shutdown/no shutdown** command must be performed to enable the new value.

The user can use the **clear** command or bounce MPLS using the **shutdown/no shutdown** command to force the new value to take effect for a large numbers of LSPs.

Default entropy-label inherit

Parameters **force-disable** — the ingress LER will not consider the entropy label and ELI in the label stack while sending the information to the TTM and NHLFE. The system will mark the TTM and NHLFE as ELC not supported, and applications will not insert an entropy label or entropy label indicator in the label stack.

inherit — the value of **entropy-label** is inherited from the setting in the MPLS context

enable — the ingress LER will take into consideration what is signaled from the egress node for ELC for marking the NHLFE, while the TTM is always marked. Although applications will only insert the entropy label if the far end signals ELC, the additional two labels of the entropy label and ELI are always accounted for.

exclude

Syntax [**no**] **exclude** *group-name* [*group-name*...(up to 5 max)]

Context config>router>mpls>lsp
config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary
config>router>mpls>lsp-template

Description This command specifies the admin groups to be excluded when an LSP is set up. Up to 5 groups per operation can be specified, up to 32 maximum. The admin groups are defined in the **config>router>if-attribute** context.

Use the **no** form of the command to remove the exclude command.

Default no exclude

Parameters *group-name* — specifies the existing group name to be excluded when an LSP is set up

fast-reroute

Syntax [**no**] **fast-reroute** [*frr-method*]

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command creates a precomputed protection LSP from each node in the path of the LSP. If a link or LSP failure occurs between two nodes, traffic is immediately rerouted on the precomputed protection LSP. When **fast-reroute** is specified, the default **fast-reroute** method is the one-to-one method.

When **fast-reroute** is enabled, each node along the path of the LSP tries to establish a protection LSP as follows.

- Each upstream node sets up a protection LSP that avoids only the immediate downstream node, and merges back onto the actual path of the LSP as soon as possible.
- If it is not possible to set up a protection LSP that avoids the immediate downstream node, a protection LSP can be set up to the downstream node on a different interface.
- The protection LSP may take one or more hops (see igp-shortcut) before merging back onto the main LSP path.
- When the upstream node detects a downstream link or node failure, the ingress router switches traffic to a standby path if one was set up for the LSP.

FRR is available only for the primary path. No configuration is required on the transit hops of the LSP. The ingress router will signal all intermediate routers using RSVP-TE to set up their protection LSP. TE must be enabled for fast reroute to work.

CSPF must be enabled for fast reroute to work. If an LSP is configured with **fast-reroute** *frr-method* specified but does not enable CSPF, neither global revertive nor local revertive will be available for the LSP to recover.

The one-to-one fast reroute method creates a separate detour LSP for each backed-up LSP. One-to-one is not supported for LSP templates.

The facility fast reroute method, sometimes called many-to-one, takes advantage of the MPLS label stack. Instead of creating a separate LSP for every backed-up LSP, a single LSP is created that serves to back up a set of LSPs. This LSP tunnel is called a bypass tunnel. The bypass tunnel must intersect the path of the original LSPs somewhere downstream of the point of local repair (PLR). This constrains the set of LSPs being backed up via that bypass tunnel to those LSPs that pass through a common downstream node. All LSPs that pass through the PLR and through this common node that do not also use the facilities involved in the bypass tunnel are candidates for this set of LSPs.

The **no** form of the **fast-reroute** command removes the protection LSP from each node on the primary path. This command will also remove configuration information about the hop-limit and the bandwidth for the detour routes.

Default no fast-reroute

Parameters *frr-method* — specifies the fast reroute method to use

Values one-to-one, facility

Default one-to-one

hop-limit

Syntax **hop-limit** *limit*
no hop-limit

Context config>router>mpls>lsp>fast-reroute
config>router>mpls>lsp-template>fast-reroute

Description For fast reroute, this command defines how many more routers a protection tunnel is allowed to traverse compared with the LSP itself. For example, if an LSP traverses four routers, any protection tunnel for the LSP can be no more than 10 router hops, including the ingress and egress routers.

The **no** form of the command reverts to the default value.

Default 16

Parameters *limit* — specifies the maximum number of hops

Values 0 to 255

node-protect

Syntax [**no**] **node-protect**

Context config>router>mpls>lsp>fast-reroute
config>router>mpls>lsp-template>fast-reroute

Description This command enables or disables node and link protection on the specified LSP. Node protection ensures that traffic from an LSP traversing a neighboring router will reach its destination even if the neighboring router fails.

When **node-protect** is enabled, the 7705 SAR provides node protection on the specified LSP. If node protection cannot be provided, link protection is attempted. If link protection cannot be provided, there will be no protection.

The **no** form of this command provides link protection. If link protection cannot be provided, there will be no protection.

Default node-protect (for an LSP)

no node-protect (for an LSP template)

propagate-admin-group

Syntax [**no**] **propagate-admin-group**

Context config>router>mpls>lsp>fast-reroute
config>router>mpls>lsp-template>fast-reroute

Description The command enables the signaling of the primary LSP path admin-group constraints in the FAST_REROUTE object at the ingress LER.

When this command is executed, the admin-group constraints configured in the context of the point-to-point LSP primary path, or the constraints configured in the context of the LSP and inherited by the primary path, are copied into the FAST_REROUTE object. The admin-group constraints are copied into the “include-any” or “exclude-any” fields.

The ingress LER propagates these constraints to the downstream nodes during the signaling of the LSP so that the downstream nodes can include the constraints in the selection of the FRR backup LSP for the LSP primary path.

The ingress LER inserts the FAST_REROUTE object by default in a primary LSP PATH message.

The same admin-group constraints can be copied into the SESSION_ATTRIBUTE object using the propagate-admin-group command at the **config>router>mpls>lsp** level. They are intended for the use of an LSR, typically an ABR, to expand the ERO of an inter-area LSP path. They are also used by any LSR node in the path of a CSPF or non-CSPF LSP to check the admin-group constraints against the ERO whether the hop is strict or loose.

The primary path admin-group constraints can be copied into the FAST_REROUTE object only, the SESSION_ATTRIBUTE object only, or both. The PLR rules for processing the admin-group constraints can make use of either of the two objects.

If the FAST_REROUTE object is disabled (no frr-object), the admin-group constraints will not be propagated.

Default no propagate-admin-group

from

Syntax **from** *ip-address*

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command specifies the IP address of the ingress router for the LSP. When this command is not specified, the system IP address is used. IP addresses that are not defined in the system are allowed.

If an invalid IP address is entered, LSP bring-up fails and an error is logged. This command is only allowed for an LSP template of type **mesh-p2p**.

If an interface IP address is specified as the **from** address, and the egress interface of the next-hop IP address is a different interface, the LSP is not signaled. As the egress interface changes due to changes in the routing topology, an LSP recovers if the **from** IP address is the system IP address and not a specific interface IP address.

Only one **from** address can be configured.

Default system IP address

Parameters *ip-address* — specifies the IP address of the ingress router. This can be either the interface or the system IP address. If the IP address is local, the LSP must egress through that local interface, which ensures local strictness.

Values system IP or network interface IP addresses

Default system IP address

hop-limit

Syntax **hop-limit** *number*
no hop-limit

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command specifies the maximum number of hops that an LSP can traverse, including the ingress and egress routers. An LSP is not set up if the hop limit is exceeded. This value can be changed dynamically for an LSP that is already set up, with the following implications:

- If the new value is less than the current number of hops of the established LSP, the LSP is brought down. The 7705 SAR then tries to re-establish the LSP within the new **hop-limit** number. If the new value is equal to or greater than the current number of hops of the established LSP, the LSP is not affected.

The **no** form of this command returns the parameter to the default value.

Default 255 (LSP and LSP mesh template)

2 (one-hop template)

Parameters *number* — specifies the number of hops the LSP can traverse, expressed as an integer

Values 2 to 255

igp-shortcut

Syntax **igp-shortcut** [**lfa-protect** | **lfa-only**] [**relative-metric** [*offset*]]
no igp-shortcut

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command enables the use of an RSVP-TE LSP by OSPF or IS-IS routing protocols as a shortcut or as a forwarding adjacency for resolving IGP routes.

When the **rsvp-shortcut** or the **advertise-tunnel-link** command is enabled at the OSPF or IS-IS instance level, all RSVP-TE LSPs originating on this node are eligible by default as long as the destination address of the LSP, as configured with the **config>router>mpls>lsp>to** command, corresponds to a router ID of a remote node.

If the command is used with no options, and the **rsvp-shortcut** command is enabled, the LSP is included in the main SPF but not in the LFA SPF algorithm. If the **advertise-tunnel-link** command is enabled, the tunnel is advertised as a point-to-point link if it has the best LSP metric, is included in the main SPF if advertised, but is not included in the LFA SPF algorithm.

If the command is used with the **lfa-protect** option, and the **rsvp-shortcut** command is enabled, an LSP can be included in both the main SPF and the LFA SPF algorithm. If the **advertise-tunnel-link** command is enabled, the tunnel is advertised as a point-to-point link if it has the best LSP metric, is included in the main SPF if advertised, and is included in the LFA SPF algorithm whether it is advertised or not.

For a given prefix, the LSP can be used either as a primary next hop or as an LFA next hop, but not both. If the main SPF calculation selects a tunneled primary next hop for a prefix, the LFA SPF calculation will not select an LFA next hop for this prefix and the protection of this prefix will rely on the RSVP-TE LSP FRR protection. If the main SPF calculation selects a direct primary next hop, the LFA SPF calculation will select an LFA next hop for this prefix but will prefer a direct LFA next hop over a tunneled LFA next hop.

If the command is used with the **lfa-only** option, and the **rsvp-shortcut** command is enabled, an LSP can be included in the LFA SPF algorithm only. If the **advertise-tunnel-link** command is enabled, the tunnel is not advertised as a point-to-point link, is not included in the main SPF, and is only included in the LFA SPF algorithm.

When the **lfa-only** option is enabled, the introduction of IGP shortcuts does not affect the main SPF decision. For a given prefix, the main SPF calculation always selects a direct primary next hop. The LFA SPF calculation will select an LFA next hop for this prefix but will prefer a direct LFA next hop over a tunneled LFA next hop.

When the **relative-metric** option is enabled, IGP will apply the shortest IGP cost between the endpoints of the LSP plus the value of the offset (instead of the LSP operational metric) when calculating the cost of a prefix that is resolved to the LSP. The offset value is optional and defaults to zero. The minimum net cost for a prefix is one (1) after applying the offset. The Tunnel Table Manager (TTM) continues to show the LSP operational metric as provided by MPLS; therefore, applications such as BGP and static route shortcuts will continue to use the LSP operational metric.

The **relative-metric** option and the **lfa-protect** or the **lfa-only** options are mutually exclusive. An LSP with the **relative-metric** option enabled cannot be included in the LFA SPF calculation and the **relative-metric** option cannot be enabled if the LSP is included in the LFA SPF calculation when the **rsvp-shortcut** option is enabled in the IGP.

The **relative-metric** option is ignored when forwarding adjacency is enabled in OSPF or IS-IS. In this case, IGP advertises the LSP as a point-to-point unnumbered link along with the LSP operational metric as returned by MPLS and capped to the maximum link metric allowed in that IGP.

Both the main SPF and the LFA SPF algorithms use the local IGP database to resolve the routes.

The **no** form of this command disables the use of an RSVP-TE LSP by OSPF or IS-IS as a shortcut or a forwarding adjacency for resolving IGP routes.

For more information on IGP shortcuts and LFA, refer to the 7705 SAR Routing Protocols Guide, “LDP and IP Fast Reroute (FRR) for OSPF Prefixes” and “LDP and IP Fast Reroute (FRR) for IS-IS Prefixes”.

Default igp-shortcut — all RSVP-TE LSPs originating on this node are eligible by default as long as the destination address of the LSP corresponds to a router ID of a remote node

Parameters **lfa-protect** — an LSP is included in both the main SPF and the LFA SPF calculation

lfa-only — an LSP is included in the LFA SPF calculation only

relative-metric [*offset*] — the shortest IGP cost between the endpoints of the LSP plus the configured offset, instead of the LSP operational metric returned by MPLS, is used when calculating the cost of prefix resolved to this LSP. The *offset* parameter is optional. If the **relative-metric** option is enabled without specifying the *offset* parameter value, a value of 0 is used.

Values –10 to +10

include

Syntax [**no**] **include** *group-name* [*group-name*...(up to 5max)]

Context config>router>mpls>lsp
config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary
config>router>mpls>lsp-template

Description This command specifies the admin groups to be included when an LSP is set up. Up to 5 groups per operation can be specified, and up to 32 maximum.

The **no** form of the command deletes the specified groups in the specified context.

Default no include

Parameters *group-name* — specifies admin groups to be included when an LSP is set up

least-fill

Syntax [**no**] **least-fill**

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command enables the use of the least-fill path selection method for the computation of the path of this LSP.

When MPLS requests the computation of a path for this LSP, CSPF finds all equal-cost shortest paths that satisfy the constraints of this path. Then, CSPF identifies the single link in each of these paths that has the least available bandwidth as a percentage of its maximum reservable bandwidth. It then selects the path that has the highest percentage available bandwidth. CSPF identifies the least-available bandwidth link in each equal-cost path after it has accounted for the bandwidth of the new requested path of this LSP.

CSPF applies the least-fill path selection method to all requests for a path, primary and secondary, of an LSP for which this option is enabled. The bandwidth of the path can be any value, including zero.

MPLS resignals and move the LSP to the new path in the following cases:

- initial LSP path signaling
- retry of an LSP path after failure
- MBB due to an LSP path configuration change, that is, a user change to the bandwidth parameter of the primary or secondary path, or a user enabling of the fast-reroute option for the LSP
- MBB of the path due to an update to the primary path SRLG
- MBB due to fast reroute global revertive procedures on the primary path
- manual resignaling of an LSP path or of all LSP paths by the user

During a manual resignaling of an LSP path, MPLS always resignals the path even if the new path is the same as the current path and even if the metric of the new path is the same as the metric of the current path.

During a timer-based resignaling of an LSP path that has the least-fill option enabled, MPLS only resignals the path if the metric of the new path is different from the metric of the current path.

Default no least-fill - the path of an LSP is randomly chosen among a set of equal-cost paths

metric

Syntax **metric** *metric*

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command specifies the metric for this LSP, which is used to select an LSP from among a set of LSPs that are destined for the same egress router. The LSP with the lowest metric will be selected.

The operational metric for an LSP that uses the TE metric in CSPF path calculations can be overridden by the configured administrative LSP metric parameter.

Default 1

Parameters *metric* — specifies the metric for this LSP

Values 1 to 16777215

max-sr-labels

Syntax **max-sr-labels** *label-stack-size* [**additional-frr-labels** *labels*]
no max-sr-labels

Context config>router>mpls>lsp

Description This command configures the maximum number of labels that the ingress LER can push for an SR-TE LSP.

This command is used to allow room to insert additional transport, service, and other labels when packets are forwarded in a context.

The **max-sr-labels** *label-stack-size* value should reflect the desired maximum label stack of the primary path of the SR-TE LSP.

The value in **additional-frr-labels** *labels* should reflect additional labels inserted by remote LFA for the backup next hop of the SR-TE LSP.

The sum of both label values represents the worst-case transport of SR label stack size for this SR-TE LSP. The sum is populated by MPLS in the Tunnel Table Manager (TTM) so that services and shortcut applications can check the TTM to determine whether a service can be bound or a route can be resolved to this SR-TE LSP.

The maximum label stack supported by the router is always signaled by the PCC in the PCEP Open object as part of the SR-PCE-CAPABILITY TLV. The maximum label stack is referred to as the Maximum Stack Depth (MSD).

In addition, the per-LSP value for the **max-sr-labels** option, if configured, is signaled by the PCC to the PCE in the Segment-ID (SID) Depth value in a METRIC object for both a PCE-computed LSP and a PCE-controlled LSP. The PCE will compute and provide the full explicit path with TE links specified. If there is no path with the number of hops lower than the MSD value or the SID Depth value (if signaled), a reply with no path will be returned to the PCC.

For a PCC-controlled LSP, if the label stack returned by the TE-DB hop-to-label translation exceeds the per-LSP maximum label stack size for the SR, the LSP is brought down.

Default max-sr-labels 6

additional-frr-labels 1

Parameters *label-stack-size* — specifies the label stack size of the primary path of the SR-TE LSP

Values 1 to 11

Default 6

additional-frr-labels *labels* — sets the number of additional labels inserted by remote LFA for the backup next hop of the SR-TE LSP

Values 0 to 4

Default 1

path-profile

Syntax **path-profile** *profile-id* [**path-group** *group-id*]
no path-profile *profile-id*

Context config>router>mpls>lsp

Description This command configures the PCE path profile and path group ID.

The PCE supports the computation of disjoint paths for two different LSPs originating or terminating on the same or different PE routers. In order to indicate this constraint to the PCE, the user must configure the PCE path profile ID and path group ID that the PCE-computed or PCE-controlled LSP belongs to. These parameters are passed transparently by the PCC to the PCE and are thus opaque data to the router.

The association of the optional path group ID is to allow the PCE to determine which profile ID this path group ID must be used with. One path group ID is allowed per profile ID. The user can, however, enter the same path group ID with multiple profile IDs by executing this command multiple times. A maximum of five entries of **path-profile** [**path-group**] can be associated with the same LSP.

Parameters *profile-id* — specifies the profile ID

Values 1 to 4294967295

group-id — specifies the path group ID

Values 0 to 4294967295

pce-computation

Syntax [**no**] **pce-computation**

Context config>router>mpls>lsp

Description This command enables a PCE-computed LSP mode of operation for an RSVP-TE LSP.

The user can grant only path computation requests (PCE-computed) or both path computation requests and path update (PCE-controlled) to a PCE for a specific LSP.

The **pce-computation** option allows the path computation request to be sent to the PCE instead of the local CSPF. Enabling this option allows the PCE to perform path computations for the LSP at the request of the PCC router only. This is used in cases where the operator wants to make use of the PCE-specific path computation algorithm instead of the local router CSPF algorithm.

The default configuration is **no pce-computation**. The enabling of the **pce-computation** option or **pce-control** option requires that the **cspf** option first be enabled; otherwise, this configuration will be rejected. Conversely, an attempt to disable the **cspf** option on an RSVP-TE LSP that has the **pce-computation** option or **pce-control** option enabled will be rejected.

Default no pce-computation

pce-control

Syntax [**no**] **pce-control**

Context config>router>mpls>lsp

Description This command enables a PCE-controlled LSP mode of operation for an RSVP-TE LSP.

The **pce-control** option means that the PCC router delegates full control of the LSP to the PCE (PCE-controlled). Enabling PCE control means that the PCE is acting in active stateful mode for this LSP; the PCE will be able to reroute the path following a failure or reoptimize the path and update the router without the PCC router requesting the update.

The user can delegate CSPF and non-CSPF LSPs, or LSPs that have the **pce-computation** option enabled or disabled. The LSP maintains its latest active path computed by the PCE or the PCC router at the time it is delegated. The PCE will only make an update to the path at the next network event or reoptimization.

The default configuration is **no pce-control**. The enabling of the **pce-control** option or **pce-computation** option requires that the **cspf** option first be enabled; otherwise, this configuration will be rejected. Conversely, an attempt to disable the **cspf** option on an RSVP-TE LSP that has the **pce-control** option or **pce-computation** option enabled will be rejected.

If PCE reporting is disabled for the LSP, either due to inheritance from the MPLS-level configuration or due to LSP-level configuration, enabling the **pce-control** option for the LSP has no effect.

Default no pce-control

pce-report

Syntax **pce-report** {**enable** | **disable** | **inherit**}

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command configures the reporting mode to a PCE for an RSVP-TE LSP.

The PCC LSP database is synchronized with the PCE LSP database using the PCEP PCRpt (PCE Report) message for PCC-controlled, PCE-computed, and PCE-controlled LSPs.

The global MPLS-level **pce-report** command can be used to enable or disable PCE reporting for all RSVP-TE LSPs during PCE LSP database synchronization (see **config>router>mpls>**pce-report).

The LSP-level **pce-report** command overrides the global configuration for the reporting of an LSP to the PCE. The default configuration is to inherit the global MPLS-level configuration. The **inherit** option reconfigures the LSP to inherit the global configuration.

Default pce-report inherit

Parameters **enable** — enables PCE reporting

disable — disables PCE reporting

inherit — inherits the global configuration for PCE reporting

propagate-admin-group

Syntax [**no**] **propagate-admin-group**

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command enables propagation of the SESSION_ATTRIBUTE object with resource affinity (C-type 1) in the PATH message. If a SESSION_ATTRIBUTE object with resource affinity is received at an LSR, the LSR will check the compatibility of admin groups received in the PATH message against configured admin groups on the egress interface of the LSP.

To support admin groups for inter-area LSPs, the ingress node must configure the propagation of admin groups within the SESSION_ATTRIBUTE object. If a PATH message is received by an LSR node that has the **cspf-on-loose-hop** option enabled and the message includes admin groups, then the ERO expansion by CSPF to calculate the path to the next loose hop will include the admin-group constraints received from the ingress node.

If this command is disabled, the SESSION_ATTRIBUTE object without resource affinity (C-Type 7) is propagated in the PATH message and CSPF at the LSR node will not include admin-group constraints.

If the configuration of this command is changed (enabled or disabled), the LSP will perform a make-before-break (MBB).

Default no propagate-admin-group

retry-limit

Syntax **retry-limit** *number*
no retry-limit

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This optional command specifies the number of attempts software should make to re-establish the LSP after it has failed. After each successful attempt, the counter is reset to zero.

When the specified number is reached, no more attempts are made and the LSP path is put into the **shutdown** state.

Use the **config>router>mpls**>**lsp** *lsp-name*>**no shutdown** command to bring up the path after the retry limit is exceeded.

The **no** form of this command resets the parameter to the default value.

Default 0

Parameters *number* — specifies the number of times that the 7705 SAR software will attempt to re-establish the LSP after it has failed. Allowed values are integers in the range of 0 to 10000, where 0 indicates to retry forever.

Values 0 to 10000

retry-timer

Syntax **retry-timer** *seconds*
no retry-timer

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command configures the time, in seconds, between LSP re-establishment attempts after the LSP has failed.

The **no** form of this command reverts to the default value.

Default 30

Parameters *seconds* — specifies the amount of time, in seconds, between attempts to re-establish the LSP after it has failed

Values 1 to 600

rsvp-resv-style

Syntax **rsvp-resv-style** [**se** | **ff**]

Context config>router>mpls>lsp

Description This command specifies the RSVP-TE reservation style, shared explicit (**se**) or fixed filter (**ff**). A reservation style is a set of control options that specify a number of supported parameters. The style information is part of the LSP configuration.

Default se

Parameters **ff** — fixed filter is single reservation with an explicit scope. This reservation style specifies an explicit list of senders and a distinct reservation for each of them. A specific reservation request is created for data packets from a particular sender. The reservation scope is determined by an explicit list of senders.

se — shared explicit is shared reservation with a limited scope. This reservation style specifies a shared reservation environment with an explicit reservation scope. This reservation style creates a single reservation over a link that is shared by an explicit list of senders. Because each sender is explicitly listed in the RESV message, different labels can be assigned to different sender-receiver pairs, thereby creating separate LSPs.

shutdown

Syntax [**no**] **shutdown**

Context config>router>mpls>lsp
config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary
config>router>mpls>lsp-template

Description This **lsp** form of this command disables the existing LSP, including the primary and any standby secondary paths.

The **primary** and **secondary** forms of this command administratively disable an LSP path and disable an existing LSP. Shutting down an LSP path does not change other configuration parameters for the LSP path.

To shut down only the primary path, enter the **config**>**router**>**mpls**>**lsp** *lsp-name*> **primary** *path-name*> **shutdown** command.

To shut down a specific standby secondary path, enter the **config**>**router**>**mpls**>**lsp** *lsp-name*> **secondary** *path-name*>**shutdown** command. The existing configuration of the LSP is preserved.

The **lsp-template** form of this command disables the existing LSP template.

Use the **no** form of this command to restart the LSP or LSP template. LSPs and LSP templates are created in a shutdown state. Use this command to administratively bring up the LSP or LSP template.

Default lsp — shutdown

primary — no shutdown

secondary — no shutdown

lsp-template — shutdown

to

Syntax **to** *ip-address*

Context config>router>mpls>lsp

Description This command specifies the IP address of the egress router for the LSP. This command is mandatory to create an LSP.

An IP address for which a route does not exist is allowed in the configuration. If the LSP signaling fails because the destination is not reachable, an error is logged and the LSP operational status is set to down.

If the to address does not match the SDP address, the LSP is not included in the SDP definition.

Default n/a

Parameters *ip-address* — specifies the IP address of the egress router

vprn-auto-bind

Syntax **vprn-auto-bind** [**include** | **exclude**]

Context config>router>mpls>lsp
config>router>mpls>lsp-template

Description This command determines whether the associated LSP can be used as part of the auto-bind feature for VPRN services. By default, an LSP is allowed to be used by the auto-bind feature.

When VPRN auto-bind is set to **exclude**, the associated LSP is not used by the auto-bind feature for VPRN services.

Default include

Parameters **include** — allows an associated LSP to be used by auto-bind for VPRN services

exclude — prevents the associated LSP from being used with the auto-bind feature for VPRN services

3.23.2.1.7 Primary and Secondary Path Commands

primary

Syntax [**no**] **primary** *path-name*

Context config>router>mpls>lsp

Description This command specifies a preferred path for the LSP. This command is optional only if the **secondary** path-name is included in the LSP definition. Only one primary path can be defined for an LSP.

Some of the attributes of the LSP, such as the bandwidth and hop limit, can be optionally specified as the attributes of the primary path. The attributes specified in the **primary** *path-name* command override the comparable LSP attributes that are defined in the **config**>**router**>**mpls**>**lsp** context.

The **no** form of this command deletes the association of this *path-name* from the **lsp** *lsp-name*. All configurations specific to this primary path, such as record, bandwidth, and hop limit, are deleted. The primary path must be shut down first in order to delete it. The **no primary** command will not result in any action except a warning message on the console indicating that the primary path is administratively up.

Default n/a

Parameters *path-name* — specifies the case-sensitive alphanumeric name label for the LSP path, up to 32 characters in length

secondary

Syntax [**no**] **secondary** *path-name*

Context config>router>mpls>lsp

Description This command specifies an alternative path that the LSP uses if the primary path is not available. This command is optional and is not required if the **config**>**router**>**mpls**>**lsp** *lsp-name*> **primary** *path-name* command is specified. After the switchover from the primary path to the secondary path, the 7705 SAR software continuously tries to revert to the primary path. The switch back to the primary path is based on the **retry-timer** interval.

Up to two secondary paths can be specified. Both secondary paths are considered equal, and the first available path is used. The 7705 SAR software will not switch back between secondary paths.

The 7705 SAR software starts signaling all non-standby secondary paths at the same time. Retry counters are maintained for each unsuccessful attempt. Once the retry limit is reached on a path, software will not attempt to signal the path and administratively shuts down the path. The first successfully established path is made the active path for the LSP.

The **no** form of this command removes the association between this *path-name* and *lsp-name*. All specific configurations for this association are deleted. The secondary path must be shut down first in order to delete it. The **no secondary** *path-name* command will not result in any action except a warning message on the console indicating that the secondary path is administratively up.

Default n/a

Parameters *path-name* — specifies the case-sensitive alphanumeric name label for the LSP path, up to 32 characters in length

adaptive

Syntax [**no**] **adaptive**

Context config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary

Description This command enables the make-before-break (MBB) functionality for an LSP or a primary or secondary LSP path. When enabled for the LSP, a make-before-break operation will be performed for the primary path and all the secondary paths of the LSP.

Default adaptive

bandwidth

Syntax **bandwidth** *rate-in-mbps*
no bandwidth

Context config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary

Description This command specifies the amount of bandwidth to be reserved for the LSP path.

The **no** form of this command resets bandwidth parameters (no bandwidth is reserved).

Default no bandwidth — bandwidth setting in the global LSP configuration

Parameters *rate-in-mbps* — specifies the amount of bandwidth reserved for the LSP path in Mb/s

Values 0 to 100000

hop-limit

Syntax **hop-limit** *number*
no hop-limit

Context config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary

Description This optional command overrides the **config**>**router**>**mpls**>**lsp** *lsp-name*>**hop-limit** command. This command specifies the total number of hops that an LSP traverses, including the ingress and egress routers.

This value can be changed dynamically for an LSP that is already set up with the following implications:

- If the new value is less than the current number of hops of the established LSP, then the LSP is brought down. MPLS then tries to re-establish the LSP within the new **hop-limit** number. If the new value is equal to or greater than the current hops of the established LSP, then the LSP will be unaffected.

The **no** form of this command resets the hop limit to the value defined under the LSP definition using the **config**>**router**>**mpls**>**lsp** *lsp-name*>**hop-limit** command.

Default no hop-limit

Parameters *number* — specifies the number of hops the LSP can traverse, expressed as an integer

Values 2 to 255

path-preference

Syntax **path-preference** *preference-number*
no path-preference

Context config>router>mpls>lsp>secondary

Description This command allows a priority value to be assigned to a standby secondary LSP path. The secondary LSP path must be configured in **standby** mode using the standby command to ensure that it is signaled and maintained indefinitely in a hot-standby state. The standby secondary LSP path configured with the highest priority (the lowest **path-preference** value) is made the active LSP when the primary LSP is not in use. If multiple standby secondary LSP paths are configured wit the same value, the system selects the path with the lowest uptime.

If all standby secondary paths have the default **path-preference** value, a non-standby secondary path remains the active path even though a configured standby secondary path is available.

This command only applies to secondary LSP paths that have been configured in standby mode.

The **no** form of the command resets the **path-preference** *value* to its default.

Default 255

Parameters *preference-number* — specifies a priority value for a standby secondary LSP path; the lower the value, the higher the priority.

Values 1 to 255

record

Syntax [**no**] **record**

Context config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary

Description This command enables recording of all the hops that an LSP path traverses. Enabling **record** increases the size of the PATH and RESV refresh messages for the LSP, since this information is carried end-to-end along the path of the LSP. The increase in control traffic per LSP may impact scalability.

The **no** form of this command disables the recording of all the hops for the given LSP. There are no restrictions as to when the **no** command can be used. The **no** form of this command also disables the **record-label** command.

Default record

record-label

Syntax [**no**] **record-label**

Context config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary

Description This command enables recording of all the labels at each node that an LSP path traverses. Enabling the **record-label** command will also enable the **record** command, if it is not already enabled.

The **no** form of this command disables the recording of the hops that an LSP path traverses.

Default record-label

srlg

Syntax [**no**] **srlg**

Context config>router>mpls>lsp>secondary

Description This command enables the use of the SRLG constraint in the CSPF computation of a secondary path for an LSP at the head-end LER. When this feature is enabled, CSPF includes the SRLG constraint in the computation of the secondary LSP path.

CSPF and SRLGs for Secondary Paths

CSPF requires that the primary LSP be established already and in the up state, since the head-end LER needs the most current ERO computed by CSPF for the primary path and CSPF includes the list of SRLGs in the ERO during the CSPF computation of the primary path. At a subsequent establishment of a secondary path with the SRLG constraint, the MPLS/RSVP-TE task queries CSPF again, which provides the list of SRLG numbers to be avoided. CSPF prunes all links with interfaces that belong to the same SRLGs as the interfaces included in the ERO of the primary path. If CSPF finds a path, the secondary path is set up. If CSPF does not find a path, MPLS/RSVP-TE keeps retrying the requests to CSPF.

If CSPF is not enabled on the LSP (using the **lsp** *lsp-name*>**cspf** command), then a secondary path of that LSP that includes the SRLG constraint is shut down and a specific failure code indicates the exact reason for the failure in the **show>router>mpls>lsp>path>detail** output.

Primary Path and Secondary Path Behavior

At initial primary LSP path establishment, if the primary path does not come up or is not configured, the SRLG secondary path is not signaled and is put in the down state. A specific failure code indicates the exact reason for the failure in the **show>router>mpls>lsp>path>detail** output. However, if a non-SRLG secondary path was configured, such as a secondary path with the SRLG option disabled, MPLS/RSVP-TE task signals it and the LSP uses it.

As soon as the primary path is configured and successfully established, MPLS/RSVP-TE moves the LSP to the primary path and signals all SRLG secondary paths.

Any time the primary path is reoptimized, has undergone a make-before-break (MBB) operation, or has come back up after being down, the MPLS/RSVP-TE task checks with CSPF to determine if the SRLG secondary path should be resignaled. If the MPLS/RSVP-TE task finds that the current secondary path is no longer SRLG disjoint — for example, the path became ineligible — it puts the path on a delayed make-before-break immediately after the expiry of the retry timer. If MBB fails on the first try, the secondary path is torn down and the path is put on retry.

At the next opportunity (that is, when the primary path goes down), the LSP uses of an eligible SRLG secondary path if the secondary path is in the up state. If all secondary eligible SRLG paths are in the down state, MPLS/RSVP-TE uses a non-SRLG secondary path if the path is configured and in the up state. If, while the LSP is using a non-SRLG secondary path, an eligible SRLG secondary path comes back up, MPLS/RSVP-TE will not switch the path of the LSP to it. As soon as the primary path is resignaled and comes up with a new SRLG list, MPLS/RSVP-TE resignals the secondary path using the new SRLG list.

A secondary path that becomes ineligible as a result of an update to the SRLG membership list of the primary path will have its ineligibility status removed when any of the following events occurs:

- A successful MBB operation of the standby SRLG path occurs, making it eligible again.
- The standby path goes down, in which case MPLS/RSVP-TE puts the standby on retry when the retry timer expires. If successful, it becomes eligible. If not successful after the retry timer expires or the number of retries reaches the configured retry-limit value, it is left down.
- The primary path goes down, in which case the ineligible secondary path is immediately torn down and will only be resignaled when the primary path comes back up with a new SRLG list.

Changes to SRLG Membership List

Once the primary path of the LSP is set up and is operationally up, any subsequent changes to the SRLG membership of an interface that the primary path is using is not considered until the next opportunity that the primary path is resignaled. The primary path may be resignaled due to a failure or to a make-before-break operation. A make-before-break operation occurs as a result of a global revertive operation, a timer-based or manual reoptimization of the LSP path, or a change by the user to any of the path constraints.

Once an SRLG secondary path is set up and is operationally up, any subsequent changes to the SRLG membership of an interface that the secondary path is using is not considered until the next opportunity that the secondary path is resignaled. The secondary path is resignaled due to a failure, to a resignaling of the primary path, or to a make-before-break operation. A make-before-break operation occurs as a result of a timer-based or manual reoptimization of the secondary path, or a change by the user to any of the path constraints of the secondary path, including enabling or disabling the SRLG constraint itself.

In addition, any user-configured **include** or **exclude** admin group statements for this secondary path are checked along with the SRLG constraints by CSPF.

The **no** form of the command reverts to the default value.

Default no srlg

standby

Syntax [**no**] **standby**

Context config>router>mpls>lsp>secondary

Description The secondary path LSP is normally signaled if the primary path LSP fails. The **standby** keyword ensures that the standby secondary path LSP is signaled and maintained indefinitely in a hot-standby state. When the primary path is re-established, the traffic is switched back to the primary path LSP.

Note: A priority level can be assigned to standby secondary paths using the path-preference command.

The **no** form of this command specifies that the secondary LSP is signaled when the primary path LSP fails.

Default n/a

3.23.2.1.8 LSP Path Commands

path

Syntax [**no**] **path** *path-name*

Context config>router>mpls

Description This command creates the path to be used for an LSP. A path can be used by multiple LSPs. A path can specify some or all hops from ingress to egress and they can be either **strict** or **loose**. A path can also be empty (no *path-name* specified), in which case the LSP is set up based on the IGP (best effort) calculated shortest path to the egress router. Paths are created in a **shutdown** state. A path must be shut down before making any changes (adding or deleting hops) to the path. When a path is shut down, any LSP using the path becomes operationally down.

To create a strict path from the ingress to the egress router, the ingress and the egress routers must be included in the path statement.

The **no** form of this command deletes the path and all its associated configuration information. All the LSPs that are currently using this path will be affected. Additionally, all the services that are actively using these LSPs will be affected. A path must be shut down and unbound from all LSPs using the path before it can be deleted. The **no path** *path-name* command will not result in any action except a warning message on the console indicating that the path may be in use.

Default n/a

Parameters *path-name* — specifies the unique case-sensitive alphanumeric name label for the LSP path, up to 32 characters in length

hop

Syntax **hop** *hop-index ip-address* {**strict** | **loose**}
no hop *hop-index*

Context config>router>mpls>path

Description This command specifies the IP address of the hops that the LSP should traverse on its way to the egress router. The IP address can be the interface IP address, a loopback IP address, or the system IP address. If the system IP address is specified, the LSP can choose the best available interface.

Optionally, the LSP ingress and egress IP address can be included as the first and the last hop. A hop list can include the ingress interface IP address, the system IP address, and the egress IP address of any of the hops being specified.

The **no** form of this command deletes hop list entries for the path. All the LSPs currently using this path are affected. Additionally, all services actively using these LSPs are affected. The path must be shut down first in order to delete the hop from the hop list. The **no hop** *hop-index* command will not result in any action except a warning message on the console indicating that the path is administratively up.

Default n/a

Parameters *hop-index* — specifies the hop index, which is used to order the specified hops. The LSP always traverses from the lowest hop index to the highest. The hop index does not need to be sequential.

Values 1 to 1024

ip-address — specifies the system or network interface IP address of the transit router. The IP address can be the interface IP address or the system IP address. If the system IP address is specified, the LSP can choose the best available interface. A hop list can also include the ingress interface IP address, the system IP address, and the egress IP address of any of the specified hops.

strict — specifies that the LSP must take a direct path from the previous hop router to this router. No transit routers between the previous router and this router are allowed. If the IP address specified is the interface address, then that is the interface the LSP must use. If there are direct parallel links between the previous router and this router and if the system IP address is specified, then any one of the available interfaces can be used by the LSP. The user must ensure that the previous router and this router have a direct link. Multiple hop entries with the same IP address are flagged as errors. Either the **loose** or **strict** keyword must be specified.

loose — specifies that the route taken by the LSP from the previous hop to this hop can traverse other routers. Multiple hop entries with the same IP address are flagged as errors. Either the **loose** or **strict** keyword must be specified.

3.23.2.1.9 Static LSP Commands

static-lsp

Syntax [**no**] **static-lsp** *lsp-name*

Context config>router>mpls

Description This command configures static LSPs on the ingress router. The static LSP is a manually configured LSP where the next-hop IP address and the outgoing label (push) must be specified.

The **no** form of this command deletes this static LSP and associated information.

The LSP must be shut down before it can be deleted. If the LSP is not shut down, the **no static-lsp** *lsp-name* command generates a warning message on the console indicating that the LSP is administratively up.

Parameters *lsp-name* — identifies the LSP. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

push

Syntax **push** *label* **nexthop** *ip-address*
no push *label*

Context config>router>mpls>static-lsp

Description This command specifies the label to be pushed onto the label stack and the next-hop IP address for the static LSP.

The **no** form of this command removes the association of the label to push for the static LSP.

Parameters *label* — specifies the label to push on the label stack

Label values 16 through 31 are 7705 SAR reserved

Label values 32 through 1023 are available for static assignment

Label values 1024 through 2047 are reserved for future use

Label values 2048 through 18431 are statically assigned for services

Label values 28672 through 131071 are dynamically assigned for both MPLS and services

Label values 131072 through 1048575 are reserved for future use.

Values 16 to 1048575

ip-address — specifies the IP address of the next hop towards the LSP egress router. If an ARP entry for the next hop exists, then the static LSP is marked operational. If an ARP entry does not exist, the software sets the operational status of the static LSP to down and continues to send an ARP request for the configured next hop at fixed intervals.

to

Syntax **to** *ip-address*

Context config>router>mpls>static-lsp

Description This command specifies the system IP address of the egress router for the static LSP. For LSPs that are used as transport tunnels for services, the **to** *ip-address* must be the system IP address. If the **to** *ip-address* does not match the SDP address, the LSP is not included in the SDP definition.

This command is required when creating an LSP.

Default n/a

Parameters *ip-address* — identifies the egress router system address

Values a.b.c.d

static-lsp-fast-retry

Syntax **static-lsp-fast-retry** *seconds*
no static-lsp-fast-retry

Context config>router>mpls

Description This command specifies the fast-retry timer that can be configured for static LSPs. When a static LSP is trying to come up, MPLS tries to resolve the ARP entry for the next hop of the LSP. If the next hop is still down or unavailable, the request may fail. In that case, MPLS starts a non-configurable timer of 30 seconds before making the next request. The fast-retry timer allows the user to configure a shorter retry timer so that the LSP comes up shortly after the next hop is available.

Default 30

Parameters *seconds* — fast-retry timer value, in seconds

Values 1 to 30

3.23.2.2 Configuration Commands (RSVP-TE)

- Generic Commands
- RSVP-TE Global Commands
- Interface Commands
- Message Pacing Commands

3.23.2.2.1 Generic Commands

shutdown

Syntax [**no**] **shutdown**

Context config>router>rsvp
config>router>rsvp>interface

Description This command disables the RSVP-TE protocol instance or the RSVP-related functions for the interface. The RSVP-TE configuration information associated with this interface is retained. When RSVP-TE is administratively disabled, all the RSVP-TE sessions are torn down.

The **no** form of this command administratively enables RSVP-TE on the interface.

Default shutdown

3.23.2.2.2 RSVP-TE Global Commands

rsvp

Syntax [**no**] **rsvp**

Context config>router

Description This command creates the RSVP-TE protocol instance and enables RSVP-TE configuration.

RSVP-TE is enabled by default.

RSVP-TE is used to set up LSPs. RSVP-TE should be enabled on all router interfaces that participate in signaled LSPs.

The **no** form of this command deletes this RSVP-TE protocol instance and removes all configuration parameters for this RSVP-TE instance. To suspend the execution and maintain the existing configuration, use the **shutdown** command. RSVP-TE must be shut down before the RSVP-TE instance can be deleted. If RSVP-TE is not shut down, the **no rsvp** command does nothing except issue a warning message on the console indicating that RSVP-TE is still administratively enabled.

Default no shutdown

entropy-label-capability

Syntax [**no**] **entropy-label-capability**

Context config>router>rsvp

Description This command enables or disables the entropy label capability for an RSVP-TE LSP. When enabled, the egress LER (eLER) signals to the ingress LER (iLER) that the LSP is capable of using entropy labels.

The **no** form of the command disables entropy label capability.

Default no entropy-label-capability

graceful-shutdown

Syntax [**no**] **graceful-shutdown**

Context config>router>rsvp
config>router>rsvp>interface

Description This command initiates a graceful shutdown of the specified RSVP interface (referred to as a maintenance interface) or all RSVP interfaces on the node (referred to as a maintenance node). When this command is executed, the node performs the following operations in no specific order.

A PathErr message with an error sub-code of “Local Maintenance on TE Link required” is generated for each LSP that is in transit at this node and is using a maintenance interface as its outgoing interface. A PathErr message with the error code “Local node maintenance required” is generated if all interfaces are affected.

A single make-before-break attempt is performed for all adaptive CSPF LSPs that originate on the node and whose paths make use of the maintenance interfaces listed in the PathErr message. If an alternative path for an affected LSP is not found, the LSP is maintained on its current path. The maintenance node also tears down and resignals any bypass or detour LSP that uses the maintenance interfaces as soon as they are not active. The maintenance node floods an IGP TE LSA/LSP containing a Link TLV for the links under graceful shutdown with the Traffic Engineering metric set to 0xffffffff and the Unreserved Bandwidth parameter set to zero (0).

Upon receipt of the PathErr message, an intermediate LSR tears down and resignals any bypass LSP whose path makes use of the listed maintenance interfaces as soon as no associations with a protected LSP are active. The node does not take any action on a detour LSP whose path makes use of the listed maintenance interfaces.

Upon receipt of the PathErr message, a head-end LER performs a single make-before-break attempt on the affected adaptive CSPF LSP. If an alternative path is not found, the LSP is maintained on its current path.

A node does not take any action on the paths of the following originating LSPs after receiving the PathErr message:

- an adaptive CSPF LSP for which the PathErr indicates a node address in the address list and the node corresponds to the destination of the LSP. In this case, there are no alternative paths that can be found.
- an adaptive CSPF LSP whose path has explicit hops defined using the listed maintenance interfaces or node
- a CSPF LSP that has the adaptive option disabled and whose current path is over the listed maintenance interfaces in the PathErr message. These are not subject to make-before-break.
- a non-CSPF LSP whose current path is over the listed maintenance interfaces in the PathErr message

Upon receipt of the updated IPG TE LSA/LSP for the maintenance interfaces, the head-end LER updates the TE database. This information will be used at the next scheduled CSPF computation for any LSP whose path might traverse any of the maintenance interfaces.

The **no** form of the command disables the graceful shutdown operation at the RSVP interface level or at the RSVP level. The configured TE parameters of the maintenance links are restored and the maintenance node floods the links.

Default n/a

implicit-null-label

Syntax [**no**] **implicit-null-label**

Context config>router>rsvp

Description This command enables the implicit null label to be included in RESV messages sent by the egress LER (eLER) to the previous-hop LSR. The implicit null label is enabled for all LSPs for which the router is the eLER.

When the implicit null label is signaled to the LSR, it pops the outer label before sending the MPLS packet to the eLER; this is known as penultimate hop popping.

RSVP-TE must be shut down before this command can be used.

The **no** form of this command disables the signaling of the implicit null label.

Default no implicit-null-label

keep-multiplier

Syntax [**no**] **keep-multiplier** *number*
no keep-multiplier

Context config>router>rsvp

Description This command is used by RSVP-TE to declare that a reservation is down or the neighbor is down. The **keep-multiplier** *number* is used with the **refresh-time** command to determine when RSVP-TE will declare the session down.

The **no** form of this command reverts to the default value.

Default 3

Parameters *number* — specifies the **keep-multiplier** value

Values 1 to 255

node-id-in-rro

Syntax **node-id-in-rro** {**include** | **exclude**}

Context config>router>rsvp

Description This command enables the option to include the node-id sub-object in the RRO. Propagation of the node-id sub-object is required to provide fast reroute protection for an LSP that spans multiple area domains.

Default exclude

Parameters **include** — the node-id sub-object is included in the RRO

exclude — the node-id sub-object is not included in the RRO

rapid-retransmit-time

Syntax **rapid-retransmit-time** *hundred-milliseconds*
no rapid-retransmit-time

Context config>router>rsvp

Description This command is used to define the value of the rapid retransmission interval. This is used in the retransmission mechanism based on an exponential backoff timer in order to handle unacknowledged message-_id objects. The RSVP-TE message with the same message-id is retransmitted every 2 × rapid-retransmit-time interval. The node will stop retransmission of unacknowledged RSVP-TE messages whenever the updated backoff interval exceeds the value of the regular refresh interval or the number of retransmissions reaches the value of the rapid-retry-limit parameter, whichever comes first.

The rapid retransmission interval must be smaller than the regular refresh interval configured in **config**>**router**>**rsvp**>**refresh-time**.

The **no** form of this command reverts to the default value.

Default 5 (which represents 500 msec)

Parameters *hundred-milliseconds* — 1 to 100, in units of 100 msec

rapid-retry-limit

Syntax **rapid-retry-limit** *number*
no rapid-retry-limit

Context config>router>rsvp

Description This command is used to define the value of the rapid retry limit. This is used in the retransmission mechanism based on an exponential backoff timer in order to handle unacknowledged message_id objects. The RSVP-TE message with the same message_id is retransmitted every 2 × rapid-retransmit-time interval. The node will stop retransmission of unacknowledged RSVP-TE messages whenever the updated backoff interval exceeds the value of the regular refresh interval or the number of retransmissions reaches the value of the rapid-retry-limit parameter, whichever comes first.

The **no** form of this command reverts to the default value.

Default 3

Parameters *number* — 1 to 6, integer values

refresh-reduction-over-bypass

Syntax **refresh-reduction-over-bypass** [**enable** | **disable**]

Context config>router>rsvp

Description This command enables the refresh reduction capabilities over all bypass tunnels originating on this 7705 SAR PLR node or terminating on this 7705 SAR Merge Point (MP) node.

By default, this is disabled. Since a bypass tunnel may merge with the primary LSP path in a node downstream of the next hop, there is no direct interface between the PLR and the MP node and it is possible that the latter will not accept summary refresh messages received over the bypass.

When disabled, the node as a PLR or MP will not set the “Refresh-Reduction-Capable” bit on RSVP-TE messages pertaining to LSP paths tunneled over the bypass. It will also not send message-id in RSVP-TE messages. This effectively disables summary refresh.

Default disable

refresh-time

Syntax **refresh-time** *seconds*
no refresh-time

Context config>router>rsvp

Description This command controls the interval, in seconds, between the successive PATH and RESV refresh messages. RSVP-TE declares the session down after it misses **keep-multiplier** *number* consecutive refresh messages.

The **no** form of this command reverts to the default value.

Default 30

Parameters *seconds* — specifies the refresh time in seconds

Values 1 to 65535

3.23.2.2.3 Interface Commands

interface

Syntax [**no**] **interface** *ip-int-name*

Context config>router>rsvp

Description This command enables RSVP-TE protocol support on an IP interface. No RSVP-TE commands are executed on an IP interface where RSVP-TE is not enabled.

The **no** form of this command deletes all RSVP-TE commands such as **hello-interval** and **subscription**, which are defined for the interface. The RSVP-TE interface must be shut down before it can be deleted. If the interface is not shut down, the **no interface** *ip-int-name* command does nothing except issue a warning message on the console indicating that the interface is administratively up.

Parameters *ip-int-name* — specifies the network IP interface. The interface name cannot be in the form of an IP address. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

Values 1 to 32 alphanumeric characters

auth-keychain

Syntax **auth-keychain** *name*
no auth-keychain

Context config>router>rsvp>interface

Description This command associates an authentication keychain with the RSVP-TE interface. The keychain is a collection of keys used to authenticate RSVP-TE messages from remote peers. The keychain allows the rollover of authentication keys during the lifetime of a session and also supports stronger authentication algorithms than clear text and MD5.

The keychain must already be defined in the **config>system>security>keychain** context.

Either the **authentication-key** command or the **auth-keychain** command can be used by RSVP-TE, but both cannot be supported at the same time. If both commands are configured, the **auth-keychain** configuration will be applied and the **authentication-key** command will be ignored.

By default, authentication is not enabled.

Default no auth-keychain

Parameters *name* — the name of an existing keychain, up to 32 characters

authentication-key

Syntax **authentication-key** {*authentication-key* | *hash-key*} [**hash** | **hash2**]
no authentication-key

Context config>router>rsvp>interface

Description This command specifies the authentication key to be used between RSVP-TE neighbors to authenticate RSVP-TE messages. Authentication uses the MD5 message-based digest.

When enabled on an RSVP-TE interface, authentication of RSVP-TE messages operates in both directions of the interface.

A 7705 SAR node maintains a security association using one authentication key for each interface to a neighbor. The following items are stored in the context of this security association:

- the HMAC-MD5 authentication algorithm
- the key used with the authentication algorithm
- the lifetime of the key; the user-entered key is valid until the user deletes it from the interface
- the source address of the sending system
- the latest sending sequence number used with this key identifier

A 7705 SAR RSVP-TE sender transmits an authenticating digest of the RSVP-TE message, computed using the shared authentication key and a keyed hash algorithm. The message digest is included in an integrity object that also contains a flags field, a key identifier field, and a sequence number field. The 7705 SAR RSVP-TE sender complies with the procedures for RSVP-TE message generation in RFC 2747, *RSVP Cryptographic Authentication*.

A 7705 SAR RSVP-TE receiver uses the key together with the authentication algorithm to process received RSVP-TE messages.

When a PLR node switches the path of the LSP to a bypass LSP, it does not send the integrity object in the RSVP-TE messages sent over the bypass tunnel. If the PLR receives an RSVP-TE message with an integrity object, it will perform the digest verification for the key of the interface over which the packet was received. If this fails, the packet is dropped. If the received RSVP-TE message is an RESV message and does not have an integrity object, then the PLR node will accept it only if it originated from the MP node.

A 7705 SAR MP node will accept RSVP-TE messages received over the bypass tunnel with and without the integrity object. If an integrity object is present, the proper digest verification for the key of the interface over which the packet was received is performed. If this fails, the packet is dropped.

The 7705 SAR MD5 implementation does not support the authentication challenge procedures in RFC 2747.

Either the **authentication-key** command or the **auth-keychain** command can be used by RSVP-TE, but both cannot be supported at the same time. If both commands are configured, the **auth-keychain** configuration will be applied and the **authentication-key** command will be ignored.

The **no** form of this command disables authentication.

Default no authentication-key — the authentication key value is the null string

Parameters *authentication-key* — specifies the authentication key. The key can be any combination of ASCII characters up to 16 characters in length (unencrypted). If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

hash-key — specifies the hash key. The key can be any combination of up 33 alphanumeric characters. If spaces are used in the string, enclose the entire string in quotation marks (“ ”).

This is useful when a user must configure the parameter, but for security purposes, the actual unencrypted key value is not provided.

hash — specifies the key is entered in an encrypted form. If the **hash** keyword is not used, the key is assumed to be in a non-encrypted, clear text form. For security, all keys are stored in encrypted form in the configuration file with the **hash** parameter specified.

hash2 — specifies the key is entered in a more complex encrypted form. If the **hash2** keyword is not used, the less-encrypted **hash** form is assumed.

bfd-enable

Syntax [**no**] **bfd-enable**

Context config>router>rsvp>interface

Description This command enables the use of bidirectional forwarding (BFD) to control the state of the associated RSVP-TE interface. This causes RSVP-TE to register the interface with the BFD session on that interface.

The user configures the BFD session parameters, such as **transmit-interval**, **receive-interval**, and **multiplier**, under the IP interface in the **config**>**router**>**if**>**bfd** context.

The BFD session on the interface might already have been started because of a prior registration with another protocol; for example, OSPF or IS-IS.

The registration of an RSVP-TE interface with BFD is performed when a neighbor gets its first session, which means registration occurs when this node sends or receives a new PATH message over the interface. However, if the session did not come up due to not receiving an RESV for a new PATH message sent after the maximum number of retries, the LSP is shut down and the node deregisters with BFD. In general, the registration of RSVP-TE with BFD is removed as soon as the last RSVP-TE session is cleared.

The registration of an RSVP-TE interface with BFD is performed independently of whether RSVP-TE hello is enabled on the interface or not. However, hello timeout clears all sessions toward the neighbor and RSVP-TE deregisters with BFD at the clearing of the last session.

An RSVP-TE session is associated with a neighbor based on the interface address that the PATH message is sent to. If multiple interfaces exist to the same node, each interface is treated as a separate RSVP-TE neighbor. The user must enable BFD on each interface, and RSVP-TE will register with the BFD session running with each of those neighbors independently.

Similarly, disabling BFD on the interface results in removing registration of the interface with BFD.

When a BFD session transitions to the down state, the following actions are triggered. For RSVP-TE signaled LSPs, this triggers activation of FRR bypass or detour backup LSPs (PLR role), global revertive (head-end role), and switchover to secondary (if any) (head-end role) for affected LSPs with FRR enabled. It triggers a switchover to secondary (if any) and scheduling of retries for signaling the primary path of the non-FRR-affected LSPs (head-end role).

The **no** form of this command removes BFD from the associated RSVP-TE protocol adjacency.

Default no bfd-enable

hello-interval

Syntax **hello-interval** *milli-seconds*
no hello-interval

Context config>router>rsvp>interface

Description This command configures the time interval between RSVP-TE hello messages.

RSVP-TE hello packets are used to detect loss of RSVP-TE connectivity with the neighboring node. Hello packets detect the loss of a neighbor more quickly than it would take for the RSVP-TE session to time out based on the refresh interval. After the loss of the of **keep-multiplier** *number* consecutive hello packets, the neighbor is declared to be in a down state.

The **no** form of this command reverts to the default value of the **hello-interval**. To disable sending hello messages, set the value to zero.

Default 3000

Parameters *milli-seconds* — specifies the RSVP-TE hello interval in milliseconds, in multiples of 1000. A 0 (zero) value disables the sending of RSVP-TE hello messages.

Values 0 to 60000 milliseconds (in multiples of 1000)

implicit-null-label

Syntax **implicit-null-label** {**enable** | **disable**}
no implicit-null-label

Context config>router>rsvp>interface

Description This command enables or disables the use of the implicit null label over a specific RSVP-TE interface.

The implicit null label is enabled for all LSPs for which the router is the eLER and for which the PATH message is received from the previous-hop LSR over the RSVP-TE interface.

With facility backup, if the eLER is also the merge point (MP) node, the incoming interface for the PATH refresh message over the bypass tunnel dictates whether the packet will use the implicit null label. Similarly, with one-to-one backup, if the eLER is also the detour merge point (DMP) node, the incoming interface for the PATH refresh message over the detour LSP dictates whether the packet will use the implicit null label.

By default, an RSVP-TE interface inherits the RSVP-TE level configuration.

The interface must be shut down before this command can be used.

The **no** form of this command resets the interface to the RSVP-TE level configuration.

Default no implicit-null-label

Parameters **enable** — enables the implicit null label on the interface

disable — disables the implicit null label on the interface

refresh-reduction

Syntax [**no**] **refresh-reduction**

Context config>router>rsvp>interface

Description This command enables the use of the RSVP-TE overhead refresh reduction capabilities on this RSVP-TE interface.

When this option is enabled, a 7705 SAR node will enable support for three capabilities:

- it will accept bundle RSVP-TE messages from its peer over this interface
- it will attempt to perform reliable RSVP-TE message delivery to its peer
- it will use summary refresh messages to refresh PATH and RESV states

The reliable message delivery must be explicitly enabled by the user after refresh reduction is enabled. The other two capabilities are enabled immediately.

A bundle RSVP-TE message is intended to reduce the overall message handling load. A bundle message consists of a bundle header followed by one or more bundle sub-messages. A sub-message can be any regular RSVP-TE message except another bundle message. A 7705 SAR node will only process received bundle RSVP-TE messages but will not generate them.

When reliable RSVP-TE message delivery is supported by both the node and its peer over the RSVP-TE interface, an RSVP-TE message is sent with a message_id object. A message_id object can be added to any RSVP-TE message when sent individually or as a sub-message of a bundle message.

If the sender sets the ack_desired flag in the message_id object, the receiver acknowledges the receipt of the RSVP-TE message by piggy-backing a message_ack object to the next RSVP-TE message it sends to its peer. Alternatively, an ACK message can also be used to send the message_ack object. In both cases, one or many message_ack objects could be included in the same message.

The 7705 SAR supports the sending of separate ACK messages only, but is capable of processing received message_ack objects piggy-backed to hop-by-hop RSVP-TE messages, such as PATH and RESV.

The 7705 SAR sets the ack_desired flag only in non-refresh RSVP-TE messages and in refresh messages that contain new state information.

A retransmission mechanism based on an exponential backoff timer is supported in order to handle unacknowledged message_id objects. The RSVP-TE message with the same message_id is retransmitted every 2 × rapid-retransmit-time interval. The rapid-retransmit-time is referred to as the rapid retransmission interval because it must be smaller than the regular refresh interval configured in the **config**>**router**>**rsvp**>**refresh-time** context.

There is also a maximum number of retransmissions of an unacknowledged RSVP-TE message rapid-retry-limit. The node will stop retransmission of unacknowledged RSVP-TE messages whenever the updated backoff interval exceeds the value of the regular **refresh-time** interval or the number of retransmissions reaches the value of the **rapid-retry-limit** parameter, whichever comes first. These two parameters are configurable globally on a system in the **config**>**router**>**rsvp** context.

Summary refresh consists of sending a summary refresh message containing a message_id list object. The fields of this object are populated each with the value of the message_identifier field in the message_id object of a previously sent individual PATH or RESV message. The summary refresh message is sent every refresh regular interval as configured by the user using the refresh-time command in the **config**>**router**>**rsvp** context. The receiver checks each message_id object against the saved PATH and RESV states. If a match is found, the state is updated as if a regular PATH or RESV refresh message was received from the peer. If a specific message_identifier field does not match, then the node sends a message_id_nack object to the originator of the message.

The above capabilities are referred to collectively as “refresh overhead reduction extensions”. When the refresh-reduction is enabled on a 7705 SAR RSVP-TE interface, the node indicates this to its peer by setting a “refresh-reduction-capable” bit in the flags field of the common RSVP-TE header. If both peers of an RSVP-TE interface set this bit, all the above three capabilities can be used. Furthermore, the node monitors the settings of this bit in received RSVP-TE messages from the peer on the interface. As soon as this bit is cleared, the 7705 SAR stops sending summary refresh messages. If a peer did not set the “refresh-reduction-capable” bit, a node does not attempt to send summary refresh messages.

However, if the peer did not set the “refresh-reduction-capable” bit, then a node with refresh reduction enabled and reliable message delivery enabled will still attempt to perform reliable message delivery with this peer. If the peer does not support the message_id object, it returns the error message “unknown object class”. In this case, the 7705 SAR node retransmits the RSVP-TE message without the message_id object and reverts to using this method for future messages destined for this peer.

The **no** form of the command reverts to the default value.

Default no refresh-reduction

reliable-delivery

Syntax [**no**] **reliable-delivery**

Context config>router>rsvp>if>refresh-reduction

Description This command enables reliable delivery of RSVP-TE messages over the RSVP-TE interface. When **refresh-reduction** is enabled on an interface and **reliable-delivery** is disabled, then the 7705 SAR will send a message_id and not set ACK desired in the RSVP-TE messages over the interface.

The 7705 SAR does not expect an ACK but will accept it if received. The node will also accept message ID and reply with an ACK when requested. In this case, if the neighbor set the “refresh-reduction-capable” bit in the flags field of the common RSVP-TE header, the node will enter summary refresh for a specific message_id it sent regardless of whether it received an ACK or not to this message from the neighbor.

When the **reliable-delivery** option is enabled on any interface, RSVP-TE message pacing is disabled on all RSVP-TE interfaces of the system; for example, the user cannot enable the **msg-pacing** option in the **config**>**router**>rsvp context, and an error message is returned in CLI. When the **msg-pacing** option is enabled, the user cannot enable the **reliable-delivery** option on any interface on this system. An error message will also be generated in CLI after such an attempt.

The **no** form of the command reverts to the default value.

Default no reliable-delivery

subscription

Syntax **subscription** *percentage*
no subscription

Context config>router>rsvp>interface

Description This command configures the percentage of the link bandwidth that RSVP-TE can use for reservation and sets a limit for the amount of over-subscription or under-subscription allowed on the interface.

When the **subscription** is set to zero, no new sessions are permitted on this interface. If the percentage is exceeded, the reservation is rejected and a log message is generated.

The **no** form of this command resets the percentage to the default value.

Default 100

Parameters *percentage* — specifies the percentage of the interface's bandwidth that RSVP-TE allows to be used for reservations

Values 0 to 1000

3.23.2.2.4 Message Pacing Commands

msg-pacing

Syntax [**no**] **msg-pacing**

Context config>router>rsvp

Description This command enables RSVP-TE message pacing, which is defined by the **max-burst** and **period** commands. A count is kept of the messages that were dropped because the output queue for the interface used for message pacing was full.

Default no msg-pacing

max-burst

Syntax **max-burst** *number*
no max-burst

Context config>router>rsvp>msg-pacing

Description This command specifies the maximum number of RSVP-TE messages that can be sent under normal operating conditions, as specified by the **period** command. The **no** form of this command reverts to the default value.

Default 650

Parameters *number* — maximum number of RSVP-TE messages

Values 100 to 1000, in increments of 10

period

Syntax **period** *milli-seconds*
no period

Context config>router>rsvp>msg-pacing

Description This command specifies the time interval, in milliseconds, during which the router can send RSVP-TE messages, as specified by the **max-burst** command. The **no** form of this command reverts to the default value.

Default 100

Parameters *milli-seconds* — the time interval during which the router can send RSVP-TE messages

Values 100 to 1000 milliseconds, in increments of 10 milliseconds

3.23.2.3 Show Commands (MPLS)

Note: The following command outputs are examples only; actual displays may differ depending on supported functionality and user configuration.

admin-group

Syntax **admin-group** *group-name*

Context show>router>mpls

Description This command displays MPLS administrative group information.

Parameters *group-name* — specifies the administrative group name

Output The following output is an example of MPLS administrative group information, and Table 9 describes the fields.

Output Example

```
A:ALU-1# show router mpls admin-group
===============================================
MPLS Administrative Groups
===============================================
Group Name                          Group Value
-----------------------------------------------
green                               15
red                                 25
yellow                              20
-----------------------------------------------
No. of Groups: 3
===============================================
A:ALU-1#
```

Table 9 **Router MPLS Admin-Group Field Descriptions**

Label	Description
Group Name	The name of the administrative group. The name identifies the administrative group within a router instance.
Group Value	The unique group value associated with the administrative group. If the value displays “-1”, then the group value for this entry has not been set.
No. of Groups	The total number of configured administrative groups within the router instance

bypass-tunnel

Syntax **bypass-tunnel** [**to** *ip-address*] [**protected-lsp** [*lsp-name*]] [**dynamic** | **manual**] [**detail**]

Context show>router>mpls

Description If fast reroute is enabled on an LSP and the facility method is selected, instead of creating a separate LSP for every LSP that is to be backed up, a single LSP is created that serves as a backup for a set of LSPs. This type of LSP tunnel is called a bypass tunnel.

Parameters *ip-address* — specifies the IP address of the egress router

lsp-name — specifies the name of the LSP protected by the bypass tunnel

dynamic — displays dynamically assigned labels for bypass protection

manual — displays manually assigned labels for bypass protection

detail — displays detailed information

Output The following output is an example of MPLS bypass tunnel information, and Table 10 describes the fields.

Output Example

```
A:ALU-12>show>router>mpls# bypass-tunnel to 10.20.1.4
===============================================================================
Legend :  m - Manual              d - Dynamic
===============================================================================
To              State     Out I/F  Out Label   Reserved    Protected     Type
                                                 BW (Kbps)   LSP Count
-------------------------------------------------------------------------------
10.20.1.4       Up        lag        *-*          131071      0
-------------------------------------------------------------------------------
Bypass Tunnels : 1
===============================================================================
A:ALU-12>show>router>mpls#
```

Table 10 **Router MPLS Bypass-Tunnel Field Descriptions**

Label	Description
To	The system IP address of the egress router
State	The administrative state of the LSP
Out I/F	The name of the network IP interface
Out Label	The incoming MPLS label on which to match
Reserved BW (Kbps)	The amount of bandwidth in kilobytes per second (Kbps) reserved for the LSP
Protected LSP Count	The number of times this LSP has used a protected LSP

Table 10 **Router MPLS Bypass-Tunnel Field Descriptions (Continued)**

Label	Description
Type	The type of protected LSP

interface

Syntax **interface** [*ip-int-name* | *ip-address*] [**label-map** [*label*]]
interface [*ip-int-name* | *ip-address*] **statistics**

Context show>router>mpls

Description This command displays MPLS interface information.

Parameters *ip-int-name* — identifies the network IP interface. The interface name cannot be in the form of an IP address. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

ip-address — specifies the system or network interface IP address

label-map label — specifies the MPLS label on which to match

Values 32 to 1023

statistics — displays IP address and the number of packets and octets sent and received on an interface basis

Output The following output is an example of MPLS interface information, and Table 11 describes the fields.

Output Example

```
ALU-12# show router mpls interface
===============================================================================
MPLS Interfaces
===============================================================================
Interface                     Port-id          Adm          Opr        TE-metric
-------------------------------------------------------------------------------
system                        vport-1           Up           Up        None
  Admin Groups                None
  Srlg Groups                 None
ip-10.10.1.2                  1/1/1             Up           Up        None
  Admin Groups                None
  Srlg Groups                 None
ip-10.10.4.2                  1/1/2             Up           Up        None
  Admin Groups                None
  Srlg Groups                 None
ip-10.10.3.2                  1/1/3             Up           Up        None
  Admin Groups                None
  Srlg Groups                 None
-------------------------------------------------------------------------------
```

```
Interfaces : 4
===============================================================================


*A:ALU-48>config>router>mpls# show router mpls interface "to-104" label-map 35
===============================================================================
MPLS Interface : to-104 (Label-Map 35)
===============================================================================
In Label  In I/F     Out Label Out I/F    Next Hop          Type      Adm  Opr
-------------------------------------------------------------------------------
35        1/1/1      n/a       n/a        n/a               Static    Up   Down
-------------------------------------------------------------------------------
Interfaces : 1
===============================================================================
*A:ALU-48>config>router>mpls#


ALU-12# show router mpls interface statistics
===============================================================================
MPLS Interface (statistics)
===============================================================================
Interface      : ip-10.10.1.1
  Transmitted  : Pkts - 6                    Octets - 540
  Received     : Pkts - 0                    Octets - 0
  Invalid      : Labels             - 0
  Invalid      : IPoMPLS Pkts       - 0
  Invalid      : Stack Too Big Pkts - 0
  Invalid      : TTL Expired Pkts   - 0
  Invalid      : Other Discard Pkts - 0
  Last Invalid : Label Value        - 0
  Last Invalid : Label Position     - 0
Interface      : ip-10.10.2.1
  Transmitted  : Pkts - 0                    Octets - 0
  Received     : Pkts - 0                    Octets - 0
  Invalid      : Labels             - 0
  Invalid      : IPoMPLS Pkts       - 0
  Invalid      : Stack Too Big Pkts - 0
  Invalid      : TTL Expired Pkts   - 0
  Invalid      : Other Discard Pkts - 0
  Last Invalid : Label Value        - 0
  Last Invalid : Label Position     - 0
===============================================================================
ALU-12#
```

Table 11 Router MPLS Interface Field Descriptions

Label	Description
Interface	The interface name
Port-id	The port ID in the *slot/mda/port* format
Adm	The administrative state of the interface
Opr	The operational state of the interface
Te-metric	The traffic engineering metric used on the interface

Table 11 **Router MPLS Interface Field Descriptions (Continued)**

Label	Description
Srlg Groups	The shared risk link group (SRLG)
Interfaces	The total number of interfaces
Transmitted	The number of packets and octets transmitted from the interface
Received	The number of packets and octets received
In Label	The ingress label
In I/F	The ingress interface
Out Label	The egress label
Out I/F	The egress interface
Next Hop	The next-hop IP address for the static LSP
Type	Indicates whether the label value is statically or dynamically assigned
Invalid	Labels — the number of incoming packets discarded due to invalid labels
	IPoMPLS Pkts — the number of incoming labeled packets discarded due to invalid IP packet headers in the packet
	Stack Too Big Pkts — the number of incoming packets discarded due to having greater than the maximum number of labels in the label stack (that is, greater than five)
	TTL Expired Pkts — the number of incoming packets discarded due to exceeding the maximum Time-To-Live (TTL) value
	Other Discard Pkts — the number of incoming packets discarded due to internal errors (for example, memory corruption or invalid label table programming)
Last Invalid	Label Value — the value of the last invalid label received
	Label Position — the position in the label stack of the last invalid label received

lsp

Syntax **lsp** [*lsp-name*] [**status** {**up** | **down**}] [**from** *ip-address* | **to** *ip-address*] [**detail**] [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]
lsp {**transit** | **terminate**} [**status** {**up** | **down**}] [**from** *ip-address* | **to** *ip-address* | **lsp-name** *name*] [**detail**]
lsp count
lsp [*lsp-name*] **activepath** [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]
lsp [*lsp-name*] **path** [*path-name*] [**status** {**up** | **down**}] [**detail**] [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]
lsp [*lsp-name*] **path** [*path-name*] **mbb** [**auto-lsp** {**all** | **mesh-p2p** | **one-hop-p2p**}]

Context show>router>mpls

Description This command displays LSP details.

Parameters *lsp-name* — specifies the name of the LSP used in the path

status up — displays an LSP that is operationally up

status down — displays an LSP that is operationally down

from *ip-address* — displays the IP address of the ingress router for the LSP

to *ip-addres***s** — displays the IP address of the egress router for the LSP

transit — displays the LSPs that transit the router

terminate — displays the LSPs that terminate at the router

name — displays the IP address of the named LSP

count — displays the total number of LSPs

activepath — displays the present path being used to forward traffic

path-name — specifies the name of the path carrying the LSP

mbb — displays make-before-break (MBB) information

detail — displays detailed information

auto-lsp {**all** | **mesh-p2p** | **one-hop-p2p**} — specifies the type of auto LSP or all auto LSPs

Output The following outputs are examples of MPLS LSP information:

- MPLS LSP (Output Example, Table 12)
- MPLS LSP Detail (Output Example, Table 13)
- MPLS LSP Path Detail (Output Example, Table 14)
- MPLS LSP Path MBB (Output Example, Table 15)
- MPLS Auto LSP (Output Example, Table 16)

Output Example

```
A:ALU-48# show router mpls lsp
===============================================================================
MPLS LSPs (Originating)
===============================================================================
LSP Name                            To                 Fastfail     Adm   Opr
                                                       Config
-------------------------------------------------------------------------------
to-104                              10.10.10.104       Yes          Up    Up
to-103                              10.0.0.0           Yes          Up    Up
to-99                               10.10.10.99        No           Up    Up
to-100                              10.10.10.100       No           Up    Up
to-49                               10.20.30.49        No           Dwn   Up
-------------------------------------------------------------------------------
LSPs : 5
===============================================================================
A:ALU-48#

*A:ALU-48# show router mpls lsp to-104
===============================================================================
MPLS LSPs (Originating)
===============================================================================
LSP Name                            To                 Fastfail     Adm   Opr
                                                       Config
-------------------------------------------------------------------------------
to-104                              10.10.10.104       Yes          Up    Dwn
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================
*A:ALU-48#
```

Table 12 **Router MPLS LSP Field Descriptions**

Label	Description
LSP Name	The name of the LSP used in the path
To	The system IP address of the egress router for the LSP
FastFail Config	enabled — fast reroute is enabled. In the event of a failure, traffic is immediately rerouted on the precomputed protection LSP, thus minimizing packet loss
	disabled — there is no protection LSP from each node on the primary path
Adm State	Down — the path is administratively disabled
	Up — the path is administratively enabled
Oper State	Down — the path is operationally down
	Up — the path is operationally up
LSPs	The total number of LSPs configured

Output Example

```
*A:ALU-48# show router mpls lsp to-104 detail
===============================================================================
MPLS LSPs (Originating) (Detail)
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : to-104                          LSP Tunnel ID  : 1
From        : 10.10.10.103                    To             : 10.10.10.104
Adm State   : Up                              Oper State     : Down
LSP Up Time : 0d 00:00:00                     LSP Down Time  : 0d 00:46:50
Transitions : 0                               Path Changes   : 0
Retry Limit : 0                               Retry Timer    : 30 sec
Signaling   : RSVP                            Resv. Style    : FF
Hop Limit   : 10                              Negotiated MTU : 0
Adaptive    : Enabled
FastReroute : Enabled                         Oper FR        : Disabled
FR Method   : Facility                        FR Hop Limit   : 16
FR Bandwidth: 0 Mbps                          FR Node Protect: Enabled
FR Object   : Enabled
CSPF        : Enabled                         ADSPEC         : Enabled
Metric      : 1                               Use TE metric  : Disabled
Include Grps:                                 Exclude Grps   :
None                                          None
Type        : RegularLsp

Auto BW     : Disabled
LdpOverRsvp : Disabled                        VprnAutoBind   : Disabled
IGP Shortcut: Enabled
IGP LFA     : Disabled                        IGP Rel Metric : -1
BGPTransTun : Enabled
Oper Metric : 20
Prop Adm Grp: Disabled

Secondary   : secondary-path                  Down Time      : 0d 00:46:50
Bandwidth   : 50000 Mbps
Primary     : to-NYC                          Down Time      : 0d 00:46:50
Bandwidth   : 0 Mbps
===============================================================================
```

Table 13 Router MPLS LSP Detail Field Descriptions

Label	Description
LSP Name	The name of the LSP used in the path
From	The IP address of the ingress router for the LSP
To	The system IP address of the egress router for the LSP
Adm State	Down — the path is administratively disabled
	Up — the path is administratively enabled

Table 13 **Router MPLS LSP Detail Field Descriptions (Continued)**

Label	Description
Oper State	Down — the path is operationally down
	Up — the path is operationally up
LSP Up Time	The length of time the LSP has been operational
LSP Down Time	The total time in increments that the LSP path has not been operational
Transitions	The number of transitions that have occurred for the LSP
Path Changes	The number of path changes this LSP has had. For every path change (path down, path up, path change), a corresponding syslog/trap (if enabled) is generated.
Retry Limit	The number of attempts that the software should make to re-establish the LSP after it has failed
Retry Timer	The time, in seconds, for LSP re-establishment attempts after an LSP failure
Signaling	Specifies the signaling style
Resv Style	se — specifies a shared reservation environment with a limited reservation scope. This reservation style creates a single reservation over a link that is shared by an explicit list of senders.
	ff — specifies a shared reservation environment with an explicit reservation scope. Specifies an explicit list of senders and a distinct reservation for each of them.
Hop Limit	The maximum number of hops that an LSP can traverse, including the ingress and egress routers
Negotiated MTU	The size of the maximum transmission unit (MTU) that is negotiated during establishment of the LSP
Adaptive	Indicates whether make-before-break is enabled or disabled for resignaled paths
Fast Reroute	Enabled — fast reroute is enabled. In the event of a failure, traffic is immediately rerouted on the precomputed protection LSP, thus minimizing packet loss.
	Disabled — there is no protection LSP from each node on the primary path
Oper FR	Indicates whether FRR has been enabled or disabled
FR Method	The type of Fast Reroute (FRR) that is used by the path

Table 13 **Router MPLS LSP Detail Field Descriptions (Continued)**

Label	Description
FR Hop Limit	The total number of hops a protection LSP can take before merging back onto the main LSP path
FR Bandwidth	The amount of bandwidth reserved for fast reroute
FR Node Protect	Indicates whether FRR has node protection enabled or disabled
FR Object	Indicates whether signaling the frr-object is on or off
CSPF	Indicates whether CSPF has been enabled or disabled
ADSPEC	enabled — the LSP will include advertising data (ADSPEC) objects in RSVP-TE messages
	disabled — the LSP will not include advertising data (ADSPEC) objects in RSVP-TE messages
Metric	The TE metric value
Use TE metric	Indicates whether the use of the TE metric is enabled or disabled
Include Grps	The admin groups that are to be included by an LSP when signaling a path
Exclude Grps	The admin groups that are to be avoided by an LSP when signaling a path
Type	The type of LSP
IGP Shortcut	Indicates whether this LSP can be used as a shortcut by OSPF or IS-IS
IGP LFA	Indicates whether the LSP is included in the LFA SPF calculation
IGP Rel Metric	The relative metric of the LSP
Secondary	The alternate path that the LSP will use if the primary path is not available
Down Time	The length of time that the path has been down
Bandwidth	The amount of bandwidth in megabits per second (Mbps) reserved for the LSP path
Primary	The preferred path for the LSP

Output Example

```
*A:ALU-48# show router mpls lsp path detail
===============================================================================
MPLS LSP  Path  (Detail)
===============================================================================
Legend :
    @ - Detour Available              # - Detour In Use
    b - Bandwidth Protected           n - Node Protected
===============================================================================
LSP 1 Path 1
-------------------------------------------------------------------------------
LSP Name    : 1                                   Path LSP ID : 30226
From        : 10.20.1.1                           To          : 10.20.1.2
Adm State   : Up                                  Oper State  : Up
Path Name   : 1                                   Path Type   : Primary
Path Admin  : Up                                  Path Oper   : Up
OutInterface: 1/1/1                               Out Label   : 131071
Path Up Time: 0d 00:59:39                         Path Dn Time: 0d 00:00:00
Retry Limit : 20                                  Retry Timer : 30 sec
RetryAttempt: 0                                   Next Retry *: 0 sec
Bandwidth   : 200 Mbps                            Oper Bandwi*: 50 Mbps
Hop Limit   : 255
Record Route: Record                              Record Label: Record
Oper MTU    : 1500                                Neg MTU     : 1500
Adaptive    : Enabled
Include Grps:                                     Exclude Grps:
None                                              None
Preference  : 1
Path Trans  : 9                                   CSPF Queries: 205
Failure Code: noError                             Failure Node: n/a
ExplicitHops:
    No Hops Specified
Actual Hops :
    10.20.1.1, If Index : 2 @ n                   Record Label : N/A
 -> 10.20.1.2, If Index : 2 @ n                   Record Label : 131071
 -> 10.20.1.4, If Index : 2                       Record Label : 131071
 -> 10.20.1.6, If Index : 2                       Record Label : 131071
ComputedHops:
    10.20.1.1, If Index : 2(S)
 -> 10.20.1.2, If Index : 2(S)
 -> 10.20.1.4, If Index : 2(S)
 -> 10.20.1.6, If Index : 2(S)
LastResignalAttempt: 2008/04/08 11:42:33.22 PST  Metric      : 1000

Last MBB:
MBB Type    : Timer-based Resignal                MBB State   : Success/Failed
Ended at    : 2008/04/08 11:12:23.76 PST          Old Metric  : 3000

In Progress MBB:
MBB Type    : Config Change                       NextRetryIn : 16 sec
Started at  : 2008/04/08 12:01:02.20 PST          RetryAttempt: 3
Failure Code: noCspfRouteToDestination            Failure Node: 10.20.1.1
===============================================================================
*A:ALU-48#
```

Table 14 **Router MPLS LSP Path Detail Field Descriptions**

Label	Description
LSP Name	The name of the LSP used in the path
Path LSP ID	The LSP ID for the path
From	The IP address of the ingress router for the LSP
To	The system IP address of the egress router for the LSP
Adm State	Down — the path is administratively disabled
	Up — the path is administratively enabled
Oper State	Down — the path is operationally down
	Up — the path is operationally up
Path Name	The alphanumeric name of the path
Path Type	The type of path: primary or secondary
Path Admin	The administrative status of the path
Path Oper	The operational status of the path
OutInterface	The output interface of the LSP
Out Label	The output label of the LSP
Path Up Time	The length of time that the path has been operationally up
Path Down Time	The length of time that the path has been operationally down
Retry Limit	The number of times an LSP will retry before giving up
Retry Timer	The length of time between LSP signaling attempts
Retry Attempt	The number of attempts that have been made to re-establish the LSP
Next Retry	The time when the next attempt to re-establish the LSP will occur
Bandwidth	The amount of bandwidth in megabits per second (Mbps) reserved for the LSP
Oper Bandwidth	The bandwidth reserved by the LSP
Hop Limit	The limit on the number of hops taken by the LSP
Record Route	Indicates whether a list of routers for the LSP has been recorded
Record Label	Indicates whether a list of router labels has been recorded

Table 14 **Router MPLS LSP Path Detail Field Descriptions (Continued)**

Label	Description
Oper MTU	The operational MTU of the connection to the next hop
Neg MTU	The MTU negotiated between the router and its next hop
Adaptive	Indicates whether make-before-break is enabled or disabled for resignaled paths
Include Grps	The admin groups that are to be included by an LSP when signaling a path
Exclude Grps	The admin groups that are to be avoided by an LSP when signaling a path
Preference	The path-preference priority number assigned to a standby secondary LSP path
Path Trans	The number of times a path has made a transition between up and down states
CSPF Queries	The number of requests made by the LSP to the TE database
Failure Code	The reason code for in-progress MBB failure. A value of **none** indicates that no failure has occurred.
Failure Node	The IP address of the node in the LSP at which the in-progress MBB failed. If no failure has occurred, this value is **none**.
Explicit Hops	The hops that have been specified by the user
Actual Hops	The hops that the route has taken, either numbered or unnumbered
Record Label	The label recorded at the specified hop
Computed Hops	The hops computed and returned from the routing database, either numbered or unnumbered
LastResignalAttempt	The system up time when the last attempt to resignal this LSP was made
Last Resignal	The last time the route was resignaled
Metric	The value of the metric
Last MBB	The header for the last make-before-break (MBB) information
MBB Type	An enumerated integer that specifies the type of make-before-break (MBB) operation. If **none** displays, then there is no MBB in progress or no last MBB.
MBB State	The state of the most recent invocation of the make-before-break functionality

Table 14 **Router MPLS LSP Path Detail Field Descriptions (Continued)**

Label	Description
Ended at	The system up time when the last MBB ended
Old Metric	The cost of the traffic engineered path for the LSP prior to MBB
In Progress MBB	Header for the currently in-progress MBB information
MBB Type	An enumerated integer that specifies the type of make-before-break (MBB) operation. If **none** displays, then there is no MBB in progress or no last MBB.
NextRetryIn	The amount of time remaining, in seconds, before the next attempt is made to retry the in-progress MBB
Started At	The time the current MBB began
RetryAttempt	The number of attempts for the MBB in progress
Failure Code	The reason code for in-progress MBB failure. A value of **none** indicates that no failure has occurred.
Failure Node	The IP address of the node in the LSP at which the in-progress MBB failed. If no failure has occurred, this value is **none**.

Output Example

```
*A:ALU-48# show router mpls lsp path mbb
===============================================================================
MPLS LSP Path MBB
===============================================================================
LSP 1 Path 1
-------------------------------------------------------------------------------
LastResignalAttempt: 2008/04/08 11:42:33.22 PST  CSPF Metric  : 0

Last MBB:
MBB Type    : Timer-based Resignal               MBB State   : Success/Failed
Ended at    : 2008/04/08 11:12:23.76 PST         Old Metric  : 3000

In Progress MBB:
MBB Type    : Config Change                      NextRetryIn : 16 sec
Started at  : 2008/04/08 12:01:02.20 PST         RetryAttempt: 3
Failure Code: noCspfRouteToDestination           Failure Node: 10.20.1.1

-------------------------------------------------------------------------------
LSP 2 Path 1
-------------------------------------------------------------------------------
LastResignalAttempt: 2008/04/08 11:42:33.54 PST  CSPF Metric  : 0

Last MBB:
MBB Type    : Timer-based Resignal               MBB State   : Success/Failed
Ended at    : 2008/04/08 11:12:24.76 PST         Old Metric  : 2000
```

```
-------------------------------------------------------------------------------
LSP 4 Path 1
-------------------------------------------------------------------------------
LastResignalAttempt: 2008/04/08 11:42:34.12 PST  CSPF Metric  : 0

In Progress MBB:
MBB Type    : Global Revertive                   NextRetryIn : 10 sec
Started at  : 2008/04/08 11:45:02.20 PST         RetryAttempt: 2
Failure Code: noCspfRouteToDestination           Failure Node: 10.20.1.1
===============================================================================
*A:ALU-48#
```

Table 15 **Router MPLS LSP Path MBB Field Descriptions**

Label	Description
LastResignalAttempt	The system up time when the last attempt to resignal this LSP was made
CSPF Metric	The value of the CSPF metric
Last MBB	Header for the last make-before-break (MBB) information
MBB Type	An enumerated integer that specifies the type of make-before-break (MBB) operation. If **none** displays, then there is no MBB in progress or no last MBB.
MBB State	The state of the most recent invocation of the make-before-break functionality
Ended at	The system up time when the last MBB ended
Old Metric	The cost of the traffic-engineered path for the LSP path prior to MBB
In Progress MBB	The header for the currently in-progress MBB information
MBB Type	An enumerated integer that specifies the type of make-before-break (MBB) operation. If **none** displays, then there is no MBB in progress or no last MBB.
NextRetryIn	The amount of time remaining, in seconds, before the next attempt is made to retry the in-progress MBB
Started At	The time that the current MBB began
RetryAttempt	The number of attempts for the MBB in progress
Failure Code	The reason code for in-progress MBB failure. A value of **none** indicates that no failure has occurred.
Failure Node	The IP address of the node in the LSP path at which the in-progress MBB failed. When no failure has occurred, this value is **none**.

Output Example

```
A:ALU-48# show router mpls lsp auto-lsp mesh-p2p
===============================================================================
MPLS LSPs (Originating)
===============================================================================
LSP Name                          Type               Fastfail     Admin  Oper
                                                     Config       State  State
-------------------------------------------------------------------------------
MESH-192.0.2.8-61456              MeshP2P            Yes           Up     Up
MESH-192.0.2.9-61457              MeshP2P            Yes           Up     Up
-------------------------------------------------------------------------------
Auto-LSPs : 2
===============================================================================
A:ALU-48#
```

Table 16 **Router MPLS Auto LSP Field Descriptions**

Label	Description
LSP Name	The name of the LSP used in the path
Type	The type of auto LSP
FastFail Config	enabled — fast reroute is enabled. In the event of a failure, traffic is immediately rerouted on the precomputed protection LSP, thus minimizing packet loss
	disabled — there is no protection LSP from each node on the primary path
Admin State	Down — the path is administratively disabled
	Up — the path is administratively enabled
Oper State	Down — the path is operationally down
	Up — the path is operationally up
LSPs	The total number of LSPs configured

lsp-egress-stats

Syntax **lsp-egress-stats** [**type** *lsp-type*] [**active**] [**template-match**]
lsp-egress-stats lsp *lsp-name*

Context show>router>mpls

Description This command displays RSVP LSP egress statistical information.

Parameters *lsp-type* — specifies the type of LSP to display. The only available options are **p2p** and **p2mp**.

active — displays information from all LSPs with statistics collection enabled

template-match — displays information for a one-hop point-to-point, mesh point-to-point, or point-to-multipoint LSP template

lsp-name — the name that identifies the LSP

Output The following output is an example of RSVP LSP egress statistical information.

Output Example

```
a.show>router>mpls>lsp-egress-stats lsp_1
-------------------------------------------------------------------------------
LSP Name      : toNodeC_1
-------------------------------------------------------------------------------
Collect Stats : Disabled                Accting Plcy. : None
Adm State     : Up                      PSB Match     : True
FC BE
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC L2
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC AF
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC L1
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC H2
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC EF
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC H1
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC NC
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
-------------------------------------------------------------------------------
LSP Egress Statistics : 1
===============================================================================
```

lsp-ingress-stats

Syntax **lsp-ingress-stats** [**type** *lsp-type*] [**active**] [**template-match** *SessionNameString* [**sender** *ip-address*]]

lsp-ingress-stats lsp *lsp-name* **sender** *ip-address*

Context show>router>mpls

Description This command displays RSVP LSP ingress statistical information.

Parameters *lsp-type* — specifies the type of LSP to display. The only available options are **p2p** and **p2mp**.

active — displays information from all LSPs with statistics collection enabled

template-match — displays information for a one-hop point-to-point, mesh point-to-point, or point-to-multipoint LSP template

SessionNameString — the name of the session, up to 64 characters long

ip-address — the system IP address of the sender (a.b.c.d)

lsp-name — the name that identifies the LSP

Output The following output is an example of RSVP LSP ingress statistical information.

Output Example

```
b.show>router>mpls>lsp-ingress-stats 1.2.2.2 lsp lsp_1
===============================================================================
MPLS LSPs Ingress Statistics
===============================================================================
-------------------------------------------------------------------------------
LSP Name      : toNodeA_1
Sender        : 10.10.10.29
-------------------------------------------------------------------------------
Collect Stats : Disabled                Accting Plcy. : None
Adm State     : Up                      PSB Match     : True
FC BE
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC L2
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC AF
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC L1
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC H2
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC EF
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC H1
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
FC NC
InProf Pkts   : 0                       OutProf Pkts  : 0
InProf Octets : 0                       OutProf Octets: 0
-------------------------------------------------------------------------------
LDP Ingress Statistics : 1
===============================================================================
```

lsp-template

Syntax **lsp-template** [*template-name*] **bindings**
lsp-template [*template-name*] [**detail**]

Context show>router>mpls

Description This command displays MPLS LSP template information.

Parameters *template-name* — the unique name for the LSP template

bindings — displays any bindings associated with the LSP template

detail — displays detailed information for the LSP template

Output The following output is an example of MPLS LSP template information, and Table 17 describes the fields.

Output Example

```
A:ALU-12# show router mpls lsp-template detail
===============================================================================
MPLS LSP Templates (Detail)
===============================================================================
-------------------------------------------------------------------------------
LSP Template : MeshTemplateWithLoosePath
-------------------------------------------------------------------------------
Type               : MeshP2P            Admin State         : Up
From               : 10.20.1.3
Default Path       : LooseHopPathNameW* Adaptive            : Enabled
Bandwidth          : 0 Mbps             Hop Limit           : 18
CSPF               : Enabled            Use TE metric       : Disabled
Propagate Admin Grp: Enabled
Include Groups     :                    Exclude Groups      :
None                                    G0
                                        G1
                                        G2
                                        G3
FastReroute        : Enabled
FR Method          : Facility           FR Hop Limit        : 13
FR Prop Admin Group: Enabled
FR Node Protect    : Disabled
Record Route       : Record             Record Label       : Record
Retry Limit        : 100                Retry Timer        : 30 sec
LSP Count          : 3                  Ref Count          : 0
LdpOverRsvp        : Disabled           VprnAutoBind       : Enabled
IGP Shortcut       : Enabled            BGP Shortcut       : Disabled
IGP LFA            : Disabled           IGP Rel Metric     : Disabled
Least Fill         : Enabled            Metric             : 25
SetupPriority      : 7                  Hold Priority      : 0
Egress Stats       : Disabled
Collect Stats      : Disabled           Accounting Policy  : None
Class Type         : 0                  Backup Class Type  : 0
Main CT Retry Limit: 0                  BGP Transport Tunn : Enabled
ADSPEC             : Disabled
===============================================================================
A:ALU-12#
```

Table 17 **Router MPLS LSP Template Field Descriptions**

Label	Description
Type	The type of LSP
Admin State	Down — the path is administratively disabled
	Up — the path is administratively enabled
From	The IP address of the ingress router for the LSP
Default Path	The value used to order the hops in a path
Adaptive	Indicates whether the adaptive option is enabled or disabled
Bandwidth	n/a
Hop Limit	The maximum number of hops that an LSP can traverse, including the ingress and egress routers
CSPF	Indicates whether the CSPF option is enabled or disabled (always enabled for LSP templates)
Use TE metric	Indicates whether the TE metric option is enabled or disabled
Propagate Admin Grp	Indicates whether the propagate admin group option is enabled or disabled
Include Groups	The admin groups that are to be included by an LSP when signaling a path
Exclude Groups	The admin groups that are to be excluded by an LSP when signaling a path
FastReroute	Indicates whether the Fast Reroute option is enabled or disabled
FR Method	The type of Fast Reroute (FRR) that is used by the path (always Facility for LSP templates)
FR Hop Limit	The total number of hops a protection LSP can take before merging back onto the main LSP path
FR Prop Admin Group	Indicates whether the FRR propagate admin group option is enabled or disabled
FR Node Protect	Indicates whether FRR has node protection enabled or disabled
Record Route	Indicates whether the route is being recorded
Record Label	Indicates whether the label is being recorded
Retry Limit	The maximum number of retries allowed

Table 17 **Router MPLS LSP Template Field Descriptions (Continued)**

Label	Description
Retry Timer	The time between retry attempts
LSP Count	The number of LSPs belonging to the LSP template
Ref Count	n/a
LdpOverRsvp	n/a
VprnAutoBind	Indicates whether the VPRN auto-bind option is enabled or disabled
IGP Shortcut	Indicates whether the IGP shortcut option is enabled or disabled
BGP Shortcut	n/a
IGP LFA	Indicates whether the IGP LFA option is enabled or disabled
IGP Rel Metric	Indicates whether the IGP relative metric option is enabled or disabled
Least Fill	Indicates whether the least fill option is enabled or disabled
Metric	The TE metric value
SetupPriority	n/a
Hold Priority	n/a
Egress Stats	n/a
Collect Stats	n/a
Accounting Policy	n/a
Class Type	n/a
Backup Class Type	n/a
Main CT Retry Limit	n/a
BGP Transport Tunn	Indicates whether the BGP transport tunnel option is enabled or disabled
ADSPEC	enabled — the LSP will include advertising data (ADSPEC) objects in RSVP-TE messages
	disabled — the LSP will not include advertising data (ADSPEC) objects in RSVP-TE messages

path

Syntax **path** [*path-name*] [**lsp-binding**]

Context show>router>mpls

Description This command displays MPLS paths.

Parameters *path-name* — the unique name label for the LSP path

lsp-binding — displays binding information

Output The following output is an example of MPLS path information, and Table 18 describes the fields.

Output Example

```
A:ALU-12# show router mpls path
===============================================================================
MPLS Path:
===============================================================================
Path Name                       Adm  Hop Index   IP Address       Strict/Loose
-------------------------------------------------------------------------------
nyc_to_sjc_via_dfw              Up   20          192.20.1.4       Strict
                                     30          192.20.1.6       Strict
                                     40          192.20.1.8       Strict
                                     50          192.20.1.10      Strict

nyc_to_sjc_via_den              Up   10          192.20.1.5       Strict
                                     20          192.20.1.7       Loose
                                     30          192.20.1.9       Loose
                                     40          192.20.1.11      Loose
                                     50          192.20.1.13      Strict
secondary_path2                 Down no hops     n/a              n/a
-------------------------------------------------------------------------------
Paths : 3
===============================================================================
A:ALU-12#

A:ALU-12# show router mpls path lsp-binding
===============================================================================
MPLS Path:
===============================================================================
Path Name                       Opr  LSP Name                        Binding
-------------------------------------------------------------------------------
nyc_to_sjc_via_dfw              Up   NYC_SJC_customer1               Primary
nyc_to_sjc_via_den              Up   NYC_SJC_customer1               Standby
secondary_path2                 Down NYC_SJC_customer1               Seconda*
-------------------------------------------------------------------------------
Paths : 3
===============================================================================
A:ALU-12#
```

Table 18 **Router MPLS Path Field Descriptions**

Label	Description
Path Name	The unique name label for the LSP path
Adm	Down — the path is administratively disabled
	Up — the path is administratively enabled
Hop Index	The value used to order the hops in a path
IP Address	The IP address of the hop that the LSP should traverse on the way to the egress router
Strict/Loose	Strict — the LSP must take a direct path from the previous hop router to the next router
	Loose — the route taken by the LSP from the previous hop to the next hop can traverse other routers
Opr	The operational status of the path (up or down)
LSP Name	The name of the LSP used in the path
Binding	Primary — the preferred path for the LSP
	Secondary — the standby path for the LSP
Paths	Total number of paths configured

sr-te-lsp

Syntax **sr-te-lsp** [*lsp-name*] [**status** {**up** | **down**}] [**detail**] **path** [*path-name*]
sr-te-lsp [*lsp-name*] [**detail**]
sr-te-lsp [*sp-name*] [**status** {**up** | **down**}] [**to** *ip-address*] [**detail**]

Context show>router>mpls

Description This command displays segment routing-traffic engineering (SR-TE) LSP information.

Parameters *lsp-name* — displays SR-TE LSPs with the specified LSP name

status — displays SR-TE LSPs with the specified status (up or down)

detail — displays detailed information for the LSP template

path-name — displays SR-TE LSPs with the specified path name

ip-address — displays SR-TE LSPs connected to the IP address

Output The following outputs are examples of MPLS SR-TE path information.

- Output Example: SR-TE LSP

- Output Example: PCEP SR-TE LSP Configurations

Output Example: SR-TE LSP

```
*A:7705:Dut-A# show router mpls sr-te-lsp
===============================================================================
MPLS SR-TE LSPs (Originating)
===============================================================================
LSP Name                            To              Tun     Protect   Adm  Opr
                                                    Id      Path
-------------------------------------------------------------------------------
sr-te-lsp-to-Dut-C                  10.20.1.3       1       N/A       Up   Up
sr-te-lsp-to-Dut-B                  10.20.1.22      3       N/A       Up   Up
sr-te-lsp-to-Dut-D                  10.20.1.4       4       N/A       Up   Up
-------------------------------------------------------------------------------
LSPs : 3
===============================================================================


*A:7705:Dut-A# show router mpls sr-te-lsp   detail
===============================================================================
MPLS SR-TE LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : sr-te-lsp-to-Dut-C
LSP Type        : SrTeLsp                   LSP Tunnel ID        : 1
LSP Index       : 65536                     TTM Tunnel Id        : 655362
From            : 10.20.1.1                 To                   : 10.20.1.3
Adm State       : Up                        Oper State           : Up
LSP Up Time     : 0d 00:17:48               LSP Down Time        : 0d 00:00:00
Transitions     : 1                         Path Changes         : 1
Retry Limit     : 0                         Retry Timer          : 20 sec
Hop Limit       : 255                       Negotiated MTU       : 1550
CSPF            : Disabled
Metric          : N/A
Include Grps    :                           Exclude Grps         :
None                                           None
VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                  IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 16777215
PCE Report      : Inherited
PCE Compute     : Disabled                  PCE Control          : Disabled
Max SR Labels   : 4                         Additional FRR Labels: 1
Path Profile    :
None
Primary(a)      : sr-te-to-Dut-C            Up Time              : 0d 00:17:48
Bandwidth       : 0 Mbps
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : sr-te-lsp-to-Dut-B
LSP Type        : SrTeLsp                   LSP Tunnel ID        : 3
LSP Index       : 65538                     TTM Tunnel Id        : 655364
From            : 10.20.1.1                 To                   : 10.20.1.22
```

```
Adm State       : Up                          Oper State           : Up
LSP Up Time     : 0d 00:17:48                 LSP Down Time        : 0d 00:00:00
Transitions     : 1                           Path Changes         : 1
Retry Limit     : 0                           Retry Timer          : 20 sec
Hop Limit       : 255                         Negotiated MTU       : 1550
CSPF            : Disabled
Metric          : N/A
Include Grps    :                             Exclude Grps         :
None                                             None
VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                    IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 16777215
PCE Report      : Inherited
PCE Compute     : Disabled                    PCE Control          : Disabled
Max SR Labels   : 4                           Additional FRR Labels: 1
Path Profile    :
None
Primary(a)      : sr-te-to-Dut-B              Up Time              : 0d 00:17:48
Bandwidth       : 0 Mbps
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : sr-te-lsp-to-Dut-D
LSP Type        : SrTeLsp                     LSP Tunnel ID        : 4
LSP Index       : 65539                       TTM Tunnel Id        : 655365
From            : 10.20.1.1                   To                   : 10.20.1.4
Adm State       : Up                          Oper State           : Up
LSP Up Time     : 0d 00:17:22                 LSP Down Time        : 0d 00:00:00
Transitions     : 1                           Path Changes         : 1
Retry Limit     : 0                           Retry Timer          : 20 sec
Hop Limit       : 255                         Negotiated MTU       : 1542
CSPF            : Disabled
Metric          : N/A
Include Grps    :                             Exclude Grps         :
None                                             None
VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                    IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 16777215
PCE Report      : Inherited
PCE Compute     : Disabled                    PCE Control          : Disabled
Max SR Labels   : 4                           Additional FRR Labels: 1
Path Profile    :
None
Primary(a)      : sr-te-to-Dut-D              Up Time              : 0d 00:17:22
Bandwidth       : 0 Mbps
===============================================================================

*A:7705:Dut-A# show router mpls sr-te-lsp "sr-te-lsp-to-Dut-C" detail
===============================================================================
MPLS SR-TE LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : sr-te-lsp-to-Dut-C
```

```
LSP Type        : SrTeLsp                   LSP Tunnel ID        : 1
LSP Index       : 65536                     TTM Tunnel Id        : 655362
From            : 10.20.1.1                 To                   : 10.20.1.3
Adm State       : Up                        Oper State           : Up
LSP Up Time     : 0d 00:18:43               LSP Down Time        : 0d 00:00:00
Transitions     : 1                         Path Changes         : 1
Retry Limit     : 0                         Retry Timer          : 20 sec
Hop Limit       : 255                       Negotiated MTU       : 1550
CSPF            : Disabled
Metric          : N/A
Include Grps    :                           Exclude Grps         :
None                                           None
VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                  IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 16777215
PCE Report      : Inherited
PCE Compute     : Disabled                  PCE Control          : Disabled
Max SR Labels   : 4                         Additional FRR Labels: 1
Path Profile    :
None
Primary(a)      : sr-te-to-Dut-C            Up Time              : 0d 00:18:43
Bandwidth       : 0 Mbps
===============================================================================


*A:7705:Dut-A# show router mpls sr-te-lsp "sr-te-lsp-to-Dut-C" path detail
===============================================================================
MPLS SR-TE LSP sr-te-lsp-to-Dut-C Path  (Detail)
===============================================================================
Legend :
    S - Strict                          L - Loose
===============================================================================
-------------------------------------------------------------------------------
SR-TE LSP sr-te-lsp-to-Dut-C Path sr-te-to-Dut-C
-------------------------------------------------------------------------------
LSP Name         : sr-te-lsp-to-Dut-C
Path LSP ID      : 46592
From             : 10.20.1.1            To                   : 10.20.1.3
Admin State      : Up                   Oper State           : Up
Path Name        : sr-te-to-Dut-C       Path Type            : Primary
Path Admin       : Up                   Path Oper            : Up
Path Up Time     : 0d 00:19:10          Path Down Time       : 0d 00:00:00
Retry Limit      : 0                    Retry Timer          : 20 sec
Retry Attempt    : 1                    Next Retry In        : 0 sec
CSPF             : Disabled             Oper CSPF            : Disabled
Bandwidth        : No Reservation       Oper Bandwidth       : 0 Mbps
Hop Limit        : 255                  Oper HopLimit        : 255
Setup Priority   : 7                    Oper Setup Priority  : 7
Hold Priority    : 0                    Oper Hold Priority   : 0
Inter-area       : N/A

PCE Updt ID      : 0                    PCE Updt State       : None
PCE Upd Fail Code: noError
PCE Report       : Inherited            Oper PCE Report      : Disabled
PCE Control      : Disabled             Oper PCE Control     : Disabled
PCE Compute      : Disabled             Oper PCE Compute     : Disabled
Include Groups   :                      Oper Include Groups  :
None                                           None
```

```
Exclude Groups   :                        Oper Exclude Groups  :
None                                             None

IGP/TE Metric    : 16777215               Oper Metric          : 16777215
Oper MTU         : 1550                   Path Trans           : 1
Failure Code     : noError
Failure Node     : n/a
Explicit Hops    :
    10.20.1.3(L)
Actual Hops      :
    10.20.1.3 (10.20.1.3)                          Record Label        : 22003
===============================================================================

*A:7705:Dut-A# show router mpls sr-te-lsp status up
===============================================================================
MPLS SR-TE LSPs (Originating)
===============================================================================
LSP Name                            To               Tun     Protect   Adm  Opr
                                                     Id      Path
-------------------------------------------------------------------------------
sr-te-lsp-to-Dut-C                  10.20.1.3        1       N/A       Up   Up
sr-te-lsp-to-Dut-B                  10.20.1.22       3       N/A       Up   Up
sr-te-lsp-to-Dut-D                  10.20.1.4        4       N/A       Up   Up
-------------------------------------------------------------------------------
LSPs : 3
===============================================================================

*A:7705:Dut-A# show router mpls sr-te-lsp to 10.20.1.4
===============================================================================
MPLS SR-TE LSPs (Originating)
===============================================================================
LSP Name                            To               Tun     Protect   Adm  Opr
                                                     Id      Path
-------------------------------------------------------------------------------
sr-te-lsp-to-Dut-D                  10.20.1.4        4       N/A       Up   Up
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================

*A:7705:Dut-A# show router mpls sr-te-lsp to 10.20.1.4 detail
===============================================================================
MPLS SR-TE LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : sr-te-lsp-to-Dut-D
LSP Type        : SrTeLsp                  LSP Tunnel ID        : 4
LSP Index       : 65539                    TTM Tunnel Id        : 655365
From            : 10.20.1.1                To                   : 10.20.1.4
Adm State       : Up                       Oper State           : Up
LSP Up Time     : 0d 00:20:22              LSP Down Time        : 0d 00:00:00
Transitions     : 1                        Path Changes         : 1
Retry Limit     : 0                        Retry Timer          : 20 sec
Hop Limit       : 255                      Negotiated MTU       : 1542
CSPF            : Disabled
Metric          : N/A
Include Grps    :                          Exclude Grps         :
```

```
None                                              None
VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                  IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 16777215
PCE Report      : Inherited
PCE Compute     : Disabled                  PCE Control          : Disabled
Max SR Labels   : 4                         Additional FRR Labels: 1
Path Profile    :
None
Primary(a)      : sr-te-to-Dut-D            Up Time              : 0d 00:20:22
Bandwidth       : 0 Mbps
===============================================================================


*A:7705:Dut-A# show router mpls sr-te-lsp status up detail path  "sr-te-lsp-to-Dut-
D"
===============================================================================
MPLS SR-TE LSP sr-te-lsp-to-Dut-D Path  (Detail)
===============================================================================
Legend :
    S - Strict                          L - Loose
===============================================================================
-------------------------------------------------------------------------------
SR-TE LSP sr-te-lsp-to-Dut-D Path sr-te-to-Dut-D
-------------------------------------------------------------------------------
LSP Name          : sr-te-lsp-to-Dut-D
Path LSP ID       : 57856
From              : 10.20.1.1               To                   : 10.20.1.4
Admin State       : Up                      Oper State           : Up
Path Name         : sr-te-to-Dut-D          Path Type            : Primary
Path Admin        : Up                      Path Oper            : Up
Path Up Time      : 0d 00:22:23             Path Down Time       : 0d 00:00:00
Retry Limit       : 0                       Retry Timer          : 20 sec
Retry Attempt     : 2                       Next Retry In        : 0 sec
CSPF              : Disabled                Oper CSPF            : Disabled
Bandwidth         : No Reservation          Oper Bandwidth       : 0 Mbps
Hop Limit         : 255                     Oper HopLimit        : 255
Setup Priority    : 7                       Oper Setup Priority  : 7
Hold Priority     : 0                       Oper Hold Priority   : 0
Inter-area        : N/A

PCE Updt ID       : 0                       PCE Updt State       : None
PCE Upd Fail Code: noError
PCE Report        : Inherited               Oper PCE Report      : Disabled
PCE Control       : Disabled                Oper PCE Control     : Disabled
PCE Compute       : Disabled                Oper PCE Compute     : Disabled
Include Groups    :                         Oper Include Groups  :
None                                              None
Exclude Groups    :                         Oper Exclude Groups  :
None                                              None

IGP/TE Metric     : 16777215                Oper Metric          : 16777215
Oper MTU          : 1542                    Path Trans           : 1
Failure Code      : noError
Failure Node      : n/a
Explicit Hops     :
    10.10.3.2(S)       -> 10.10.12.3(S)      -> 10.10.11.4(S)
Actual Hops       :
```

```
    10.10.3.2 (10.20.1.22)                       Record Label        : 131066
-> 10.10.12.3 (10.20.1.3)                       Record Label        : 131054
-> 10.10.11.4 (10.20.1.4)                       Record Label        : 131066
===============================================================================

*A:7705:Dut-A# show router mpls sr-te-lsp  "sr-te-lsp-to-Dut-D"
===============================================================================
MPLS SR-TE LSPs (Originating)
===============================================================================
LSP Name                            To              Tun     Protect   Adm  Opr
                                                    Id      Path
-------------------------------------------------------------------------------
sr-te-lsp-to-Dut-D                  10.20.1.4       4       N/A       Up   Up
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================

*A:7705:Dut-A# show router mpls sr-te-lsp  "sr-te-lsp-to-Dut-D" path detail
===============================================================================
MPLS SR-TE LSP sr-te-lsp-to-Dut-D Path  (Detail)
===============================================================================
Legend :
    S - Strict                          L - Loose
===============================================================================
-------------------------------------------------------------------------------
SR-TE LSP sr-te-lsp-to-Dut-D Path sr-te-to-Dut-D
-------------------------------------------------------------------------------
LSP Name          : sr-te-lsp-to-Dut-D
Path LSP ID       : 57856
From              : 10.20.1.1             To                  : 10.20.1.4
Admin State       : Up                    Oper State          : Up
Path Name         : sr-te-to-Dut-D        Path Type           : Primary
Path Admin        : Up                    Path Oper           : Up
Path Up Time      : 0d 00:23:15           Path Down Time      : 0d 00:00:00
Retry Limit       : 0                     Retry Timer         : 20 sec
Retry Attempt     : 2                     Next Retry In       : 0 sec
CSPF              : Disabled              Oper CSPF           : Disabled
Bandwidth         : No Reservation        Oper Bandwidth      : 0 Mbps
Hop Limit         : 255                   Oper HopLimit       : 255
Setup Priority    : 7                     Oper Setup Priority : 7
Hold Priority     : 0                     Oper Hold Priority  : 0
Inter-area        : N/A

PCE Updt ID       : 0                     PCE Updt State      : None
PCE Upd Fail Code: noError
PCE Report        : Inherited             Oper PCE Report     : Disabled
PCE Control       : Disabled              Oper PCE Control    : Disabled
PCE Compute       : Disabled              Oper PCE Compute    : Disabled
Include Groups    :                       Oper Include Groups :
None                                            None
Exclude Groups    :                       Oper Exclude Groups :
None                                            None

IGP/TE Metric     : 16777215              Oper Metric         : 16777215
Oper MTU          : 1542                  Path Trans          : 1
Failure Code      : noError
Failure Node      : n/a
Explicit Hops     :
```

```
    10.10.3.2(S)       -> 10.10.12.3(S)      -> 10.10.11.4(S)
Actual Hops      :
    10.10.3.2 (10.20.1.22)                       Record Label        : 131066
-> 10.10.12.3 (10.20.1.3)                       Record Label        : 131054
-> 10.10.11.4 (10.20.1.4)                       Record Label        : 131066
===============================================================================
*A:7705:Dut-A#
```

Output Example: PCEP SR-TE LSP Configurations

The following CLI displays are output examples of a PCEP SR-TE LSP in three configurations:

- PCE-computation enabled, PCE-report disabled (via inheritance), and PCE-control disabled
- PCE-computation enabled, PCE-report enabled, and PCE-control disabled
- PCE-computation enabled, PCE-report enabled, and PCE-control enabled

The configuration can be determined by checking the PCE Report, PCE Compute, and PCE Control fields.

```
*A:7705:Dut-C# show  router mpls sr-te-lsp detail
===============================================================================
MPLS SR-TE LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : test_lsp_1
LSP Type        : SrTeLsp                   LSP Tunnel ID        : 1
LSP Index       : 65536                     TTM Tunnel Id        : 655362
From            : 10.20.1.3                 To                   : 10.20.1.4
Adm State       : Up                        Oper State           : Up
LSP Up Time     : 0d 00:00:44               LSP Down Time        : 0d 00:00:00
Transitions     : 1                         Path Changes         : 1
Retry Limit     : 0                         Retry Timer          : 30 sec
Hop Limit       : 255                       Negotiated MTU       : 1492
CSPF            : Enabled
Metric          : N/A                       Use TE metric        : Disabled
Include Grps    :                           Exclude Grps         :
None                                           None

VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                  IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 100
PCE Report      : Inherited
PCE Compute     : Enabled                   PCE Control          : Disabled
Max SR Labels   : 6                         Additional FRR Labels: 1
Path Profile    :
None

Primary(a)      : fully_loose               Up Time              : 0d 00:00:44
Bandwidth       : 0 Mbps
===============================================================================
```

```
*A:7705:Dut-C#

*A:7705:Dut-C# show  router mpls sr-te-lsp detail
===============================================================================
MPLS SR-TE LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : test_lsp_1
LSP Type        : SrTeLsp                   LSP Tunnel ID        : 1
LSP Index       : 65536                     TTM Tunnel Id        : 655362
From            : 10.20.1.3                 To                   : 10.20.1.4
Adm State       : Up                        Oper State           : Up
LSP Up Time     : 0d 00:00:02               LSP Down Time        : 0d 00:00:00
Transitions     : 3                         Path Changes         : 3
Retry Limit     : 0                         Retry Timer          : 30 sec
Hop Limit       : 255                       Negotiated MTU       : 1492
CSPF            : Enabled
Metric          : N/A                       Use TE metric        : Disabled
Include Grps    :                           Exclude Grps         :
None                                           None
VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                  IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 100
PCE Report      : Enabled
PCE Compute     : Enabled                   PCE Control          : Disabled
Max SR Labels   : 6                         Additional FRR Labels: 1
Path Profile    :
None

Primary(a)      : fully_loose               Up Time              : 0d 00:00:02
Bandwidth       : 0 Mbps
===============================================================================
*A:7705:Dut-C#

*A:7705:Dut-C# show  router mpls sr-te-lsp detail
===============================================================================
MPLS SR-TE LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : test_lsp_1
LSP Type        : SrTeLsp                   LSP Tunnel ID        : 1
LSP Index       : 65536                     TTM Tunnel Id        : 655362
From            : 10.20.1.3                 To                   : 10.20.1.4
Adm State       : Up                        Oper State           : Up
LSP Up Time     : 0d 00:00:42               LSP Down Time        : 0d 00:00:00
Transitions     : 3                         Path Changes         : 3
Retry Limit     : 0                         Retry Timer          : 30 sec
Hop Limit       : 255                       Negotiated MTU       : 1492
CSPF            : Enabled
Metric          : N/A                       Use TE metric        : Disabled
Include Grps    :                           Exclude Grps         :
None                                           None
```

```
VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                  IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 100
PCE Report      : Enabled
PCE Compute     : Enabled                   PCE Control          : Enabled
Max SR Labels   : 6                         Additional FRR Labels: 1
Path Profile    :
None

Primary(a)      : fully_loose               Up Time              : 0d 00:00:42
Bandwidth       : 0 Mbps
===============================================================================
*A:7705:Dut-C#
```

srlg-group

Syntax **srlg-group** [*group-name*]

Context show>router>mpls

Description This command displays MPLS shared risk link groups (SRLGs)

Parameters *group-name* — specifies the name of the SRLG within a router instance.

Output The following output is an example of MPLS SRLG group information, and Table 19 describes the fields.

Output Example

```
*A:ALU-48>show>router>mpls# srlg-group test2
===============================================================================
MPLS Srlg Groups
===============================================================================
Group Name                      Group Value   Interfaces
-------------------------------------------------------------------------------
test2                           2             to-104
-------------------------------------------------------------------------------
No. of Groups: 1
===============================================================================
*A:ALU-48>show>router>mpls#
```

Table 19 **Router MPLS SRLG Group Field Descriptions**

Label	Description
Group Name	The name of the SRLG group within a router instance
Group Value	The group value associated with this SRLG group
Interfaces	The interface where the SRLG group is associated

Table 19 **Router MPLS SRLG Group Field Descriptions (Continued)**

Label	Description
No. of Groups	The total number of SRLG groups associated with the output

static-lsp

Syntax **static-lsp** [*lsp-name*]
static-lsp [*lsp-type*]
static-lsp count

Context show>router>mpls

Description This command displays MPLS static LSP information.

Parameters *lsp-name* — name that identifies the LSP. The LSP name can be up to 32 characters long and must be unique.

lsp-type — type that identifies the LSP. The LSP type is one of the keywords **transit** or **terminate**, where **terminate** displays the number of static LSPs that terminate at the router, and **transit** displays the number of static LSPs that transit the router.

count — the number of static LSPs that originate and terminate at the router

Output The following output is an example of MPLS static LSP information, and Table 20 describes the fields.

Output Example - static-lsp

```
ALU-12# show router mpls static-lsp
===============================================================================
MPLS Static LSPs (Originating)
===============================================================================
LSP Name     To              Next Hop        Out Label Up/Down Time   Adm  Opr
 ID                                          Out Port
-------------------------------------------------------------------------------
to131        10.9.9.9        10.1.2.2        131       30d 02:42:53   Up   Down
 1                                           n/a
to121        10.8.8.8        10.1.3.2        121       30d 02:42:53   Up   Down
 2                                           n/a
static-lsp_- 10.9.9.9        10.1.2.2        35        0d 01:39:34    Up   Down
cc
 3                                           n/a
-------------------------------------------------------------------------------
LSPs : 3
===============================================================================
*A:ALU-12>show>router>mpls#
```

Output Example - static-lsp transit

```
A:ALU-12# show router mpls static-lsp transit
===============================================================================
MPLS Static LSPs (Transit)
===============================================================================
In Label    In I/F      Out Label   Out I/F     Next Hop            Adm   Opr
-------------------------------------------------------------------------------
1020        1/1/1       1021        1/1/5       10.10.10.6          Up    Up
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================
```

Output Example - static-lsp terminate

```
*A:ALU-12>show>router>mpls# static-lsp terminate
===============================================================================
MPLS Static LSPs (Terminate)
===============================================================================
In Label    In Port     Out Label   Out Port    Next Hop            Adm   Opr
-------------------------------------------------------------------------------
131         1/3/1       n/a         n/a         n/a                 Up    Down
121         1/2/1       n/a         n/a         n/a                 Up    Down
35          1/3/1       n/a         n/a         n/a                 Up    Down
-------------------------------------------------------------------------------
LSPs : 3
===============================================================================
```

Output Example - static-lsp count

```
*A:ALU-12>show>router>mpls# static-lsp count
============================================================
MPLS Static-LSP Count
============================================================
Originate           Transit             Terminate
------------------------------------------------------------
0                   0                   0
============================================================
*A:ALU-12>show>router>mpls# static-lsp
```

Table 20 Router MPLS Static LSP Field Descriptions

Label	Description
Lsp Name	The name of the LSP used in the path
To	The system IP address of the egress router for the LSP
Next Hop	The system IP address of the next hop in the LSP path
Out Label	The egress label
Adm	Down — indicates that the path is administratively disabled
	Up — indicates that the path is administratively enabled

Table 20 **Router MPLS Static LSP Field Descriptions (Continued)**

Label	Description
Opr	Down — indicates that the path is operationally down
	Up — indicates that the path is operationally up
LSPs	The total number of static LSPs
In Label	The ingress label
In Port	The ingress port
Out Port	The egress port
Up/Down Time	The duration that the LSP is either operationally up or down
Static-LSP Count	The number of originating, transit, and terminating static LSPs

status

Syntax **status**

Context show>router>mpls

Description This command displays MPLS operation information.

Output The following output is an example of MPLS status information, and Table 21 describes the fields.

Output Example

```
A:NOK-Dut-B# show router mpls status
===============================================================================
MPLS Status
===============================================================================
Admin Status              : Up          Oper Status               : Up
Oper Down Reason          : n/a
FRR Object                : Enabled     Resignal Timer            : Disabled
Hold Timer                : 1 seconds   Next Resignal             : N/A
Admin Group Frr           : Disabled
Dynamic Bypass            : Enabled     User Srlg Database        : Disabled
BypassResignalTimer       : Disabled    BypassNextResignal        : N/A
LeastFill Min Thd         : 5 percent   LeastFill Reopti Thd      : 10 percent
Local TTL Prop            : Enabled     Transit TTL Prop          : Enabled
Exp Backoff Retry         : Disabled    CSPF On Loose Hop         : Disabled
Lsp Init RetryTimeout     : 30 seconds
Logger Event Bundling     : Disabled
RetryIgpOverload          : Disabled
Sec FastRetryTimer        : Disabled    Static LSP FR Timer       : 30 seconds
P2PActPathFastRetry       : Disabled
In Maintenance Mode       : No
Pce-report                : None
```

```
Next Available Lsp Index  : 4
Entropy Label RSVP-TE     : Enabled     Entropy Label SR-TE       : Enabled
===============================================================================
MPLS LSP Count
===============================================================================
                    Originate           Transit             Terminate
-------------------------------------------------------------------------------
Static LSPs         0                   0                   0
Dynamic LSPs        0                   0                   0
Detour LSPs         0                   0                   0
Mesh-P2P LSPs       0                   N/A                 N/A
One Hop-P2P LSPs    0                   N/A                 N/A
SR-TE LSPs          0                   N/A                 N/A
===============================================================================
A:NOK-Dut-B#
```

Table 21 **Router MPLS Status Field Descriptions**

Label	Description
Admin Status	Down — indicates that MPLS is administratively disabled
	Up — indicates that MPLS is administratively enabled
Oper Status	Down — indicates that MPLS is operationally down
	Up — indicates that MPLS is operationally up
FRR Object	Enabled — specifies that fast reroute object is signaled for the LSP
	Disabled — specifies that fast reroute object is not signaled for the LSP
Resignal Timer	Enabled — specifies that the resignal timer is enabled for the LSP
	Disabled — specifies that the resignal timer is disabled for the LSP
Hold Timer	The amount of time that the ingress node holds before programming its data plane and declaring the LSP up to the service module
Oper Down Reason	The reason that MPLS is operationally down
Next Resignal	The amount of time until the next resignal for the LSP
Dynamic Bypass	Indicates whether dynamic bypass is enabled or disabled
Next Available Lsp Index	The next free LSP index ID

Table 21 **Router MPLS Status Field Descriptions (Continued)**

Label	Description
Entropy Label RSVP-TE	Enabled — specifies that entropy label is enabled for the RSVP-TE LSP
	Disabled — specifies that entropy label is disabled for the RSVP-TE LSP
Entropy Label SR-TE	Enabled — specifies that entropy label is enabled for the SR-TE LSP
	Disabled — specifies that entropy label is disabled for the SR-TE LSP
MPLS LSP Counts	The number of originate, transit, and terminate LSPs that are Static, Dynamic, Detour, Mesh-P2P, One Hop-P2P, or SR-TE

3.23.2.4 Show Commands (MPLS-Labels)

label

Syntax **label** *start-label* [*end-label* | [**in-use** | *label-owner*]]

Context show>router>mpls-labels

Description This command displays MPLS labels exchanged by signaling protocols.

Parameters *start-label* — specifies the label value assigned at the ingress router

Values 32 to 131071

end-label — specifies the label value assigned for the egress router

Values 32 to 131071

in-use — specifies the number of in-use labels displayed

label-owner — specifies the owner of the label

Values bgp, evpn, ildp, mirror, rsvp, static, sr, svcmgr, tldp, vprn

Output The following output is an example of MPLS label information, and Table 22 describes the fields.

Output Example

```
ALU-12# show router mpls-labels label 32
===============================================================
MPLS Label 32
===============================================================
Label               Label Type          Label Owner
---------------------------------------------------------------
32                  static-lsp          Not-in-use
---------------------------------------------------------------
In-use labels in entire range  : 7
===============================================================
ALU-12#

*A:Sar18 Dut-B>show>router>mpls-labels># label 32 131071 ildp
===============================================================
MPLS Labels from 32 to 131071 (Owner: ILDP)
===============================================================
Label               Label Type          Label Owner
---------------------------------------------------------------
131070              dynamic             ILDP
131071              dynamic             ILDP
---------------------------------------------------------------
In-use labels (Owner: ILDP) in specified range  : 2
In-use labels (Owner: All) in specified range   : 2
In-use labels in entire range                   : 2
===============================================================
```

Table 22 **Router MPLS-Labels Label Field Descriptions**

Label	Description
Label	The value of the label
Label Type	Specifies whether the label value is statically or dynamically assigned
Label Owner	The label owner
In-use labels (Owner: ILDP) in specified range	The total number of labels in the specified range being used by the specified owner
In-use labels (Owner: All) in specified range	The total number of labels in the specified range being used by all owners
In-use labels in entire range	The total number of labels being used

label-range

Syntax **label-range**

Context show>router>mpls-labels

Description This command displays the MPLS label range.

Output The following output is an example of MPLS label range information, and Table 23 describes the fields.

Output Example

```
ALU-12# show router mpls-labels label-range
===============================================================================
Label Ranges
===============================================================================
Label Type      Start Label End Label   Aging       Available   Total
-------------------------------------------------------------------------------
Static          32          18431       -           18400       18400
Dynamic         18432       131071      0           112638      112640
Seg-Route       0           0           -           0           112640
===============================================================================
ALU-12#
```

Table 23 **Router MPLS-Labels Label Range Field Descriptions**

Label	Description
Label Type	Displays information about **static-lsp**, **static-svc**, and **dynamic** label types
Start Label	The label value assigned at the ingress router
End Label	The label value assigned for the egress router
Aging	The number of labels released from a service that are transitioning back to the label pool. Labels are aged for 15 seconds.
Available	The number of label values available in the label range
Total	The total number of label values in the label range

summary

Syntax **summary**

Context show>router>mpls-labels

Description This command displays a summary of MPLS label usage.

Output The following output is an example of MPLS label summary information, and Table 24 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>mpls-labels># summary
===============================================================================
Mpls-Labels Summary
===============================================================================
Static Label Range                    : 18400
Bgp Labels Hold Timer                 : 0
Segment Routing Start Label           : 0
Segment Routing End Label             : 0
===============================================================================
```

Table 24 **Router MPLS-Labels Summary Field Descriptions**

Label	Description
Static Label Range	The number of label values available in the static label range
Bgp Labels Hold Timer	The number of BGP labels in use under control of the hold timer

Table 24 **Router MPLS-Labels Summary Field Descriptions (Continued)**

Label	Description
Segment Routing Start Label	The start label value for segment routing labels
Segment Routing End Label	The end label value for segment routing labels

3.23.2.5 Show Commands (RSVP)

Note: The following command outputs are examples only; actual displays may differ depending on supported functionality and user configuration.

interface

Syntax **interface** [*ip-int-name* | *ip-address*] **statistics** [**detail**]

Context show>router>rsvp

Description This command shows RSVP-TE interface information.

Parameters *ip-int-name* — identifies the network IP interface. The interface name cannot be in the form of an IP address. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes

ip-address — the system or network interface IP address

statistics — the IP address and the number of packets sent and received on an per-interface basis

detail — displays detailed information

Output The following outputs are examples of RSVP-TE interface information:

- RSVP-TE Interface (Output Example, Table 25)
- RSVP-TE Interface Detail (Output Example, Table 26)
- RSVP-TE Interface Statistics (Output Example, Table 27)

Output Example

```
A:ALU-12# show router rsvp interface
===============================================================================
RSVP Interfaces
===============================================================================
Interface                        Total    Active    Total BW  Resv BW   Adm Opr
                                 Sessions Sessions  (Mbps)    (Mbps)
-------------------------------------------------------------------------------
system                           -        -         -         -         Up  Up
ip-10.10.1.1                     1        1         100       0         Up  Up
ip-10.10.2.1                     1        1         100       0         Up  Up
ip-10.10.3.1                     0        0         100       0         Up  Up
-------------------------------------------------------------------------------
Interfaces : 4
===============================================================================
A:ALU-12#
```

Table 25 **Router RSVP-TE Interface Field Descriptions**

Label	Description
Interface	The name of the IP interface
Total Sessions	The total number of RSVP-TE sessions on this interface. This count includes sessions that are active as well as sessions that have been signaled but a response has not yet been received.
Active Sessions	The total number of active RSVP-TE sessions on this interface
Total BW (Mbps)	The amount of bandwidth in megabits per second (Mbps) available to be reserved for the RSVP-TE protocol on the interface
Resv BW (Mbps)	The amount of bandwidth in megabits per second (Mbps) reserved on this interface. A value of zero (0) indicates that no bandwidth is reserved.
Adm	Down — the RSVP-TE interface is administratively disabled
	Up — the RSVP-TE interface is administratively enabled
Opr	Down — the RSVP-TE interface is operationally down
	Up — the RSVP-TE interface is operationally up
Interfaces	The number of interfaces listed in the display

Output Example

```
A: ALU-12# show router rsvp interface "ip-10.10.1.1" detail
===============================================================================
RSVP Interfaces (Detailed): ip-10.10.1.1
-------------------------------------------------------------------------------
Interface : ip-10.10.1.1
-------------------------------------------------------------------------------
Interface         : ip-10.10.1.1
Port ID           : 1/1/1
Admin State       : Up                      Oper State     : Up
Active Sessions   : 0                       Active Resvs   : 0
Total Sessions    : 0
Subscription      : 10 %                    Port Speed     : 1000 Mbps
Total BW          : 100 Mbps                Aggregate      : Dsabl
Hello Interval    : 3000 ms                 Hello Timeouts : 0
Key Type Auth     : Disabled
Keychain Auth     : Disabled
Auth Rx Seq Num   : n/a                     Auth Key Id    : n/a
Auth Tx Seq Num   : n/a                     Auth Win Size  : n/a
Refresh Reduc.    : Disabled                Reliable Deli. : Disabled
Bfd Enabled       : No                      Graceful Shut. : Disabled
ImplicitNullLabel : Disabled*               GR helper      : Disabled

IGP Update
```

```
Up Thresholds(%)  : 0 15 30 45 60 75 80 85 90 95 96 97 98 99 100 *
Down Thresholds(%): 100 99 98 97 96 95 90 85 80 75 60 45 30 15 0 *
IGP Update Pending: No
Next Update       : N/A
No Neighbors.
* Indicates Inherited Values
-------------------------------------------------------------------------------
A: ALU-12#
```

Table 26 **Router RSVP-TE Interface Detail Field Descriptions**

Label	Description
Interface	The name of the IP interface
Port ID	The physical port bound to the interface
Admin State	Down — the RSVP-TE interface is administratively disabled
	Up — the RSVP-TE interface is administratively enabled
Oper State	Down — the RSVP-TE interface is operationally down
	Up — the RSVP-TE interface is operationally up
Active Sessions	The total number of active RSVP-TE sessions on this interface
Active Resvs	The total number of active RSVP-TE sessions that have reserved bandwidth
Total Sessions	The total number of RSVP-TE sessions on this interface. This count includes sessions that are active as well as sessions that have been signaled but a response has not yet been received.
Subscription	The percentage of the link bandwidth that RSVP-TE can use for reservation. When the value is zero (0), no new sessions are permitted on this interface.
Port Speed	The speed on the interface
Total BW	The amount of bandwidth in megabits per second (Mbps) available to be reserved for the RSVP-TE protocol on this interface
Aggregate	Indicates whether aggregate messages are sent. Aggregate messages are used to pack multiple RSVP messages into a single packet to reduce the network overhead. When the value is true, RSVP negotiates with each neighbor and gets consensus before sending aggregate messages.

Table 26 **Router RSVP-TE Interface Detail Field Descriptions (Continued)**

Label	Description
Hello Interval	The length of time, in seconds, between the Hello packets that the router sends on the interface. This value must be the same for all routers attached to a common network. A value of zero (0) indicates that the sending of hello messages is disabled. A value of n/a indicates that the interface is an unnumbered interface.
Hello Timeouts	The total number of Hello messages that timed out on this RSVP-TE interface. A value of n/a indicates that the interface is an unnumbered interface.
Auth Rx Seq Num	The received MD5 sequence number
Auth Key Id	The MD5 key identifier
Auth Tx Seq Num	The transmitted MD5 sequence number
Auth Win Size	The MD5 window size
Refresh Reduc.	Indicates whether refresh reduction capabilities are enabled or disabled
Reliable Deli.	Indicates whether reliable delivery is enabled or disabled
Bfd Enabled	Indicates whether BFD is enabled or disabled on the RSVP-TE interface. A value of n/a indicates that BFD is not applicable because the interface is an unnumbered interface.
Graceful Shut.	Indicates whether graceful shutdown is enabled or disabled
ImplicitNullLabel	Indicates whether the implicit null label is enabled or disabled
GR helper	Indicates whether Graceful-Restart Helper is enabled or disabled
IGP Update	
Up Thresholds (%)	Indicates up threshold levels for the interface
Down Thresholds (%)	Indicates down threshold levels for the interface
IGP Update Pending	Indicates whether an IGP update will occur
Next Update	Indicates when the next IGP update will be, if there is one pending

Output Example

```
A:ALU-12# show router rsvp interface statistics
===============================================================================
RSVP Interface (statistics)
===============================================================================
Interface system
-------------------------------------------------------------------------------
Interface                    : Up
Total Packets        (Sent) : 0                    (Recd.): 0
Bad Packets          (Sent) : 0                    (Recd.): 0
Paths                (Sent) : 0                    (Recd.): 0
Path Errors          (Sent) : 0                    (Recd.): 0
Path Tears           (Sent) : 0                    (Recd.): 0
Resvs                (Sent) : 0                    (Recd.): 0
Resv Confirms        (Sent) : 0                    (Recd.): 0
Resv Errors          (Sent) : 0                    (Recd.): 0
Resv Tears           (Sent) : 0                    (Recd.): 0
Refresh Summaries    (Sent) : 0                    (Recd.): 0
Refresh Acks         (Sent) : 0                    (Recd.): 0
Bundle Packets       (Sent) : 0                    (Recd.): 0
Hellos               (Sent) : 0                    (Recd.): 0
Auth Errors          (Sent) : 0                    (Recd.): 0
-------------------------------------------------------------------------------
```

Table 27 **Router RSVP-TE Interface Statistics Field Descriptions**

Label	Description
Interface	The name of the IP interface displayed in the header
Interface (status)	The status of the interface (up or down)
Sent	The total number of error-free RSVP-TE packets that have been transmitted on the RSVP-TE interface
Recd	The total number of error-free RSVP-TE packets received on the RSVP-TE interface
Total Packets	The total number of RSVP-TE packets, including errors, received on the RSVP-TE interface
Bad Packets	The total number of RSVP-TE packets with errors transmitted on the RSVP-TE interface
Paths	The total number of RSVP-TE PATH messages received on the RSVP-TE interface
Path Errors	The total number of RSVP-TE PATH ERROR messages transmitted on the RSVP-TE interface
Path Tears	The total number of RSVP-TE PATH TEAR messages received on the RSVP-TE interface

Table 27 **Router RSVP-TE Interface Statistics Field Descriptions**

Label	Description
Resvs	The total number of RSVP-TE RESV messages received on the RSVP-TE interface
Resv Confirms	The total number of RSVP-TE RESV CONFIRM messages received on the RSVP-TE interface
Resv Errors	The total number of RSVP-TE RESV ERROR messages received on the RSVP-TE interface
Resv Tears	The total number of RSVP-TE RESV TEAR messages received on the RSVP-TE interface
Refresh Summaries	The total number of RSVP-TE RESV summary refresh messages received on the RSVP-TE interface
Refresh Acks	The total number of RSVP-TE RESV acknowledgment messages received when refresh reduction is enabled on the RSVP-TE interface
Bundle Packets	The total number of RSVP-TE RESV bundle packets received on the RSVP-TE interface
Hellos	The total number of RSVP-TE RESV HELLO REQ messages received on the RSVP-TE interface
Auth Errors	The number of authentication errors

neighbor

Syntax **neighbor** [*ip-address*] [**detail**]

Context show>router>rsvp

Description This command displays RSVP-TE neighbors.

Parameters *ip-address* — the IP address of the originating router

detail — displays detailed information

Output The following output is an example of RSVP-TE neighbor information, and Table 28 describes the fields.

Output Example

```
*A:ALU-12>show>router>rsvp# neighbor
===============================================================================
RSVP Neighbors
===============================================================================
Legend :
    LR - Local Refresh Reduction          RR - Remote Refresh Reduction
    LD - Local Reliable Delivery          RM - Remote Node supports Message ID
===============================================================================
Neighbor        Interface                          Hello  Last Oper     Flags
                                                          Change
===============================================================================
10.20.1.2       ip-10.10.1.1                       N/A    0d 00:00:44
10.20.1.3       ip-10.10.2.1                       N/A    0d 00:00:44
-------------------------------------------------------------------------------
Neighbors : 2
===============================================================================
```

Table 28 **Router RSVP-TE Neighbor Field Descriptions**

Label	Description
Neighbor	The IP address of the RSVP-TE neighbor
Interface	The interface ID of the RSVP-TE neighbor
Hello	The status of the Hello message
Last Oper Change	The time of the last operational change to the connection
Flags	Any flags associated with the connection to the neighbor

session

Syntax **session** [*session-type*] [**from** *ip-address* | **to** *ip-address* | **lsp-name** *name*] [**status** {**up** | **down**}] [**detail**]

Context show>router>rsvp

Description This command shows RSVP-TE session information.

Parameters *session-type* — specifies the session type

Values originate, transit, terminate, detour, detour-transit, detour-terminate, bypass-tunnel, manual-bypass

from *ip-address* — specifies the IP address of the originating router

to *ip-address* — specifies the IP address of the egress router

name — specifies the name of the LSP used in the path

status up — specifies to display a session that is operationally up

status down — specifies to display a session that is operationally down

detail — displays detailed information

Output The following output is an example of RSVP-TE session information, and Table 29 describes the fields.

Output Example

```
A:ALU-12# show router rsvp session
===============================================================================
RSVP Sessions
===============================================================================
From            To              Tunnel LSP   Name                          State
                                ID     ID
-------------------------------------------------------------------------------
10.20.1.3       10.20.1.1       1      37    C_A_1::C_A_1                  Up
10.20.1.3       10.20.1.1       2      38    C_A_2::C_A_2                  Up
10.20.1.3       10.20.1.1       3      39    C_A_3::C_A_3                  Up
10.20.1.3       10.20.1.1       4      40    C_A_4::C_A_4                  Up
10.20.1.1       10.20.1.3       2      40    A_C_2::A_C_2                  Up
10.20.1.1       10.20.1.3       3      41    A_C_3::A_C_3                  Up
10.20.1.1       10.20.1.3       4      42    A_C_4::A_C_4                  Up
10.20.1.1       10.20.1.3       5      43    A_C_5::A_C_5                  Up
10.20.1.1       10.20.1.3       6      44    A_C_6::A_C_6                  Up
10.20.1.1       10.20.1.3       7      45    A_C_7::A_C_7                  Up
10.20.1.1       10.20.1.3       8      46    A_C_8::A_C_8                  Up
10.20.1.3       10.20.1.1       5      41    C_A_5::C_A_5                  Up
10.20.1.3       10.20.1.1       6      42    C_A_6::C_A_6                  Up
10.20.1.3       10.20.1.1       7      43    C_A_7::C_A_7                  Up
10.20.1.3       10.20.1.1       8      44    C_A_8::C_A_8                  Up
...
-------------------------------------------------------------------------------
Sessions : 65
===============================================================================
A:ALU-12#

A:ALU-12# show router rsvp session lsp-name A_C_2::A_C_2 status up
===============================================================================
RSVP Sessions
===============================================================================
From            To              Tunnel LSP   Name                          State
                                ID     ID
-------------------------------------------------------------------------------
10.20.1.1       10.20.1.3       2      40    A_C_2::A_C_2                  Up
-------------------------------------------------------------------------------
Sessions : 1
===============================================================================
A:ALU-12#
```

Table 29 **Router RSVP-TE Session Field Descriptions**

Label	Description
From	The IP address of the originating router
To	The IP address of the egress router
Tunnel ID	The ID of the ingress node of the tunnel supporting this RSVP-TE session
LSP ID	The ID assigned by the agent to this RSVP-TE session
Name	The administrative name assigned to the RSVP-TE session by the agent
State	Down — the operational state of this RSVP-TE session is down
	Up — the operational state of this RSVP-TE session is up

statistics

Syntax **statistics**

Context show>router>rsvp

Description This command displays global statistics in the RSVP-TE instance.

Output The following output is an example of RSVP-TE statistics information, and Table 30 describes the fields.

Output Example

```
A:ALU-12# show router rsvp statistics
===============================================================================
RSVP Global Statistics
===============================================================================
PATH Timeouts      : 0                    RESV Timeouts      : 0
GR Helper PATH Tim*: 0                    GR Helper RESV Tim*: 0
===============================================================================
```

Table 30 **Router RSVP-TE Statistics Field Descriptions**

Label	Description
PATH Timeouts	The total number of PATH timeouts
RESV Timeouts	The total number of RESV timeouts
GR Helper PATH Timeouts	The total number of graceful restart helper PATH timeouts
GR Helper RESV Timeouts	The total number of graceful restart helper RESV timeouts

status

Syntax **status**

Context show>router>rsvp

Description This command displays RSVP-TE operational status.

Output The following output is an example of RSVP-TE status information, and Table 31 describes the fields.

Output Example

```
A:ALU-12# show router rsvp status
===============================================================================
RSVP Status
===============================================================================
Admin Status       : Down               Oper Status        : Down
Keep Multiplier    : 3                  Refresh Time       : 30 sec
Message Pacing     : Disabled           Pacing Period      : 100 msec
Max Packet Burst   : 650 msgs           Refresh Bypass     : Disabled
Rapid Retransmit   : 5 hmsec            Rapid Retry Limit  : 3
Graceful Shutdown  : Disabled           SoftPreemptionTimer: 300 sec
GR Max Recovery    : 300 sec            GR Max Restart     : 120 sec
Implicit Null Label: Disabled           Node-id in RRO     : Exclude
P2P Merge Point Ab*: Disabled           P2MP Merge Point A*: Disabled
DiffServTE AdmModel: Basic              Entropy Label      : Disabled
Percent Link Bw CT0: 100                Percent Link Bw CT4: 0
Percent Link Bw CT1: 0                  Percent Link Bw CT5: 0
Percent Link Bw CT2: 0                  Percent Link Bw CT6: 0
Percent Link Bw CT3: 0                  Percent Link Bw CT7: 0
TE0 -> Class Type  : 0                  Priority           : 0
TE1 -> Class Type  : 0                  Priority           : 1
TE2 -> Class Type  : 0                  Priority           : 2
TE3 -> Class Type  : 0                  Priority           : 3
TE4 -> Class Type  : 0                  Priority           : 4
TE5 -> Class Type  : 0                  Priority           : 5
TE6 -> Class Type  : 0                  Priority           : 6
TE7 -> Class Type  : 0                  Priority           : 7
IgpThresholdUpdate : Disabled
Up Thresholds(%)   : 0 15 30 45 60 75 80 85 90 95 96 97 98 99 100
Down Thresholds(%) : 100 99 98 97 96 95 90 85 80 75 60 45 30 15 0
```

```
Update Timer       : N/A
Update on CAC Fail : Disabled
===============================================================================
```

Table 31 **Router RSVP-TE Status Field Descriptions**

Label	Description
Admin Status	Down — RSVP-TE is administratively disabled
	Up — RSVP-TE is administratively enabled
Oper Status	Down — RSVP-TE is operationally down
	Up — RSVP-TE is operationally up
Keep Multiplier	The **keep-multiplier** *number* used by RSVP-TE to declare that a reservation is down or the neighbor is down
Refresh Time	The **refresh-time** *interval*, in seconds, between the successive PATH and RESV refresh messages
Message Pacing	Enabled — RSVP-TE messages, specified in the **max-burst** command, are sent in a configured interval, specified in the **period** command
	Disabled — message pacing is disabled. RSVP-TE message transmission is not regulated.
Pacing Period	The time interval, in milliseconds, during which the router can send the number of RSVP-TE messages specified in the **max-burst** command
Max Packet Burst	The maximum number of RSVP-TE messages that are sent under normal operating conditions in the period specified
Refresh Bypass	Enabled — the **refresh-reduction-over-bypass** command is enabled
	Disabled — the **refresh-reduction-over-bypass** command is disabled
Rapid Retransmit	The time interval for the rapid retransmission time, which is used in the retransmission mechanism that handles unacknowledged message_id objects (the units “hmsec” represent hundreds of msec; for example, 5 hmsec represents 500 msec)
Rapid Retry Limit	The value of the rapid retry limit, which is used in the retransmission mechanism that handles unacknowledged message_id objects
Graceful Shutdown	Specifies whether graceful shutdown of the RSVP node is enabled

3.23.2.6 Clear Commands

interface

Syntax **interface** [*ip-int-name*] [**statistics**]

Context clear>router>mpls

Description This command resets or clears statistics for MPLS interfaces.

Parameters *ip-int-name* — specifies an existing IP interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

statistics — clears only statistics

lsp

Syntax **lsp** [*lsp-name*]

Context clear>router>mpls

Description This command resets and restarts an LSP.

Parameters *lsp-name* — specifies the name of the LSP to clear

lsp-egress-stats

Syntax **lsp-egress-stats** [*lsp-name*]

Context clear>router>mpls

Description This command clears RSVP LSP egress statistics.

Note: When RSVP LSP statistics are cleared, the current aggregate statistics count is recorded as a baseline and is used to provide a relative count each time the statistics are viewed with the **show** command. Because this baseline number is not reconciled between the active and inactive CSMs, after a CSM activity switch the statistics on the newly active CSM will show the aggregate count as though no clear command has been executed.

Parameters *lsp-name* — specifies the name of the LSP to clear

lsp-ingress-stats

Syntax **lsp-ingress-stats** [*ip-address* **lsp** *lsp-name*]

Context clear>router>mpls

Description This command clears RSVP LSP ingress statistics.

Note: When RSVP LSP statistics are cleared, the current aggregate statistics count is recorded as a baseline and is used to provide a relative count each time the statistics are viewed with the **show** command. Because this baseline number is not reconciled between the active and inactive CSMs, after a CSM activity switch the statistics on the newly active CSM will show the aggregate count as though no clear command has been executed.

Parameters *ip-address* — the system IP address of the sender (a.b.c.d)

lsp-name — the name that identifies the LSP

interface

Syntax **interface** [*ip-int-name*] [**statistics**]

Context clear>router>rsvp

Description This command resets or clears statistics for an RSVP-TE interface.

Parameters *ip-int-name* — identifies the IP interface to clear. The interface name cannot be in the form of an IP address. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes

statistics — clears only statistics

statistics

Syntax **statistics**

Context clear>router>rsvp

Description This command clears global statistics for the RSVP-TE instance; for example, clears **path** and **resv timeout** counters.

3.23.2.7 Debug Commands

mpls

Syntax [**no**] **mpls** [**lsp** *lsp-name*] [**sender** *source-address*] [**endpoint** *endpoint-address*] [**tunnel-id** *tunnel-id*] [**lsp-id** *lsp-id*] [**interface** *ip-int-name*]

Context debug>router

Description This command enables and configures debugging for MPLS.

Parameters *lsp-name* — the name that identifies the LSP. The LSP name can be up to 32 characters long and must be unique.

source-address — specifies the system IP address of the sender

endpoint-address — specifies the far-end system IP address

tunnel-id — specifies the MPLS SDP ID

Values 0 to 4294967295

lsp-id — specifies the LSP ID

Values 1 to 65535

ip-int-name — identifies the interface. The interface name cannot be in the form of an IP address. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

event

Syntax [**no**] **event**

Context debug>router>mpls
debug>router>rsvp

Description This command enables debugging for specific events.

The **no** form of the command disables the debugging.

all

Syntax **all** [**detail**]
no all

Context debug>router>mpls>event
debug>router>rsvp>event

Description This command debugs all events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about all events

frr

Syntax **frr** [**detail**]
no frr

Context debug>router>mpls>event

Description This command debugs fast reroute events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about reroute events

iom

Syntax **iom** [**detail**]
no iom

Context debug>router>mpls>event

Description This command debugs MPLS IOM events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about MPLS IOM events

lsp-setup

Syntax **lsp-setup** [**detail**]
no lsp-setup

Context debug>router>mpls>event

Description This command debugs LSP setup events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about LSP setup events

mbb

Syntax **mbb** [**detail**]
no mbb

Context debug>router>mpls>event

Description This command debugs the state of the most recent invocation of the make-before-break (MBB) functionality.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about MBB events

misc

Syntax **misc** [**detail**]
no misc

Context debug>router>mpls>event
debug>router>rsvp>event

Description This command debugs miscellaneous events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about miscellaneous events

xc

Syntax **xc** [**detail**]
no xc

Context debug>router>mpls>event

Description This command debugs cross-connect events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about cross-connect events

rsvp

Syntax [**no**] **rsvp** [**lsp** *lsp-name*] [**sender** *sender-address*] [**endpoint** *endpoint-address*] [**tunnel-id** *tunnel-id*] [**lsp-id** *lsp-id*] [**interface** *ip-int-name*]
no rsvp

Context debug>router

Description This command enables and configures debugging for RSVP.

Parameters *lsp-name* — name that identifies the LSP. The LSP name can be up to 80 characters long and must be unique.

sender-address — specifies the system IP address of the sender (a.b.c.d)

endpoint-address — specifies the far-end system IP address (a.b.c.d)

tunnel-id — specifies the RSVP-TE tunnel ID

Values 0 to 4294967295

lsp-id — specifies the LSP ID

Values 1 to 65535

ip-int-name — identifies the interface. The interface name cannot be in the form of an IP address. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

auth

Syntax **auth**
no auth

Context debug>router>rsvp>event

Description This command debugs authentication events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about authentication events

nbr

Syntax **nbr** [**detail**]
no nbr

Context debug>router>rsvp>event

Description This command debugs neighbor events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about neighbor events

path

Syntax **path** [**detail**]
no path

Context debug>router>rsvp>event

Description This command debugs path-related events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about path-related events

resv

Syntax **resv** [**detail**]
no resv

Context debug>router>rsvp>event

Description This command debugs RSVP-TE reservation events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about RSVP-TE reservation events

rr

Syntax **rr**
no rr

Context debug>router>rsvp>event

Description This command debugs refresh reduction events.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about refresh reduction events

packet

Syntax [**no**] **packet**

Context debug>router>rsvp

Description This command enters the context to debug packets.

ack

Syntax **ack** [**detail**]
no ack

Context debug>router>rsvp>packet

Description This command debugs ack packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about RSVP-TE ack packets

all

Syntax **all** [**detail**]
no all

Context debug>router>rsvp>packet

Description This command debugs all packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about all RSVP-TE packets

bundle

Syntax **bundle** [**detail**]
no bundle

Context debug>router>rsvp>packet

Description This command debugs bundle packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about RSVP-TE bundle packets

hello

Syntax **hello** [**detail**]
no hello

Context debug>router>rsvp>packet

Description This command debugs hello packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about hello packets

path

Syntax **path** [**detail**]
no path

Context debug>router>rsvp>packet

Description This command enables debugging for RSVP-TE path packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about path-related events

patherr

Syntax **patherr** [**detail**]
no patherr

Context debug>router>rsvp>packet

Description This command debugs path error packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about path error packets

pathtear

Syntax **pathtear** [**detail**]
no pathtear

Context debug>router>rsvp>packet

Description This command debugs path tear packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about path tear packets

resv

Syntax **resv** [**detail**]
no resv

Context debug>router>rsvp>packet

Description This command enables debugging for RSVP-TE RESV packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about RSVP-TE RESV packets

resverr

Syntax **resverr** [**detail**]
no resverr

Context debug>router>rsvp>packet

Description This command debugs ResvErr packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about ResvErr packets

resvtear

Syntax **resvtear** [**detail**]
no resvtear

Context debug>router>rsvp>packet

Description This command debugs ResvTear packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about ResvTear packets

srefresh

Syntax **srefresh** [**detail**]
no srefresh

Context debug>router>rsvp>packet

Description This command debugs srefresh packets.

The **no** form of the command disables the debugging.

Parameters **detail** — displays detailed information about RSVP-TE srefresh packets

4 PCEP

This section contains information on the following topics:

4.1 Introduction to the Path Computation Element (PCE) Communication Protocol (PCEP)

Note: The 7705 SAR operates as a PCE Client (PCC) only, supporting PCC capabilities for RSVP-TE LSPs and SR-TE LSPs. References to PCE router operation apply to the 7750 SR product family and are included for informational purposes only.

The Path Computation Element Communication Protocol (PCEP) is one of several protocols used for communication between a wide area network (WAN) software-defined network (SDN) controller and network elements.

The Nokia WAN SDN Controller is known as the Network Services Platform (NSP). The NSP is a set of applications which are built on a common framework that hosts and integrates them by providing common functions. The applications are developed in a Java environment.

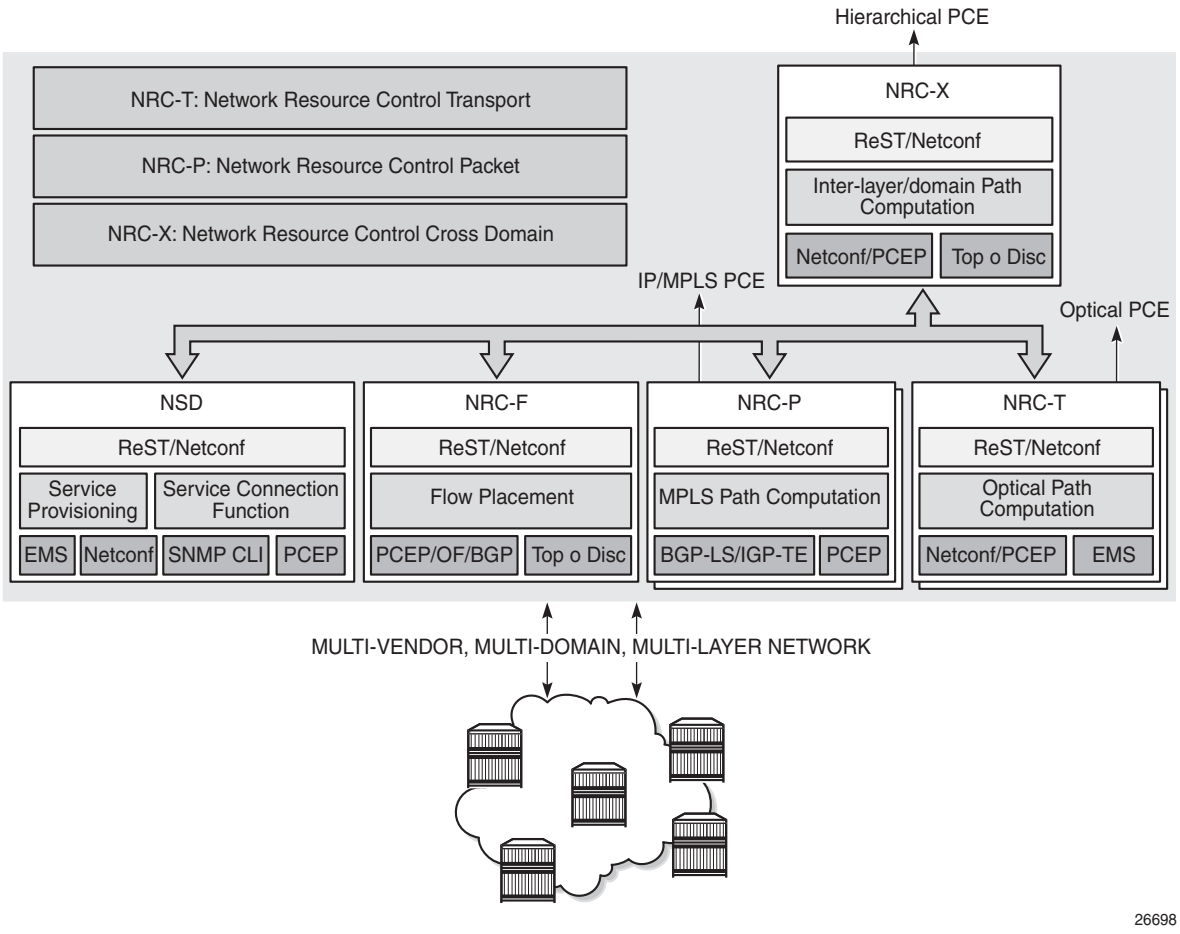
The NSP provides two major functions:

- programmable multi-vendor service provisioning
- network resource control, including resource management at Layer 0 (optical path), Layer 1 (ODU path), Layer 2 (MPLS tunnel), and at the IP flow level

The network discovery and control function implements a common set of standards-based southbound interfaces to the network elements for both topology discovery and tunnel and flow programming. A virtual SR OS (vSROS) image applies the southbound interfaces to the network elements and the adaptation layer to the applications. The southbound interfaces include IGP and the Network Functions Manager - Packet (NSP NFM-P) for topology discovery, PCEP for handling path computation requests and LSP state updates with the network elements, and forwarding plane programming protocols such as Openflow, BGP flowspec, and I2RS.

The above NSP functions are provided in a number of modules that can be used together or separately as illustrated in Figure 16.

Figure 16 **NSP Functional Modules**



The two main components of the NSP are:

- Network Services Director (NSD)

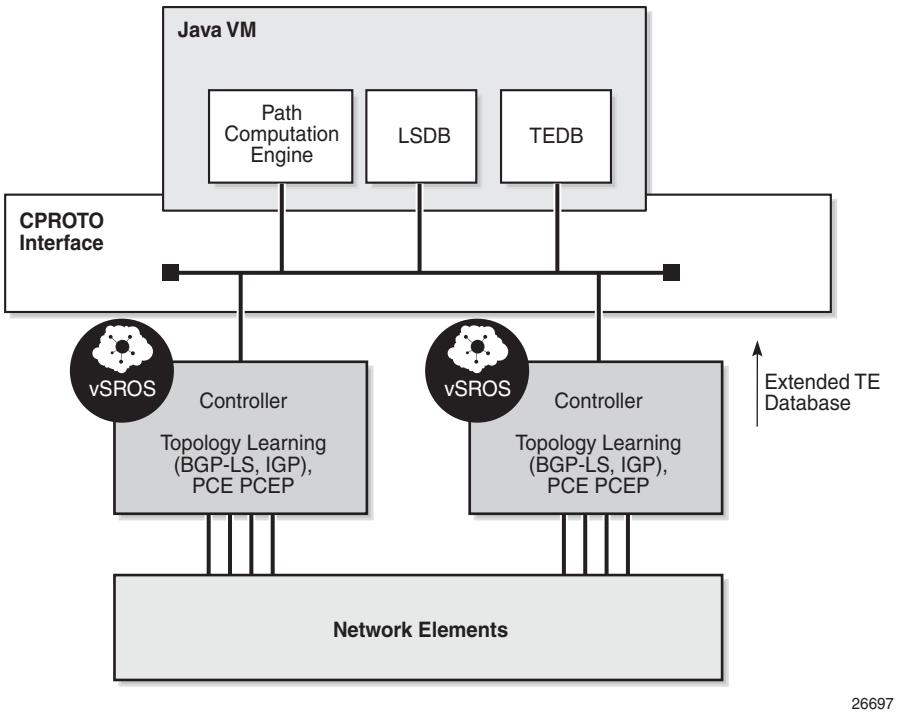
  The NSD is a programmable and multi-vendor service provisioning tool providing a single and simple API to the user and OSS. It implements a service model abstraction and adapts to each vendor-specific service model. It supports provisioning services such as E-Line, E-LAN, E-Tree, Layer 3 VPN, traffic steering, and service chaining.

- Network Resource Controller (NRC)

  The NRC implements separate modules for computing and managing optimal paths for optical tunnels (NRC-T) and MPLS tunnels (NRC-P), and for computing optimal routing and placement of IP flows (NRC-F). In addition, a resource controller for inter-layer IP and optical path computation and more complex inter-domain MPLS path computation is provided as part of the NRC-X.

The Network Resource Controller - Packet (NRC-P) implements the stateful Path Computation Element (PCE) for packet networks. Figure 17 illustrates the NRC-P architecture and its main components.

Figure 17 **NRC-P Architecture**



The NRC-P has the following architecture:

- a single Virtual Machine (VM) handling the Java implementation of an MPLS path computation engine, a TE graph database, and an LSP database
- a plug-in adapter with the Nokia CPROTO interface, providing reliable, TCP-based message delivery between vSROS and Java-VM. The plug-in adapter implements a compact encoding/decoding (codec) function for the message content using Google ProtoBuf. Google ProtoBuf also provides for automatic C++ (vSROS side) and Java (Java-VM side) code generation to process the exchanged message content.
- a single VM running a vSROS image that handles the functions of topology discovery of multiple IGP instances and areas via IGP and NSP NFM-P. For larger network domains, one VM running the vSROS image can be dedicated to a specific function.

The PCE module uses PCEP to communicate with its PCE Clients (PCCs). It also uses PCEP to communicate with other PCEs to coordinate inter-domain path computation. Each router acting as a PCC initiates a PCEP session to the PCE in its domain.

When the user enables PCE control for one or more segment routing (SR) or RSVP-TE LSPs, the PCE owns the path updating and periodic reoptimization of the LSPs. In this case, the PCE acts in an active stateful role. The PCE can also act in a passive stateful role for other LSPs on the router by discovering the LSPs and taking into account their resource consumption when computing the path for the LSPs it has control ownership of.

The following is a high-level description of the PCE and PCC capabilities:

- base PCEP implementation, as per RFC 5440
- active and passive stateful PCE LSP update, as per *draft-ietf-pce-stateful-pce*
- delegation of LSP control to the PCE
- synchronization of the LSP database with network elements for PCE-controlled LSPs and network element-controlled LSPs
- support for PCC-initiated LSPs, as per *draft-ietf-pce-stateful-pce*
- support for LSP path diversity across different LERs using extensions to the PCE path profile, as per *draft-alvarez-pce-path-profiles*
- support for LSP path bidirectionality constraints using extensions to the PCE path profile, as per *draft-alvarez-pce-path-profiles*

4.2 Base Implementation of Path Computation Elements (PCE)

The base implementation of the PCE uses the PCEP extensions defined in RFC 5440.

The main functions of PCEP are:

- PCEP session establishment, maintenance, and closing
- path computation requests using the PCReq message
- path computation replies using the PCRep message
- notification messages (PCNtf) by which the PCEP speaker can inform its peer about events, such as path request cancellation by the PCC or path computation cancellation by the PCE
- error messages (PCErr) by which the PCEP speaker can inform its peer about errors related to processing requests, message objects, or TLVs

Table 32 lists the base PCEP TLVs, objects, and messages.

Table 32 **Base PCEP TLVs, Objects, and Messages**

TLV, Object, or Message	Contained in Object	Contained in Message
OPEN Object	N/A	OPEN, PCErr
Request Parameter (RP) Object	N/A	PCReq, PCRep, PCErr, PCNtf
NO-PATH Object	N/A	PCRep
END-POINTS Object	N/A	PCReq
BANDWIDTH Object	N/A	PCReq, PCRep, PCRpt [1]
METRIC Object	N/A	PCReq, PCRep, PCRpt [1]
Explicit Route Object (ERO)	N/A	PCRep
Reported Route Object (RRO)	N/A	PCReq
LSPA Object	N/A	PCReq, PCRep, PCRpt [1]
Include Route Object (IRO)	N/A	PCReq, PCRep
SVEC Object	N/A	PCReq
NOTIFICATION Object	N/A	PCNtf

Table 32 **Base PCEP TLVs, Objects, and Messages (Continued)**

TLV, Object, or Message	Contained in Object	Contained in Message
PCEP-ERROR Object	N/A	PCErr
LOAD-BALANCING Object	N/A	PCReq
CLOSE Object	N/A	CLOSE

Note:

1. Nokia proprietary

The behavior and limitations of the implementation of the objects in Table 32 are as follows.

- The PCE treats all supported objects received in a PCReq message as mandatory, regardless of whether the P-flag in the object's common header is set (mandatory object) or not (optional object).
- The PCC implementation will always set the B-flag (B=1) in the metric object containing the hop metric value, which means that a bound value must be included in PCReq message. The PCE returns the computed value in the PCRep message with flags set identically to the PCReq message.
- The PCC implementation will always set flags B=0 and C=1 in the metric object for the IGP or TE metric values in the PCReq message. This means that the request is to optimize (minimize) the metric without providing a bound value. The PCE returns the computed value in the PCRep message with flags set identically to the PCReq message.
- The IRO and LOAD-BALANCING objects are not part of the NSP PCE feature. If the PCE receives a PCReq message with one or more of these objects, it will ignore them regardless of the setting of the P-flag, and will process the path computations normally.
- The LSPA, metric, and bandwidth objects are also included in the PCRpt message. The inclusion of these objects in the PCRpt message is proprietary to Nokia.

The following features are not supported on the 7705 SAR:

- PCE discovery using IS-IS, per RFC 5089, and OSPF, per RFC 5088, along with corresponding extensions for discovering stateful PCE, per *draft-sivabalan-pce-disco-stateful*
- security of the PCEP session using MD5 or TLS between PCEP peers
- PCEP synchronization optimization as per *draft-ietf-pce-stateful-sync-optimizations*

- support of end-to-end secondary backup paths for an LSP. PCE standards do not currently support an LSP container with multiple paths, and the PCE treats each request as a path with a unique PLSP-ID. It is up to the router to tie the two paths together to create 1:1 protection and to request path or SRLG diversity among them when it makes the request to the PCE.
- jitter, latency, and packet loss metrics support as per RFC 7471 and *draft-ietf-isis-te-metric-extensions*, and their use in the PCE metric object as per *draft-ietf-pce-pcep-service-aware*

4.3 PCEP Session Establishment and Maintenance

PCEP operates over TCP using destination TCP port 4189. The PCC always initiates the connection. When the user configures the PCEP local address and the peer address on the PCC, the PCC initiates a TCP connection to the PCE. When a connection is established, the PCC and PCE exchange OPEN messages, which initializes the PCEP session and exchanges the session parameters to be negotiated.

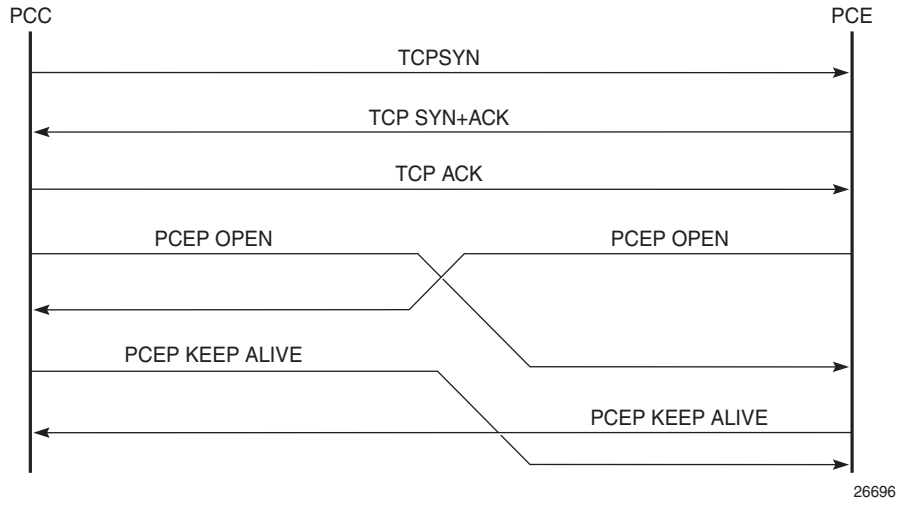
The PCC always checks first to determine if the remote PCE address is reachable out-of-band via the management port. If the remote address is not reachable, the PCC will try to reach the remote PCE address in-band. When the session comes up out-of-band, the system IP address is always used; the local address configured by the user is ignored and is only used for an in-band session.

A keepalive mechanism is used as an acknowledgment of the acceptance of the session within the negotiated parameters. It is also used as a maintenance function to detect whether or not the PCEP peer is still alive.

The negotiated parameters include the keepalive timer and the dead timer, and one or more PCEP capabilities such as support of stateful PCE and the LSP Path type.

The PCEP session initialization steps are illustrated in Figure 18.

Figure 18 **PCEP Session Initialization**



If the session to the PCE times out, the router acting as a PCC keeps the last successfully programmed path provided by the PCE until the session to the PCE is re-established. Any subsequent change to the state of an LSP is synchronized at the time the session is re-established.

When a PCEP session to a peer times out or closes, the rate at which the PCEP speaker attempts the establishment of the session is subject to an exponential back-off mechanism.

4.4 PCEP Parameters

The following PCEP parameters are user-configurable on the PCC:

- keepalive timer

  A PCEP speaker must send a keepalive message if no other PCEP message is sent to the peer at the expiry of this timer. This timer is restarted every time a PCEP message is sent or the keepalive message is sent.

  The keepalive mechanism is asymmetric, meaning that each peer can use a different keepalive timer value.

  The range of this timer is 1 to 255 seconds and the default value is 30 seconds.
- dead timer

  This timer tracks the amount of time a PCEP speaker waits after the receipt of the last PCEP message before declaring its peer down.

  The dead timer mechanism is asymmetric, meaning that each PCEP speaker can propose a different dead timer value to its peer to use to detect session timeouts.

  The range of this timer is 1 to 255 seconds and the default value is 120 seconds.
- maximum rate of unknown messages

  When the rate of received unrecognized or unknown messages reaches the configured limit, the PCEP speaker closes the session to the peer.

  The range of this message rate is 1 to 255 messages per minute and the default value is 10 messages per minute.
- session reestablishment and state timeout

  If the PCEP session to the PCE goes down, all delegated PCC-initiated LSPs have their state maintained in the PCC and are not timed out. The PCC continues to try re-establishing the PCEP session. When the PCEP session is re-established, the LSP database is synchronized with the PCE database, and any LSP that went down since the last time the PCEP session was up has its path updated by the PCE.

4.4.1 PCC Configuration

The following PCC parameters can be modified while the PCEP session is operational:

- **report-path-constraints**
- **unknown-message-rate**

The following PCC parameters cannot be modified while the PCEP session is operational:

- **local-address**
- **keepalive**
- **dead-timer**
- **peer** (regardless of **shutdown** state)

4.4.2 Stateful PCE

The main function introduced by stateful PCE over the base PCE implementation is the ability to synchronize the LSP state between the PCC and the PCE. This allows the PCE to have all the required LSP information to perform reoptimization and updating of the LSP paths.

Table 33 describes the TLVs, objects, and messages supported by stateful PCE on the 7705 SAR.

Table 33 **PCEP Stateful PCE Extension TLVs, Objects, and Messages**

TLV, Object, or Message	Contained in Object	Contained in Message
Path Computation State Report (PCRpt)	N/A	New message
Path Computation Update Request (PCUpd)	N/A	New message
STATEFUL-PCE-CAPABILITY TLV	OPEN	OPEN
Stateful Request Parameter (SRP) Object	N/A	PCRpt [1], PCErr
LSP Object	ERO	PCRpt [1], PCReq, PCRep
LSP-IDENTIFIERS TLV	LSP	PCRpt [1]
SYMBOLIC-PATH-NAME TLV	LSP, SRP	PCRpt [1]
LSP-ERROR-CODE TLV	LSP	PCRpt [1]
RSVP-ERROR-SPEC TLV	LSP	PCRpt [1]

Note:

1. Nokia proprietary

The behavior and limitations of the implementation of the TLVs, objects, and messages in Table 33 are as follows.

- The PCC and PCE support all PCEP capability TLVs defined in this document and will always advertise them. If the OPEN object received from a PCEP speaker does not contain one or more of the capabilities, the PCE or PCC will not use them during that specific PCEP session.
- The PCC always includes the LSP object in the PCReq message to make sure that the PCE can correlate the PLSP-ID for this LSP when a subsequent PCRpt message arrives with the delegation bit set. The PCE will, however, still honor a PCReq message without the LSP Object.
- PCE path computation will only consider the bandwidth used by LSPs in its LSP-DB. As a result, there are two situations where PCE path computation will not accurately take into account the bandwidth used in the network:
  - when there are LSPs that are signaled by the routers but are not synchronized with the PCE. The user can enable the reporting of the LSP to the PCE LSP database for each LSP.
  - when the stateful PCE is peering with a third-party stateless PCC, implementing only the original RFC 5440. While the PCE will be able to bring the PCEP session up, the LSP database will not be updated, because stateless PCC does not support the PCRpt message. Therefore, PCE path computation will not accurately take into account the bandwidth used by these LSPs in the network.
- The PCE ignores the R-flag (reoptimize flag) in the PCReq message when acting in passive stateful mode for an LSP and will always return the newly computed path, regardless whether it is link-by-link identical or has the same metric as the current path. The decision whether to initiate the new path in the network belongs to the PCC.
- The synchronization vector (SVEC) object is not supported on the 7705 SAR and the NSP. If the PCE receives a PCReq message with the SVEC object, it will ignore the SVEC object and treat each path computation request in the PCReq message as independent, regardless of the setting of the P-flag in the SVEC object common header.
- When an LSP is delegated to the PCE, there may be no prior state in the NRC-P LSP database for the LSP. This could be due to the PCE not having received a PCReq message for the same PLSP-ID. In order for the PCE to become aware of the original constraints of such an LSP, the following additional procedures are performed. These procedures are proprietary to Nokia.
  - The PCC appends a duplicate of each of the LSPA, metric, and bandwidth objects in the PCRpt message. The only difference between the two objects of the same type is that the P-flag is set in the common header of the duplicate object to indicate a mandatory object for processing by the PCE.

- The value of the metric or bandwidth in the duplicate object contains the original constraint value, while the first object contains the operational value. This is applicable to hop metrics in the metric object and bandwidth object only. The 7705 SAR PCC does not support putting a bound value on the IGP or TE metric in the path computation.
- The path computation on the PCE uses the first set of objects when updating a path if the PCRpt message contains a single set. If the PCRpt message contains a duplicate set, PCE path computation must use the constraints in the duplicate set.
- For interoperability, implementations compliant with PCEP standards should be able to accept the first metric object and ignore the second object without additional error handling. Because there are also bandwidth and LSPA objects, the [**no**] **report-path-constraints** command is provided in the PCC on a per-PCEP session basis to disable the inclusion of the duplicate objects. Duplicate objects are included by default.

4.4.3 PCEP Extensions in Support of SR-TE LSPs

In order for the PCE and PCC to manage the path of an SR-TE LSP, they both implement the following extensions to PCEP in support of segment routing.

- The PCC and PCE support a Segment Routing capability TLV in the OPEN object to indicate support of segment routing tunnels by the PCE and the PCC during PCEP session initialization. This TLV is referred to as the SR-PCE-CAPABILITY TLV.
- The PCC and PCE support all PCEP capability TLVs defined in this chapter and will always advertise them. If the OPEN object received from a PCEP speaker does not contain one or more of the capabilities, the PCE or the PCC will not use them during that specific PCEP session.
- The PCC and PCE support a new Path Setup Type TLV for SR-TE LSPs to be included in the Stateful PCE Request Parameters (SRP) object during path report (PCRpt) messages by the PCC.

  A Path Setup Type TLV with a value of 1 identifies an SR-TE LSP.
- The PCC and PCE support a new Segment Routing ERO and RRO with sub-objects, referred to as SR-ERO and SR-RRO sub-objects, which encode the SID information in PCRpt messages.

- The PCE implementation supports the Segment-ID (SID) Depth value in the METRIC object. This is always signaled by the PCC in the PCEP Open object as part of the SR-PCE-CAPABILITY TLV. It is referred to as the Maximum Stack Depth (MSD). In addition, the per-LSP value for the **max-sr-labels** option, if configured, is signaled by the PCC to the PCE in the SID Depth value in a METRIC object for both a PCE-computed LSP and a PCE-controlled LSP. The PCE will compute and provide the full explicit path with TE links specified. If there is no path with the number of hops lower than the MSD value or the SID Depth value (if signaled), a reply with no path will be returned to the PCC.
- For a PCC-controlled LSP, if the label stack returned by the TE-DB hop-to-label translation exceeds the per-LSP maximum SR label stack size, the LSP is brought down.
- If the Path Setup Type (PST) TLV is not included in the PCReq message, the PCE or PCC must assume it is for an RSVP-TE LSP.

Table 34 describes the segment routing extension objects and TLVs supported on the 7705 SAR.

Table 34 **PCEP Segment Routing Extension Objects and TLVs**

TLV, Object, or Message	Contained in Object	Contained in Message
SR PCE CAPABILITY TLV	OPEN	OPEN
Path Setup Type (PST) TLV	SRP	PCReq, PCRep, PCRpt [1]
SR-ERO sub-object	ERO	PCRep, PCRpt [1]
SR-RRO sub-object	RRO	PCReq, PCRpt [1]
Segment-ID (SID) Depth Value in METRIC object	METRIC	PCReq, PCRpt [1]

Note:

1. Nokia proprietary

4.4.4 LSP Initiation

An LSP that is configured on the router is referred to as a PCC-initiated LSP. An LSP that is not configured on the router, but is instead created by the PCE at the request of an application or a service instantiation, is referred to as a PCE-initiated LSP.

The 7705 SAR supports three modes of operation for PCC-initiated LSPs, which are configurable on a per-LSP basis:

- **PCC-initiated and PCC-controlled**

  When the path of the LSP is computed and updated by the router acting as a PCE Client (PCC), the LSP is referred to as PCC-initiated and PCC-controlled.

  A PCC-initiated and PCC-controlled LSP has the following characteristics:

  - The LSP can contain strict or loose hops, or a combination of both.
  - CSPF is supported for RSVP-TE LSPs. Local path computation takes the form of hop-to-label translation for LSPs.
  - LSPs can be reported to synchronize the LSP database of a stateful PCE server using the **pce-report** option. In this case, the PCE acts in passive stateful mode for this LSP. The LSP path cannot be updated by the PCE. The control of the LSP is maintained by the PCC.

- **PCC-initiated and PCE-computed**

  When the path of the LSP is computed by the PCE at the request of the PCC, it is referred to as PCC-initiated and PCE-computed.

  A PCC-initiated and PCE-computed LSP has the following characteristics:

  - The **pce-computation** option must be enabled for the LSP so that the PCE can perform path computation at the request of the PCC only. The PCC retains control.
  - LSPs can be reported to synchronize the LSP database of a stateful PCE server using the **pce-report** option. In this case, the PCE acts in passive stateful mode for this LSP.

- **PCC-initiated and PCE-controlled**

  When the path of the LSP is updated by the PCE following a delegation from the PCC, it is referred to as PCC-initiated and PCE-controlled.

  A PCC-initiated and PCE-controlled LSP has the following characteristics:

  - The **pce-control** option must be enabled for the LSP so that the PCE can perform path updates following a network event without an explicit request from the PCC. The PCC delegates full control.
  - The **pce-report** option must be enabled for LSPs that cannot be delegated to the PCE. The PCE acts in active stateful mode for this LSP.

4.4.5 PCC-Initiated and PCE-Computed or PCE-Controlled LSPs

The following is the procedure for configuring and programming a PCC-initiated LSP when control is delegated to the PCE.

Step 1. The LSP configuration is created on the PE router via CLI or via the OSS/NSP NFM-P.

The configuration dictates which PCE control mode is desired: active (**pce-control** and **pce-report** options enabled) or passive (**pce-computation** enabled and **pce-control** disabled).

Step 2. PCC assigns a unique PLSP-ID to the LSP. The PLSP-ID uniquely identifies the LSP on a PCEP session and must remain constant during its lifetime. PCC on the router must keep track of the association of the PLSP-ID to the Tunnel-ID and Path-ID, and use the latter to communicate with MPLS about a specific path of the LSP. PCC also uses the SRP-ID to correlate PCRpt messages for each new path of the LSP.

Step 3. The PE router does not validate the entered path. Note however that in the 7705 SAR, the PCE supports the computation of a path for an LSP with empty-hops in its path definition. While PCC will include the IRO objects in the PCReq message to PCE, the PCE will ignore them and compute the path with the other constraints except the IRO.

Step 4. The PE router sends a PCReq message to the PCE to request a path for the LSP, and includes the LSP parameters in the METRIC object, the LSPA object, and the BANDWIDTH object. The PE router also includes the LSP object with the assigned PLSP-ID. At this point, the PCC does not delegate the control of the LSP to the PCE.

Step 5. The PCE computes a new path, reserves the bandwidth, and returns the path in a PCRep message with the computed ERO in the ERO object. It also includes the LSP object with the unique PLSP-ID, the METRIC object with any computed metric value, and the BANDWIDTH object.

Note: For the PCE to be able to use the SRLG path diversity and admin-group constraints in the path computation, the user must configure the SRLG and admin-group membership against the MPLS interface and make sure that the **traffic-engineering** option is enabled in IGP. This causes IGP to flood the link SRLG and admin-group membership in its participating area, and for PCE to learn it in its TE database.

Step 6. The PE router updates the CPM and the data path with the new path.

Up to this point, the PCC and PCE are using passive stateful PCE procedures. The next steps will synchronize the LSP database of the PCC and PCE for both PCE-computed and PCE-controlled LSPs. They will also initiate the active PCE stateful procedures for the PCE-controlled LSP only.

Step 7. The PE router sends a PCRpt message to update the PCE with an Up state, and also sends the RRO as confirmation. It now includes the LSP object with the unique PLSP-ID. For a PCE-controlled LSP, the PE router also sets the delegation control flag to delegate control to the PCE. The state of the LSP is now synchronized between the router and the PCE.

Step 8. Following a network event or a reoptimization, the PCE computes a new path for a PCE-controlled LSP and returns it in a PCUpd message with the new ERO. It will include the LSP object with the same unique PLSP-ID assigned by the PCC, as well as the Stateful Request Parameter (SRP) object with a unique SRP-ID-number to track error and state messages specific to this new path.

Step 9. The PE router updates the CPM and the data path with the new path.

Step 10. The PE router sends a PCRpt message to inform the PCE that the older path is deleted. It includes the unique PLSP-ID value in the LSP object and the R (Remove) bit set.

Step 11. The PE router sends a new PCRpt message to update PCE with an Up state, and also sends the RRO to confirm the new path. The state of the LSP is now synchronized between the router and the PCE.

Step 12. If PCE owns the delegation of the LSP and is making a path update, MPLS will initiate the LSP and update the operational value of the changed parameters while the configured administrative values will not change. Both the administrative and operational values are shown in the details of the LSP path in MPLS.

Step 13. If the user makes any configuration change to the PCE-computed or PCE-controlled LSP, MPLS requests that the PCC first revoke delegation in a PCRpt message (PCE-controlled only), and then MPLS and PCC follow the above steps to convey the changed constraint to PCE which will result in the programming of a new path into the data path, the synchronization of the PCC and PCE LSP databases, and the return of delegation to PCE.

The above procedure is followed when the user performs a **no shutdown** command on a PCE-controlled or PCE-computed LSP. The starting point is an LSP which is administratively down with no active path. For an LSP with an active path, the following items may apply:

a. If the user enabled the **pce-computation** option on a PCC-controlled LSP with an active path, no action is performed until the next time the router needs a path for the LSP following a network event of a LSP parameter change. At that point, the prior procedure is followed.

b. If the user enabled the **pce-control** option on a PCC-controlled or PCE-computed LSP with an active path, the PCC will issue a PCRpt message to the PCE with an Up state, as well as the RRO of the active path. It will set the delegation control flag to delegate control to the PCE. The PCE will keep the active path of the LSP and make no updates to it until the next network event or reoptimization. At that point, the prior procedure is followed.

4.5 PCEP Support for RSVP-TE LSPs

This section describes the support of PCC-initiated RSVP-TE LSPs. PCEP support of an RSVP-TE LSP is described in LSP Initiation with the following differences:

- each primary and secondary path is assigned its own unique path LSP-ID (PLSP-ID)
- the PCC indicates to the PCE the state of each path (either up or down) and which path is currently active and carrying traffic (active state)

This section includes the following topics:

- RSVP-TE LSP Configuration for a PCC Router
- Behavior of the LSP Path Update
- Behavior of LSP MBB
- Behavior of Secondary LSP Paths
- PCE Path Profile Support

4.5.1 RSVP-TE LSP Configuration for a PCC Router

The following MPLS-level and LSP-level CLI commands are used to configure RSVP-TE LSPs in a router acting as a PCEP Client (PCC). See MPLS and RSVP-TE Command Reference for command descriptions.

- **config>router>mpls>**
  pce-report rsvp-te {**enable** | **disable**}
- **config>router>mpls>lsp>**
  path-profile *profile-id* [**path-group** *group-id*]
  pce-computation
  pce-control
  pce-report {**enable** | **disable** | **inherit**}
- **config>router>mpls>lsp-template**
  pce-report {**enable** | **disable** | **inherit**}

The **cspf** option must be enabled on the LSP before enabling the **pce-computation** or **pce-control** options. An attempt to disable the **cspf** option on an RSVP-TE LSP that has the **pce-computation** or **pce-control** options enabled will be rejected.

If the LSP has disabled PCE reporting, either due to inheritance from the MPLS-level configuration or due to LSP-level configuration, enabling the **pce-control** option for the LSP has no effect. To help troubleshoot this situation, the output of the **show** commands for the LSP displays the operational values of both the **pce-report** and **pce-control** options.

Note: The PCE function implemented in the NSP and referred to as the NRC-P, supports only Shared Explicit (SE) style bandwidth management for RSVP-TE LSPs. The PCEP does not support the ability of the PCC to convey this value to the PCE. Therefore, whether the LSP configuration option **rsvp-resv-style** is set to **se** or **ff**, the PCE will always use the SE style in the CSPF computation of the path for a PCE-computed or PCE-controlled RSVP-TE LSP.

A **one-hop-p2p** or a **mesh-p2p** RSVP-TE **auto-lsp** only supports the **pce-report** command in the LSP template:

- **config**>**router**>**mpls**>**lsp-template**>
  pce-report {**enable** | **disable** | **inherit**}

The user must first shut down the LSP template before changing the value of the **pce-report** option.

A manual bypass LSP does not support any of the PCE-related commands. Reporting a bypass LSP to the PCE is not required because the bypass LSP does not book bandwidth.

All other MPLS, LSP, and path-level commands are supported, with the exception of the following commands:

- **least-fill**
- **srlg** (on secondary standby path)

For more information on RSVP-TE PCC instantiation modes, see LSP Initiation.

4.5.2 Behavior of the LSP Path Update

When the **pce-control** option is enabled, the PCC delegates control of the RSVP-TE LSP to the PCE.

The NRC-P sends a path update using the PCUpd message in the following cases:

- a failure event that impacts a link or a node in the path of a PCE-controlled LSP

  The operation is performed by the PCC as a Make-Before-Break (MBB) if the LSP remained in the up state due to protection provided by FRR or a secondary path. If the LSP went down, the update brings it into the up state. A PCRpt message is sent by the PCC for each change to the state of the LSP during this process. See Behavior of LSP MBB for more information.
- a topology change that impacts a link in the path of a PCE-controlled LSP

  This topology change can be a change to the IGP metric, the TE metric, admin-group, or SRLG membership of an interface. This update is performed as an MBB by the PCC.
- the user performed a manual resignal of a PCE-controlled RSVP-TE LSP path from the NRC-P

  This update is performed as an MBB by the PCC.
- the user performed a Global Concurrent Optimization (GCO) on a set of PCE-controlled RSVP-TE LSPs from the NRC-P

  This update is performed as an MBB by the PCC.

The procedures for the path update are described in LSP Initiation. However, for an RSVP-TE LSP, the PCUpd message from the PCE contains the interface IP address or system IP address in the computed ERO. The PCC signals the path using the ERO returned by the PCE and, if successful, programs the data path, then sends the PCRpt message with the resulting RRO and hop labels provided by RSVP-TE signaling.

If the signaling of the ERO fails, the ingress LER returns a PCErr message to the PCE with the LSP Error code field of the LSP-ERROR-CODE TLV set to a value of 8 (RSVP signaling error).

If an RSVP-TE LSP has the **no adaptive** option set, the ingress LER cannot perform an MBB for the LSP. A PCUpd message received from the PCE is then failed by the ingress LER, which returns a PCErr message to the PCE with the LSP Error code field of the LSP-ERROR-CODE TLV set to a value of 8 (RSVP signaling error).

4.5.2.1 Path Update with Empty ERO

When the NRC-P reoptimizes the path of a PCE-controlled RSVP-TE LSP, it is possible that a path that satisfies the constraints of the LSP no longer exists. In this case, the NRC-P sends a PCUpd message with an empty ERO, which forces the PCC to bring down the path of the RSVP-TE LSP.

The NRC-P sends a PCUpd message with an empty ERO if any of the following cases are true:

- the requested bandwidth is the same as the current bandwidth, which avoids bringing down the path due to a resignal during an MBB transition
- local protection is not currently in use, which avoids bringing down a path that activated an FRR backup path. The LSP can remain on the FRR backup path until a new primary path can be found by the NRC-P.
- the links of the current path are all operationally up, which allows the NRC-P to ensure that the RSVP control plane will report the path down when a link is down and not prematurely bring the path down with an empty ERO

4.5.3 Behavior of LSP MBB

In addition to the MBB support when the PCC receives a path update, as described in Behavior of the LSP Path Update, an RSVP-TE LSP supports the MBB procedure for any parameter configuration change, including the PCEP-related commands when they result in a change to the path of the LSP.

If the user adds or modifies the **path-profile** command for an RSVP-TE LSP, a config change MBB is only performed if the **pce-computation**, **pce-report**, or **pce-control** options are enabled on the LSP. Otherwise, no action occurs. When **pce-computation**, **pce-report**, or **pce-control** are enabled on the LSP, the path update MBB (**tools>perform>router>mpls>update-path**) fails, resulting in no operation.

MBB is also supported for the manual resignal and auto-bandwidth MBB types.

When the LSP goes into an MBB state at the ingress LER, the behavior is dependent on the operating mode of the LSP.

This section contains information on the following LSP MBB procedures:

- PCC-Controlled LSPs
- PCE-Computed LSPs
- PCE-Controlled LSPs

4.5.3.1 PCC-Controlled LSPs

All MBB types are supported for PCC-controlled LSPs. The LSP MBB procedures for a PCC-controlled LSP (**pce-computation** and **pce-control** disabled) are as follows.

1. MPLS submits a path request, including the updated path constraints, to the local CSPF.
2. If the local CSPF returns a path, the PCC signals the LSP with the RSVP control plane and moves traffic to the new MBB path. If **pce-report** is enabled for this LSP, the PCC sends a PCRpt message with the delegation bit clear to retain control and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the new MBB path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear, which indicates the operational values of these parameters. Unless the user disables the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, and bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.
3. If the CSPF returns no path or the RSVP-TE signaling of the returned path fails, MPLS puts the LSP into retry mode and sends a request to the local CSPF every *retry-timer* seconds and up to the value of *retry-count*.
4. When **pce-report** is enabled for the LSP and the FRR global revertive MBB is triggered following a bypass LSP activation by a PLR in the network, the PCC issues an updated PCRpt message with the new RRO reflecting the PLR and RRO hops. The PCE releases the bandwidth on the links that are no longer used by the LSP path.

4.5.3.2 PCE-Computed LSPs

All MBB types are supported for PCE-computed LSPs. The LSP MBB procedures for a PCE-computed LSP (**pce-computation** enabled and **pce-control** disabled) are as follows.

1. The PCC issues a PCReq for the same PLSP-ID and includes the updated constraints in the metric, LSPA, and bandwidth objects.
   - If the PCE successfully finds a path, it replies with a PCRep message with the ERO.
   - If the PCE does not find a path, it replies with a PCRep message containing the No-Path object.

2. If the PCE returns a path, the PCC signals the LSP with the RSVP control plane and moves traffic to the new MBB path. If **pce-report** is enabled for this LSP, the PCC sends a PCRpt message with the delegation D-bit clear to retain control and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the new MBB path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear, which indicates the operational values of these parameters. Unless the user disables the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, and bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.
3. If the PCE returns no path or the RSVP-TE signaling of the returned path fails, MPLS puts the LSP into retry mode and sends a request to PCE every *retry-timer* seconds and up to the value of *retry-count*.
4. When the **pce-report** is enabled for the LSP and the FRR global revertive MBB is triggered following a bypass LSP activation by a PLR in the network, the PCC issues an updated PCRpt message with the new RRO reflecting the PLR and RRO hops. The PCE releases the bandwidth on the links that are no longer used by the LSP path.
5. If the user changes the RSVP-TE LSP configuration from **pce-computation** to **no pce-computation**, MBB procedures are not supported. In this case, the LSP path is torn down and is put into retry mode to compute a new path from the local CSPF on the router to signal the LSP.

4.5.3.3 PCE-Controlled LSPs

The LSP MBB procedures for a PCE-controlled LSP (**pce-control** enabled) are as follows.

Note: Items 1 through 5 of the following procedure apply to the config change, manual resignal, and auto-bandwidth MBB types. The delayed retry MBB type used with the SRLG on secondary standby LSP feature is not supported with a PCE-controlled LSP. See Behavior of Secondary LSP Paths for information about the SRLG on secondary standby LSP feature.

1. The PCC temporarily removes delegation by sending a PCRpt message for the corresponding path LSP-ID (PLSP-ID) with the delegation D-bit clear.
2. For an LSP with **pce-computation** disabled, MPLS submits a path request to the local CSPF, which includes the updated path constraints.
3. For an LSP with **pce-computation** enabled, the PCC issues a PCReq for the same PLSP-ID and includes the updated constraints in the metric, LSPA, or bandwidth objects.

- If the PCE successfully finds a path, it replies with a PCRep message with the ERO.
- If the PCE does not find a path, it replies with a PCRep message containing the No-Path object.

4. If the local CSPF or the PCE returns a path, the PCC performs the following actions.
   - The PCC signals the LSP with the RSVP control plane and moves traffic to the new MBB path. It then sends a PCRpt message with the delegation D-bit set to return delegation and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the new MBB path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear, which indicates the operational values of these parameters. Unless the user disabled the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, or bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.
   - The PCC sends a PathTear message to delete the state of the older path in the network. The PCC then sends a PCRpt message to the PCE with the older path LSP (PLSP-ID) and the remove R-bit set to also have the PCE remove the state of that LSP from its database.
5. If the local CSPF or the PCE returns no path or the RSVP-TE signaling of the returned path fails, the router makes no further requests. That is, there is no retry for the MBB.
   - The PCC sends a PCErr message to the PCE with the LSP Error code field of the LSP-ERROR-CODE TLV set to a value of 8 (RSVP signaling error) if the MBB failed due to a RSVP-TE signaling error.
   - The PCC sends a PCRpt message with the delegation D-bit set to return delegation and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the currently active path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear to indicate the operational values of these parameters. Unless the user disabled the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, and bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.
6. The ingress LER takes no action in the case of a network event triggered MBB, such as FRR global revertive or TE graceful shutdown.
   - The ingress PE keeps the information as required and sets the state of MBB to one of the FRR global revertive or TE graceful shutdown MBB values but does not perform the MBB action.

- The NRC-P computes a new path for the global revertive MBB due to a failure event. This computation uses the PCUpd message to update the path using the MBB procedure described in Behavior of the LSP Path Update. The activation of a bypass LSP by a point of local repair (PLR) in the network causes the PCC to issue an updated PCRpt message with the new RRO reflecting the PLR and RRO hops. The PCE will release the bandwidth on the links that are no longer used by the LSP path.
- The NRC-P computes a new path for the TE graceful shutdown MBB if the RSVP-TE is using the TE metric, because the TE metric of the link in TE graceful shutdown is set to infinity. This computation uses the PCUpd message to update the path using the MBB procedure described in Behavior of the LSP Path Update.
- The NRC-P does not act on the TE graceful shutdown MBB if the RSVP-TE is using the IGP metric; however, the user can perform a manual resignal of the LSP path from the NRC-P to force a new path computation, which accounts for the newly available bandwidth on the link that caused the MBB event. This computation uses the PCUpd message to update the path using the MBB procedure described in Behavior of the LSP Path Update.
- The user can perform a manual resignal of the LSP path from the ingress LER, which forces an MBB for the path as per the remove-delegation/MBB/return-delegation procedures described in this section.
- If the user performs **no pce-control** while the LSP still has the state for any of the network event triggered MBBs, the MBB is performed immediately by the PCC as described in the procedures in PCE-Computed LSPs for a PCE-computed LSP and as described in the procedures in PCC-Controlled LSPs for a PCC-controlled LSP.

7. The timer-based manual resignal MBB behaves like the TE graceful shutdown MBB. The user can perform a manual resignal of the LSP path from the ingress LER or from the PCE.
8. The path update MBB (**tools>perform>router>mpls>update-path**) fails, which results in no operation. This is true in all cases when the RSVP-TE LSP enables the **pce-report** option.

4.5.4 Behavior of Secondary LSP Paths

Each of the primary, secondary standby, and secondary non-standby paths of the same LSP must use a separate path LSP-ID (PLSP-ID). The PCE function of the NSP, the NRC-P, checks the LSP-IDENTIFIERS TLV in the LSP object and can identify which PLSP-IDs are associated with the same LSP or the same RSVP-TE session. The parameters are the IPv4 Tunnel Sender Address, the Tunnel ID, the Extended Tunnel ID, and the IPv4 Tunnel Endpoint Address. This approach allows the use of all the PCEP procedures for all three types of LSP paths.

The PCC indicates to the PCE the following states for the path in the LSP object: down, up (signaled but not carrying traffic), or active (signaled and carrying traffic).

The PCE tracks active paths and displays them in the NSP GUI. It also provides only the tunnel ID of an active PLSP-ID to a destination prefix when a request is made by a service or a steering application.

The PCE recomputes the paths of all PLSP-IDs that are affected by a network event. The user can select each path separately on the NSP GUI and trigger a manual resignal of one or more paths of the RSVP-TE LSP.

Note: Enabling the **srlg** option on a secondary standby path results in no operation. The NRC-P supports link and SRLG disjointness using the PCE path profile. The user can apply the PCE path profile to the primary and secondary paths of the same LSP. See PCE Path Profile Support for more information.

4.5.5 PCE Path Profile Support

The PCE path profile ID and path group ID are configured at the LSP level (**config>router>mpls>lsp>path-profile**).

The NRC-P can enforce path disjointness and bidirectionality among a pair of forward and a pair of reverse LSP paths. Both pairs of LSP paths must use a unique path group ID along with the same path profile ID.

When the user wants to apply path disjointness and path bidirectionality constraints to RSVP-TE LSP paths, it is important to follow the following guidelines. The user can configure the following sets of LSP paths:

- a set consisting of a pair of forward RSVP-TE LSPs and a pair of reverse RSVP-TE LSPs, each with a single primary or secondary path. The pair of forward LSPs can originate and terminate on different routers. The pair of reverse LSPs must mirror the forward pair. In this case, the path profile ID and the path group ID configured for each LSP must match. Because each LSP has a single path, the bidirectionality constraint applies automatically to the forward and reverse LSPs, which share the same originating node and the same terminating routers.
- a pair consisting of a forward RSVP-TE LSP and a reverse RSVP-TE LSP, each with a primary path and a single secondary path, or each with two secondary paths. Because the two paths of each LSP inherit the same LSP level path profile ID and path group ID configuration, the NRC-P path computation algorithm cannot guarantee that the primary paths in both directions meet the bidirectionality constraint. That is, it is possible that the primary path for the forward LSP shares the same links as the secondary path of the reverse LSP and vice-versa.

4.6 LSP Path Diversity and Bidirectionality Constraints

The PCE path profile defined in *draft-alvarez-pce-path-profiles* is used to request path diversity or a disjoint for two or more LSPs originating on the same or different PE routers. It is also used to request that paths of two unidirectional LSPs between the same two routers use the same TE links. This is referred to as the bidirectionality constraint.

Path profiles are defined by the user directly on the NRC-P Policy Manager with a number of LSP path constraints, which are metrics with upper bounds specified, and with an objective, which are metrics optimized with no bounds specified. The NRC-P Policy Manager allows the following PCE constraints to be configured within each PCE path profile:

- path diversity, node-disjoint, link-disjoint
- path bidirectionality, symmetric reverse route preferred, symmetric reverse route required
- maximum path IGP metric (cost)
- maximum path TE metric
- maximum hop count

The user can also specify which PCE objective to use to optimize the path of the LSP in the PCE path profile, one of:

- IGP metric (cost)
- TE metric
- hops (span)

The CSPF algorithm will optimize the objective. If a constraint is provided for the same metric, the CSPF algorithm ensures that the selected path achieves a lower or equal value to the bound value specified in the constraint.

For hop-count metrics, if a constraint is sent in a metric object and is also specified in a PCE profile referenced by the LSP, the constraint in the metric object is used.

For IGP and TE metrics, if an objective is sent in a metric object and is also specified in a PCE profile referenced by the LSP, the objective in the path profile is used.

The constraints in the bandwidth object and the LSPA object, specifically the include and exclude admin-group constraints and setup and hold priorities, are not supported in the PCE profile.

In order to indicate the path diversity and bidirectionality constraints to the PCE, the user must configure the profile ID and path group ID of the PCE path that the LSP belongs to. The CLI commands for this are described in Configuring RSVP-TE LSPs with PCEP Using the CLI. The path group ID does not need to be defined in the PCE as part of the path profile configuration and identifies implicitly the set of paths that must have the path diversity constraint applied.

The user can only associate a single path group ID with a specific PCE path profile ID for an LSP. However, the same path group ID can be associated with multiple PCE profile IDs for the same LSP.

The path profiles are inferred using the path ID in the path request by the PCC. When the PE router acting as a PCC wants to request path diversity from a set of other LSPs belonging to a path group ID value, it adds a new PATH-PROFILE object in the PCReq message. The object contains the path profile ID and the path group ID as an extended ID field. In other words, the diversity metric is carried in an opaque way from the PCC to the PCE.

The bidirectionality constraint operates the same way as the diversity constraint. The user can configure a PCE profile with both the path diversity and bidirectionality constraints. The PCE will check if there is an LSP in the reverse direction that belongs to the same path group ID as an originating LSP it is computing the path for, and will enforce the constraint.

In order for the PCE to be aware of the path diversity and bidirectionality constraints for an LSP that is delegated but for which there is no prior state in the NRC-P LSP database, the PATH-PROFILE object is included in the PCRpt message with the P-flag set in the common header to indicate that the object must be processed. This is proprietary to Nokia.

Table 35 describes the new objects and TLVs introduced in the PCE path profile.

Table 35 **PCEP Path Profile Extension Objects and TLVs**

TLV, Object, or Message	Contained in Object	Contained in Message
PATH-PROFILE-CAPABILITY TLV	OPEN	OPEN
PATH-PROFILE Object	N/A	PCReq, PCRpt [1]

Note:

1. Nokia proprietary

A PATH-PROFILE object can contain multiple TLVs containing each profile ID and extend ID, and should be processed properly. If multiple PATH-PROFILE objects are received, the first object is interpreted and the others are ignored. The PCC and the PCE support all PCEP capability TLVs defined in this chapter and will always advertise them. If the OPEN object received from a PCEP speaker does not contain one or more of the capabilities, the PCE or PCC will not use them during that PCEP session.

4.7 Configuring RSVP-TE LSPs with PCEP Using the CLI

This section provides information about using the CLI to configure and operate RSVP-TE LSPs with PCEP.

The following information describes the detailed configuration of an inter-area RSVP-TE LSP with both a primary path and a secondary path. The network uses IS-IS with the backbone area in Level 2 and the leaf areas in Level 1. Topology discovery is learned by the NRC-P using IGP and the NSP NFM-P.

The LSP uses an admin-group constraint to keep the paths of the secondary and primary links disjoint in the backbone area. The LSP is PCE-controlled but also has **pce-computation** enabled so that the initial path, and any MBB path, is also computed by the PCE.

The NSP and 7705 SAR load versions used to produce this example in this section are:

- NSP: NSP-2.0.3-rel.108
- PCE SROS: TiMOS-B-0.0.W129
- PCC: TiMOS-B-0.0.I4902

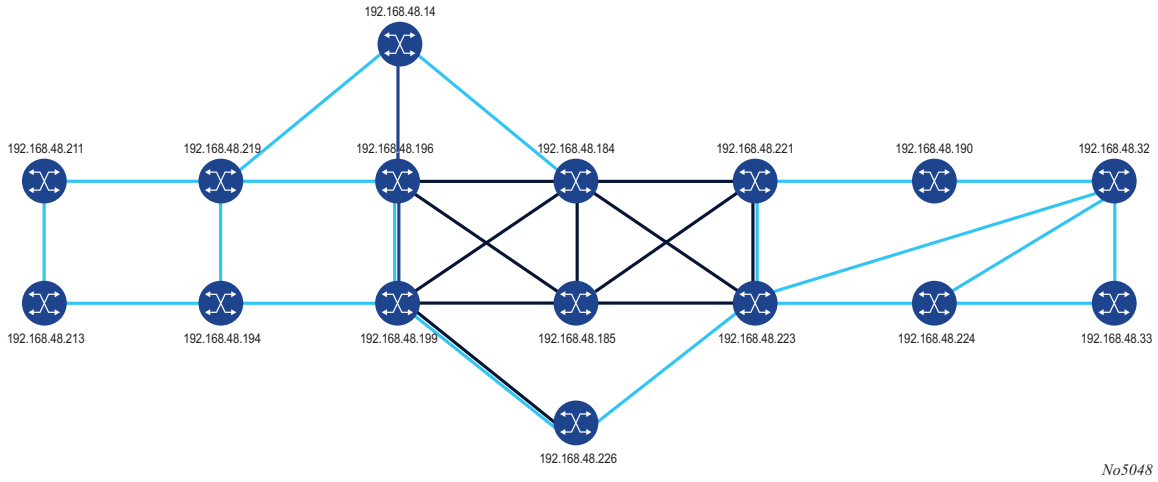
This section provides configuration and show commands for the following examples:

- PCEP on the PCE Node and the PCC Node
- MPLS on the PCC Node

4.7.1 PCEP on the PCE Node and the PCC Node

Figure 19 shows a multi-level IS-IS topology in the NSP GUI.

Figure 19 **Multi-level IS-IS Topology in the NSP GUI**



The following example shows the configuration and show command output of the PCEP on the PCE node and the PCC node.

Note: The 7705 SAR operates as a PCE Client (PCC) only, supporting PCC capabilities for RSVP-TE LSPs and SR-TE LSPs. References to PCE router operation apply to the 7750 SR product family and are included for informational purposes only.

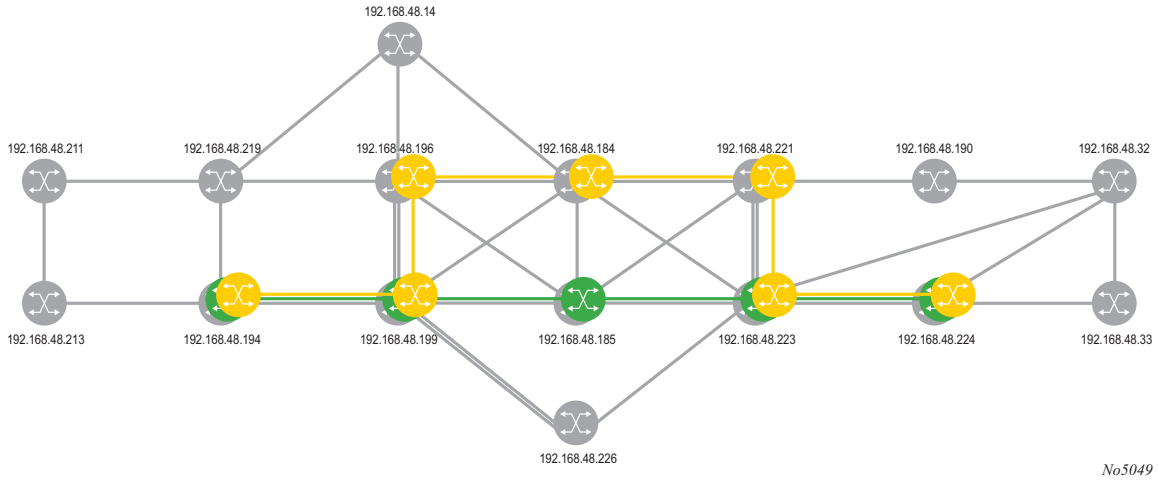
```
*A:PCE Server 226>config>router>pcep>pce# info
----------------------------------------------
            local-address 192.168.48.226
            no shutdown
----------------------------------------------
*A:Reno 194>config>router>pcep>pcc# info
----------------------------------------------
            peer 192.168.48.226
                no shutdown
            exit
            no shutdown
----------------------------------------------

*A:PCE Server 226>config>router>pcep>pce# show router pcep pce status
===============================================================================
Path Computation Element Protocol (PCEP) Path Computation Element (PCE) Info
===============================================================================
Admin Status           : Up              Oper Status          : Up
Unknown Msg Limit      : 10 msg/min
Keepalive Interval     : 30 seconds      DeadTimer Interval   : 120 seconds
Capabilities List      : stateful-delegate stateful-pce segment-rt-path
Local Address          : 192.168.48.226
PCE Overloaded         : false
-------------------------------------------------------------------------------
PCEP Path Computation Element (PCE) Peer Info
-------------------------------------------------------------------------------
Peer                        Sync State            Oper Keepalive/Oper DeadTimer
```

```
-------------------------------------------------------------------------------
192.168.48.190:4189        done                   30/120
192.168.48.194:4189        done                   30/120
192.168.48.198:4189        done                   30/120
192.168.48.199:4189        done                   30/120
192.168.48.219:4189        done                   30/120
192.168.48.221:4189        done                   30/120
192.168.48.224:4189        done                   30/120
-------------------------------------------------------------------------------
===============================================================================

*A:Reno 194# show router pcep pcc status
===============================================================================
Path Computation Element Protocol (PCEP) Path Computation Client (PCC) Info
===============================================================================
Admin Status           : Up              Oper Status          : Up
Unknown Msg Limit      : 10 msg/min
Keepalive Interval     : 30 seconds      DeadTimer Interval   : 120 seconds
Capabilities List      : stateful-delegate stateful-pce segment-rt-path
Address                : 192.168.48.194
Report Path Constraints: True
-------------------------------------------------------------------------------
PCEP Path Computation Client (PCC) Peer Info
-------------------------------------------------------------------------------
Peer                       Admin State/Oper State Oper Keepalive/Oper DeadTimer
-------------------------------------------------------------------------------
192.168.48.226             Up/Up                  30/120
-------------------------------------------------------------------------------
===============================================================================

*A:Reno 194# show router pcep pcc lsp-db
===============================================================================
PCEP Path Computation Client (PCC) LSP Update Info
===============================================================================
PCEP-specific LSP ID: 11
LSP ID              : 14378             LSP Type            : rsvp-p2p
Tunnel ID           : 1                 Extended Tunnel Id  : 192.168.48.194
LSP Name            : From Reno to Atlanta RSVP-TE::primary_empty
Source Address      : 192.168.48.194    Destination Address : 192.168.48.224
LSP Delegated       : True              Delegate PCE Address: 192.168.48.226
Oper Status         : active
-------------------------------------------------------------------------------
PCEP-specific LSP ID: 12
LSP ID              : 14380             LSP Type            : rsvp-p2p
Tunnel ID           : 1                 Extended Tunnel Id  : 192.168.48.194
LSP Name            : From Reno to Atlanta RSVP-TE::secondary_empty
Source Address      : 192.168.48.194    Destination Address : 192.168.48.224
LSP Delegated       : True              Delegate PCE Address: 192.168.48.226
Oper Status         : up
===============================================================================
```

4.7.2 MPLS on the PCC Node

Figure 20 shows primary and secondary RSVP-TE LSP paths in the NSP GUI.

Figure 20 **Primary and Secondary RSVP-TE LSP Paths in the NSP GUI**



The following example shows the configuration and show command output of the MPLS on the PCC node.

```
*A:Reno 194>config>router>mpls>lsp# info
----------------------------------------------
                to 192.168.48.224
                egress-statistics
                    shutdown
                exit
                cspf
                fast-reroute facility
                    no node-protect
                exit
                pce-computation
                pce-report enable
                pce-control
                revert-timer 1
                primary "primary_empty"
                    exclude "top"
                    bandwidth 10
                exit
                secondary "secondary_empty"
                    standby
                    exclude "bottom"
                    bandwidth 5
                exit
                no shutdown
----------------------------------------------

*A:Reno 194# show router mpls lsp "From Reno to Atlanta RSVP-TE" path detail
===============================================================================
```

```
MPLS LSP From Reno to Atlanta RSVP-TE Path  (Detail)
===============================================================================
Legend :
    @ - Detour Available              # - Detour In Use
    b - Bandwidth Protected           n - Node Protected
    s - Soft Preemption
    S - Strict                        L - Loose
    A - ABR
===============================================================================
-------------------------------------------------------------------------------
LSP From Reno to Atlanta RSVP-TE Path primary_empty
-------------------------------------------------------------------------------
LSP Name          : From Reno to Atlanta RSVP-TE
Path LSP ID       : 14382
From              : 192.168.48.194       To                   : 192.168.48.224
Admin State       : Up                   Oper State           : Up
Path Name         : primary_empty        Path Type            : Primary
Path Admin        : Up                   Path Oper            : Up
Out Interface     : 1/1/1                Out Label            : 262094
Path Up Time      : 0d 00:00:22          Path Down Time       : 0d 00:00:00
Retry Limit       : 0                    Retry Timer          : 30 sec
Retry Attempt     : 0                    Next Retry In        : 0 sec
BFD Template      : None                 BFD Ping Interval    : 60
BFD Enable        : False
Adspec            : Disabled             Oper Adspec          : Disabled
CSPF              : Enabled              Oper CSPF            : Enabled
Least Fill        : Disabled             Oper LeastFill       : Disabled
FRR               : Enabled              Oper FRR             : Enabled
FRR NodeProtect   : Disabled             Oper FRR NP          : Disabled
FR Hop Limit      : 16                   Oper FRHopLimit      : 16
FR Prop Admin Gr* : Disabled             Oper FRPropAdmGrp    : Disabled
Propogate Adm Grp : Disabled             Oper Prop Adm Grp    : Disabled
Inter-area        : False
PCE Updt ID       : 0
PCE Report        : Enabled              Oper PCE Report      : Enabled
PCE Control       : Enabled              Oper PCE Control     : Enabled
PCE Compute       : Enabled
Neg MTU           : 1496                 Oper MTU             : 1496
Bandwidth         : 10 Mbps              Oper Bandwidth       : 10 Mbps
Hop Limit         : 255                  Oper HopLimit        : 255
Record Route      : Record               Oper Record Route    : Record
Record Label      : Record               Oper Record Label    : Record
Setup Priority    : 7                    Oper Setup Priority  : 7
Hold Priority     : 0                    Oper Hold Priority   : 0
Class Type        : 0                    Oper CT              : 0
Backup CT         : None
MainCT Retry      : n/a
    Rem           :
MainCT Retry      : 0
    Limit         :
Include Groups    :                      Oper Include Groups  :
None                                       None
Exclude Groups    :                      Oper Exclude Groups  :
top                                        top
Adaptive          : Enabled              Oper Metric          : 40
Preference        : n/a
Path Trans        : 7                    CSPF Queries         : 7172
Failure Code      : noError
Failure Node      : n/a
```

```
Explicit Hops    :
    No Hops Specified
Actual Hops      :
    10.202.5.194 (192.168.48.194) @              Record Label        : N/A
 -> 10.202.5.199 (192.168.48.199) @              Record Label        : 262094
 -> 192.168.48.185 (192.168.48.185)              Record Label        : 262111
 -> 10.0.5.185                                   Record Label        : 262111
 -> 192.168.48.223 (192.168.48.223)              Record Label        : 262121
 -> 10.0.7.223                                   Record Label        : 262121
 -> 192.168.48.224 (192.168.48.224)              Record Label        : 262116
 -> 10.101.4.224                                 Record Label        : 262116
Computed Hops    :
    10.202.5.199(S)
 -> 10.0.5.185(S)
 -> 10.0.7.223(S)
 -> 10.101.4.224(S)
Resignal Eligible: False
Last Resignal    : n/a                   CSPF Metric          : 40
-------------------------------------------------------------------------------
LSP From Reno to Atlanta RSVP-TE Path secondary_empty
-------------------------------------------------------------------------------
LSP Name         : From Reno to Atlanta RSVP-TE
Path LSP ID      : 14384
From             : 192.168.48.194        To                   : 192.168.48.224
Admin State      : Up                    Oper State           : Up
Path Name        : secondary_empty       Path Type            : Standby
Path Admin       : Up                    Path Oper            : Up
Out Interface    : 1/1/1                 Out Label            : 262091
Path Up Time     : 0d 00:00:25           Path Down Time       : 0d 00:00:00
Retry Limit      : 0                     Retry Timer          : 30 sec
Retry Attempt    : 0                     Next Retry In        : 0 sec
BFD Template     : None                  BFD Ping Interval    : 60
BFD Enable       : False
Adspec           : Disabled              Oper Adspec          : Disabled
CSPF             : Enabled               Oper CSPF            : Enabled
Least Fill       : Disabled              Oper LeastFill       : Disabled
Propogate Adm Grp: Disabled              Oper Prop Adm Grp    : Disabled
Inter-area       : False
PCE Updt ID      : 0
PCE Report       : Enabled               Oper PCE Report      : Enabled
PCE Control      : Enabled               Oper PCE Control     : Enabled
PCE Compute      : Enabled
Neg MTU          : 1496                  Oper MTU             : 1496
Bandwidth        : 5 Mbps                Oper Bandwidth       : 5 Mbps
Hop Limit        : 255                   Oper HopLimit        : 255
Record Route     : Record                Oper Record Route    : Record
Record Label     : Record                Oper Record Label    : Record
Setup Priority   : 7                     Oper Setup Priority  : 7
Hold Priority    : 0                     Oper Hold Priority   : 0
Class Type       : 0                     Oper CT              : 0
Include Groups   :                       Oper Include Groups  :
None                                           None
Exclude Groups   :                       Oper Exclude Groups  :
bottom                                         bottom
Adaptive         : Enabled               Oper Metric          : 60
Preference       : 255
Path Trans       : 28                    CSPF Queries         : 10
Failure Code     : noError
Failure Node     : n/a
```

```
Explicit Hops    :
    No Hops Specified
Actual Hops      :
    10.202.5.194 (192.168.48.194)                 Record Label        : N/A
 -> 10.202.5.199 (192.168.48.199)                 Record Label        : 262091
 -> 10.0.9.198 (192.168.48.198)                   Record Label        : 262096
 -> 192.168.48.184 (192.168.48.184)               Record Label        : 262102
 -> 10.0.2.184                                   Record Label        : 262102
 -> 192.168.48.221 (192.168.48.221)               Record Label        : 262119
 -> 10.0.4.221                                   Record Label        : 262119
 -> 192.168.48.223 (192.168.48.223)               Record Label        : 262088
 -> 10.0.10.223                                  Record Label        : 262088
 -> 192.168.48.224 (192.168.48.224)               Record Label        : 262115
 -> 10.101.4.224                                 Record Label        : 262115
Computed Hops    :
    10.202.5.199(S)
 -> 10.0.9.198(S)
 -> 10.0.2.184(S)
 -> 10.0.4.221(S)
 -> 10.0.10.223(S)
 -> 10.101.4.224(S)
Srlg             : Disabled
Srlg Disjoint    : False
Resignal Eligible: False
Last Resignal    : n/a                   CSPF Metric          : 60
===============================================================================
```

The following CLI displays are output examples of a PCEP SR-TE LSP in three configurations:

- PCE-computation enabled, PCE-report disabled (via inheritance), and PCE-control disabled
- PCE-computation enabled, PCE-report enabled, and PCE-control disabled
- PCE-computation enabled, PCE-report enabled, and PCE-control enabled

The configuration can be determined by checking the PCE Report, PCE Compute, and PCE Control fields. An example of the output is shown below. For more information and CLI output examples, see the **show>router>mpls>**sr-te-lsp command description.

```
*A:7705:Dut-C# show  router mpls sr-te-lsp detail
===============================================================================
MPLS SR-TE LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name        : test_lsp_1
LSP Type        : SrTeLsp                   LSP Tunnel ID       : 1
LSP Index       : 65536                     TTM Tunnel Id       : 655362
From            : 10.20.1.3                 To                  : 10.20.1.4
Adm State       : Up                        Oper State          : Up
LSP Up Time     : 0d 00:00:44               LSP Down Time       : 0d 00:00:00
Transitions     : 1                         Path Changes        : 1
Retry Limit     : 0                         Retry Timer         : 30 sec
```

```
Hop Limit       : 255                       Negotiated MTU       : 1492
CSPF            : Enabled
Metric          : N/A                       Use TE metric        : Disabled
Include Grps    :                           Exclude Grps         :
None                                           None

VprnAutoBind    : Enabled
IGP Shortcut    : Enabled
IGP LFA         : Disabled                  IGP Rel Metric       : Disabled
BGPTransTun     : Enabled
Oper Metric     : 100
PCE Report      : Inherited
PCE Compute     : Enabled                   PCE Control          : Disabled
Max SR Labels   : 6                         Additional FRR Labels: 1
Path Profile    :
None

Primary(a)      : fully_loose               Up Time              : 0d 00:00:44
Bandwidth       : 0 Mbps
===============================================================================
*A:7705:Dut-C#
```

4.8 PCEP Configuration Command Reference

4.8.1 Command Hierarchies

- PCEP Commands
- Show Commands

4.8.1.1 PCEP Commands

```
config
    — router
        — [no] pcep
            — [no] pcc
                — dead-timer seconds
                — no dead-timer
                — keepalive seconds
                — no keepalive
                — local-address ip-address
                — no local-address
                — [no] peer ip-address
                    — [no] shutdown
                — [no] report-path-constraints
                — [no] shutdown
                — unknown-message-rate msg/min
                — no unknown-message-rate
```

4.8.1.2 Show Commands

```
show
    — router
        — pcep
            — pcc
                — detail
                — lsp-db [lsp-type lsp-type] [delegated-pce ip-address]
                — lsp-db [lsp-type lsp-type] from ip-address [delegated-pce ip-address]
                — lsp-db [lsp-type lsp-type] lsp lsp-name [delegated-pce ip-address]
                — lsp-db [lsp-type lsp-type] to ip-address [tunnel-id [tunnel-id]]
                — lsp-db [lsp-type lsp-type] tunnel-id [tunnel-id]
                — path-request [lsp-type {rsvp-p2p}] [dest ip-address] [detail]
                — peer [ip-address] [detail]
                — status
```

4.8.2 Command Descriptions

4.8.2.1 PCEP Commands

pcep

Syntax [**no**] **pcep**

Context config>router

Description This command enables the Path Computation Element Communication Protocol (PCEP) and enters the context to configure PCEP parameters.

The **no** form of the command disables PCEP.

pcc

Syntax [**no**] **pcc**

Context config>router>pcep

Description This command enables the context to configure PCC parameters.

dead-timer

Syntax **dead-timer** *seconds*
no dead-timer

Context config>router>pcep>pcc

Description This command configures the PCEP session dead timer value, which is the amount of time a PCEP speaker will wait after the receipt of the last PCEP message before declaring its peer down.

The dead timer mechanism is asymmetric, meaning that each PCEP speaker can propose a different dead timer value to its peer to use to detect session timeout.

The **no** form of the command returns the dead timer to the default value.

Default 120

Parameters *seconds* — the dead timer value, in seconds

Values 1 to 255

keepalive

Syntax **keepalive** *seconds*
no keepalive

Context config>router>pcep>pcc

Description This command configures the PCEP session keepalive value. A PCEP speaker must send a keepalive message if no other PCEP message is sent to the peer at the expiry of this timer. This timer is restarted every time a PCEP message or keepalive message is sent.

The keepalive mechanism is asymmetric, meaning that each peer can use a different keepalive timer value at its end.

The **no** form of the command returns the keepalive timer to the default value.

Default 30

Parameters *seconds* — the keepalive value, in seconds

Values 1 to 255

local-address

Syntax **local-address** *ip-address*
no local-address

Context config>router>pcep>pcc

Description This command configures the local address of the PCEP speaker.

The PCEP protocol operates over TCP using destination TCP port 4189. The PCE client (PCC) always initiates the connection. When the user configures the PCEP local address and the peer address on the PCC, the PCC initiates a TCP connection to the PCE. When the connection is established, the PCC and PCE exchange OPEN messages, which initializes the PCEP session and exchanges the session parameters to be negotiated.

The PCC always checks first to determine if the remote PCE address is reachable out-of-band via the management port. If the remote address is not reachable, the PCC will check if the remote PCE address is reachable in-band. When the session comes up out-of-band, the system IP address is always used. The local address configured by the user is only used for in-band sessions and is otherwise ignored.

The **no** form of the command removes the configured local address of the PCEP speaker.

Parameters *ip-address* — the IP address of the PCEP speaker to be used for in-band sessions

peer

Syntax [**no**] **peer** *ip-address*

Context config>router>pcep>pcc

Description This command configures the IP address of a peer PCEP speaker. The address is used as the destination address in the PCEP session messages to a PCEP peer.

The **no** form of the command removes the specified peer PCEP speaker.

Parameters *ip-address* — the IP address of the PCEP peer to be used as the destination address in the PCEP session

Values a.b.c.d

report-path-constraints

Syntax [**no**] **report-path-constraints**

Context config>router>pcep>pcc

Description This command enables the inclusion of LSP path constraints in the PCE report messages sent from the PCC to a PCE.

In order for the PCE to know about the original constraints for an LSP that is delegated but for which there is no prior state in its LSP database; for example, if no PCReq message was sent for the same PLSP-ID, the following proprietary behavior is observed:

- the PCC appends a duplicate of each of the LSPA, metric, and bandwidth objects in the PCRpt message. The only difference between two objects of the same type is that the P-flag is set in the common header of the duplicate object to indicate that it is a mandatory object for processing by the PCE.
- the value of the metric or bandwidth in the duplicate object contains the original constraint value, while the first object contains the operational value. This is applicable to hop metrics in the metric and bandwidth objects only. The 7705 SAR PCC does not support configuring a boundary on the path computation IGP or TE metrics.
- the path computation on the PCE must use the first set of objects when updating a path if the PCRpt message contained a single set. If the PCRpt message contained a duplicate set, PCE path computation must use the constraints in the duplicate set.

The **no** form of the command disables the above behavior in case of interoperability issues with third-party PCE implementations.

Default report-path-constraints

shutdown

Syntax [**no**] **shutdown**

Context config>router>pcep>pcc
config>router>pcep>pcc>peer

Description This command administratively disables the PCC process.

The following PCC parameters can be modified without shutting down the PCEP session:

- **report-path-constraints**
- **unknown-message-rate**

The following PCC parameters can only be modified when the PCEP session is shut down:

- **local-address**
- **keepalive**
- **dead-timer**
- **peer**

Default shutdown

unknown-message-rate

Syntax **unknown-message-rate** *msg/min*
no unknown-message-rate

Context config>router>pcep>pcc

Description This command configures the maximum rate of unknown messages that can be received during a PCEP session.

When the rate of received unrecognized or unknown messages reaches the configured limit, the PCEP speaker closes the session to the peer.

The **no** form of the command returns the unknown message rate to the default value.

Default 10

Parameters *msg/min* — the rate of unknown messages, in messages per minute

Values 1 to 255

4.8.2.2 Show Commands

Note: The following command outputs are examples only; actual displays may differ depending on supported functionality and user configuration.

detail

Syntax **detail**

Context show>router>pcep>pcc

Description This command displays PCEP PCC detailed information.

Output The following output is an example of PCEP PCC detailed information, and Table 36 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>pcep# pcc detail
===============================================================================
Path Computation Element Protocol (PCEP) Path Computation Client (PCC) Info
===============================================================================
Admin Status           : Down            Oper Status          : Down
Unknown Msg Limit      : 10 msg/min
Keepalive Interval     : 50 seconds      DeadTimer Interval   : 150 seconds
Capabilities List      : stateful-delegate stateful-pce rsvp-path
Address                : 10.10.10.10
Report Path Constraints: True
Open Wait Timer        : 60 seconds      Keep Wait Timer      : 60 seconds
Sync Timer             : 60 seconds      Request Timer        : 120 seconds
Connection Timer       : 60 seconds      Allow Negotiations   : False
Max Sessions           : 1               Max Unknown Req      : 1000
===============================================================================
*A:Sar18 Dut-B>show>router>pcep#
```

Table 36 **PCEP PCC Field Descriptions**

Label	Description
Admin Status	The administrative status of the PCC
Oper Status	The operational status of the PCC
Unknown Msg Limit	The maximum rate of unknown messages that can be received on a PCEP session
Keepalive Interval	The specified keepalive interval for the PCEP session
DeadTimer Interval	The specified dead time interval for the PCEP session

Table 36 **PCEP PCC Field Descriptions (Continued)**

Label	Description
Capabilities List	The capabilities list for the PCEP session
Address	The local IP address of the PCEP speaker
Report Path Constraints	Indicates whether to include LSP path constraints in the PCE report messages sent from the PCC to a PCE
Open Wait Timer	The value of the open wait timer for the PCEP session
Keep Wait Timer	The value of the keep wait timer for the PCEP session
Sync Timer	The value of the synchronization timer for the PCEP session
Request Timer	The value of the request timer for the PCEP session
Connection Timer	The value of the keep wait timer for the PCEP session
Allow Negotiations	Indicates where negotiations between PCEP PCC and PCE are allowed
Max Sessions	The maximum number of PCEP sessions on the router
Max Unknown Req	The maximum number of unknown requests for PCEP sessions on the router

lsp-db

Syntax **lsp-db** [**lsp-type** *lsp-type*] [**delegated-pce** *ip-address*]
lsp-db [**lsp-type** *lsp-type*] **from** *ip-address* [**delegated-pce** *ip-address*]
lsp-db [**lsp-type** *lsp-type*] **lsp** *lsp-name* [**delegated-pce** *ip-address*]
lsp-db [**lsp-type** *lsp-type*] **to** *ip-address* [**tunnel-id** [*tunnel-id*]]
lsp-db [**lsp-type** *lsp-type*] **tunnel-id** [*tunnel-id*]

Context show>router>pcep>pcc

Description This command displays PCEP PCC LSP information.

Parameters *lsp-type* — specifies the type of LSP to display. The only available option is RSVP-TE point-to-point LSPs (rsvp-p2p).

tunnel-id — specifies a tunnel ID

Values 0 to 65535

ip-address — specifies an IPv4 address

Values a.b.c.d

Output The following output is an example of PCEP PCC LSP information.

Output Example

```
*A:7705:Dut-C# show router pcep pcc lsp-db
===============================================================================
PCEP Path Computation Client (PCC) LSP Update Info
===============================================================================
PCEP-specific LSP ID: 1
LSP ID              : 21504             LSP Type            : rsvp-p2p
Tunnel ID           : 1                 Extended Tunnel Id  : 10.20.1.3
LSP Name            : test_lsp::fully_loose
Source Address      : 10.20.1.3         Destination Address : 10.20.1.1
LSP Delegated       : True              Delegate PCE Address: 192.120.210.36
Oper Status         : active
-------------------------------------------------------------------------------
PCEP-specific LSP ID: 2
LSP ID              : 21510             LSP Type            : rsvp-p2p
Tunnel ID           : 1                 Extended Tunnel Id  : 10.20.1.3
LSP Name            : test_lsp::stdby_fully_loose_2
Source Address      : 10.20.1.3         Destination Address : 10.20.1.1
LSP Delegated       : True              Delegate PCE Address: 192.120.210.36
Oper Status         : up
===============================================================================
*A:7705:Dut-C#
```

path-request

Syntax **path-request** [**lsp-type** {**rsvp-p2p**}] [**dest** *ip-address*] [**detail**]

Context show>router>pcep>pcc

Description This command displays PCEP PCC path request information.

Parameters **lsp-type** — specifies the type of LSP to display. The only available option is RSVP-TE point-to-point LSPs.

ip-address — specifies the destination IPv4 address to display

Values a.b.c.d

detail — displays detailed path request information

Output The following output is an example of PCEP PCC path request information.

Output Example

```
*A:7705:Dut-C# show router pcep pcc path-request
===============================================================================
PCEP Path Computation Client (PCC) Path Computation Request (PCReq) Info
===============================================================================
Request ID          : 4                 Message State       : sent-for-compute
Tunnel ID           : 2                 Extended Tunnel Id : 10.20.1.3
LSP ID              : 62468             LSP Type            : rsvp-p2p
LSP Name            : test_lsp::fully_loose
Source Address      : 10.20.1.3         Destination Address: 10.20.1.1
SVEC Id             : 4                 LSP Bandwidth       : 0
===============================================================================
```

peer

Syntax **peer** [*ip-address*] [**detail**]

Context show>router>pcep>pcc

Description This command displays PCEP PCC peer information.

Parameters *ip-address* — specifies a peer IPv4 address to display

Values a.b.c.d

detail — displays detailed peer information

Output The following output is an example of a PCEP PCC peer information, and Table 37 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>pcep>pcc# peer detail
===============================================================================
PCEP Path Computation Client (PCC) Peer Info
===============================================================================
IP Address            : 10.10.10.11
Admin Status          : Down            Oper Status             : Down
Peer Capabilities     : (Not Specified)
Speaker ID            : (Undefined)
Sync State            : not-initialized Peer Overloaded         : False
Session Establish Time: 0d 00:00:00
Oper Keepalive        : N/A             Oper DeadTimer          : N/A
Session Setup Count   : 0               Session Setup Fail Count: 0
-------------------------------------------------------------------------------
Statistics Information
-------------------------------------------------------------------------------
                              Sent                      Received
-------------------------------------------------------------------------------
PC Request Message            0                         0
PC Reply Message              0                         0
PC Error Message              0                         0
PC Notification Message       0                         0
PC Keepalive Message          0                         0
PC Update Message             0                         0
PC Report Message             0                         0
Path Report                   0                         0
Path Request                  0                         0
-------------------------------------------------------------------------------
===============================================================================
*A:Sar18 Dut-B>show>router>pcep>pcc#
```

Table 37 **PCEP PCC Peer Field Descriptions**

Label	Description
IP Address	The IP address of the PCC peer

Table 37 **PCEP PCC Peer Field Descriptions (Continued)**

Label	Description
Admin Status	The administrative status of the PCC peer
Oper Status	The operational status of the PCC peer
Peer Capabilities	The PCEP capabilities of the PCC peer
Speaker ID	The IP address of the PCC peer speaker
Sync State	The synchronization state of the
Peer Overloaded	Indicates whether the PCC peer is overloaded
Session Establish Time	The length of time since the PCEP session was established
Oper Keepalive	The operational value for the PCC peer keepalive timer
Oper DeadTimer	The operational value for the PCC peer dead timer
Session Setup Count	The number of times that the PCEP session has been set up
Session Setup Fail Count	The number of times that the PCEP session failed to be set up
Statistics Information	
PC Request Message	The number of path computation (PC) request messages sent the PCC peer and received from the PCC peer
PC Reply Message	The number of PC reply messages sent to the PCC peer and received from the PCC peer
PC Error Message	The number of PC error messages sent to the PCC peer and received from the PCC peer
PC Notification Message	The number of PC notification messages sent to the PCC peer and received from the PCC peer
PC Keepalive Message	The number of PC keepalive messages sent to the PCC peer and received from the PCC peer
PC Update Message	The number of PC update messages sent to the PCC peer and received from the PCC peer
PC Report Message	The number of PC report messages sent to the PCC peer and received from the PCC peer
Path Report	The number of path reports sent to the PCC peer and received from the PCC peer
Path Request	The path requests sent to the PCC peer and received from the PCC peer

status

Syntax **status**

Context show>router>pcep>pcc

Description This command displays PCEP PCC status information.

Output The following output is an example of a PCEP PCC status information, and Table 38 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>pcep>pcc# status
===============================================================================
Path Computation Element Protocol (PCEP) Path Computation Client (PCC) Info
===============================================================================
Admin Status           : Down            Oper Status          : Down
Unknown Msg Limit      : 10 msg/min
Keepalive Interval     : 50 seconds      DeadTimer Interval   : 150 seconds
Capabilities List      : stateful-delegate stateful-pce rsvp-path
Address                : 10.10.10.10
Report Path Constraints: True
-------------------------------------------------------------------------------
PCEP Path Computation Client (PCC) Peer Info
-------------------------------------------------------------------------------
Peer                       Admin State/Oper State Oper Keepalive/Oper DeadTimer
-------------------------------------------------------------------------------
10.10.10.11                Down/Down              Not-Applicable/Not-Applicable
-------------------------------------------------------------------------------
===============================================================================
*A:Sar18 Dut-B>show>router>pcep>pcc#
```

Table 38 **PCEP PCC Status Field Descriptions**

Label	Description
Admin Status	The administrative status of the PCC
Oper Status	The operational status of the PCC
Unknown Msg Limit	The maximum rate of unknown messages that can be received on a PCEP session
Keepalive Interval	The specified keepalive interval for the PCEP session
DeadTimer Interval	The specified dead time interval for the PCEP session
Capabilities List	The capabilities list for the PCEP session
Address	The local IP address of the PCEP speaker
Report Path Constraints	Indicates whether to include LSP path constraints in the PCE report messages sent from the PCC to a PCE

Table 38 **PCEP PCC Status Field Descriptions (Continued)**

Label	Description
PCEP Path Computation Client (PCC) Peer Info	
Peer	The IP address of the PCC peer
Admin State/Oper State	The administrative and operational states of the PCC peer
Oper Keepalive/ Oper DeadTimer	The operational keepalive and dead timer intervals of the PCC peer

5 Label Distribution Protocol

This chapter provides information to enable the Label Distribution Protocol (LDP).

Topics in this chapter include:

5.1 Label Distribution Protocol

Label Distribution Protocol (LDP) is used to distribute labels in non-traffic-engineered applications. LDP allows routers to establish LSPs through a network by mapping network-layer routing information directly to data link LSPs.

An LSP is defined by the set of labels from the ingress LER to the egress LER. LDP associates a Forwarding Equivalence Class (FEC) with each LSP it creates. A FEC is a collection of common actions associated with a class of packets. When an ingress LER assigns a label to a FEC, it must let other LSRs in the path know about the label. LDP helps to establish the LSP by providing a set of procedures that LSRs can use to distribute labels.

The FEC associated with an LSP specifies which packets are mapped to that LSP. LSPs are extended through a network by each LSR, where each LSR splices incoming labels for the FEC to the outgoing label assigned to the next hop for the FEC.

LDP allows an LSR to request a label from a downstream LSR so it can bind the label to a specific FEC. The downstream LSR responds to the request from the upstream LSR by sending the requested label.

LSRs can distribute a FEC label binding in response to an explicit request from another LSR. This is known as Downstream On Demand (DOD) label distribution. LSRs can also distribute label bindings to LSRs that have not explicitly requested them. This is called Downstream Unsolicited (DU). For LDP on the 7705 SAR, Downstream Unsolicited (DU) mode is implemented.

This section contains the following topics:

- LDP Fast Reroute (FRR)
- LDP-to-Segment Routing Stitching for IPv4 /32 Prefixes (IS-IS)
- LDP FRR Remote LFA and TI-LFA Backup Using an SR Tunnel for IPv4 /32 Prefixes (IS-IS)
- TCP MD5 Authentication

5.1.1 LDP and MPLS

LDP performs dynamic label distribution in MPLS environments. The LDP operation begins with a Hello discovery process network to form an adjacency with an LDP peer in the network. LDP peers are two MPLS routers that use LDP to exchange label/FEC mapping information. An LDP session is created between LDP peers. A single LDP session allows each peer to learn the other's label mappings and to distribute its own label information (LDP is bidirectional), and exchange label binding information.

LDP signaling works with the MPLS label manager to manage the relationships between labels and the corresponding FEC. For service-based FECs, LDP works in tandem with the Service Manager to identify the virtual leased lines (VLLs) and pseudowires (PWs) to signal.

An MPLS label identifies a set of actions that the forwarding plane performs on an incoming packet before discarding it. The FEC is identified through the signaling protocol (in this case LDP), and is allocated a label. The mapping between the label and the FEC is communicated to the forwarding plane. In order for this processing on the packet to occur at high speeds, optimized tables that enable fast access and packet identification are maintained in the forwarding plane.

When an unlabeled packet ingresses the 7705 SAR, classification policies associate it with a FEC, the appropriate label is imposed on the packet, and then the packet is forwarded. Other actions can also take place on a packet before it is forwarded, including imposing additional labels, other encapsulations, or learning actions. Once all actions associated with the packet are completed, the packet is forwarded.

When a labeled packet ingresses the router, the label or stack of labels indicates the set of actions associated with the FEC for that label or label stack. The actions are performed on the packet and then the packet is forwarded.

The LDP implementation provides support for DU, ordered control, and liberal label retention mode.

For LDP label advertisement, DU mode is supported. To prevent filling the uplink bandwidth with unassigned label information, Ordered Label Distribution Control mode is supported.

A PW/VLL label can be dynamically assigned by targeted LDP operations. Targeted LDP allows the inner labels (that is, the VLL labels) in the MPLS headers to be managed automatically. This makes it easier for operators to manage the VLL connections. There is, however, additional signaling and processing overhead associated with this targeted LDP dynamic label assignment.

5.1.1.1 BFD for T-LDP

BFD is a simple protocol for detecting failures in a network. BFD uses a “hello” mechanism that sends control messages periodically to the far end and receives periodic control messages from the far end. BFD is implemented in asynchronous mode only, meaning that neither end responds to control messages; rather, the messages are sent in the time period configured at each end.

A T-LDP session is a session between either directly or non-directly connected peers and requires that adjacencies be created between two peers. BFD for T-LDP sessions allows support for tracking of failures of nodes that are not directly connected. BFD timers must be configured under the system router interface context before being enabled under T-LDP.

BFD tracking of an LDP session associated with a T-LDP adjacency allows for faster detection of the status of the session by registering the loopback address of the peer as the transport address.

5.1.2 LDP Architecture

LDP comprises a few processes that handle the protocol PDU transmission, timer-related issues, and protocol state machine. The number of processes is kept to a minimum to simplify the architecture and to allow for scalability. Scheduling within each process prevents starvation of any particular LDP session, while buffering alleviates TCP-related congestion issues.

The LDP subsystems and their relationships to other subsystems are illustrated in Figure 21. This illustration shows the interaction of the LDP subsystem with other subsystems, including memory management, label management, service management, SNMP, interface management, and RTM. In addition, debugging capabilities are provided through the logger.

Communication within LDP tasks is typically done by interprocess communication through the event queue, as well as through updates to the various data structures. The following list describes the primary data structures that LDP maintains:

- FEC/label database — this database contains all the FEC-to-label mappings, including both sent and received. It also contains both address FECs (prefixes and host addresses) as well as service FECs (L2 VLLs).
- Timer database — this database contains all the timers for maintaining sessions and adjacencies
- Session database — this database contains all the session and adjacency records, and serves as a repository for the LDP MIB objects

5.1.3 LDP Subsystem Interrelationships

Figure 21 shows the relationships between LDP subsystems and other 7705 SAR subsystems. The following sections describe how the subsystems work to provide services.

5.1.3.1 Memory Manager and LDP

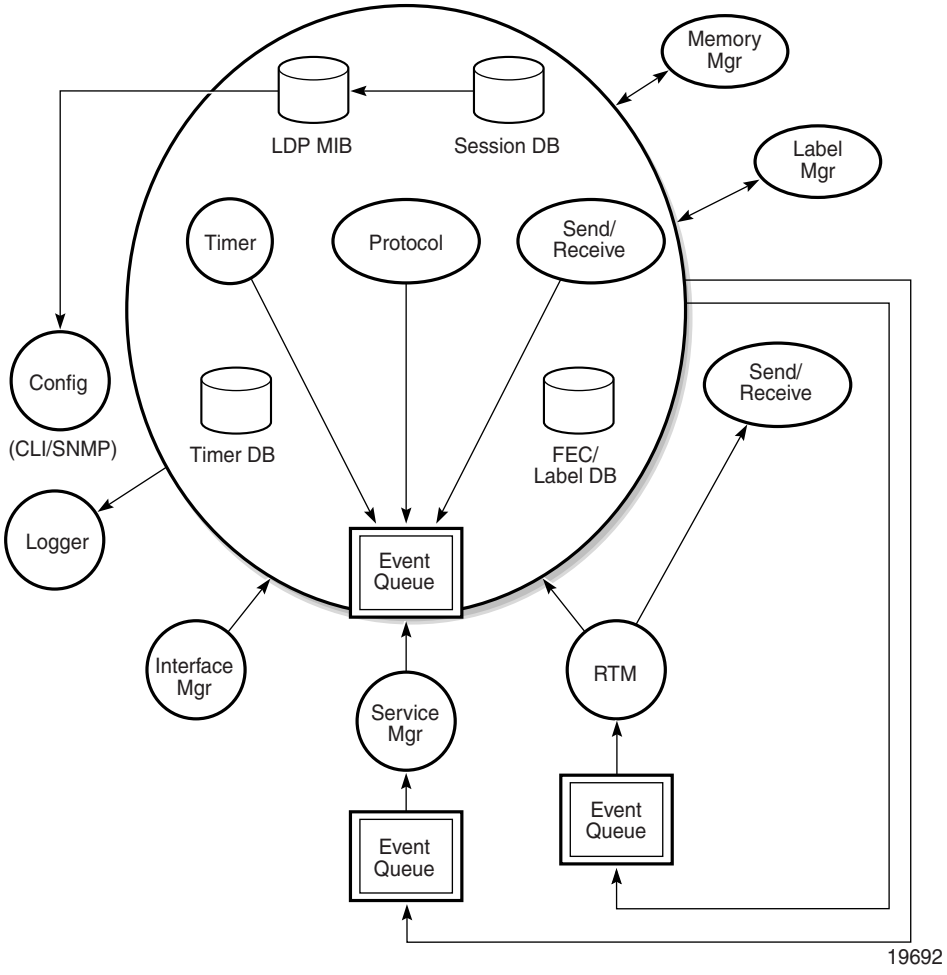
LDP does not use any memory until it is instantiated. It preallocates some amount of fixed memory so that initial startup actions can be performed. Memory allocation for LDP comes out of a pool reserved for LDP that can grow dynamically as needed.

Fragmentation is minimized by allocating memory in large chunks and managing the memory internally to LDP. When LDP is shut down, it releases all memory allocated to it.

5.1.3.2 Label Manager

LDP assumes that the label manager is up and running. LDP will abort initialization if the label manager is not running. The label manager is initialized at system boot-up; hence anything that causes it to fail will likely indicate that the system is not functional. The 7705 SAR uses a label range from 28 672 (28K) to 131 071 (128K-1) to allocate all dynamic labels, including VC labels.

Figure 21 **LDP Subsystem Interrelationships**



5.1.3.3 LDP Configuration

The 7705 SAR uses a single consistent interface to configure all protocols and services. CLI commands are translated to SNMP requests and are handled through an agent-LDP interface. LDP can be instantiated or deleted through SNMP. Also, targeted LDP sessions can be set up to specific endpoints. Targeted session parameters are configurable.

5.1.3.4 Logger

LDP uses the logger interface to generate debug information relating to session setup and teardown, LDP events, label exchanges, and packet dumps. Per-session tracing can be performed. Refer to the 7705 SAR System Management Guide for logger configuration information.

5.1.3.5 Service Manager

All interaction occurs between LDP and the service manager, since LDP is used primarily to exchange labels for Layer 2 services. In this context, the service manager informs LDP when an LDP session is to be set up or torn down, and when labels are to be exchanged or withdrawn. In turn, LDP informs the service manager of relevant LDP events, such as connection setups and failures, timeouts, and labels signaled or withdrawn.

5.1.4 Execution Flow

LDP activity in the 7705 SAR is limited to service-related signaling. Therefore, the configurable parameters are restricted to system-wide parameters, such as hello and keepalive timeouts.

5.1.4.1 Initialization

MPLS must be enabled when LDP is initialized. LDP makes sure that the various prerequisites are met, such as ensuring that the system IP interface and the label manager are operational, and ensuring that there is memory available. It then allocates a pool of memory to itself and initializes its databases.

5.1.4.2 Session Lifetime

In order for a targeted LDP session to be established, an adjacency has to be created. The LDP extended discovery mechanism requires hello messages to be exchanged between two peers for session establishment. Once the adjacency is established, session setup is attempted.

5.1.4.2.1 Adjacency Establishment

In the 7705 SAR, adjacency management is done through the establishment of a Service Destination Point (SDP) object, which is a service entity in the Nokia service model.

The service model uses logical entities that interact to provide a service. The service model requires the service provider to create and configure four main entities:

- customers
- services
- Service Access Points (SAPs) on local 7705 SAR routers
- SDPs that connect to one or more remote 7705 SAR routers or 77x0 SR routers

An SDP is the network-side termination point for a tunnel to a remote 7705 SAR or 77x0 SR router. An SDP defines a local entity that includes the system IP address of the remote 7705 SAR routers and 77x0 SR routers, and a path type.

Each SDP comprises:

- the SDP ID
- the transport encapsulation type, MPLS
- the far-end system IP address

If the SDP is identified as using LDP signaling, then an LDP extended hello adjacency is attempted.

If another SDP is created to the same remote destination and if LDP signaling is enabled, no further action is taken, since only one adjacency and one LDP session exists between the pair of nodes.

An SDP is a unidirectional object, so a pair of SDPs pointing at each other must be configured in order for an LDP adjacency to be established. Once an adjacency is established, it is maintained through periodic hello messages.

5.1.4.2.2 Session Establishment

When the LDP adjacency is established, the session setup follows as per the LDP specification. Initialization and keepalive messages complete the session setup, followed by address messages to exchange all interface IP addresses. Periodic keepalives or other session messages maintain the session liveness.

Since TCP is back-pressured by the receiver, it is necessary to be able to push that back-pressure all the way into the protocol. Packets that cannot be sent are buffered on the session object and reattempted as the back-pressure eases.

5.1.5 Label Exchange

Label exchange is initiated by the service manager. When an SDP is attached to a service (that is, once the service gets a transport tunnel), a message is sent from the service manager to LDP. This causes a label mapping message to be sent. Additionally, when the SDP binding is removed from the service, the VC label is withdrawn. The peer must send a label release to confirm that the label is not in use.

5.1.5.1 Implicit Null Label

The implicit null label option enables an eLER to receive MPLS packets from the previous-hop LSR without the outer LSP label.

The implicit null label is signaled by the eLER to the previous-hop LSR during FEC signaling by the LDP control protocol. When the implicit null label is signaled to the LSR, it pops the outer label before sending the MPLS packet to the eLER; this is known as penultimate hop popping.

The implicit null label option can be enabled for all LDP FECs for which the router is the eLER by using the **implicit-null-label** command in the **config>router>ldp** context.

If the implicit null configuration is changed, LDP withdraws all the FECs and readvertises them using the new label value.

5.1.5.2 Other Reasons for Label Actions

Label actions can also occur for the following reasons:

- MTU changes — LDP withdraws the previously assigned label and resignals the FEC with the new Maximum Transmission Unit (MTU) in the interface parameter
- clear labels — when a service manager command is issued to clear the labels, the labels are withdrawn and new label mappings are issued
- SDP down — when an SDP goes administratively down, the VC label associated with that SDP for each service is withdrawn

- memory allocation failure — if there is no memory to store a received label, the received label is released
- VC type unsupported — when an unsupported VC type is received, the received label is released

5.1.5.3 Cleanup

LDP closes all sockets, frees all memory, and shuts down all its tasks when it is deleted, so that it uses no memory (0 bytes) when it is not running.

5.1.6 LDP Filters

The 7705 SAR supports both inbound and outbound LDP label binding filtering.

Inbound filtering (import policy) allows the user to configure a policy to control the label bindings an LSR (Label Switch Router) accepts from its peers.

Import policy label bindings can be filtered based on the following:

- neighbor — match on bindings received from the specified peer
- prefix-list — match on bindings with the specified prefix/prefixes

The default import behavior is to accept all FECs received from peers.

Outbound filtering (export policy) allows the user to configure a policy to control the set of LDP label bindings advertised by the LSR (Label Switch Router).

Because the default behavior is to originate label bindings for the system IP address only, when a non-default loopback address is used as the transport address, the 7705 SAR will not advertise the loopback FEC automatically. With LDP export policy, the user is now able to explicitly export the loopback address in order to advertise the loopback address label and allow the node to be reached by other network elements.

Export policy label bindings can be filtered based on the following:

- all — all local subnets by specifying “direct” as the match protocol
- prefix-list — match on bindings with the specified prefix/prefixes

Note: In order for the 7705 SAR to consider a received label to be active, there must be an exact match to the FEC advertised together with the label found in the routing table, or a longest prefix match (if the aggregate-prefix-match option is enabled; see Multi-area and Multi-instance Extensions to LDP). This can be achieved by configuring a static route pointing to the prefix encoded in the FEC.

5.1.7 LDP FEC Statistics

LDP FEC statistics allow operators to monitor traffic being forwarded between any two PE routers and for all services using an LDP SDP. LDP FEC statistics are available for the egress data path at the ingress LER and LSR. Because an ingress LER is also potentially an LSR for an LDP FEC, combined egress data path statistics are provided whenever applicable. For more information, see RSVP LSP and LDP FEC Statistics.

5.1.8 Multi-area and Multi-instance Extensions to LDP

When a network has two or more IGP areas, or instances, inter-area LSPs are required for MPLS connectivity between the PE devices that are located in the distinct IGP areas. In order to extend LDP across multiple areas of an IGP instance or across multiple IGP instances, the current standard LDP implementation based on RFC 3036, *LDP Specification*, requires that all /32 prefixes of PEs be leaked between the areas or instances. IGP route leaking is the distribution of the PE loopback addresses across area boundaries. An exact match of the prefix in the routing table (RIB) is required to install the prefix binding in the FIB and set up the LSP.

This behavior is the default behavior for the 7705 SAR when it is configured as an Area Border Router (ABR). However, exact prefix matching causes performance issues for the convergence of IGP on routers deployed in networks where the number of PE nodes scales to thousands of nodes. Exact prefix matching requires the RIB and FIB to contain the IP addresses maintained by every LSR in the domain and requires redistribution of a large number of addresses by the ABRs. Security is a potential issue as well, as host routes leaked between areas can be used in DoS and DDoS attacks and spoofing attacks.

To avoid these performance and security issues, the 7705 SAR can be configured for an optional behavior in which LDP installs a prefix binding in the LDP FIB by performing a longest prefix match with an aggregate prefix in the routing table (RIB). This behavior is described in RFC 5283, *LDP Extension for Inter-Area Label Switched Paths*. The LDP prefix binding continues to be advertised on a per-individual /32 prefix basis.

When the longest prefix match option is enabled and an LSR receives a FEC-label binding from an LDP neighbor for a prefix-address FEC element, FEC1, it installs the binding in the LDP FIB if:

- the routing table (RIB) contains an entry that matches FEC1. Matching can either be a longest IP match of the FEC prefix or an exact match.
- the advertising LDP neighbor is the next hop to reach FEC1

When the FEC-label binding has been installed in the LDP FIB, LDP programs an NHLFE entry in the egress data path to forward packets to FEC1. LDP also advertises a new FEC-label binding for FEC1 to all its LDP neighbors.

When a new prefix appears in the RIB, LDP checks the LDP FIB to determine if this prefix is a closer match for any of the installed FEC elements. If a closer match is found, this may mean that the LSR used as the next hop will change; if so, the NHLFE entry for that FEC must be changed.

When a prefix is removed from the RIB, LDP checks the LDP FIB for all FEC elements that matched this prefix to determine if another match exists in the routing table. If another match exists, LDP must use it. This may mean that the LSR used as the next hop will change; if so, the NHLFE entry for that FEC must be changed. If another match does not exist, the LSR removes the FEC binding and sends a label withdraw message to its LDP neighbors.

If the next hop for a routing prefix changes, LDP updates the LDP FIB entry for the FEC elements that matched this prefix. It also updates the NHLFE entry for the FEC elements.

5.1.9 ECMP Support for LDP

Equal-Cost Multipath Protocol (ECMP) support for LDP performs load balancing for services that use LDP-based LSPs as transport tunnels, by having multiple equal-cost outgoing next hops for an IP prefix.

ECMP for LDP load-balances traffic across all equal-cost links based on the output of the hashing algorithm using the allowed inputs, based on the service type. For detailed information, refer to “LAG and ECMP Hashing” in the 7705 SAR Interface Configuration Guide.

There is only one next-hop peer for a network link. To offer protection from a network link or next-hop peer failure, multiple network links can be configured to connect to different next-hop peers, or multiple links to the same peer. For example, an MLPPP link and an Ethernet link can be connected to two peers, or two Ethernet links can be connected to the same peer. ECMP occurs when the cost of each link reaching a target IP prefix is equal.

The 7705 SAR uses a liberal label retention mode, which retains all labels for an IP prefix from all next-hop peers. A 7705 SAR acting as an LSR load-balances the MPLS traffic over multiple links using a hashing algorithm.

The 7705 SAR supports the following optional fields as hash inputs and supports profiles for various combinations:

- hashing algorithms
  - label-only option: hashing is done on the MPLS label stack, up to a maximum of 10 labels (default)
  - label-IP option: hashing is done on the MPLS label stack and the IPv4 source and destination IP address if an IPv4 header is present after the MPLS labels
  - Layer 4 header (source or destination UDP or TCP port number) and TEID: hashing is done on the MPLS label stack, the IPv4 source and destination IP address (if present), then on the Layer 4 source and destination UDP or TCP port fields (if present) and the TEID in the GTP header (if present)
- label stack profile options on significance of the bottom-of-stack label (VC label)
  - profile 1: favors better load balancing for pseudowires when the VC label distribution is contiguous (default)
  - profile 2: similar to profile 1 where the VC labels are contiguous, but provides an alternate distribution
  - profile 3: all labels have equal influence in hash key generation
- ingress LAG port at the LSR (default is disabled)

  The **use-ingress-port** option, when enabled, specifies that the ingress port will be used by the hashing algorithm at the LSR. This option should be enabled for ingress LAG ports because packets with the same label stack can arrive on all ports of a LAG interface. In this case, using the ingress port in the hashing algorithm will result in better egress load balancing, especially for pseudowires.

The option should be disabled for LDP ECMP so that the ingress port is not used by the hashing algorithm. For ingress LDP ECMP, if the ingress port is used by the hashing algorithm, the hash distribution could be biased, especially for pseudowires.

- system IP address – hashing on the system IP address is enabled and disabled at the system level only

All of the above options can be configured with the lsr-load-balancing command, with the exception of the system IP address, which is configured with the **system-ip-load-balancing** command.

Note: The global IF index is no longer a hash input for LSR ECMP load balancing. It has been replaced with the **use-ingress-port** configurable option in the **lsr-load-balancing** command. As well, the default treatment of the MPLS label stack has changed to focus on the bottom-of-stack label (VC label). In previous releases, all labels had equal influence.

LSR load balancing can be configured at the system level or interface level. Configuration at the interface level overrides the system-level settings for the specific interface. Configuration must be done on the ingress network interface (that is, the interface on the LDP LSR node that the packet is received on).

Configuration of load balancing at the interface level provides some control to the user; for example, the label-IP option can be disabled on a specific interface if labeled packets received on the interface include non-IP packets that can be confused by the hash routine for IP packets. Disabling the label-IP option can be used in cases where the first nibble of a non-IP packet is a 4, which would result in the packet being hashed incorrectly if the label-IP option was enabled.

If ECMP is not enabled, the label from only one of the next-hop peers is selected and installed in the forwarding plane. In this case, the algorithm used to distribute the traffic flow looks up the route information, and selects the network link with the lowest IP address. If the selected network link or next-hop peer fails, another next-hop peer is selected, and LDP reprograms the forwarding plane to use the label sent by the newly selected peer.

ECMP is supported on all Ethernet ports in network mode, and is also supported on the 4-port OC3/STM1 Clear Channel Adapter card when it is configured for POS (ppp-auto) encapsulation and network mode.

For information on configuring the 7705 SAR for LSR ECMP, refer to the **lsr-load-balancing** and **system-ip-load-balancing** commands in the 7705 SAR Basic System Configuration Guide, “System Information and General Commands” and the **lsr-load-balancing** command in the 7705 SAR Router Configuration Guide, “Router Interface Commands”.

For information on LDP treetrace commands for tracing ECMP paths, refer to the 7705 SAR OAM and Diagnostics Guide.

Note: LDP treetrace works best with label-IP hashing (**lbl-ip**) enabled, rather than label-only (**lbl-only**) hashing. These options are set with the **lsr-load-balancing** command.

Note:

- Because of the built-in timeout to dynamic ARP, the MAC address of the remote peer needs to be renewed periodically. The flow of IP traffic resets the timers back to their maximum values. In the case of LDP ECMP, one link could be used for transporting user MPLS (pseudowire) traffic but the LDP session could possibly be using a different equal-cost link. For LDPs using ECMP and for static LSPs, it is important to ensure that the remote MAC address is learned and does not expire. Configuring static ARP entries or running continuous IP traffic ensures that the remote MAC address is always known. Running BFD for fast detection of Layer 2 faults or running any OAM tools with SAA ensures that the learned MAC addresses do not expire.
- ARP entries are refreshed by static ARP and BFD, SAA, OSPF, IS-IS, or BGP.
- For information on configuring static ARP and running BFD, refer to the 7705 SAR Router Configuration Guide.

5.1.9.1 Label Operations

If an LSR is the ingress router for a given IP prefix, LDP programs a PUSH operation for the prefix in the IOM. This creates an LSP ID to the Next Hop Label Forwarding Entry (NHLFE) mapping (LTN mapping) and an LDP tunnel entry in the forwarding plane. LDP will also inform the Tunnel Table Manager (TTM) about this tunnel. Both the LSP ID to NHLFE (LTN) entry and the tunnel entry will have an NHLFE for the label mapping that the LSR received from each of its next-hop peers.

If the LSR is to behave as a transit router for a given IP prefix, LDP will program a SWAP operation for the prefix in the IOM. This involves creating an Incoming Label Map (ILM) entry in the forwarding plane. The ILM entry might need to map an incoming label to multiple NHLFEs.

If an LSR is an egress router for a given IP prefix, LDP will program a POP entry in the IOM. This too will result in an ILM entry being created in the forwarding plane, but with no NHLFEs.

When unlabeled packets arrive at the ingress LER, the forwarding plane consults the LTN entry and uses a hashing algorithm to map the packet to one of the NHLFEs (PUSH label) and forward the packet to the corresponding next-hop peer. For a labeled packet arriving at a transit or egress LSR, the forwarding plane consults the ILM entry and either uses a hashing algorithm to map it to one of the NHLFEs if they exist (SWAP label) or routes the packet if there are no NHLFEs (POP label).

5.1.10 Graceful Restart Helper

Graceful Restart (GR) is part of the LDP handshake process (that is, the LDP peering session initialization) and needs to be supported by both peers. GR provides a mechanism that allows the peers to cope with a service interruption due to a CSM switchover, which is a period of time when the standby CSM is not capable of synchronizing the states of the LDP sessions and labels being advertised and received.

Graceful Restart Helper (GR-Helper) decouples the data plane from the control plane so that if the control plane is not responding (that is, there is no LDP message exchange between peers), then the data plane can still forward frames based on the last known (advertised) labels.

Because the 7705 SAR supports non-stop services / high-availability for LDP (and MPLS), the full implementation of GR is not needed. However, GR-Helper is implemented on the 7705 SAR to support non-high-availability devices. With GR-Helper, if an LDP peer of the 7705 SAR requests GR during the LDP handshake, the 7705 SAR agrees to it but does not request GR. For the duration of the LDP session, if the 7705 SAR LDP peer fails, the 7705 SAR continues to forward MPLS packets based on the last advertised labels and will not declare the peer dead until the GR timer expires.

5.1.11 Graceful Handling of Resource Exhaustion

Graceful handling of resource exhaustion enhances the behavior of LDP when a data path or a CSM resource required for the resolution of a FEC is exhausted. In prior releases, the entire LDP protocol was shut down, causing all LDP peering sessions to be torn down and therefore impacting all peers. The user was required to fix the issue that caused the FEC scaling to be exceeded, and to restart the LDP session by executing the **no shutdown** CLI command. With graceful handling of resource exhaustion, only the responsible session or sessions are shut down, which impacts only the appropriate peer or peers.

Graceful handling of resources implements a capability by which the LDP interface to the peer, or the targeted peer in the case of a targeted LDP (T-LDP) session, is shut down.

If LDP tries to resolve a FEC over a link or a T-LDP session and runs out of data path or CSM resources, LDP brings down that interface or targeted peer, which brings down the Hello adjacency over that interface to all linked LDP peers or to the targeted peer. The interface is brought down for the LDP context only and is still available to other applications such as IP forwarding and RSVP LSP forwarding.

After taking action to free up resources, the user must manually perform a **no shutdown** command on the interface or the targeted peer to bring it back into operation. This re-establishes the Hello adjacency and resumes the resolution of FECs over the interface or to the targeted peer.

5.1.12 LDP Support for Unnumbered Interfaces

Unnumbered interfaces are point-to-point interfaces that are not explicitly configured with a dedicated IP address and subnet; instead, they borrow (or link to) an IP address from another interface on the system (the system IP address, another loopback interface, or any other numbered interface) and use it as the source IP address for packets originating from the interface. For more information on support for unnumbered interfaces, refer to the 7705 SAR Router Configuration Guide, “Unnumbered Interfaces”.

This feature allows LDP to establish a Hello adjacency and to resolve unicast FECs over unnumbered LDP interfaces.

For example, LSR A and LSR B are the two endpoints of an unnumbered link. These interfaces are identified on each system with their unique link local identifier. The combination router ID and link local identifier uniquely identifies the interface in IS-IS throughout the network.

A borrowed IP address is also assigned to the interface to be used as the source address of IP packets that must originate from the interface. The borrowed IP address defaults to the system interface address, A and B in this example. The borrowed IP interface can be configured to any IP interface by using the following CLI command: **config> router>interface>unnumbered {***ip-int-name* **|** *ip-address***}**.

The **fec-originate** command, which defines how to originate a FEC for egress and non-egress LSRs, includes a parameter to specify the name of the interface that the label for the originated FEC is swapped to. For an unnumbered interface, this parameter is mandatory because an unnumbered interface does not have its own IP address.

When the unnumbered interface is added into LDP, the follow behavior occurs.

For link LDP (L-LDP) sessions:

1. The Hello adjacency is brought up using a link Hello packet with the source IP address set to the interface borrowed IP address and a destination IP address set to 224.0.0.2.
2. Hello packets with the same source IP address should be accepted when received over parallel unnumbered interfaces from the same peer LSR ID. The corresponding Hello adjacencies are associated with a single LDP session.
3. The transport address for the TCP connection, which is encoded in the Hello packet, is always set to the LSR ID of the node whether or not the interface option was enabled using the **config>router>ldp>interface-parameters> interface>transport-address** command.
4. The **local-lsr-id** option can be configured on the interface and the value of the LSR ID can be changed to either the local interface or to some other interface name. If the local interface is selected or the provided interface name corresponds to an unnumbered IP interface, the unnumbered interface borrowed IP address is used as the LSR ID. In all cases, the transport address for the LDP session is updated to the new LSR ID value, but the link Hello packets continue to use the interface borrowed IP address as the source IP address.
5. The LSR with the highest transport address, the LSR ID in this case, bootstraps the TCP connection and LDP session.
6. The source and destination IP addresses of LDP packets are the transport addresses, that is, the LDP LSR IDs of the LSRs at the endpoints of the link (A and B in the example).

For targeted LDP (T-LDP) sessions:

1. The source and destination addresses of the targeted Hello packet are the LDP LSR IDs of systems A and B.
2. The **local-lsr-id** option can be configured on the interface for the targeted session and the value of the LSR ID can be changed to either the local interface or to some other interface name. If the local interface is selected or the provided interface name corresponds to an unnumbered IP interface, the unnumbered interface borrowed IP address is used as the LSR ID. In all cases, the transport address for the LDP session and the source IP address of the targeted Hello message are updated to the new LSR ID value.
3. The LSR with the highest transport address, the LSR ID in this case, bootstraps the TCP connection and LDP session.
4. The source and destination IP addresses of LDP packets are the transport addresses, that is, the LDP LSR IDs of the LSRs at the endpoints of the link (A and B in the example).

FEC resolution:

- LDP advertises/withdraws unnumbered interfaces using the Address/Address-Withdraw message. The borrowed IP address of the interface is used.
- A FEC can be resolved to an unnumbered interface in the same way as it is resolved to a numbered interface. The outgoing interface and next hop are looked up in the RTM cache. The next hop is the router ID and link identifier of the interface at the peer LSR.
- LDP FEC ECMP next hops over a mix of unnumbered and numbered interfaces are supported.
- All LDP FEC types are supported.
- The **fec-originate** command is supported when the next hop is over an unnumbered interface.

All LDP features supported for numbered IP interfaces are supported for unnumbered interfaces, with the following exceptions:

- BFD is not supported on unnumbered IP interfaces
- LDP FRR is not triggered by a BFD session timeout, only by a physical failure or the local interface going down
- unnumbered IP interfaces cannot be added into LDP global and peer prefix policies

The unnumbered interface feature also extends the support of LSP ping and LSP traceroute to test an LDP unicast FEC that is resolved over an unnumbered LDP interface.

5.1.13 LDP Fast Reroute (FRR)

LDP Fast Reroute (FRR) provides local protection for an LDP FEC by precalculating and downloading a primary and a backup NHLFE for the FEC to the LDP FIB. The primary NHLFE corresponds to the label of the FEC received from the primary next hop as per the standard LDP resolution of the FEC prefix in the RTM. The backup NHLFE corresponds to the label received for the same FEC from a Loop-Free Alternate (LFA) next hop.

LDP FRR protects against single link or single node failure. SRLG failure protection is not supported.

Without FRR, when a local link or node fails, the router must signal the failure to its neighbors via the IGP providing the routing (OSPF or IS-IS), recalculate primary next-hop NHLFEs for all affected FECs, and update the FIB. Until the new primary next hops are installed in the FIB, any traffic destined for the affected FECs is discarded. This process can take hundreds of milliseconds.

LDP FRR improves convergence in case of a local link or node failure in the network, by using the label-FEC binding received from the LFA next hop to forward traffic for a given prefix as soon as the primary next hop is not available. This means that a router resumes forwarding LDP packets to a destination prefix using the backup path without waiting for the routing convergence. Convergence times should be similar to RSVP-TE FRR, in the tens of milliseconds.

OSPF or IS-IS must perform the Shortest Path First (SPF) calculation of an LFA next hop, as well as the primary next hop, for all prefixes used by LDP to resolve FECs. The IGP also populates both routes in the RTM.

When LDP FRR is enabled and an LFA backup next hop exists for the FEC prefix in the RTM, or for the longest prefix the FEC prefix matches to when the **aggregate-prefix-match** option is enabled, LDP will program the data path with both a primary NHLFE and a backup NHLFE for each next hop of the FEC.

In order to perform a switchover to the backup NHLFE in the fast path, LDP follows the standard FRR failover procedures, which are also supported for RSVP-TE FRR.

When any of the following events occurs, the backup NHLFE is enabled for each affected FEC next hop:

- an LDP interface goes operationally down or is administratively shut down

  In this case, LDP sends a neighbor/next hop down message to each LDP with which it has an adjacency over the interface.
- an LDP session to a peer goes down because the Hello timer or keepalive timer has expired over an interface

  In this case, LDP sends a neighbor/next hop down message to the affected peer.
- the TCP connection used by a link LDP session to a peer goes down

  In this case, LDP sends a neighbor/next hop down message to the affected peer.

Refer to RFC 5286, *Basic Specification for IP Fast Reroute: Loop-Free Alternates*, for more information on LFAs.

5.1.13.1 ECMP vs FRR

If ECMP is enabled, which provides multiple primary next hops for a prefix, LDP FRR is not used. That is, the LFA next hops are not populated in the RTM and the ECMP paths are used instead.

5.1.13.2 IGP Shortcuts (RSVP-TE Tunnels)

IGP shortcuts are an MPLS functionality where LSPs are treated like physical links within IGPs; that is, LSPs can be used for next-hop reachability. If an RSVP-TE LSP is used as a shortcut by OSPF or IS-IS, it is included in the SPF calculation as a point-to-point link for both primary and LFA next hops. It can also be advertised to neighbors so that the neighboring nodes can also use the links to reach a destination via the advertised next hop.

IGP shortcuts can be used to simplify remote LFA support and simplify the number of LSPs required in a ring topology.

When both IGP shortcuts and LFA are enabled under OSPF or IS-IS, and LDP FRR is also enabled, the following applies:

- a FEC that is resolved to a direct primary next hop can be backed up by a tunneled LFA next hop
- a FEC that is resolved to a tunneled primary next hop will not have an LFA next hop; it relies on RSVP-TE FRR for protection

5.1.13.3 LDP FRR Configuration

To configure LDP FRR, LFA calculation by the SPF algorithm must first be enabled under the OSPF or IS-IS protocol level with the command:

config>router>ospf>loopfree-alternate
or
config>router>ospf3>loopfree-alternate
or
config>router>isis>loopfree-alternate

Next, LDP must be enabled to use the LFA next hop with the command **config>router>ldp>fast-reroute**.

If IGP shortcuts are used, they must be enabled under the OSPF or IS-IS routing protocol. As well, they must be enabled under the MPLS LSP context, using the command **config>router>mpls>lsp>igp-shortcut**.

For information on LFA and IGP shortcut support for OSPF and IS-IS, refer to the 7705 SAR Routing Protocols Guide, “LDP and IP Fast Reroute for OSPF Prefixes” and “LDP and IP Fast Reroute for IS-IS Prefixes”.

Both LDP FRR and IP FRR are supported; for information on IP FRR, refer to the 7705 SAR Router Configuration Guide, “IP Fast Reroute (FRR)”.

5.1.14 LDP-to-Segment Routing Stitching for IPv4 /32 Prefixes (IS-IS)

This feature provides stitching between an LDP FEC and an SR node SID route for the same IPv4 /32 IS-IS prefix by allowing the export of SR tunnels from the Tunnel Table Manager (TTM) to LDP (IGP). In the LDP-to-SR data path direction, the LDP tunnel table route export policy supports the exporting of SR tunnels from the TTM to LDP.

A route policy option is configured to support LDP-to-SR stitching using the **config>router>policy-options** context. Refer to the 7705 SAR Router Configuration Guide, “Configuring LDP-to-Segment Routing Stitching Policies”, for a configuration example and to “Route Policy Command Reference” for information on the commands that are used.

After the route policy option is configured, the SR tunnels are exported from the TTM into LDP (IGP) using the **config>router>ldp>export-tunnel-table** command. See LDP Command Reference for more information on this command.

When configuring a route policy option, the user can restrict the exporting of SR tunnels from the TTM to LDP from a specific prefix list by excluding the prefix from the list.

The user can also restrict the exporting of SR tunnels from the TTM to a specific IS-IS IGP instance by specifying the instance ID in the **from protocol** statement. The **from protocol** statement is valid only when the protocol value is **isis**. Policy entries with any other protocol value are ignored when the route policy is applied. If the user configures multiple **from protocol** statements in the same policy or does not include the **from protocol** statement but adds a **default-action** of **accept**, then LDP routing uses the lowest instance ID in the IS-IS protocol to select the SR tunnel.

When the routing policy is enabled, LDP checks the SR tunnel entries in the TTM. Whenever an LDP FEC primary next hop cannot be resolved using an RTM route and an SR tunnel of type **isis** to the same destination IPv4 /32 prefix matches an entry in the export policy, LDP programs an LDP ILM and stitches it to the SR node SID tunnel endpoint. LDP then originates a FEC for the prefix and redistributes it to its LDP peer. When a LDP FEC is stitched to an SR tunnel, forwarded packets benefit from the protection of the LFA/remote LFA or TI-LFA backup next hop of the SR tunnel.

When resolving a FEC, LDP attempts a resolution in the RTM before attempting a resolution in the TTM, when both are available. That is, a swapping operation from the LDP ILM to an LDP NHLFE is attempted before stitching the LDP ILM to an SR tunnel endpoint.

In the SR-to-LDP data path direction, the SR mapping server provides a global policy for the prefixes corresponding to the LDP FECs the SR needs to stitch to. Therefore, a tunnel table export policy is not used. The user enables the exporting of the LDP tunnels for FEC prefixes advertised by the mapping server to an IGP instance using the command **config>router>isis>segment-routing>export-tunnel-table ldp**. Refer to the 7705 SAR Routing Protocols Guide, “IS-IS Command Reference”, for more information on this command.

When the **export-tunnel-table ldp** command is enabled, the IGP monitors the LDP tunnel entries in the TTM. Whenever an IPv4 /32 LDP tunnel destination matches a prefix for which the IGP received a prefix SID sub-TLV from the mapping server, the IGP instructs the SR module to program the SR ILM and to stitch it to the LDP tunnel endpoint. The SR ILM can stitch to an LDP FEC resolved over the LDP link. When an SR tunnel is stitched to an LDP FEC, forwarded packets benefit from the protection of the LFA backup next hop of the LDP FEC.

When resolving a node SID, the IGP attempts a resolution of the prefix SID received in an IP reachability TLV before attempting a resolution of a prefix SID received via the mapping server, when both are available. That is, a swapping operation of the SR ILM to an SR NHLFE is attempted before stitching it to an LDP tunnel endpoint. Refer to the 7705 SAR Routing Protocols Guide, “Prefix SID Resolution for a Segment Routing Mapping Server”, for more information about prefix SID resolution.

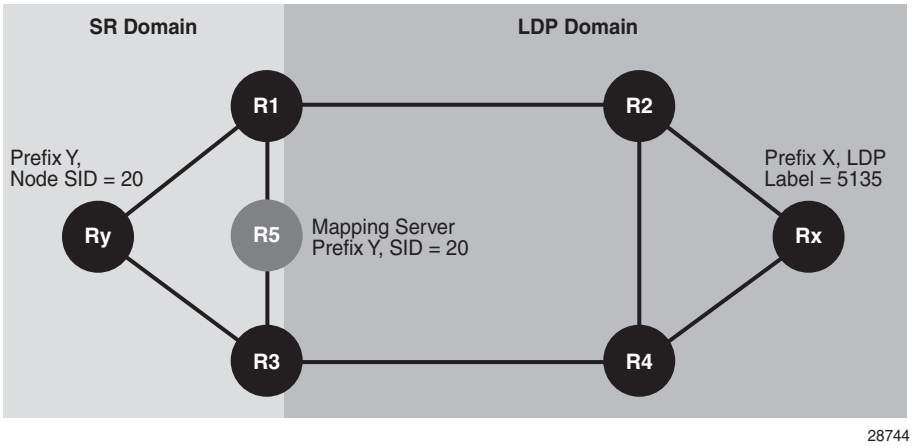
It is recommended that the **bfd-enable** option be enabled on the interfaces for both LDP and IGP contexts to speed up the failure detection and the activation of the LFA/remote LFA backup next hop in either direction. This applies particularly for remote failures. For the LDP context, the **config>router>ldp>interface-parameters>interface>bfd-enable** command string is used; see LDP Commands. For the IGP context, the **config>router>isis>interface>bfd-enable** command string is used; refer to the 7705 SAR Routing Protocols Guide, “IS-IS Command Reference”.

The sections that follow describe how stitching is performed in the LDP-to-SR and SR-to-LDP data path directions.

5.1.14.1 Stitching in the LDP-to-SR Direction

Stitching in the data plane in the LDP-to-SR direction is based on the LDP module monitoring the TTM for an SR tunnel of a prefix matching an entry in the LDP TTM export policy.

Figure 22 **Stitching in the LDP-to-SR Direction**



In Figure 22, router R1 is at the boundary between an SR domain and an LDP domain and is configured to stitch between SR and LDP. Link R1-R2 is LDP-enabled, but router R2 does not support SR or SR is disabled.

The following steps are performed by the boundary router R1 to configure stitching:

1. Router R1 receives a prefix SID sub-TLV in an IS-IS IP reachability TLV originated by router Ry for prefix Y.
2. R1 resolves the prefix SID and programs an NHLFE on the link toward the next hop in the SR domain. R1 programs an SR ILM and points it to the NHLFE.
3. Because R1 is programmed to stitch LDP to SR, LDP in R1 checks the TTM and finds the SR tunnel to prefix Y. LDP programs an LDP ILM and points it to the SR tunnel. As a result, both the SR ILM and LDP ILM are now pointing to the SR tunnel, one via the SR NHLFE and the other via the SR tunnel endpoint.
4. R1 advertises the LDP FEC for prefix Y to all its LDP peers. R2 is now able to install an LDP tunnel towards Ry.

5. If R1 finds multiple SR tunnels to destination prefix Y, R1 uses the lowest instance ID in the IS-IS protocol to select the tunnel.
6. If the user configured multiple **from** statements or did not include the **from** statement but added a default action of **accept** for the IS-IS protocol, R1 selects the tunnel to destination prefix Y by using the lowest instance ID in the IS-IS protocol.

Note: If R1 has already resolved an LDP FEC for prefix Y, it has an ILM assigned to it. However, this ILM will not be updated to point toward the SR tunnel because LDP attempts a resolution in the RTM before attempting a resolution in the TTM. Therefore, an LDP tunnel is selected before an SR tunnel. Similarly, if an LDP FEC is received after the stitching is programmed, the LDP ILM is updated to point to the LDP NHLFE because LDP is able to resolve the LDP FEC in the RTM.

7. The user enables SR in R2. R2 resolves the prefix SID for prefix Y and installs the SR ILM and the SR NHLFE. R2 is now able to forward packets over the SR tunnel to router Ry. There is no activity in R1 because the SR ILM is already programmed.
8. The user disables LDP over the R1-R2 interface in both directions. This causes the LDP FEC ILM and NHLFE to be removed in R1 and in R2, which can then only do forwarding using the SR tunnel toward Ry.

5.1.14.2 Stitching in the SR-to-LDP Direction

Stitching in the data plane in the SR-to-LDP direction is based on the IGP monitoring the TTM for an LDP tunnel of a prefix matching an entry in the SR TTM export policy.

In Figure 22, router R1 is at the boundary between an SR domain and an LDP domain and is configured to stitch between SR and LDP. Link R1-R2 is LDP-enabled but router R2 does not support SR or SR is disabled.

The following steps are performed by the boundary router R1 to configure stitching:

1. R1 receives an LDP FEC for prefix X from router Rx in the LDP domain. The RTM in R1 indicates that the interface to R2 is the next hop for prefix X.
2. LDP in R1 resolves the received FEC in the RTM and creates an LDP ILM for the FEC with an ingress label (for example, label L1), and points it to an LDP NHLFE toward R2 with egress label L2.
3. R1 receives a prefix SID sub-TLV from the R5 mapping server for prefix X.

4. The IGP in R1 attempts to resolve in its routing table the next hop of prefix X over the interface to R2. R1 detects that R2 did not advertise support of SR and therefore the SID resolution for prefix X in the routing table fails.
5. The IGP in R1 then attempts to resolve the prefix SID of prefix X in the TTM because it detects that it is configured for SR-to-LDP stitching. R1 finds an LDP tunnel to prefix X in the TTM, instructs the SR module to program an SR ILM with ingress label L3, and points it to the LDP tunnel endpoint, thus stitching ingress label L3 to egress label L2.

Note:

- The ILMs for LDP and SR are both pointing to the same LDP tunnel, one via NHLFE and one via the tunnel endpoint.
- No SR tunnel to destination prefix X should be programmed in the TTM following the resolution of the prefix SID of prefix X in the TTM.
- If the IGP is not able to resolve the SID resolution for prefix X in step 4 and step 5, a trap is generated for the prefix SID resolution failure. An existing trap for the prefix SID resolution failure is enhanced to state whether the prefix SID that failed the resolution attempts was part of a mapping server TLV or an IP reachability TLV.

6. The user enables segment routing on R2.
7. The IGP in R1 discovers that R2 supports SR.

   Because R1 still has a prefix SID for prefix X from the mapping server R5, it maintains the stitching of the SR ILM for prefix X to the LDP FEC.
8. The user disables the LDP interface between R1 and R2 in both directions. This causes the LDP FEC ILM and NHLFE for prefix X to be removed in R1 and triggers the re-evaluation of the SIDs.
9. R1 first attempts the resolution in the routing table. Because the next hop for prefix X supports SR, the IGP instructs the SR module to program an NHLFE for the prefix SID of prefix X with egress label L4 and with an outgoing interface to R2. R1 creates an SR tunnel in the TTM for destination prefix X. R1 also changes the SR ILM with ingress label L3 to point to the SR NHLFE with egress label L4.

   Router R2 now becomes the SR-LDP stitching router.
10. Router Rx, which owns prefix X, is upgraded to support SR. Rx sends a prefix SID sub-TLV to R1 in an IS-IS IP reachability TLV for prefix X. The SID information may or may not be the same as the information received from the mapping server R5. If the SID information is not the same, the IGP in R1 chooses the prefix SID originated by Rx and updates the SR ILM and NHLFE with the appropriate labels.
11. The user then cleans up the mapping server and removes the mapping entry for prefix X, which is then withdrawn by IS-IS.

5.1.14.3 TTL Propagation and ICMP Tunneling

When stitching is performed between an LDP FEC and an SR IS-IS node SID tunnel, the TTL of the outer LDP or SR label is decreased, similar to a regular swapping operation at an LSR.

5.1.15 LDP FRR Remote LFA and TI-LFA Backup Using an SR Tunnel for IPv4 /32 Prefixes (IS-IS)

This feature allows an SR tunnel to be used as a remote LFA or TI-LFA backup tunnel next hop by an LDP FEC. The feature is enabled using the CLI command string **config>router>ldp>fast-reroute backup-sr-tunnel**. See LDP Commands for more information.

This feature requires the LDP-to-Segment Routing Stitching for IPv4 /32 Prefixes (IS-IS) feature as a prerequisite, because the LSR performs the stitching of the LDP ILM to an SR tunnel when the primary LDP next hop of the FEC fails. Therefore, LDP monitors SR tunnels programmed by the IGP in the TTM without the need for a mapping server.

It is assumed that:

- the **backup-sr-tunnel** option is enabled in LDP
- the **loopfree-alternate ti-lfa** or **loopfree-alternate remote-lfa** option is enabled in the IGP instance (refer to the 7705 SAR Routing Protocols Guide, “IS-IS Command Reference”)

Note: The **loopfree-alternate** options can be enabled separately or together. If both options are enabled, TI-LFA backup takes precedence over remote LFA backup.

- LDP was able to resolve the primary next hop of the LDP FEC in the RTM

If the IGP LFA SPF does not find a regular LFA backup next hop for an LDP FEC prefix, it runs the TI-LFA and remote LFA algorithms. If the IGP LFA SPF finds a remote LFA or TI-LFA tunnel next hop, LDP programs the primary next hop of the FEC using an LDP NHLFE and programs the remote LFA or TI-LFA backup tunnel next hop using an LDP NHLFE pointing to the SR tunnel endpoint.

Note: The LDP packet is not sent over the SR tunnel. The LDP label is stitched to the segment routing label stack. LDP points both the LDP ILM and the LTN to the backup LDP NHLFE, which uses the SR tunnel endpoint.

5.1.15.1 Feature Behavior

The following describes the behavior of this feature.

- When LDP resolves a primary next hop in the RTM or a remote LFA or TI-LFA backup next hop using an SR tunnel in the TTM, LDP programs a primary LDP NHLFE and a backup LDP NHLFE with an implicit null label value pointing to the SR tunnel that has the remote LFA or TI-LFA backup programmed for the same prefix.
- If the LDP FEC primary next hop fails and LDP has preprogrammed a remote LFA and TI-LFA next hop with an LDP backup NHLFE pointing to an SR tunnel, the LDP ILM/LTN switches to it.

Note: If the LDP FEC primary next hop failure impacts only the LDP tunnel primary next hop but not the SR tunnel primary next hop, the LDP backup NHLFE points to the primary next hop of the SR tunnel; the LDP ILM/LTN traffic follows this path instead of the remote LFA or TI-LFA next hop of the SR tunnel until the remote LFA or TI-LFA next hop is activated.

- If the LDP FEC primary next hop becomes unresolved in the RTM, LDP switches the resolution to an SR tunnel in the TTM, if one exists, following the steps described in Stitching in the LDP-to-SR Direction.
- If both the LDP primary next hop and a regular LFA next hop become resolved in RTM, the LDP FEC programs the primary NHLFE and backup NHLFE.

5.1.16 TCP MD5 Authentication

The operation of a network can be compromised if an unauthorized system is able to form or hijack an LDP session and inject control packets by falsely representing itself as a valid neighbor. This risk can be mitigated by enabling TCP MD5 authentication on one or more of the sessions.

When TCP MD5 authentication is enabled on a session, every TCP segment exchanged with the peer includes a TCP option (19) containing a 16-byte MD5 digest of the segment (more specifically the TCP/IP pseudo-header, TCP header, and TCP data). The MD5 digest is generated and validated using an authentication key that must be known to both sides. If the received digest value is different from the locally computed one, the TCP segment is dropped, thereby protecting the router from a spoofed TCP segment.

The TCP Enhanced Authentication Option, as specified in *draft-bonica-tcpauth-05.txt*, *Authentication for TCP-based Routing and Management Protocols*, is a TCP extension that enhances security for LDP, BGP, and other TCP-based protocols. It extends the MD5 authentication option to include the ability to change keys in an LDP or BGP session seamlessly without tearing down the session, and allows for stronger authentication algorithms to be used. It is intended for applications where secure administrative access to both endpoints of the TCP connection is normally available.

TCP peers can use this extension to authenticate messages passed between one another. This strategy improves upon the practice described in RFC 2385, *Protection of BGP Sessions via the TCP MD5 Signature Option*. Using this new strategy, TCP peers can update authentication keys during the lifetime of a TCP connection. TCP peers can also use stronger authentication algorithms to authenticate routing messages.

TCP enhanced authentication uses keychains that are associated with every protected TCP connection.

Keychains are configured in the **config>system>security>keychain** context. For more information about configuring keychains, refer to the 7705 SAR System Management Guide, “TCP Enhanced Authentication and Keychain Authentication”.

5.2 LDP Point-to-Multipoint Support

The 7705 SAR supports point-to-multipoint mLDP. This section contains information on the following topics:

- LDP Point-to-Multipoint Configuration
- LDP Point-to-Multipoint Protocol
- Make-Before-Break (MBB)
- ECMP Support

5.2.1 LDP Point-to-Multipoint Configuration

A node running LDP also supports point-to-multipoint LSP setup using LDP. By default, the node advertises the capability to a peer node using the point-to-multipoint capability TLV in LDP initialization message.

The **multicast-traffic** configuration option (per interface) restricts or allows the use of an interface for LDP multicast traffic forwarding towards a downstream node. The **interface** configuration option does not restrict or allow the exchange of the point-to-multipoint FEC by way of an established session to the peer on an interface, but only restricts or allows the use of next hops over the interface.

5.2.2 LDP Point-to-Multipoint Protocol

Only a single generic identifier range is defined for signaling a multipoint data tree (MDT) for all client applications. Implementation on the 7705 SAR reserves the range 1 to 8292 for generic point-to-multipoint LSP ID values for static point-to-multipoint LSP on the root node.

5.2.3 Make-Before-Break (MBB)

When a transit or leaf node detects that the upstream node towards the root node of a multicast tree has changed, the node follows the graceful procedure that allows make-before-break transition to the new upstream node. Make-before-break support is optional via the **mp-mbb-time** command. If the new upstream node does not support MBB procedures, the downstream node waits for the configured timer to time out before switching over to the new upstream node.

5.2.4 ECMP Support

If multiple ECMP paths exist between two adjacent nodes, then the upstream node of the multicast receiver programs all entries in the forwarding plane. Only one entry is active and it is based on the ECMP hashing algorithm.

5.3 Multicast LDP Fast Upstream Switchover

This feature allows a downstream LSR of a multicast LDP (mLDP) FEC to perform a fast switchover in order to source the traffic from another upstream LSR while IGP and LDP are converging due to a failure of the upstream LSR, where the upstream LSR is the primary next hop of the root LSR for the point-to-multipoint FEC. The feature is enabled through the **mcast-upstream-frr** command.

The feature provides upstream fast reroute (FRR) node protection for mLDP FEC packets. The protection is at the expense of traffic duplication from two different upstream nodes into the node that performs the fast upstream switchover.

The detailed procedures for this feature are described in *draft-pdutta-mpls-mldp-up-redundancy*.

5.3.1 mLDP Fast Upstream Switchover Configuration

To enable the mLDP fast upstream switchover feature, configure the following option in the CLI:

config>router>ldp>mcast-upstream-frr

When **mcast-upstream-frr** is enabled and LDP is resolving an mLDP FEC received from a downstream LSR, LDP checks for the existence of an ECMP next hop or a loop-free alternate (LFA) next hop to the root LSR node. If LDP finds one, it programs a primary incoming label map (ILM) on the interface corresponding to the primary next hop and a backup ILM on the interface corresponding to the ECMP or LFA next hop. LDP then sends the corresponding labels to both upstream LSR nodes. In normal operation, the primary ILM accepts packets and the backup ILM drops them. If the interface or the upstream LSR of the primary ILM goes down, causing the LDP session to go down, the backup ILM starts accepting packets.

To use the ECMP next hop, configure the **ecmp** *max-ecmp-routes* value in the system to be at least 2, using the following command:

config>router>ecmp *max-ecmp-routes*

To use the LFA next hop, enable LFA using the following commands (as needed):

config>router>isis>loopfree-alternate
or
config>router>ospf>loopfree-alternate

Enabling IP FRR or LDP FRR is not strictly required, since LDP only needs to know the location of the alternate next hop to the root LSR in order to send the label mapping message and program the backup ILM during the initial signaling of the tree. That is, enabling the LFA option is sufficient for providing the backup ILM information. However, if unicast IP and LDP prefixes need to be protected, then IP FRR and LDP FRR—and the mLDP fast upstream switchover—can be enabled concurrently using the following commands:

config>router>ip-fast-reroute
or
config>router>ldp>fast-reroute

An mLDP FRR fast switchover relies on the fast detection of a lost LDP session to the upstream peer to which the primary ILM label had been advertised. To ensure fast detection of a lost LDP session, do the following:

Step 1. Enable BFD on all LDP interfaces to upstream LSR nodes. When BFD detects the loss of the last adjacency to the upstream LSR, it brings down the LDP session immediately, which causes the CSM to activate the backup ILM.

Step 2. If there is a concurrent T-LDP adjacency to the same upstream LSR node, enable BFD on the T-LDP peer in addition to enabling it on the interface.

Step 3. Enable the **ldp-sync-timer** option on all interfaces to the upstream LSR nodes. If an LDP session to the upstream LSR to which the primary ILM is resolved goes down for any reason other than a failure of the interface or the upstream LSR, then routing and LDP go out of synchronization. This means that the backup ILM remains activated until the next time SPF is run by IGP.

By enabling the IGP-LDP synchronization feature, the advertised link metric changes to the maximum value as soon as the LDP session goes down. This, in turn, triggers an SPF, and LDP will likely download a new set of primary and backup ILMs.

5.3.2 mLDP Fast Upstream Switchover Behavior

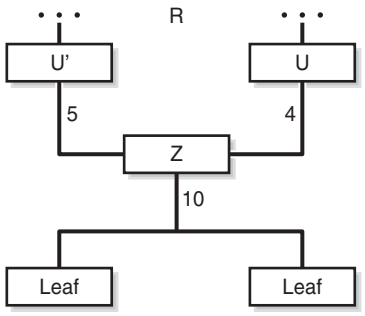
This feature allows a downstream LSR to send a label binding to two upstream LSR nodes, but only accept traffic as follows:

- for normal operation, traffic is accepted from the ILM on the interface to the primary next hop of the root LSR for the point-to-multipoint FEC
- for failure operation, traffic is accepted from the ILM on the interface to the backup next hop

A candidate upstream LSR node must be either an ECMP next hop or an LFA next hop. Either option allows the downstream LSR to perform a fast switchover and to source the traffic from another upstream LSR while IGP is converging due to a failure of the LDP session of the upstream peer, which is the primary next hop of the root LSR for the point-to-multipoint FEC. That is, the candidate upstream LSR node provides upstream FRR node protection for the mLDP FEC packets.

Multicast LDP fast upstream switchover is illustrated in Figure 23. LSR U is the primary next hop for the root LSR R of the point-to-multipoint FEC. LSR U' is an ECMP or LFA backup next hop for the root LSR R of the same point-to-multipoint FEC.

Figure 23 **Multicast LDP Fast Upstream Switchover**



In Figure 23, downstream LSR Z sends a label mapping message to both upstream LSR nodes, and programs the primary ILM on the interface to LSR U and the backup ILM on the interface to LSR U'. The labels for the primary and backup ILMs must be different. Thus LSR Z attracts traffic from both ILMs. However, LSR Z blocks the ILM on the interface to LSR U' and only accepts traffic from the ILM on the interface to LSR U.

If the link to LSR U fails, or LSR U fails, causing the LDP session to LSR U to go down, LSR Z will detect the failure and reverse the ILM blocking state. In addition, LSR Z immediately starts receiving traffic from LSR U' until IGP converges and provides a new primary next hop and a new ECMP or LFA backup next hop, which may or may not be on the interface to LSR U'. When IGP convergence is complete, LSR Z updates the primary and backup ILMs in the datapath.

Note: LDP uses the interface of either an ECMP next hop or an LFA next hop to the root LSR prefix, whichever is available, to program the backup ILM. However, ECMP next hop and LFA next hop are mutually exclusive for a given prefix. IGP installs the ECMP next hop in preference to the LFA next hop as a prefix in the routing table manager (RTM).

If one or more ECMP next hops for the root LSR prefix exist, LDP picks the interface for the primary ILM based on the rules of mLDP FEC resolution specified in RFC 6388, *Label Distribution Protocol Extensions for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Paths*:

1. The candidate upstream LSRs are numbered from lowest to highest IP address.
2. The following hash is performed:

   H = (CRC32(Opaque Value)) modulo N

   where **N** is the number of upstream LSRs

   The Opaque Value is the field in the point-to-multipoint FEC element immediately after the Opaque Length field. The Opaque Length indicates the opaque value used in this calculation.
3. The selected upstream LSR U is the LSR that has the number **H**.

LDP then picks the interface for the backup ILM using the following new rules:

```
if (H + 1 < NUM_ECMP) {

// If the hashed entry is not last in the next hops then pick up
   the next as backup.

    backup = H + 1;

} else {

// Wrap around and pick up the first.

    backup = 1;

}
```

In some topologies, it is possible that no ECMP or LFA next hop is found. In this case, LDP programs the primary ILM only.

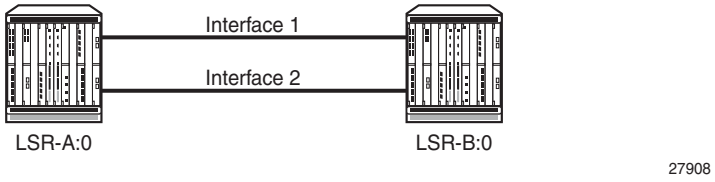
5.4 LDP IPv6

The 7705 SAR extends the LDP control plane and data plane to support LDP IPv6 adjacencies and sessions using 128-bit LSR ID.

The implementation allows for concurrent support of independent LDP IPv4 (which uses a 32-bit LSR ID) and LDP IPv6 adjacencies and sessions between peer LSRs and over the same interfaces or different set of interfaces.

Figure 24 shows an example of an LDP adjacency and session over an IPv6 interface.

Figure 24 **LDP Adjacency and Session over an IPv6 Interface**



LSR-A and LSR-B have the following IPv6 LDP identifiers respectively:

- <LSR Id=A/128> : <label space id=0>
- <LSR Id=B/128> : <label space id=0>

By default, LSR-A/128 and LSR-B/128 use the system interface IPv6 address.

Although the LDP control plane can operate using only the IPv6 system address, it is recommended that the user must configure the IPv4-formatted router ID in order for OSPF, IS-IS, and BGP to operate properly.

The following sections describe LDP IPv6 behavior on the 7705 SAR:

- Link LDP
- Targeted LDP
- FEC Resolution
- LDP Session Capabilities
- LDP Adjacency Capabilities
- IP Address and FEC Distribution
- IGP and Static Route Synchronization with LDP
- BFD Operation

- Services Using SDP with an LDP IPv6 FEC
- Mirror Services
- OAM Support with LDP IPv6
- Interoperability
- Upgrading from IPv4 to IPv6

5.4.1 Link LDP

LDP IPv6 uses a 128-bit LSR ID as defined in draft- pdutta-mpls-ldp-v2-00. See LDP Process Overview for more information about interoperability of this implementation with a 32-bit LSR ID, as defined in draft-ietf- mpls-ldp-ipv6-14.

A Hello adjacency is brought up using a link Hello packet with a source IP address set to the interface link local unicast address and a destination IP address set to the link local multicast address FF02:0:0:0:0:0:0:2.

The transport address for the TCP connection, which is encoded in the Hello packet, is set by default to the LSR ID of the LSR. The transport address is instead set to the interface IPv6 address if the user enables the **interface** option in one of the following contexts:

- **config>router>ldp>if-params>ipv6>transport-address**
- **config>router>ldp>if-params>if>ipv6>transport-address**

The user can configure the **local-lsr-id** option on the interface and change the value of the LSR ID to either the local interface or to another interface name, including loopback. The global unicast IPv6 address corresponding to the primary IPv6 address of the interface is used as the LSR ID. If the interface does not have a global unicast IPv6 address in the configuration of the transport address or the configuration of the local-lsr-id option, the session does not come up and an error message is displayed.

The LSR with the highest transport address will bootstrap the IPv6 TCP connection and IPv6 LDP session.

The source and destination addresses of LDP/TCP session packets are the IPv6 transport addresses.

5.4.2 Targeted LDP

The source and destination addresses of targeted Hello packets are the LDP IPv6 LSR- IDs of systems A and B in Figure 24.

The user can configure the **local-lsr-id** option on the targeted session and change the value of the LSR ID to either the local interface or to some other interface name, including loopback or not. The global unicast IPv6 address corresponding to the primary IPv6 address of the interface is used as the LSR ID. If the user invokes an interface that does not have a global unicast IPv6 address in the configuration of the transport address or the configuration of the **local-lsr-id** option, the session does not come up and an error message is displayed. In all cases, the transport address for the LDP session and the source IP address of targeted Hello messages are updated with the new LSR ID value.

The LSR with the highest transport address (in this case, the LSR ID) will bootstrap the IPv6 TCP connection and IPv6 LDP session.

The source and destination IP addresses of LDP/TCP session packets are the IPv6 transport addresses the LDP LSR IDs of systems A and B in Figure 24.

5.4.3 FEC Resolution

LDP advertises and withdraws all interface IPv6 addresses using the Address/ Address-Withdraw message. Both the link local unicast address and the configured global unicast addresses of an interface are advertised.

Like LDP IPv4 sessions, LDP FEC types can be exchanged over an LDP IPv6 session. The LSR does not advertise a FEC for a link local address and, if received, the LSR will not resolve it.

An IPv4 or IPv6 prefix FEC can be resolved to an LDP IPv6 interface in the same way it is resolved to an LDP IPv4 interface. The outgoing interface and next hop are looked up in the RTM cache. The next hop can be the link local unicast address of the other side of the link or a global unicast address. The FEC is resolved to the LDP IPv6 interface of the downstream LDP IPv6 LSR that advertised the IPv4 or IPv6 address of the next hop.

A PW FEC can be resolved to a targeted LDP IPv6 adjacency with an LDP IPv6 LSR if there is a context for the FEC with local spoke SDP configuration or spoke SDP auto-creation from a service such as BGP-AD VPLS, BGP-VPWS, or dynamic MS-PW.

5.4.4 LDP Session Capabilities

LDP can advertise all FEC types over an LDP IPv4 or an LDP IPv6 session. The FEC types are: IPv4 prefix FEC, IPv6 prefix FEC, IPv4 P2MP FEC (with MVPN), and PW FEC 128.

LDP also supports signaling the enabling or disabling of the advertisement of the following subset of FEC types during the LDP IPv4 or IPv6 session initialization phase, and when the session is already up.

- IPv4 prefix FEC

  This is performed using the State Advertisement Control (SAC) capability TLV as specified in draft-ietf-mpls-ldp-ip-pw-capability. The SAC capability TLV includes the IPv4 SAC element having the D-bit (Disable- bit) set or reset to disable or enable this FEC type respectively. The LSR can send this TLV in the LDP Initialization message and subsequently in an LDP capability message.
- IPv6 prefix FEC

  This is performed using the State Advertisement Control (SAC) capability TLV as specified in draft-ietf-mpls-ldp-ip-pw-capability. The SAC capability TLV includes the IPv6 SAC element having the D-bit (Disable- bit) set or reset to disable or enable this FEC type respectively. The LSR can send this TLV in the LDP Initialization message and subsequently in an LDP capability message to update the state of this FEC type.
- P2MP FEC (IPv4 only)

  This is performed using the P2MP capability TLV as specified in RFC 6388. The P2MP capability TLV has the S-bit (State-bit) with a value of set or reset to enable or disable this FEC type respectively. The LSR can send this TLV in the LDP initialization message and, subsequently, in an LDP capability message to update the state of this FEC type.

During LDP session initialization, each LSR indicates to its peers which FEC type it supports by including the capability TLV for it in the LDP initialization message. The 7705 SAR enables the IPv4 and IPv6 Prefix FEC types by default and sends their corresponding capability TLVs in the LDP initialization message. If one or both peers advertise the disabling of a capability in the LDP Initialization message, no FECs of the corresponding FEC type are exchanged between the two peers for the lifetime of the LDP session unless a capability message is sent to explicitly enable it. The same behavior applies if no capability TLV for a FEC type is advertised in the LDP initialization message, except for the IPv4 prefix FEC which is assumed to be supported by all implementations by default.

Dynamic Capability, as defined in RFC 5561, allows all FEC types to update the enabled or disabled state after the LDP session initialization phase. An LSR informs its peer that it supports Dynamic Capability by including the Dynamic Capability Announcement TLV in the LDP initialization message. If both LSRs advertise this capability, the user can enable or disable any of the above FEC types while the session is up and the change takes effect immediately. The LSR then sends a SAC capability message with the IPv4 or IPv6 SAC element having the D-bit (Disable-bit) set or reset, or the P2MP capability TLV (IPv4 only) in a capability message with the S-bit (State-bit) set or reset. Each LSR then takes the consequent action of withdrawing or advertising the FECs of that type to the peer LSR. If one or both LSRs did not advertise the Dynamic Capability Announcement TLV in the LDP initialization message, any change to the enabled or disabled FEC types only takes effect the next time the LDP session is restarted.

The user can enable or disable a specific FEC type for a given LDP session to a peer by using the following CLI commands:

- **config>router>ldp>session-params>peer>fec-type-capability>prefix-ipv4**
- **config>router>ldp>session-params>peer>fec-type-capability>prefix-ipv6**
- **config>router>ldp>session-params>peer>fec-type-capability>p2mp**

5.4.5 LDP Adjacency Capabilities

Adjacency-level FEC-type capability advertisement is defined in draft-pdutta-mpls-ldp-adj-capability. By default, all FEC types supported by the LSR are advertised in the LDP IPv4 or IPv6 session initialization; see LDP Session Capabilities for more information. If a given FEC type is enabled at the session level, it can be disabled over a given LDP interface at the IPv4 or IPv6 adjacency level for all IPv4 or IPv6 peers over that interface. If a given FEC type is disabled at the session level, then FECs will not be advertised and enabling that FEC type at the adjacency level will not have any effect. The LDP adjacency capability can be configured on link Hello adjacency only and does not apply to targeted Hello adjacency.

The LDP adjacency capability TLV is advertised in the Hello message with the D-bit (Disable-bit) set or reset to disable or enable the resolution of this FEC type over the link of the Hello adjacency. It is used to restrict which FECs can be resolved over a given interface to a peer. This provides the ability to dedicate links and data path resources to specific FEC types. For IPv4 and IPv6 prefix FECs, a subset of ECMP links to an LSR peer may be configured to carry one of the two FEC types. An mLDP P2MP FEC (IPv4 only) can exclude specific links to a downstream LSR from being used to resolve this type of FEC.

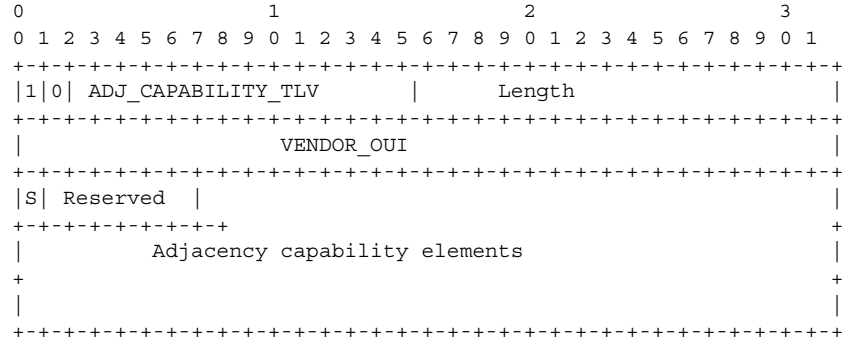
Like the LDP session-level FEC-type capability, the adjacency FEC-type capability is negotiated for both directions of the adjacency. If one or both peers advertise the disabling of a capability in the LDP Hello message, no FECs of the corresponding FEC type will be resolved by either peer over the link of this adjacency for the lifetime of the LDP Hello adjacency, unless one or both peers sends the LDP adjacency capability TLV subsequently to explicitly enable it.

The user can enable or disable a specific FEC type for a given LDP interface to a peer by using the following CLI commands:

- **config>router>ldp>if-params>if>ipv4>fec-type-capability>p2mp-ipv4**
- **config>router>ldp>if-params>if>ipv4/ipv6>fec-type-capability>prefix-ipv4**
- **config>router>ldp>if-params>if> ipv4/ipv6>fec-type-capability>prefix-ipv6**

These commands, when applied to the IPv4 P2MP FEC, deprecate the existing **multicast-traffic** command under the interface. Unlike the session-level capability, these commands can disable multicast FEC for IPv4.

The encoding of the adjacency capability TLV uses a PRIVATE Vendor TLV. It is used only in a Hello message to negotiate a set of capabilities for a specific LDP IPv4 or IPv6 hello adjacency.



The value of the U-bit for the TLV is set to 1 so that a receiver must silently ignore if the TLV is deemed unknown.

The value of the F-bit is 0. After being advertised, this capability cannot be withdrawn; thus, the S-bit is set to 1 in a Hello message.

Adjacency capability elements are encoded as follows:

```
0 1 2 3 4 5 6 7
+-+-+-+-+-+-+-+-+
|D| CapFlag     |
+-+-+-+-+-+-+-+-+
```

D bit: Controls the capability state.

- 1 : Disable capability
- 0 : Enable capability

CapFlag: The adjacency capability

- 1 : Prefix IPv4 forwarding
- 2 : Prefix IPv6 forwarding
- 3 : P2MP IPv4 forwarding
- 4 : P2MP IPv6 forwarding (not supported on the 7705 SAR)
- 5 : MP2MP IPv4 forwarding
- 6 : MP2MP IPv6 forwarding

Each CapFlag appears no more than once in the TLV. If duplicates are found, the D-bit of the first element is used. For forward compatibility, if the CapFlag is unknown, the receiver must silently discard the element and continue processing the rest of the TLV.

5.4.6 IP Address and FEC Distribution

When an LDP LSR initializes the LDP session to the peer LSR and the session comes up, IP addresses and FECs are distributed. Local IPv4 and IPv6 interface addresses are exchanged using the Address and Address Withdraw messages. FECs are exchanged using label mapping messages.

By default, IPv6 address distribution is determined by whether the dual-stack capability TLV, which is defined in *draft-ietf-mpls-ldp-ipv6*, is present in the Hello message from the peer. This requirement is designed to address interoperability issues found with existing third-party LDP IPv4 implementations.

IP address and FEC distribution behavior is described below.

- If the peer LSR sent the dual-stack capability TLV in the Hello message, then local IPv6 addresses are sent to the peer. The user can configure an address export policy to restrict which local IPv6 interface addresses are sent to the peer.

  - If the peer explicitly stated enabling of LDP IPv6 FEC type by including the IPv6 SAC TLV in the initialization message with the D-bit set to 0, then IPv6 FECs are also sent to the peer.
  - If the peer sent the dual-stack capability TLV in the Hello message, but explicitly stated disabling of LDP IPv6 FEC type by including the IPv6 SAC TLV in the initialization message with the D-bit set to 1, then IPv6 local addresses instead of IPv6 FECs are sent to the peer. The user can configure an address export policy to further restrict which local IPv6 interface addresses to send to the peer.
- If the peer did not send the dual-stack capability TLV in the Hello message, then no IPv6 addresses or IPv6 FECs are sent to that peer, regardless of the presence or not of the IPv6 SAC TLV in the initialization message. This case is added to prevent interoperability issues with some third-party LDP IPv4 implementations. The user can override the distribution defined by the initial Hello message by explicitly configuring an address export policy and a FEC export policy to select IPv6 addresses and FECs to send to the peer.

The above behavior applies to LDP IPv4 and IPv6 addresses and FECs. The procedure is summarized in the flowchart diagrams in Figure 25 and Figure 26.

Figure 25 **LDP IPv6 Address and FEC Distribution Procedure**

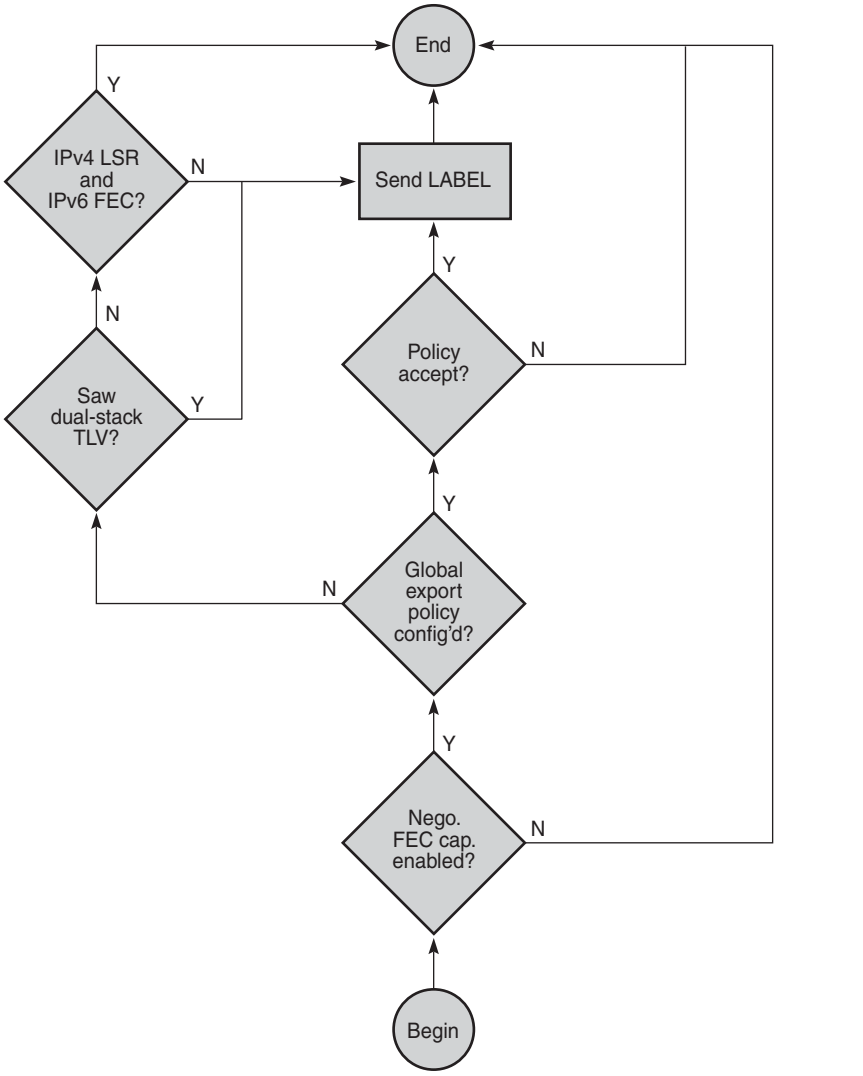
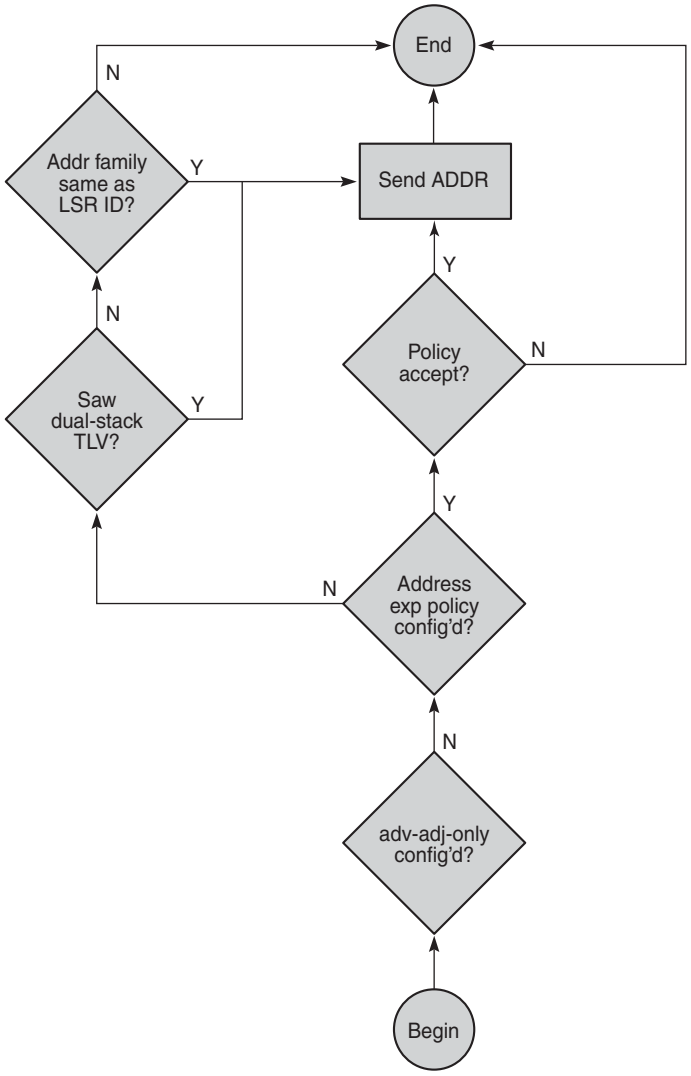


Figure 26 **LDP IPv6 Address and FEC Distribution Procedure**



5.4.7 IGP and Static Route Synchronization with LDP

The IGP-LDP synchronization and the static route-to-LDP synchronization features are modified to operate on a dual-stack IPv4 or IPv6 LDP interface as follows.

- If the router interface goes down or both LDP IPv4 and LDP IPv6 sessions go down, IGP sets the interface metric to the maximum value and all static routes with the **ldp-sync** option enabled and resolved on this interface are deactivated.

- If the router interface is up and only one of the LDP IPv4 or LDP IPv6 interfaces goes down, no action is taken.
- When the router interface comes up from a down state, and the LDP IPv4 or LDP IPv6 sessions comes up, IGP starts the sync timer. When the sync timer expires, the interface metric is restored to its configured value and all static routes with the **ldp-sync** option enabled are activated.

Given the above behavior, it is recommended that the user configures the sync timer to a value which allows enough time for both the LDP IPv4 and LDP IPv6 sessions to come up.

5.4.8 BFD Operation

The operation of BFD over an LDP interface tracks the next hop of prefix IPv4 and prefix IPv6 in addition to tracking of the LDP peer address of the Hello adjacency over that link. Tracking is required because LDP can resolve both IPv4 and IPv6 prefix FECs over a single IPv4 or IPv6 LDP session and therefore, the next hop of a prefix will not necessarily match the LDP peer source address of the Hello adjacency. If any of the BFD tracking sessions fail, the LFA backup NHLFE for the FEC is activated, or, if there is no FRR backup, the FEC is re-resolved.

The user can configure tracking with only an IPv4 BFD session, only an IPv6 BFD session, or with both using the **config>router>ldp>if-params>if>bfd-enable [ipv4] [ipv6]** command.

This command provides flexibility in case the user does not need to track both Hello adjacency and the next hops of FECs.

For example, if the user configures **bfd-enable ipv6** only to save on the number of BFD sessions, then LDP will track the IPv6 Hello adjacency and the next hops of IPv6 prefix FECs. LDP will not track next hops of IPv4 prefix FECs resolved over the same LDP IPv6 adjacency. If the IPv4 data plane encounters errors and the IPv6 Hello adjacency is not affected and remains up, traffic for the IPv4 prefix FECs resolved over that IPv6 adjacency will be black holed. If the BFD tracking the IPv6 Hello adjacency times out, then all IPv4 and IPv6 prefix FECs will be updated.

5.4.9 Services Using SDP with an LDP IPv6 FEC

The 7705 SAR supports SDPs of type LDP with far-end options using IPv6 addresses. The addresses need not be of the same family (IPv6 or IPv4) for the SDP configuration to be allowed. The user can have an SDP with an IPv4 (or IPv6) control plane for the T-LDP session and an IPv6 (or IPv4) LDP FEC as the tunnel.

Because IPv6 LSP is only supported with LDP, the use of a far-end IPv6 address is not allowed with a BGP or RSVP/MPLS LSP. In addition, the CLI does not allow an SDP with a combination of an IPv6 LDP LSP and an IPv4 LSP of a different control plane. As a result, the following commands are blocked in the SDP configuration context when the far end is an IPv6 address:

- **bgp-tunnel**
- **lsp**
- **mixed-lsp-mode**

SDP admin groups are not supported with an SDP using an LDP IPv6 FEC, and the attempt to assign them is blocked in CLI.

Services that use the LDP control plane (such as T-LDP VPLS and R-VPLS, VLL, and IES/VPRN spoke interface) have the spoke SDP (PW) signaled with an IPv6 T-LDP session when the far-end option is configured to an IPv6 address. By default, the spoke SDP for these services binds to an SDP that uses an LDP IPv6 FEC that matches the prefix of the far end address.

In addition, the IPv6 PW control word is supported with data plane packets and VCCV OAM packets. Hash label is also supported with the above services, including the signaling and negotiation of hash label support using T-LDP (Flow sub-TLV) with the LDP IPv6 control plane. Finally, network domains are supported in VPLS.

5.4.10 Mirror Services

The user can configure a spoke SDP bound to an LDP IPv6 LSP to forward mirrored packets from a mirror source to a remote mirror destination. In the configuration of the mirror destination service at the destination node, the **remote-source** command must use a spoke SDP with a VC ID that matches the VC-ID that is configured in the mirror destination service at the mirror source node. The **far-end** option is not supported with an IPv6 address.

5.4.10.1 Configuration at mirror source node

Use the following rules and syntax to configure a spoke SDP at the mirror source node.

- The *sdp-id* must match an SDP that uses an LDP IPv6 FEC.
- Configuring the *egress-vc-label* is optional.

CLI Syntax:
```
no spoke-sdp sdp-id:vc-id
spoke-sdp sdp-id:vc-id [create] egress
vc-label egress-vc-label
```

5.4.10.2 Configuration at mirror destination node

Use the following rules and syntax to configure mirror service at the mirror destination node.

- The **far-end** *ip-address* command is not supported with LDP IPv6 transport tunnel. The user must reference a spoke SDP using an LDP IPv6 SDP coming from mirror source node.
- In the **spoke-sdp** *sdp-id:vc-id* command, the *vc-id* should match that of the **spoke-sdp** configured in the **mirror-destination** context at the mirror source node.
- Configuring the *ingress-vc-label* is optional; both Static and T-LDP are supported.

CLI Syntax:
```
far-end ip-address [vc-id vc-id] [ing-svc-label ingress-
 vc-label | tldp] [icb]
no far-end ip-address
spoke-sdp sdp-id:vc-id [create] ingress-vc-label
 ingress-vc-label exit
no shutdown exit
exit
```

Mirroring is also supported with the PW redundancy feature when the endpoint spoke SDP, including the ICB, is using an LDP IPv6 tunnel.

5.4.11 OAM Support with LDP IPv6

MPLS OAM tools LSP ping and LSP trace can operate with LDP IPv6 and support the following:

- use of IPv6 addresses in the echo request and echo reply messages, including in DSMAP TLV, as per RFC 4379
- use of LDP IPv6 prefix target FEC stack TLV, as per RFC 4379
- use of IPv6 addresses in the DDMAP TLV and FEC stack change sub-TLV, as per RFC 6424
- use of 127/8 IPv4 mapped IPv6 address; that is, in the range ::ffff:127/104, as the destination address of the echo request message, as per RFC 4379
- use of 127/8 IPv4 mapped IPv6 address; that is, in the range ::ffff:127/104, as the **path-destination** address when the user wants to exercise a specific LDP ECMP path

The behavior at the sender and receiver nodes supports both LDP IPv4 and IPv6 target FEC stack TLVs. Specifically:

- The IP family (IPv4/IPv6) of the UDP/IP echo request message will always match the family of the LDP target FEC stack TLV as entered by the user in the **prefix** option.
- The **src-ip-address** option is extended to accept IPv6 address of the sender node. If the user did not enter a source IP address, the system IPv6 address will be used. If the user entered a source IP address of a different family than the LDP target FEC stack TLV, an error is returned and the command is aborted.
- The IP family of the UDP/IP echo reply message must match that of the received echo request message.
- For **lsp-trace**, the downstream information in DSMAP/DDMAP will be encoded as the same family as the LDP control plane of the link LDP or targeted LDP session to the downstream peer.
- The sender node inserts the experimental value of 65503 in the Router Alert Option in the echo request packet IPv6 header, as per RFC 5350. Once a value is allocated by IANA for MPLS OAM as part of draft-ietf-mpls-oam-ipv6-rao, it will be updated.

VCCV ping and VCCV trace for a single-hop PW support IPv6 PW FEC 128, as per RFC 6829. In addition, the PW OAM control word is supported with VCCV packets when the **control-word** option is enabled on the spoke SDP configuration. When the value of the Channel Type field is set to 0x57, it indicates that the Associated Channel carries an IPv6 packet, as per RFC 4385.

5.4.12 Interoperability

5.4.12.1 Interoperability with Implementations Compliant with draft-ietf-mpls-ldp-ipv6

The 7705 SAR uses a 128-bit LSR ID as defined in *draft-pdutta-mpls-ldp-v2* to establish an LDP IPv6 session with a peer LSR. This is so that a routable system IPv6 address can be used by default to bring up the LDP task on the router and establish link LDP and T-LDP sessions to other LSRs. More importantly, using a 128-bit LSR ID allows for the establishment of control plane-independent LDP IPv4 and IPv6 sessions between two LSRs over the same interface or different set of interfaces because each session uses a unique LSR ID (32-bit for IPv4 and 128-bit for IPv6).

The 7705 SAR LDP implementation does not interoperate with a system using a 32-bit LSR ID (as defined in *draft-ietf-mpls-ldp-ipv6*) to establish an IPv6 LDP session. The latter specifies that an LSR can send both IPv4 and IPv6 Hello messages over an interface, allowing the system to establish either an IPv4 or an IPv6 LDP session with LSRs on the same subnet. It does not allow for separate LDP IPv4 and LDP IPv6 LDP sessions between two routers.

The 7705 SAR LDP implementation interoperates with systems using a 32-bit LSR ID (as defined in *draft-ietf-mpls-ldp-ipv6*) to establish an IPv4 LDP session and to resolve both IPv4 and IPv6 prefix FECs.

The 7705 SAR otherwise complies with all other aspects of *draft-ietf-mpls-ldp-ipv6*, including the support of the dual-stack capability TLV in the Hello message. The latter is used by an LSR to inform its peer that it is capable of establishing either an LDP IPv4 or LDP IPv6 session and to convey the IP family preference for the LDP Hello adjacency and thus for the resulting LDP session. This is required because the implementation described in *draft-ietf-mpls-ldp-ipv6* allows for a single session between LSRs, and both LSRs must agree if the session should be brought up using IPv4 or IPv6 when both IPv4 and IPv6 Hellos are exchanged between the two LSRs. The 7705 SAR implementation has a separate session for each IP family between two LSRs and, as such, this TLV is used to specify the family preference and to indicate that the system supports resolving IPv6 FECs over an IPv4 LDP session.

5.4.12.2 Interoperability with Implementations Compliant with RFC 5036 for IPv4 LDP Control Plane Only

Some third-party LDP implementations are compliant with RFC 5036 for LDP IPv4 but are not compliant with RFC 5036 for handling IPv6 address or IPv6 FECs over an LDP IPv4 session.

An LSR based on the 7705 SAR in a LAN with a broadcast interface can peer with any third-party LSR, including those that are incapable of handling IPv6 address or IPv6 FECs over an LDP IPv4 session. When the 7705 SAR uses the IPv4 LDP control plane to advertise IPv6 addresses or IPv6 FECs to that peer, it can cause the IPv4 LDP session to go down.

To address this issue, *draft-ietf-mpls-ldp-ipv6* modifies RFC 5036 and requires compliant systems to check for the dual-stack capability TLV in the IPv4 Hello message from the peer. If the peer does not advertise this TLV, the LSR does not send IPv6 addresses and FECs to that peer. The 7705 SAR supports advertising and resolving IPv6 prefix FECs over an LDP IPv4 session using a 32-bit LSR ID in compliance with *draft-ietf-mpls-ldp-ipv6*.

5.4.13 Upgrading from IPv4 to IPv6

For smooth transition from IPv4 to IPv6, it is recommended to follow the steps below.

Step 1. Create a new IPv6 interface in the 7750 SR management VPRN.

Step 2. Configure a new Layer 3 Spoke SDP configured with LDPv6 and a far-end IPv6 address, and assign it to the new IPv6 interface.

Step 3. On the 7705 SAR, in the management Epipe create an endpoint object and assign the endpoint to the existing IPv4 PW. Ensure there is no traffic lost during this step.

Step 4. On the 7705 SAR, create a new SDP with LDPv6 and a far-end IPv6 address.

Step 5. On the 7705 SAR, within the management Epipe, assign the new SDP to a spoke SDP with the same endpoint as the IPv4 spoke SDP.

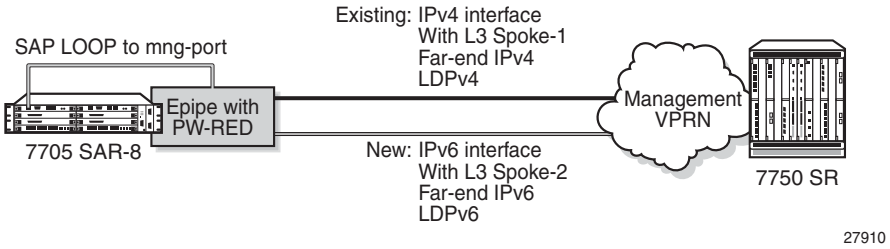
Step 6. On the 7750 SAR, shut down the IPv4 interface.

Step 7. On the 7705 SAR, start IPv6 traffic and ensure reachability to 7705 via the IPv6 SDP.

Step 8. Remove the IPv4 SDP and spokes from the 7705 SAR Epipe and 7750 SR VPRN.

Figure 27 shows an example of a network ensuring a smooth upgrade from IPv4 to IPv6 with PW redundancy.

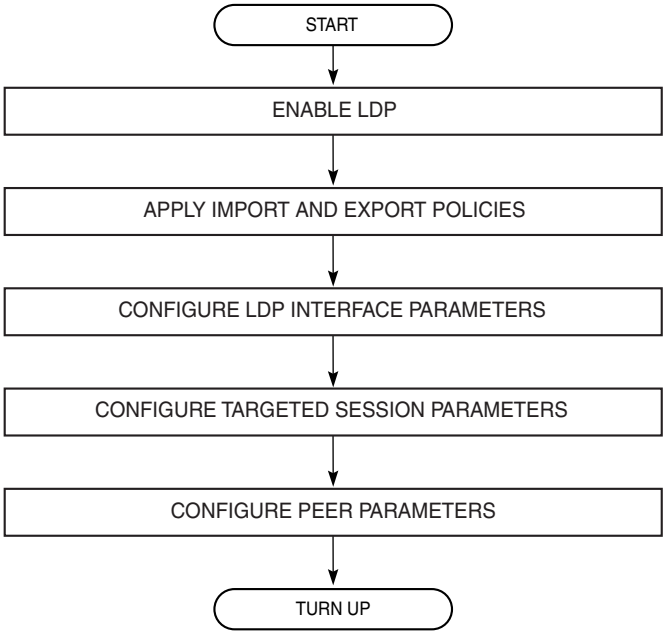
Figure 27 **Smooth Management Transition From IPv4 to IPv6**



5.5 LDP Process Overview

Figure 28 displays the process to provision basic LDP parameters.

Figure 28 **LDP Configuration and Implementation**



5.6 Configuration Notes

Refer to the 7705 SAR Services Guide for information about signaling.

5.6.1 Reference Sources

For information on supported IETF drafts and standards, as well as standard and proprietary MIBs, refer to Standards and Protocol Support.

5.7 Configuring LDP with CLI

This section provides information to configure LDP using the command line interface.

Topics in this section include:

5.8 LDP Configuration Overview

When the 7705 SAR implementation of LDP is instantiated, the protocol is in the **no shutdown** state. In addition, targeted sessions are then enabled. The default parameters for LDP are set to the documented values for targeted sessions in *draft-ietf-mpls-ldp-mib-09.txt*.

LDP must be enabled in order for signaling to be used to obtain the ingress and egress labels in frames transmitted and received on the service destination point (SDP). When signaling is off, labels must be manually configured when the SDP is bound to a service.

5.9 Basic LDP Configuration

This section provides information to configure LDP and gives configuration examples of common configuration tasks.

The LDP protocol instance is created in the **no shutdown** (enabled) state.

The following example displays the default LDP configuration output.

```
ALU-1>config>router>ldp# info
----------------------------------------------
            interface-parameters
            exit
            targeted-session
            exit
----------------------------------------------
ALU-1>config>router>ldp#
```

5.10 Common Configuration Tasks

This section provides a brief overview of the following common configuration tasks to configure LDP:

- Enabling LDP
- Configuring Graceful Restart Helper Parameters
- Applying Import and Export Policies
- Configuring Interface Parameters
- Specifying Targeted Session Parameters
- Specifying Peer Parameters
- Configuring LDP Support for Multicast VPN (MVPN)
- Configuring LDP Support for LDP-to-SR Stitching
- Enabling LDP Signaling and Services

5.10.1 Enabling LDP

LDP must be enabled in order for the protocol to be active. MPLS must also be enabled. MPLS is enabled in the **config>router>mpls** context.

Use the following CLI syntax to enable LDP on a 7705 SAR router:

CLI Syntax: `ldp`

Example: `config>router# ldp`

The following example displays the enabled LDP configuration output.

```
ALU-1>config>router# info
----------------------------------------------
...
#------------------------------------------
echo "LDP Configuration"
#------------------------------------------
        ldp
            interface-parameters
            exit
            targeted-session
            exit
        exit
----------------------------------------------
...
ALU-1>config>router#
```

5.10.2 Configuring Graceful Restart Helper Parameters

Graceful Restart Helper advertises to its LDP neighbors by carrying the fault tolerant (FT) session TLV in the LDP initialization message, assisting the LDP in preserving its IP forwarding state across the restart. The 7705 SAR recovery is self-contained and relies on information stored internally to self-heal.

Maximum recovery time is the time (in seconds) that the sender of the TLV would like the receiver to wait, after detecting the failure of LDP communication with the sender.

Neighbor liveness time is the time (in seconds) that the LSR is willing to retain its MPLS forwarding state. The time should be long enough to allow the neighboring LSRs to resynchronize all the LSPs in a graceful manner, without creating congestion in the LDP control plane.

Use the following syntax to configure graceful restart parameters:

CLI Syntax:

```
config>router>ldp
   [no] graceful-restart
      [no] maximum-recovery-time interval
      [no] neighbor-liveness-time interval
```

Example:

```
config>router>ldp
config>router>ldp# graceful-restart
config>router>ldp>graceful-restart# maximum-recovery-
  time 120
config>router>ldp>graceful-restart# neighbor-liveness-
  time 60
config>router>ldp# exit
config>router#
```

The following example displays the import policy configuration output.

```
ALU-1>config>router>ldp>graceful-restart# info
----------------------------------------------
               maximum-recovery-time 120
               neighbor-liveness-time 60
----------------------------------------------
ALU-1>config>router>ldp>graceful-restart#
```

5.10.3 Applying Import and Export Policies

Inbound filtering (import policy) allows a route policy to control the label bindings that an LSR accepts from its peers. An import policy can accept or reject label bindings received from LDP peers. Label bindings can be filtered based on the following:

- neighbor — match on bindings received from the specified peer
- prefix-list — match on bindings with the specified prefix or prefixes

Outbound filtering (export policy) allows a route policy to control the label bindings advertised by the LSR to its peers. Label bindings can be filtered based on the following:

- all — all local subnets by specifying “direct” as the match protocol
- prefix-list — match on bindings with the specified prefix/prefixes

Import or export policies must already exist before they are applied to LDP. Policies are configured in the **config>router>policy-options** context. Refer to the “Route Policies” section in the 7705 SAR Router Configuration Guide for details.

Note:

- The 7705 SAR supports a specific number of labels, which varies by platform and software release. If the number of labels is exceeded for a specific protocol (for example, LDP or RSVP), a log message will appear by default in logs 99 and 100. The log message states the affected protocol and the label count that was exceeded. For example: “mpls_label_ilm_helper: XXXX XXX XXXX limit reached max obj count of YYYY”.
- For the LDP protocol, when the label count is exceeded, LDP sessions will be shut down and all labels will be removed. To recover the LDP sessions, perform a **shutdown**/**no shutdown** combination of commands in the **config>router>ldp** context.

Use the following CLI syntax to apply import or export policies:

CLI Syntax:

```
config>router>ldp
   import policy-name [policy-name...(up to 5 max)]
   export policy-name [policy-name...(up to 5 max)]
```

Example:

```
config>router>ldp
config>router>ldp# import LDP-import
config>router>ldp# export LDP-export
config>router>ldp# exit
config>router#
```

The following example displays the import and export policy configuration output.

```
ALU-1>config>router>ldp# info
----------------------------------------------
            export "LDP-export"
            import "LDP-import"
            interface-parameters
            exit
            targeted-session
            exit
----------------------------------------------
```

5.10.4 Configuring Interface Parameters

Use the following CLI syntax to configure LDP interface parameters:

CLI Syntax:

```
config>router# ldp
   interface-parameters
      hello timeout factor
      interface ip-int-name
         hello timeout factor
         keepalive timeout factor
         local-lsr-id {system | interface}
         transport-address {system | interface}
         no shutdown
      keepalive timeout factor
      transport-address {system|interface}
```

Example:

```
config>router# ldp
config>router>ldp# interface-parameters
config>router>ldp>if-params# interface to-104
config>router>ldp>if-params>if# hello 15 3
config>router>ldp>if-params>if# local-lsr-id system
config>router>ldp>if-params>if# no shutdown
config>router>ldp>if-params>if# exit
config>router>ldp>if-params# exit
config>router>ldp#
```

The following example displays the LDP interface parameter configuration output.

```
ALU-1>config>router>ldp# info
----------------------------------------------
          import "LDP-import"
            interface-parameters
                hello 15 3
                keepalive 30 3
                interface "to-104"
                    hello 15 3
                    keepalive 30 3
```

```
                    local-lsr-id system
                    no shutdown
                exit
            exit
          targeted-session
          exit
          no shutdown
-----------------------------------------------
ALU-1>config>router>ldp#
```

5.10.5 Specifying Targeted Session Parameters

Use the following CLI syntax to specify targeted session parameters:

CLI Syntax:

```
config>router# ldp
  targeted-session
    disable-targeted-session
    hello timeout factor
    keepalive timeout factor
    peer ip-address
      bfd-enable
      hello timeout factor
      keepalive timeout factor
      local-lsr-id interface-name
      no shutdown
```

Example:

```
config>router# ldp
config>router>ldp# targeted-session
config>router>ldp>targ-session# bfd-enable
config>router>ldp>targ-session# hello 5000 255
config>router>ldp>targ-session# keepalive 5000 255
config>router>ldp>targ-session# peer 10.10.10.104
config>router>ldp>targ-session>peer# hello 2500 100
config>router>ldp>targ-session>peer# keepalive 15 3
config>router>ldp>targ-session>peer# local-lsr-id to-104
config>router>ldp>targ-session>peer# no shutdown
config>router>ldp>targ-session>peer# exit
config>router>ldp>targ-session# exit
config>router>ldp#
```

The following example displays the LDP targeted session configuration output.

```
ALU-1>config>router>ldp# info
-----------------------------------------------
          import "LDP-import"
          interface-parameters
                hello 15 3
                keepalive 30 3
                interface "to-104"
```

```
                    hello 15 3
                    keepalive 30 3
                    no shutdown
                exit
            exit
              targeted-session
                hello 5000 255
                keepalive 5000 255
                peer 10.10.10.104
                    hello 2500 100
                    keepalive 15 3
                    local-lsr-id "to-104"
                exit
              exit
-------------------------------------------
```

5.10.6 Specifying Peer Parameters

Use the following CLI syntax to specify LDP peer parameters:

CLI Syntax:

```
config>router# ldp
  peer-parameters
    peer ip-address
      auth-keychain name
      authentication-key {authentication-key | hash-
        key} [hash | hash2]
```

Example:

```
config>router# ldp
config>router>ldp# peer-parameters
config>router>ldp>peer-params# peer 10.10.10.104
config>router>ldp>peer-params>peer$ authentication-key
  testuser
config>router>ldp>peer-params>peer$ exit
```

The following example displays the LDP peer parameters configuration output.

```
ALU-1>config>router>ldp# info
-----------------------------------------------
          import "LDP-import"
          graceful-restart
          exit
          import "LDP-import"
          peer-parameters
               peer 10.10.10.104
                   authentication-key "nGjXyHQtCgHxbBm.kDeYdzSmPZy9KK03" hash2
               exit
          exit
          interface-parameters
               interface "test"
               exit
               interface "to-104"
```

```
                    hello 15 3
                exit
            exit
            targeted-session
                hello 5000 255
                keepalive 5000 255
                peer 10.10.10.104
                    hello 2500 100
                    keepalive 15 3
                exit
            exit
-------------------------------------------
ALU-1>config>router>ldp#
```

5.10.7 Configuring LDP Support for Multicast VPN (MVPN)

For LDP support for MVPN, configure the **multicast-traffic**, **mp-mbb-time**, and **mcast-upstream-frr** commands.

The following example displays the LDP MVPN configuration output.

```
*A:SarAx Dut-D>config>router>ldp# info detail
-------------------------------------------
            no aggregate-prefix-match
            no export
            no fast-reroute
            no import
            no graceful-restart
            mcast-upstream-frr
            mp-mbb-time 5
            no tunnel-down-damp-time
            interface-parameters
                hello 15 3
                keepalive 30 3
                transport-address system
                interface "mcast_if"
                    no bfd-enable
                    no hello
                    no keepalive
                    no local-lsr-id
                    multicast-traffic enable
                    no transport-address
                    no shutdown
                exit
            exit
            targeted-session
                no disable-targeted-session
                hello 45 3
                keepalive 40 4
            exit
            no shutdown
-------------------------------------------
*A:SarAx Dut-D>config>router>ldp#
```

5.10.8 Configuring LDP Support for LDP-to-SR Stitching

Configure the **export-tunnel-table** command using the following CLI syntax to support LDP-to-SR stitching.

CLI Syntax:
```
config>router# ldp
   export-tunnel-table policy-name [policy-name...(up to
      5 max)]
```

Note: The specified policy name must be the same as the policy-statement name defined when configuring the route policy options for LDP-to-SR stitching. Refer to the 7705 SAR Router Configuration Guide, “Configuring LDP-to-Segment Routing Stitching Policies”.

Example:
```
config>router>ldp# export-tunnel-table "export-SR"
config>router>ldp# exit
```

The following example displays the LDP-to-SR stitching LDP configuration output.

```
*A:NOK-1 Dut-B>config>router>ldp# info
----------------------------------------------
            export-tunnel-table "export-SR"
            ...
            exit
            ...
----------------------------------------------
*A:NOK-1 Dut-B>config>router>ldp#
```

5.10.9 Enabling LDP Signaling and Services

When LDP is enabled, targeted sessions can be established to create remote adjacencies with nodes that are not directly connected. When service destination points (SDPs) are configured, extended discovery mechanisms enable LDP to send periodic targeted hello messages to the SDP’s far-end point. The exchange of LDP hellos triggers session establishment. The SDP’s signaling default enables **tldp**. The SDP uses the targeted-session parameters configured in the **config>router>ldp> targeted-session** context.

The **service>sdp>ldp** and **router>lsp** commands are mutually exclusive; you can either specify an LSP or enable an LDP. There cannot be two methods of transport in a single SDP.

To enable LDP on the SDP when an LSP is already specified, the LSP must be removed from the configuration using the **no lsp** *lsp-name* command. For further information about configuring SDPs, refer to the 7705 SAR Services Guide.

Use the following CLI syntax to enable LDP on an MPLS SDP:

CLI Syntax:
```
config>service>sdp#
   ldp
   signaling {off|tldp}
```

The following example displays an SDP configuration output with the signaling default **tldp** enabled.

```
ALU-1>config>service>sdp# info detail
----------------------------------------------
            description "MPLS: to-99"
            far-end 10.10.10.99
            ldp
            signaling tldp
            path-mtu 4462
            keep-alive
                hello-time 10
                hold-down-time 10
                max-drop-count 3
                timeout 5
                no message-length
                no shutdown
            exit
            no shutdown
----------------------------------------------
ALU-1>config>service>sdp#
```

5.11 LDP Configuration Management Tasks

This section discusses the following LDP configuration management tasks:

- Disabling LDP
- Modifying Targeted Session Parameters
- Modifying Interface Parameters

5.11.1 Disabling LDP

The **no ldp** command disables the LDP protocol on the router. All parameters revert to the default settings. LDP must be shut down before it can be disabled.

Use the following CLI syntax to disable LDP:

CLI Syntax:
```
no ldp
   shutdown
```

Example:
```
config>router# ldp
config>router>ldp# shutdown
config>router>ldp# exit
config>router# no ldp
```

5.11.2 Modifying Targeted Session Parameters

You can modify targeted session parameters without shutting down entities. However, for any LDP timers (hello or keepalive timers), the changes do not take effect until a **shutdown/no shutdown** command is performed on the LDP session.

The **no** form of a **targeted-session** parameter command reverts modified values back to the default.

The following example displays the CLI syntax to revert targeted session parameters back to the default values.

Example:
```
config>router# ldp
config>router>ldp# targeted-session
config>router>ldp>targeted# no disable-targeted-session
config>router>ldp>targeted# no hello
config>router>ldp>targeted# no keepalive
config>router>ldp>targeted# shutdown
config>router>ldp>targeted# no shutdown
config>router>ldp>targeted# no peer 10.10.10.99
```

The following example displays the default value output.

```
ALU-1>config>router>ldp>targeted# info detail
----------------------------------------------
                no disable-targeted-session
                hello 45 3
                keepalive 40 4
----------------------------------------------
ALU-1>config>router>ldp>targeted#
```

5.11.3 Modifying Interface Parameters

You can modify LDP interface parameters without shutting down entities. However, at the global timer configuration level (**ldp>interface-parameters**), the **hello** and **keepalive** parameter modifications do not take effect until a **shutdown/no shutdown** command is performed on the LDP session. At the interface timer configuration level (**ldp>interface-parameters>interface)**, any changes to the **keepalive** parameter do not take effect until a **shutdown/no shutdown** command is performed on the LDP session. For all other parameters, the changes take effect immediately.

Individual parameters cannot be deleted. The **no** form of an **interface-parameter** command changes modified values back to the defaults.

The following example displays the CLI syntax to change interface parameters back to the default values.

Example:
```
config>router# ldp
config>router>ldp>interface-parameters
config>router>ldp>if-params# no hello
config>router>ldp>if-params# interface to-104
config>router>ldp>if-params>if# no keepalive
config>router>ldp>if-params>if# no transport-address
config>router>ldp>if-params>if# shutdown
config>router>ldp>if-params>if# no shutdown
config>router>ldp>if-params>if# exit
config>router>ldp>if-params# exit
config>router>ldp# shutdown
config>router>ldp# no shutdown
```

The following example displays the default value output.

```
ALU-1>config>router>ldp>if-params# info detail
----------------------------------------------
               hello 15 3
               keepalive 30 3
               no transport-address
----------------------------------------------
ALU-1>config>router>ldp>params#
```

5.12 LDP Command Reference

5.12.1 Command Hierarchies

5.12.1.1 LDP Commands

```
config
    — router [router-name]
        — [no] ldp
            — [no] aggregate-prefix-match
                — prefix-exclude policy-name [policy-name...(up to 5 max)]
                — no prefix-exclude
                — [no] shutdown
            — egress-statistics
                — [no] fec-prefix ip-prefix[/mask]
                    — accounting-policy policy-id
                    — no accounting-policy
                    — [no] collect-stats
                    — [no] shutdown
            — export policy-name [policy-name...(up to 5 max)]
            — no export
            — export-tunnel-table policy-name [policy-name...(up to 5 max)]
            — no export-tunnel-table
            — fast-reroute [backup-sr-tunnel]
            — no fast-reroute
            — fec-originate ip-address/mask [advertised-label in-label] [swap-label out-label]
                interface interface-name
            — fec-originate ip-address/mask [advertised-label in-label] next-hop ip-address
                [swap-label out-label]
            — fec-originate ip-address/mask [advertised-label in-label] next-hop ip-address
                [swap-label out-label] interface interface-name
            — fec-originate ip-address/mask [advertised-label in-label] pop
            — no fec-originate ip-address/mask interface interface-name
            — no fec-originate ip-address/mask next-hop ip-address
            — no fec-originate ip-address/mask next-hop ip-address interface interface-name
            — no fec-originate ip-address/mask pop
            — [no] graceful-restart
                — maximum-recovery-time interval
                — no maximum-recovery-time
                — neighbor-liveness-time interval
                — no neighbor-liveness-time
            — [no] implicit-null-label
            — import policy-name [policy-name...(up to 5 max)]
            — no import
            — interface-parameters
                —  interface ip-int-name [dual-stack]
                — [no] interface ip-int-name
                    — bfd-enable [ipv4] [ipv6]
                    — [no] bfd-enable
                    — [no] ipv4
                        — fec-type-capability
                            — p2mp-ipv4 {enable | disable}
                            — p2mp-ipv6 {enable | disable}
                            — prefix-ipv4 {enable | disable}
                            — prefix-ipv6 {enable | disable}
                        — hello timeout factor
                        — no hello
```

```
                    — keepalive timeout factor
                    — no keepalive
                    — local-lsr-id {system | interface}
                    — no local-lsr-id
                    — [no] shutdown
                    — transport-address {system | interface}
                    — no transport-address
                — [no] ipv6
                    — fec-type-capability
                        — p2mp-ipv4 {enable | disable}
                        — p2mp-ipv6 {enable | disable}
                        — prefix-ipv4 {enable | disable}
                        — prefix-ipv6 {enable | disable}
                    — hello timeout factor
                    — no hello
                    — keepalive timeout factor
                    — no keepalive
                    — local-lsr-id {system | interface}
                    — no local-lsr-id
                    — [no] shutdown
                    — transport-address {system | interface}
                    — no transport-address
            — ipv4
                — hello timeout factor
                — no hello
                — keepalive timeout factor
                — no keepalive
                — transport-address {system | interface}
                — no transport-address
            — ipv6
                — hello timeout factor
                — no hello
                — keepalive timeout factor
                — no keepalive
                — transport-address {system | interface}
                — no transport-address
        — [no] legacy-ipv4-lsr-interop
        — [no] mcast-upstream-frr
        — mp-mbb-time interval
        — no mp-mbb-time
        — session-parameters
            — [no] peer ip-address
                — export-addresses policy-name [policy-name... (up to 5 max)]
                — no export-addresses
                — fec-type-capability
                    — p2mp {enable | disable}
                    — prefix-ipv4 {enable | disable}
                    — prefix-ipv6 {enable | disable}
        — [no] shutdown
        — targeted-session
            — [no] disable-targeted-session
            — ipv4
                — hello timeout factor
                — no hello
```

```
            — keepalive timeout factor
            — no keepalive
         — ipv6
            — hello timeout factor
            — no hello
            — keepalive timeout factor
            — no keepalive
         — [no] peer ip-address
            — [no] bfd-enable
            — hello timeout factor
            — no hello
            — keepalive timeout factor
            — no keepalive
            — local-lsr-id interface-name
            — no local-lsr-id
            — [no] shutdown
            — [no] tunneling
               — [no] lsp lsp-name
      — tcp-session-parameters
         — [no] peer-transport ip-address
            — auth-keychain name
            — no auth-keychain
            — authentication-key {authentication-key | hash-key} [hash | hash2]
            — no authentication-key
            — no authentication-key
      — tunnel-down-damp-time seconds
      — no tunnel-down-damp-time
```

5.12.1.2 Show Commands

The show commands in this section are organized into the following areas:

- Show LDP Commands
- Show LDP Bindings Commands

5.12.1.2.1 Show LDP Commands

show
— **router** [*router-instance*]
— **ldp**
— **discovery** [**state** *state*] [**detail** | **summary**] [**adjacency-type** *type*] [**session** *ip-addr*[*label-space*]]
— **discovery** [**state** *state*] [**detail** | **summary**] [**adjacency-type** *type*] [*family*]
— **discovery** **interface** [*ip-int-name*] [**state** *state*] [**detail** | **summary**] [**session** *ip-addr*[*label-space*]] [*family*]
— **discovery** **peer** [*ip-address*] [**state** *state*] [**detail** | **summary**] [**session** *ip-addr*[*label-space*]]
— **fec-egress-stats** [*ip-prefix/mask*]
— **fec-egress-stats** [**active**] [**family**]
— **fec-originate** [*ip-address/mask*] [**operation-type**]
— **fec-originate** [**operation-type**] [*family*]
— **interface** [*ip-int-name* | *ip-address*] [**detail**] [*family*]
— **parameters**
— **session** [*ip-addr*[**:***label-space*]] **local-addresses** [**sent** | **recv**] **ip-addr** *ip-address*
— **session** [*ip-addr*[**:***label-space*]] [**session-type**] [**state** *state*] [**detail** | **summary**]
— **session** [*ip-addr*[**:***label-space*]] **local-addresses** [**sent** | **recv**] [*family*]
— **session** [*ip-addr*[**:***label-space*]] **statistics** [*packet-type*] [**session-type**]
— **session** **statistics** [*packet-type*] [**session-type**] [*family*]
— **session** [**session-type**] [**state** *state*] [**detail** | **summary**] [*family*]
— **session-parameters** [*family*]
— **session-parameters** [*peer-ip-address*]
— **status**
— **targ-peer** [*ip-address*] [**detail**]
— **targ-peer** [**detail**] [*family*]
— **tcp-session-parameters** [*family*]
— **tcp-session-parameters** [**keychain** *keychain*]
— **tcp-session-parameters** *transport-peer-ip-address*

5.12.1.2.2 Show LDP Bindings Commands

```
show
  — router
    — ldp
      — bindings
        — active detail [family] [egress-if port-id]
        — active detail [family] [egress-lsp tunnel-id]
        — active detail [egress-nh ip-address] [family]
        — active egress-if port-id [summary | detail] [family]
        — active egress-lsp tunnel-id [summary | detail] [family]
        — active egress-nh [family] [summary | detail] ip-address
        — active ipv4 [summary | detail] [egress-if port-id]
        — active ipv4 [summary | detail] [egress-lsp tunnel-id]
        — active ipv4 [summary | detail] [egress-nh ip-address]
        — active ipv6 [summary | detail] [egress-if port-id]
        — active ipv6 [summary | detail] [egress-nh ip-address]
        — active ipv6 [summary | detail] [egress-lsp tunnel-id]
        — active p2mp p2mp-id identifier root ip-address [summary | detail] [egress-if port-id]
        — active p2mp p2mp-id identifier root ip-address [summary | detail] [egress-lsp tunnel-id]
        — active p2mp p2mp-id identifier root ip-address [summary | detail] [egress-nh ip-address]
        — active p2mp [family] [summary | detail] [egress-if port-id] [opaque-type opaque-type]
        — active p2mp [family] [summary | detail] [egress-lsp tunnel-id] [opaque-type opaque-type]
        — active p2mp [family] [summary | detail] [egress-nh ip-address] [opaque-type opaque-type]
        — active p2mp source ip-address group mcast-address root ip-address [summary | detail] [egress-if port-id] inner-root ip-address
        — active p2mp source ip-address group mcast-address root ip-address [summary | detail] [egress-lsp tunnel-id] inner-root ip-address
        — active p2mp source ip-address group mcast-address root ip-address [summary | detail] [egress-nh ip-address] inner-root ip-address
        — active p2mp source ip-address group mcast-address root ip-address [rd rd] [summary | detail] [egress-if port-id]
        — active p2mp source ip-address group mcast-address root ip-address [rd rd] [summary | detail] [egress-lsp tunnel-id]
        — active p2mp source ip-address group mcast-address root ip-address [rd rd] [summary | detail] [egress-nh ip-address]
        — active p2mp source ip-address group mcast-address [family] [summary | detail] [innermost-root ip-address]
        — active prefixes [family] [summary | detail] [egress-if port-id]
        — active prefixes [family] [summary | detail] [egress-lsp tunnel-id]
        — active prefixes [egress-nh ip-address] [family] [summary | detail]
        — active prefixes prefix ip-prefix/ip-prefix-length [summary | detail] [egress-if port-id]
        — active prefixes prefix ip-prefix/ip-prefix-length [summary | detail] [egress-lsp tunnel-id]
        — active prefixes prefix ip-prefix/ip-prefix-length [egress-nh ip-address] [summary | detail]
```

— **active summary** [*family*] [**egress-if** *port-id*]
— **active summary** [*family*] [**egress-lsp** *tunnel-id*]
— **active summary** [**egress-nh** *ip-address*] [*family*]

show
— **router**
— **ldp**
— **bindings**
— **detail** [**session** *ip-addr* [*label-space*]] [*family*]
— **ipv4** [**session** *ip-addr*[*label-space*]] [**summary** | **detail**]
— **ipv6** [**session** *ip-addr*[*label-space*]] [**summary** | **detail**]
— **label-type start-label** *start-label* [**end-label** *end-label*] *label-type* [*family*]
— **p2mp p2mp-id** *identifier* **root** *ip-address* [**session** *ip-addr* [*label-space*]] [**summary** | **detail**]
— **p2mp** [**session** *ip-addr* [*label-space*]] [*family*] [**summary** | **detail**] [**opaque-type** *opaque-type*]
— **p2mp source** *ip-address* **group** *mcast-address* **root** *ip-address* [**session** *ip-addr* [*label-space*]] [*family*] [**summary** | **detail**] **inner-root** *ip-address*
— **p2mp source** *ip-address* **group** *mcast-address* **root** *ip-address* [**rd** *rd*] [**session** *ip-addr* [*label-space*]] [**summary** | **detail**]
— **p2mp source** *ip-address* **group** *mcast-address* [**session** *ip-addr* [*label-space*]] [*family*] [**summary** | **detail**] [**innermost-root** *ip-address*]
— **prefixes prefix** *ip-prefix/ip-prefix-length* [**summary** | **detail**] [**session** *ip-addr*[*label-space*]]
— **prefixes** [*family*] [**summary** | **detail**] [**session** *ip-addr*[*label-space*]]
— **services vc-type** *vc-type* **saii** *global-id*:*prefix*:*ac-id* **taii** [*256 chars max*] **agi** *agi* [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]
— **services vc-type** *vc-type* **agi** *agi* [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]
— **services** [**vc-type** *vc-type*] [**svc-fec-type**] [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]
— **services vc-type** *vc-type* **vc-id** *vc-id* [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]
— **session** [*family*] [**summary** | **detail**] *ip-addr*[*label-space*]
— **summary** [**session** *ip-addr*[*label-space*]] [**ipv4** | **ipv6**]

5.12.1.3 Clear Commands

```
clear
    — router [router-instance]
        — ldp
            — fec-egress-statistics [ip-prefix/mask]
            — instance
            — interface ip-int-name [statistics]
            — peer ip-address [statistics]
            — session [ip-addr[:label-space]] [statistics]
            — statistics
```

5.12.1.4 Debug Commands

```
[no] debug
    — router [router-instance]
        — [no] ldp
            — [no] interface interface-name
                — [no] event
                    — [no] messages
                — [no] packet
                    — hello [detail]
                    — no hello
            — [no] peer ip-address
                — [no] event
                    — [no] bindings
                    — [no] messages
                — [no] packet
                    — hello [detail]
                    — no hello
                    — init [detail]
                    — no init
                    — [no] keepalive
                    — label [detail]
                    — no label
```

5.12.2 Command Descriptions

5.12.2.1 Configuration Commands

- Generic Commands
- LDP Global Commands
- Interface Parameters Commands
- Session Parameters Commands
- Targeted Session Commands

5.12.2.1.1 Generic Commands

shutdown

Syntax [**no**] **shutdown**

Context config>router>ldp
config>router>ldp>egress-statistics
config>router>ldp>if-params>interface
config>router>ldp>if-params>if>ipv4
config>router>ldp>if-params>if>ipv6
config>router>ldp>targ-session>peer
config>router>ldp>aggregate-prefix-match

Description This command administratively disables an entity. When disabled, an entity does not change, reset, or remove any configuration settings or statistics.

The operational state of the entity is disabled as well as the operational state of any entities contained within. Many objects must be shut down before they can be deleted.

The **no** form of this command administratively enables an entity.

Unlike other commands and parameters where the default state is not indicated in the configuration file, the **shutdown** and **no shutdown** states are always indicated in system-generated configuration files.

Default no shutdown

5.12.2.1.2 LDP Global Commands

ldp

Syntax [**no**] **ldp**

Context config>router

Description This command enables the context to configure an LDP protocol instance.

When an LDP instance is created, the protocol is enabled (in the **no shutdown** state). To suspend the LDP protocol, use the **shutdown** command. Configuration parameters are not affected.

The **no** form of the command deletes the LDP protocol instance, removing all associated configuration parameters. The LDP instance must first be disabled with the **shutdown** command before being deleted.

Default n/a — LDP must be explicitly enabled

aggregate-prefix-match

Syntax [**no**] **aggregate-prefix-match**

Context config>router>ldp

Description This command enables LDP to use the aggregate prefix match function rather than requiring an exact prefix match.

When this command is enabled and an LSR receives a FEC-label binding from an LDP neighbor for a prefix-address FEC element, FEC1, it will install the binding in the LDP FIB if:

- the routing table (RIB) contains an entry that matches FEC1. Matching can either be a longest IP match of the FEC prefix or an exact match.
- the advertising LDP neighbor is the next hop to reach FEC1

When the FEC-label binding has been installed in the LDP FIB, LDP programs an NHLFE entry in the egress data path to forward packets to FEC1. LDP also advertises a new FEC-label binding for FEC1 to all its LDP neighbors.

When a new prefix appears in the RIB, LDP checks the LDP FIB to determine if this prefix is a closer match for any of the installed FEC elements. If a closer match is found, this may mean that the LSR used as the next hop will change; if so, the NHLFE entry for that FEC must be changed.

When a prefix is removed from the RIB, LDP checks the LDP FIB for all FEC elements that matched this prefix to determine if another match exists in the routing table. If another match exists, LDP must use it. This may mean that the LSR used as the next hop will change; if so, the NHLFE entry for that FEC must be changed. If another match does not exist, the LSR removes the FEC binding and sends a label withdraw message to its LDP neighbors.

If the next hop for a routing prefix changes, LDP updates the LDP FIB entry for the FEC elements that matched this prefix. It also updates the NHLFE entry for the FEC elements.

The **no** form of this command disables the use of the aggregate prefix match function. LDP then only performs an exact prefix match for FEC elements.

Default no aggregate-prefix-match

prefix-exclude

Syntax **prefix-exclude** *policy-name* [*policy-name* …(up to 5 max)]
no prefix-exclude

Context config>router>ldp>aggregate-prefix-match

Description This command specifies the policy name containing the prefixes to be excluded from the aggregate prefix match function. Against each excluded prefix, LDP performs an exact match of a specific FEC element prefix, rather than a longest prefix match of one or more LDP FEC element prefixes, when it receives a FEC-label binding or when a change to the prefix occurs in the routing table.

The **no** form of this command removes all policies from the configuration; therefore, no prefixes are excluded.

Default no prefix-exclude

Parameters *policy-name* — specifies the import route policy name. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

egress-statistics

Syntax **egress-statistics**

Context config>router>ldp

Description This command enters the context to enable egress data path statistics at the ingress LER for this FEC.

Default n/a

fec-prefix

Syntax [**no**] **fec-prefix** *ip-prefix*[*/mask*]

Context config>router>ldp>egress-statistics

Description This command configures statistics in the egress data path at the ingress LER or LSR for an LDP FEC. The user must also execute the **no shutdown** command in this context to enable statistics collection.

The **no** form of this command disables the statistics in the egress data path and removes the accounting policy association from the LDP FEC.

Default n/a

Parameters *ip-prefix[/mask]* — the IP prefix and prefix length associated with the prefix FEC

Values

ipv4-prefix:	a.b.c.d
ipv4-prefix-length:	32
ipv6-prefix:	x:x:x:x:x:x:x:x (eight 16-bit pieces)
	x:x:x:x:x:x:d.d.d.d
	x - [0 to FFFF]H
	d - [0 to 255]D
ipv6-prefix-length:	128

accounting-policy

Syntax **accounting-policy** *policy-id*
no accounting-policy

Context config>router>ldp>egr-stats>fec-prefix

Description This command associates an accounting policy with an LDP FEC. Only one accounting policy at a time can be associated with an LDP FEC on a particular node.

An accounting policy must first be configured in the **config>log>accounting-policy** context before it can be associated; otherwise an error message is generated.

The **no** form of this command removes the accounting policy association.

Default no accounting policy

Parameters *policy-id* — the accounting policy ID

Values 1 to 99

collect-stats

Syntax [**no**] **collect-stats**

Context config>router>ldp>egr-stats>fec-prefix

Description This command enables accounting and statistical data collection.

The collected statistic counters can be retrieved via **show** and **monitor** commands or with the SNMPv3 interface. The counters can be saved to an accounting file if the specific statistics collection record is included in the default accounting policy or in a user-defined accounting policy.

When the **no** form of this command is issued, statistics are still accumulated by the forwarding engine; however, the CPU will not obtain the results and write them to the accounting file. If a subsequent **collect-stats** command is issued, then the counters written to the accounting file will also include all the traffic that went through while the **no collect-stats** command was in effect.

Default no collect-stats

export

Syntax **export** *policy-name* [*policy-name* …(up to 5 max)]
no export

Context config>router>ldp

Description This command specifies export route policies that determine which routes are exported to LDP neighbors. Configuring an export policy allows the LSR (Label Switch Router) to advertise addresses other than the system IP address. Policies are configured in the **config>router>policy-options** context. Refer to the “Route Policies” section in the 7705 SAR Router Configuration Guide.

If no export policy is specified, non-LDP routes will not be exported from the routing table manager to LDP, and only LDP-learned routes will be exported to LDP neighbors.

If multiple policy names are specified, the policies are evaluated in the order they are specified. The first policy that matches is applied. If multiple export commands are issued, the last command entered will override the previous command. A maximum of five policy names can be specified. The specified names must already be defined.

The **no** form of the command removes all policies from the configuration.

Default no export

Parameters *policy-name* — specifies the export route policy name. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

export-tunnel-table

Syntax **export-tunnel-table** *policy-name* [*policy-name*...(up to 5 max)]
no export-tunnel-table

Context config>router>ldp

Description This command enables exporting of SR tunnels from the TTM into LDP (IGP) for the purpose of stitching an LDP FEC to an SR tunnel for the same destination IPv4 /32 IS-IS prefix.

The **no** form of the command disables the exporting of SR tunnels to LDP.

Default no export-tunnel-table

Parameters *policy-name* — the export-tunnel-table route policy name; must be an existing policy-statement name

fast-reroute

Syntax **fast-reroute** [**backup-sr-tunnel**]
no fast-reroute

Context config>router>ldp

Description This command enables LDP Fast Reroute (FRR). LDP FRR provides local protection for an LDP FEC by precalculating and downloading a primary and a backup NHLFE for the FEC to the LDP FIB.

This command is limited to IPv4 /32 prefixes in both LDP and SR.

When LDP FRR is enabled and an LFA backup next hop exists for the FEC prefix in the RTM, or for the longest prefix the FEC prefix matches to when the aggregate-prefix-match command is enabled, LDP programs the data path with both a primary NHLFE and a backup NHLFE for each next hop of the FEC.

The backup NHLFE is enabled for each affected FEC next hop when any of the following events occurs:

- an LDP interface goes operationally down or is administratively shut down
- an LDP session to a peer goes down because the Hello timer or keepalive timer has expired over an interface
- the TCP connection used by a link LDP session to a peer goes down

The tunnel-down-damp-time command, when enabled, does not cause the corresponding timer to be activated for a FEC as long as a backup NHLFE is still available.

Because LDP can detect the loss of a neighbor/next hop independently, it is possible that it will switch to the LFA next hop while the IGP (OSPF or IS-IS) is still using the primary next hop. As well, when the interface for the previous primary next hop is restored, the IGP may reconverge before LDP completes the FEC exchange with its neighbor over that interface. This may cause LDP to deprogram the LFA next hop from the FEC and blackhole traffic. In order to avoid this situation, IGP-LDP synchronization should be enabled on the LDP interface with the **config>router>if>ldp-sync-timer** command (refer to the 7705 SAR Router Configuration Guide, “IP Router Command Reference”, for information on configuring the **ldp-sync-timer**).

The **backup-sr-tunnel** option allows an SR tunnel to be used as a remote LFA or TI-LFA backup tunnel next hop by an LDP FEC. Before this option can be used, the LDP-to-SR stitching feature must be enabled. See LDP-to-Segment Routing Stitching for IPv4 /32 Prefixes (IS-IS) for more information on this feature.

The **no** form of this command disables LDP FRR.

Default no fast-reroute

Parameters **backup-sr-tunnel** — allows an SR tunnel to be used as a remote LFA or TI-LFA backup tunnel next hop by an LDP FEC

fec-originate

Syntax **fec-originate** *ip-address/mask* [**advertised-label** *in-label*] [**swap-label** *out-label*] **interface** *interface-name*

fec-originate *ip-address/mask* [**advertised-label** *in-label*] **next-hop** *ip-address* [**swap-label** *out-label*]

fec-originate *ip-address/mask* [**advertised-label** *in-label*] **next-hop** *ip-address* [**swap-label** *out-label*] **interface** *interface-name*

fec-originate *ip-address/mask* [**advertised-label** *in-label*] **pop**

no fec-originate *ip-address/mask* **interface** *interface-name*

no fec-originate *ip-address/mask* **next-hop** *ip-address*

no fec-originate *ip-address/mask* **next-hop** *ip-address* **interface** *interface-name*

no fec-originate *ip-address/mask* **pop**

Context config>router>ldp

Description This command adds a FEC to the LDP prefix database with a specific label operation on the node.

Permitted operations are **swap** to originate a FEC for which the LSR is not egress or **pop** to originate a FEC for which the LSR is egress.

For a swap operation, an incoming label can be swapped with a label in the range of 16 to 1048575. If a **swap-label** is not configured, the default value is 3.

A route-table entry is required for a FEC with a pop operation to be advertised. For a FEC with a swap operation, a route-table entry must exist and the user-configured next hop for the swap operation must match one of the next hops in the route-table entry.

The **next-hop**, **advertised-label**, and **swap-label** parameters are optional. If a **next-hop** is configured but no **swap-label** is specified, the swap occurs with label 3 (implicit null), then the label is popped and the packet is forwarded to the next hop. If the **next-hop** and **swap-label** parameters are configured, a regular swap occurs. If no parameters are specified, a pop and forwarding is performed.

Default no fec-originate

Parameters *ip-address/mask* — specifies the IP prefix and mask length

Values

ipv4-address	a.b.c.d (host bits must be 0)
ipv6-address	x:x:x:x:x:x:x:x (eight 16-bit pieces)
	x:x:x:x:x:x:d.d.d.d
	x: [0 to FFFF]H
	d: [0 to 255]D
	ipv6-prefix-length - [0 to 128]
mask	0 to 32

advertised label — specifies the label advertised to the upstream peer. If not configured, the label that is advertised should be from the label pool. If the configured static label is not available, the IP prefix is not advertised.

in-label — the LSR to swap the label. If configured, the LSR should swap the label with the configured *out-label*. If not configured, the default action is pop if the next-hop parameter is not defined.

Values 32 to 2047

out-label — the number of labels to send to the peer associated with this FEC

Values 16 to 1048575

interface-name — specifies the name of the interface that the label for the originated FEC is swapped to. For an unnumbered interface, this parameter is mandatory because there is no address for the next hop. For a numbered interface, it is optional.

next-hop *ip-address* — specifies the IP address of the next hop

Values a.b.c.d

pop — specifies to pop the label and transmit the packet

graceful-restart

Syntax [**no**] **graceful-restart**

Context config>router>ldp

Description This command enables graceful restart helper.

The **no** form of the command disables graceful restart.

Default graceful-restart

maximum-recovery-time

Syntax **maximum-recovery-time** *interval*
no maximum-recovery-time

Context config>router>ldp>graceful-restart

Description This command configures the local maximum recovery time, which is the time (in seconds) that the sender of the TLV would like the receiver to wait, after detecting the failure of LDP communication with the sender.

The **no** form of the command returns the default value.

Default 120

Parameters *interval* — specifies the maximum length of recovery time, in seconds

Values 15 to 1800

neighbor-liveness-time

Syntax **neighbor-liveness-time** *interval*
no neighbor-liveness-time

Context config>router>ldp>graceful-restart

Description This command configures the neighbor liveness time, which is the time (in seconds) that the LSR is willing to retain its MPLS forwarding state. The time should be long enough to allow the neighboring LSRs to resynchronize all the LSPs in a graceful manner, without creating congestion in the LDP control plane.

The **no** form of the command returns the default value.

Default 120

Parameters *interval* — specifies the length of time, in seconds

Values 5 to 300

implicit-null-label

Syntax [**no**] **implicit-null-label**

Context config>router>ldp

Description This command enables the implicit null label option for all LDP FECs for which the router is the eLER.

The implicit null label is signaled by the eLER to the previous-hop LSR during FEC signaling by the LDP control protocol. When the implicit null label is signaled to the LSR, it pops the outer label before sending the MPLS packet to the eLER; this is known as penultimate hop popping.

The **no** form of the command disables the signaling of the implicit null label.

Default no implicit-null-label

import

Syntax **import** *policy-name* [*policy-name* …(up to 5 max)]
no import

Context config>router>ldp

Description This command specifies import route policies that determine which routes are accepted from LDP neighbors. Policies are configured in the **config>router>policy-options** context. Refer to the “Route Policies” section in the 7705 SAR Router Configuration Guide.

If no import policy is specified, LDP accepts all routes from configured LDP neighbors. Import policies can be used to limit or modify the routes accepted and their corresponding parameters and metrics.

If multiple policy names are specified, the policies are evaluated in the order they are specified. The first policy that matches is applied. If multiple import commands are issued, the last command entered will override the previous command. A maximum of five policy names can be specified. The specified names must already be defined.

The **no** form of the command removes all policies from the configuration.

Default no import

Parameters *policy-name* — specifies the import route policy name. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

hello

Syntax **hello** *timeout factor*
no hello

Context config>router>ldp>if-params>ipv4
config>router>ldp>if-params>ipv6
config>router>ldp>if-params>if>ipv4
config>router>ldp>if-params>if>ipv6
config>router>ldp>targ-session>ipv4
config>router>ldp>targ-session>ipv6
config>router>ldp>targ-session>peer

Description This command configures the hold time. This is the time interval to wait before declaring a neighbor down. The *factor* parameter derives the hello interval.

Hold time is local to the system and is sent in the hello messages to the neighbor. Hold time cannot be less than three times the hello interval. The hold time can be configured globally (applies to all LDP interfaces) or per interface. The most specific value is used.

When an LDP session is being set up, the hold time is negotiated to the lower of the two peers. Once an operational value is agreed upon, the **hello** *factor* is used to derive the value of the hello interval.

The **no** form of the command:

- at the interface-parameters and targeted-session levels, sets the **hello** *timeout* and the **hello** *factor* to the default values
- at the interface level, sets the **hello** *timeout* and the **hello** *factor* to the value defined under the interface-parameters level
- at the peer level, sets the **hello** *timeout* and the **hello** *factor* to the value defined under the targeted-session level

Default The default value is dependent upon the CLI context. Table 39 lists the **hello** *timeout factor* default values.

Table 39 **Hello Timeout Factor Default Values**

Context	Timeout	Factor
config>router>ldp>if-params>ipv4 config>router>ldp>if-params>ipv6	15	3
config>router>ldp>if-params>interface>ipv4 config>router>ldp>if-params>interface>ipv6	Inherits values from **interface-parameters** context	
config>router>ldp>targ-session>ipv4 config>router>ldp>targ-session>ipv6	45	3

Table 39 **Hello Timeout Factor Default Values (Continued)**

Context	Timeout	Factor
config>router>ldp>targ-session>peer	Inherits values from **targeted-session** IPv4 or IPv6 context	

Parameters *timeout* — configures the time interval, in seconds, that LDP waits before declaring a neighbor down

Values 1 to 65535

factor — specifies the number of keepalive messages that should be sent on an idle LDP session in the hello timeout interval

Values 1 to 255

keepalive

Syntax **keepalive** *timeout factor*
no keepalive

Context config>router>ldp>if-params>ipv4
config>router>ldp>if-params>ipv6
config>router>ldp>if-params>if>ipv4
config>router>ldp>if-params>if>ipv6
config>router>ldp>targ-session>ipv4
config>router>ldp>targ-session>ipv6
config>router>ldp>targ-session>peer

Description This command configures the time interval, in seconds, that LDP waits before tearing down the session. The *factor* parameter derives the keepalive interval.

If no LDP messages are exchanged for the configured time interval, the LDP session is torn down. Keepalive timeout is usually three times the keepalive interval. To maintain the session permanently, regardless of the activity, set the value to zero.

When an LDP session is being set up, the keepalive timeout is negotiated to the lower of the two peers. Once a operational value is agreed upon, the **keepalive** *factor* is used to derive the value of the keepalive interval.

The **no** form of the command:

- at the IPv4, IPv6, and targeted-session levels, sets the **keepalive** *timeout* and the **keepalive** *factor* to the default value
- at the IPv4 or IPv6 interface level, sets the **keepalive** *timeout* and the **keepalive** *factor* to the value defined under the corresponding **interface-parameters** level
- at the peer level, sets the **keepalive** *timeout* and the **keepalive** *factor* to the value defined under the **targeted-session** level

Default The default value is dependent upon the CLI context. Table 40 lists the **keepalive** *timeout factor* default values.

Table 40 **Keepalive Timeout Factor Default Values**

Context	Timeout	Factor
config>router>ldp>if-params>ipv4 config>router>ldp>if-params>ipv6	30	3
config>router>ldp>if-params>interface>ipv4 config>router>ldp>if-params>interface>ipv6	Inherits values from **interface-parameters** context	
config>router>ldp>targ-session>ipv4 config>router>ldp>targ-session>ipv6	40	4
config>router>ldp>targ-session>peer	Inherits values from **targeted-session** IPv4 or IPv6 context	

Parameters *timeout* — configures the time interval, expressed in seconds, that LDP waits before tearing down the session

Values 1 to 65535

factor — specifies the number of keepalive messages, expressed as a decimal integer, that should be sent on an idle LDP session in the keepalive timeout interval

Values 1 to 255

legacy-ipv4-lsr-interop

Syntax [**no**] **legacy-ipv4-lsr-interop**

Context config>router>ldp

Description This command allows interoperability with third-party legacy IPv4 LSR implementations that do not comply with RFC 5036 with respect to the processing of Hello TLVs with the U-bit set.

The command is a global LDP configuration that disables the Nokia proprietary Interface Info TLV (0x3E05) in the Hello message sent to the peer. Disabling this Hello TLV also results in the non-generation of the Nokia proprietary Hello Adjacency Status TLV (0x3E06) because the Interface Info TLV is not sent.

In addition, this command disables the RFC 7552 standard dual-stack capability TLV (0x701) and the Nokia proprietary Adjacency capability TLV (0x3E07).

mcast-upstream-frr

Syntax [**no**] **mcast-upstream-frr**

Context config>router>ldp

Description This command enables the mLDP fast upstream switchover feature.

When this command is enabled and LDP is resolving an mLDP FEC received from a downstream LSR, it checks whether an ECMP next hop or an LFA next hop to the root LSR node exists. If LDP finds one, it programs a primary ILM on the interface corresponding to the primary next hop and a backup ILM on the interface corresponding to the ECMP or LFA next hop. Then, LDP sends the corresponding labels to both upstream LSR nodes. Under normal operation, the primary ILM accepts packets while the backup ILM drops them. If the interface or the upstream LSR of the primary ILM goes down, causing the LDP session to go down, the backup ILM starts accepting packets.

In order to make use of the ECMP next hop, the user must configure the **ecmp** value in the system to at least “2”, using the following command:

config>router>ecmp

In order to make use of the LFA next hop, the user must enable LFA using the following commands (as needed):

config>router>isis>loopfree-alternate

config>router>ospf>loopfree-alternate

Enabling the IP FRR or LDP FRR feature is not strictly required since LDP only needs to know the location of the alternate next hop to the root LSR so it can send the Label Mapping message to program the backup ILM at the initial signaling of the tree. Therefore, enabling the LFA option is sufficient. However, if unicast IP and LDP prefixes need to be protected, then these features and the mLDP fast upstream switchover can be enabled concurrently.

The mLDP FRR fast switchover relies on the fast detection of a loss of an LDP session to the upstream peer to which the primary ILM label had been advertised. It is strongly recommended that the following be performed:

Step 1. Enable BFD on all LDP interfaces to upstream LSR nodes. When BFD detects the loss of the last adjacency to the upstream LSR, it will immediately bring down the LDP session, which will cause the CSM to activate the backup ILM.

Step 2. If there is a concurrent T-LDP adjacency to the same upstream LSR node, enable BFD on the T-LDP peer in addition to enabling it on the interface.

Step 3. Enable the **ldp-sync-timer** option on all interfaces to the upstream LSR nodes. If an LDP session to the upstream LSR to which the primary ILM is resolved goes down for any reason other than a failure of the interface or of the upstream LSR, routing and LDP will go out of synchronization. This means that the backup ILM will remain activated until the next time SPF is run by IGP. By enabling the IGP-LDP synchronization feature, the advertised link metric will be changed to the maximum value as soon as the LDP session goes down. This, in turn, triggers an SPF, and LDP will download a new set of primary and backup ILMs.

The **no** form of this command disables fast upstream switchover for mLDP FECs.

Default no mcast-upstream-frr

mp-mbb-time

Syntax **mp-mbb-time** *interval*
no mp-mbb-time

Context config>router>ldp

Description This command configures the maximum time a point-to-multipoint transit or bud node must wait before switching over to the new path if the new node does not send an MBB TLV to inform the transit or bud node of the availability of the data plane.

The **no** form of the command sets the wait time to the default.

Default 3 s

Parameters *interval* — specifies the MP MBB wait time

Values 1 to 10 seconds

tunnel-down-damp-time

Syntax **tunnel-down-damp-time** *seconds*
no tunnel-down-damp-time

Context config>router>ldp

Description This command specifies the time interval, in seconds, that LDP waits before posting a tunnel down event to the Tunnel Table Manager (TTM).

When LDP can no longer resolve a FEC and deactivates it, it deprograms the NHLFE in the data path. It will, however, delay deleting the LDP tunnel entry in the TTM until the **tunnel-down-damp-time** timer expires. This means that users of the LDP tunnel, such as SDPs (for all services) and BGP (for Layer 3 VPNs), will not be notified immediately. Traffic is still blackholed because the NHLFE has been deprogrammed.

If the FEC gets resolved before the **tunnel-down-damp-time** timer expires, LDP programs the IOM with the new NHLFE and posts a tunnel modify event to the TTM, updating the dampened entry in the TTM with the new NHLFE information.

If the FEC does not get resolved and the **tunnel-down-damp-time** timer expires, LDP posts a tunnel down event to the TTM, which deletes the LDP tunnel.

The **no** form of the command resets the damp timer value back to the default value of 3. If the timer value is set to 0, tunnel down events are not dampened but are reported immediately.

Default 3

Parameters *seconds* — the time interval that LDP waits before posting a tunnel down event to the TTM

Values 0 to 20

5.12.2.1.3 Interface Parameters Commands

interface-parameters

Syntax **interface-parameters**

Context config>router>ldp

Description This command enables the context to configure LDP interfaces and parameters that apply to LDP interfaces.

interface

Syntax **interface** *ip-int-name* [**dual-stack**]
[**no**] **interface** *ip-int-name*

Context config>router>ldp>if-params

Description This command enables LDP on the specified IP interface.

The **no** form of the command deletes the LDP interface and all configuration information associated with the LDP interface.

The LDP interface must be disabled using the **shutdown** command before it can be deleted.

You can configure different parameters for IPv4 and IPv6 LDP interfaces by entering **ipv4** or **ipv6** as the next command.

Parameters **dual-stack** — distinguishes between configurations created prior to 7705 SAR Release 9.0 from those created in Release 9.0 or later when the interface node implementation was changed to include both IPv4 and IPv6 contexts. If the **dual-stack** keyword is used, then the IPv4 interface context is not created. If the keyword is not used, then the IPv4 interface context is automatically created.

When entering an already configured interface, there is no need to provide the keyword and it will be ignored if it is included.

By default, all configurations created in Release 9.0 or later include **dual-stack**.

ip-int-name — specifies an existing interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

ipv4

Syntax [**no**] **ipv4**

Context config>router>ldp>if-params
config>router>ldp>if-params>if
config>router>ldp>targeted-session

Description This command enables the context to configure IPv4 LDP parameters that apply to the interface.

ipv6

Syntax [**no**] **ipv6**

Context config>router>ldp>if-params
config>router>ldp>if-params>if
config>router>ldp>targeted-session

Description This command enables the context to configure IPv6 LDP parameters applied to the interface.

local-lsr-id

Syntax **local-lsr-id** {**system** | **interface**}
no local-lsr-id

Context config>router>ldp>if-params>if>ipv4
config>router>ldp>if-params>if>ipv6

Description This command enables the use of the address of the link LDP interface as the LSR ID in order to establish an LDP adjacency and session with a directly connected LDP peer.

By default, the LDP session uses the system interface address as the LSR ID unless the LSR ID is explicitly configured. This means that targeted LDP (T-LDP) and interface LDP share a common LDP TCP session and therefore a common LDP label space. The system interface must always be configured on the router or the LDP protocol will not come up on the node.

At initial configuration, the LDP session to the peer remains down while the interface is down. If the user changes the LSR ID while the LDP session is up, LDP immediately tears down the session and attempts to re-establish it using the new LSR ID. If the interface used for the local LSR ID goes down, the LDP session will also go down.

The **interface** option is the recommended setting when static route-LDP synchronization is enabled.

When the **interface** option is selected, the transport connection (TCP) for the link LDP session configured by the transport-address command is automatically set to **interface**. Having both the **local-lsr-id** and transport address set to the local interface creates two TCP sessions to the peer and therefore two different LDP label spaces: one to the interface IP address for link LDP (L-LDP) and one to the system IP address for T-LDP.

The **no** form of the command resets the **local-lsr-id** to the default value.

Default system

Parameters **system** — specifies that the system IP address is used to set up the LDP session between peers

interface — specifies that the IP interface address is used to set up the LDP session between peers

p2mp-ipv4

Syntax **p2mp-ipv4** {**enable** | **disable**}

Context config>router>ldp>session-params>if>ipv4>fec-type-capability
config>router>ldp>session-params>if>ipv6>fec-type-capability

Description This command enables or disables IPv4 P2MP FEC capability on the interface.

Default p2mp disable

Parameters **enable | disable** — enables or disables IPv4 P2MP FEC capability

p2mp-ipv6

Syntax **p2mp-ipv6** {**enable** | **disable**}

Context config>router>ldp>session-params>if>ipv4>fec-type-capability
config>router>ldp>session-params>if>ipv6>fec-type-capability

Description This command enables or disables IPv6 P2MP FEC capability on the interface.

Default p2mp disable

Parameters **enable | disable** — enables or disables IPv6 P2MP FEC capability

transport-address

Syntax **transport-address** {**system** | **interface**}
no transport-address

Context config>router>ldp>if-params>ipv4
config>router>ldp>if-params>ipv6
config>router>ldp>if-params>if>ipv4
config>router>ldp>if-params>if>ipv6

Description This command configures the transport address to be used when setting up the LDP TCP sessions. The transport address can be configured globally (applies to all LDP interfaces) or per interface. The most specific value is used.

With the **transport-address** command, you can set up the LDP interface to the connection that can be set to the interface address or the system address. However, there can be an issue of which address to use when there are parallel adjacencies. This address selection situation can also occur when there is a link and a targeted adjacency, since targeted adjacencies request the session to be set up only to the system IP address.

The **transport-address** value should not be **interface** if multiple interfaces exist between two LDP neighbors.

Depending on the first adjacency to be formed, the TCP endpoint is chosen. In other words, if one LDP interface is set up as **transport-address interface** and another as **transport-address system**, then, depending on which adjacency was set up first, the TCP endpoint addresses are determined. After that, because the hello contains the LSR ID, the LDP session can be checked to verify that it is set up and then the adjacency can be matched to the session.

The **no** form of the command:

- at the global level, sets the transport address to the default value
- at the interface level, sets the transport address to the value defined under the global level

Default system

Parameters **interface** — specifies that the IP interface address is used to set up the LDP session between neighbors. The transport address interface cannot be used if multiple interfaces exist between two neighbors, since only one LDP session is set up between two neighbors.

system — specifies that the system IP address is used to set up the LDP session between neighbors

5.12.2.1.4 Session Parameters Commands

session-parameters

Syntax **session-parameters**

Context config>router>ldp

Description This command enables the context to configure peer-specific parameters.

peer

Syntax [**no**] **peer** *ip-address*

Context config>router>ldp>session-params

Description This command configures parameters for an LDP peer.

Default n/a

Parameters *ip-address* — specifies the LDP peer in dotted-decimal notation

export-addresses

Syntax **export-addresses** *policy-name* [*policy-name*...(up to 5 max)]
no export-addresses

Context config>router>ldp>session-params>peer

Description This command specifies the export prefix policy to local addresses advertised to this peer.

Policies are configured in the **config>router>policy-options** context. A maximum of five policy names can be specified.

The **no** form of the command removes the policy from the configuration.

Default no export-addresses

Parameters *policy-name* — The export prefix route policy name. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters excluding double quotes. If the string contains spaces, use double quotes to delimit the start and end of the string. The specified name(s) must already be defined.

fec-type-capability

Syntax **fec-type-capability**

Context config>router>ldp>if-params>if>ipv4
config>router>ldp>if-params>if>ipv6
config>router>ldp>session-params>peer

Description This command enables or disables the advertisement of a FEC type on a given LDP session or Hello adjacency to a peer.

Default n/a

p2mp

Syntax **p2mp** {**enable** | **disable**}

Context config>router>ldp>session-params>peer>fec-type-capability

Description This command enables or disables P2MP FEC capability for the session.

Default p2mp disable

Parameters **enable | disable** — enables or disables P2MP FEC capability

prefix-ipv4

Syntax **prefix-ipv4** {**enable** | **disable**}

Context config>router>ldp>if-params>if>ipv4>fec-type-capability
config>router>ldp>if-params>if>ipv6>fec-type-capability
config>router>ldp>session-params>peer>fec-type-capability

Description This command enables or disables IPv4 prefix FEC capability on the session or interface.

Default prefix-ipv4 disable

Parameters **enable | disable** — enables or disables IPv4 prefix FEC capability

prefix-ipv6

Syntax **prefix-ipv6** {**enable** | **disable**}

Context config>router>ldp>if-params>if>ipv4
config>router>ldp>if-params>if>ipv6
config>router>ldp>session-params>peer>fec-type-capability

Description This command enables or disables IPv6 prefix FEC capability on the session or interface.

Default prefix-ipv6 disable

Parameters **enable | disable** — enables or disables IPv6 prefix FEC capability

tcp-session-parameters

Syntax **tcp-session-parameters**

Context config>router>ldp

Description This command enables the context to configure parameters for the TCP transport session of an LDP session to a remote peer.

Default n/a

peer-transport

Syntax [**no**] **peer-transport** *ip-address*

Context config>router>ldp>tcp-session-parameters

Description This command configures the peer transport address, which is the IPv4 or IPv6 destination address of the TCP connection to the LDP peer.

Default n/a

Parameters *ip-address* — the IPv4 or IPv6 address of the TCP connection to the LDP peer in dotted decimal notation

auth-keychain

Syntax **auth-keychain** *name*
no auth-keychain

Context config>router>ldp>tcp-session-params>peer-transport

Description This command associates an authentication keychain with LDP. The keychain is a collection of keys used to authenticate LDP messages from remote peers. The keychain allows the rollover of authentication keys during the lifetime of a session and also supports stronger authentication algorithms than clear text and MD5.

The keychain must already be defined in the **config>system>security>keychain** context.

Either the **authentication-key** command or the **auth-keychain** command can be used by LDP, but both cannot be supported at the same time. If both commands are configured, the **auth-keychain** configuration will be applied and the **authentication-key** command will be ignored.

By default, authentication is not enabled.

Default no auth-keychain

Parameters *name* — the name of an existing keychain, up to 32 characters

authentication-key

Syntax **authentication-key** {*authentication-key* | *hash-key*} [**hash** | **hash2**]
no authentication-key

Context config>router>ldp>tcp-session-params>peer-transport

Description This command specifies the authentication key to be used between LDP peers before establishing sessions. Authentication uses the MD5 message-based digest.

Either the **authentication-key** command or the **auth-keychain** command can be used by LDP, but both cannot be supported at the same time. If both commands are configured, the **auth-keychain** configuration will be applied and the **authentication-key** command will be ignored.

The **no** form of this command disables authentication.

Default n/a

Parameters *authentication-key* — specifies the authentication key. Allowed values are any string up to 16 characters long (unencrypted) composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

hash-key — specifies the hash key. Allowed values are any string up to 33 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

This is useful when a user must configure the parameter; however, for security purposes, the actual unencrypted key value is not provided.

hash — specifies that the key is entered and stored on the node in encrypted form

hash2 — specifies that the key is entered and stored on the node in a more complex encrypted form

Note: If neither the **hash** or **hash2** keyword is specified, the key is entered in clear text. However, for security purposes, the key is stored on the node using hash encryption.

5.12.2.1.5 Targeted Session Commands

targeted-session

Syntax **targeted-session**

Context config>router>ldp

Description This command configures targeted LDP sessions. Targeted sessions are LDP sessions between non-directly connected peers. Hello messages are sent directly to the peer platform instead of to all the routers on this subnet multicast address.

The discovery messages for an indirect LDP session are addressed to the specified peer and not to the multicast address.

Default n/a

disable-targeted-session

Syntax [**no**] **disable-targeted-session**

Context config>router>ldp>targeted-session

Description This command disables support for targeted sessions. Targeted sessions are LDP sessions between non-directly connected peers. The discovery messages for an indirect LDP session are addressed to the specified peer and not to the multicast address.

The **no** form of the command enables the setup of any targeted sessions.

Default no disable-targeted-session

peer

Syntax [**no**] **peer** *ip-address*

Context config>router>ldp>targeted-session

Description This command configures parameters for an LDP peer.

Default n/a

Parameters *ip-address* — specifies the IPv4 or IPv6 address of the LDP peer in dotted-decimal notation

bfd-enable

Syntax **bfd-enable** [**ipv4**] [**ipv6**]
[**no**] **bfd-enable**

Context config>router>ldp>if-params>if
config>router>ldp>targeted-session>peer

Description This command enables or disables bidirectional forwarding detection (BFD) tracking of the LDP session for the interface or the T-LDP session for the peer.

When BFD is enabled on an LDP interface, the system tracks the next hop of the IPv4 and IPv6 prefixes in addition to tracking the LDP peer address of the Hello adjacency over that link. This is required because LDP can resolve both IPv4 and IPv6 prefix FECs over a single IPv4 or IPv6 LDP session and as such, the next hop of a prefix does not necessarily match the LDP peer source address of the Hello adjacency.

The **no** form of the command disables BFD tracking.

Default n/a

local-lsr-id

Syntax **local-lsr-id** *interface-name*
no local-lsr-id

Context config>router>ldp>targeted-session>peer

Description This command enables the use of the address of a specific interface as the LSR ID in order to establish a targeted LDP (T-LDP) adjacency and session with one or more non-directly connected LDP peers. The interface can be a regular interface or a loopback interface, including the system interface.

By default, a T-LDP session uses the system interface address as the LSR ID, unless the LSR ID is explicitly configured. This means that T-LDP and interface LDP share a common LDP TCP session and therefore a common LDP label space. The system interface must be always be configured on the router or the LDP protocol will not come up on the node.

At initial configuration, the LDP session to the peers remains down while the interface is down. If the user changes the LSR ID while the LDP session is up, LDP immediately tears down the session and attempts to re-establish it using the new LSR ID. If the interface used for the local LSR ID goes down, the LDP session to all peers using this LSR ID will also go down.

The user-configured LSR ID is used for extended peer discovery to establish the T-LDP hello adjacency. It is also used as the transport address for the LDP TCP session when it is bootstrapped by the T-LDP hello adjacency. The user-configured LSR ID is not used in basic peer discovery to establish a link-level LDP hello adjacency.

The **no** form of the command resets the **local-lsr-id** to the default value, which means that the system interface address is used as the LSR ID.

Default no local-lsr-id

Parameters *interface-name* — specifies the name, up to 32 characters in length, of the network IP interface. An interface name cannot be in the form of an IP address. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

tunneling

Syntax [**no**] **tunneling**

Context config>router>ldp>targeted-session>peer

Description This command enables LDP over tunnels.

The **no** form of the command disables tunneling.

Default no tunneling

lsp

Syntax [**no**] **lsp** *lsp-name*

Context config>router>ldp>targeted-session>peer>tunneling

Description This command configures an LSP destined for this peer to be used for tunneling an LDP FEC over RSVP-TE. A maximum of four RSVP-TE LSPs can be used for tunneling LDP FECs to the T-LDP peer.

It is not necessary to specify any RSVP-TE LSP in this context unless there is a need to restrict the tunneling to selected LSPs. All RSVP-TE LSPs with a **to** address matching that of the T-LDP peer are eligible by default. The user can also exclude specific LSP names by using the **ldp-over-rsvp exclude** command in the **config>router>mpls>lsp** *lsp-name* context.

The **no** form of this command removes the LSP association.

Parameters *lsp-name* — specifies the name of the LSP

5.12.2.2 Show Commands

Note: The following command outputs are examples only; actual displays may differ depending on supported functionality and user configuration.

- Show Router LDP Commands
- Show Router LDP Bindings Commands

5.12.2.2.1 Show Router LDP Commands

discovery

Syntax **discovery** [**state** *state*] [**detail** | **summary**] [**adjacency-type** *type*] [**session** *ip-addr*[*label-space*]]
discovery [**state** *state*] [**detail** | **summary**] [**adjacency-type** *type*] [*family*]
discovery interface [*ip-int-name*] [**state** *state*] [**detail** | **summary**] [**session** *ip-addr*[*label-space*]] [*family*]
discovery peer [*ip-address*] [**state** *state*] [**detail** | **summary**] [**session** *ip-addr*[*label-space*]]

Context show>router>ldp

Description This command displays the status of the interfaces participating in LDP discovery.

Parameters *state* — specifies the current operational state of the adjacency

Values established, trying, down

detail — displays detailed information

summary — displays summary information

type — specifies the adjacency type

Values link, targeted

ip-addr — the IP address of the session

label-space — specifies the label space identifier that the router is advertising on the interface

Values 0 to 65535

family — displays either IPv4 or IPv6 LDP session information

ip-int-name — specifies an existing interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

ip-address — specifies the IP address of the peer

Output The following outputs are examples of LDP discovery information, and Table 41 describes the fields.

Output Example - show router ldp discovery

```
ALU-12# show router ldp discovery
===============================================================================
LDP IPv4 Hello Adjacencies
===============================================================================
Interface Name                   Local Addr      Peer Addr       AdjType State
-------------------------------------------------------------------------------
N/A                              10.10.10.103    10.10.10.93     Targ    Trying
N/A                              10.10.10.103    10.10.10.104    Targ    Estab
to-104                           10.0.0.103      224.0.0.2       Link    Trying
-------------------------------------------------------------------------------
No. of Hello Adjacencies: 3
===============================================================================
ALU-12#
```

Output Example - show router ldp discovery detail

```
ALU-12# show router ldp discovery detail
===============================================================================
LDP IPv4 Hello Adjacencies (Detail)
===============================================================================
Peer 10.10.10.93
-------------------------------------------------------------------------------
Local Address      : 10.10.10.103       Peer Address       : 10.10.10.93
Adjacency Type     : Targeted           State              : Trying

-------------------------------------------------------------------------------
Peer 10.10.10.104
-------------------------------------------------------------------------------
Local Address      : 10.10.10.103       Peer Address       : 10.10.10.104
Adjacency Type     : Targeted           State              : Established
Up Time            : 0d 18:26:36        Hold Time Remaining: 38
Hello Mesg Recv    : 76616920           Hello Mesg Sent    : 466580812
Remote Cfg Seq No  : 159                Remote IPv4 Address  : 198.51.100.255
Local Cfg Seq No   : 1674451            Local IPv4  Address  : 198.51.100.1
-------------------------------------------------------------------------------
Interface "to-104"
-------------------------------------------------------------------------------
Local Address      : 10.0.0.103         Peer Address       : 224.0.0.2
Adjacency Type     : Link               State              : Trying

===============================================================================
ALU-12#
```

Table 41 **LDP Discovery Field Descriptions**

Label	Description
Interface Name	The name of the interface
Local Addr	The IP address of the originating (local) router
Peer Addr	The IP address of the peer
Adj Type	The adjacency type between the LDP peer and LDP session
State	Established — indicates that the adjacency is established
	Trying — indicates that the adjacency is not yet established
No. of Hello Adjacencies	The total number of hello adjacencies discovered
Up Time	The amount of time the adjacency has been enabled
Hold-Time Remaining	The time left before a neighbor is declared to be down
Hello Mesg Recv	The number of Hello messages received for this adjacency
Hello Mesg Sent	The number of Hello messages that have been sent for this adjacency
Remote Cfg Seq No	The configuration sequence number that was in the Hello message received when this adjacency started up. This configuration sequence number changes when there is a change of configuration.
Remote IP Address	The IP address used on the remote end for the LDP session
Local Cfg Seq No	The configuration sequence number that was used in the Hello message sent when this adjacency started up. This configuration sequence number changes when there is a change of configuration.
Local IPv4 Address Local IPv6 Address	The IP address used locally for the LDP session

fec-egress-stats

Syntax **fec-egress-stats** [*ip-prefix/mask*]
fec-egress-stats [**active**] [**family**]

Context show>router>ldp

Description This command displays LDP FEC egress statistical information.

Parameters *ip-prefix[/mask]* — the IP prefix and prefix length associated with the prefix FEC

Values

ipv4-prefix:	a.b.c.d
ipv4-prefix-length:	32
ipv6-prefix:	x:x:x:x:x:x:x:x (eight 16-bit pieces) x:x:x:x:x:x:d.d.d.d x - [0 to FFFF]H d - [0 to 255]D
ipv6-prefix-length:	128

active — displays information from all LDP FECs with statistics collection enabled

family — displays either IPv4 or IPv6 LDP information

Values ipv4 or ipv6

Output The following output is an example of LDP FEC egress statistical information.

Output Example

```
e.show>router>ldp>bindings>fec-egress-stats 2.2.2.2/32
===============================================================================
LDP Egress Statistics
===============================================================================
-------------------------------------------------------------------------------
FEC Prefix/Mask    : 10.10.10.29/32
-------------------------------------------------------------------------------
Collect Stats      : Disabled             Accounting Plcy.     : None
Admin State        : Up
FC BE
InProf Pkts        : 0                    OutProf Pkts         : 0
InProf Octets      : 0                    OutProf Octets       : 0
FC L2
InProf Pkts        : 0                    OutProf Pkts         : 0
InProf Octets      : 0                    OutProf Octets       : 0
FC AF
InProf Pkts        : 0                    OutProf Pkts         : 0
InProf Octets      : 0                    OutProf Octets       : 0
FC L1
InProf Pkts        : 0                    OutProf Pkts         : 0
InProf Octets      : 0                    OutProf Octets       : 0
FC H2
InProf Pkts        : 0                    OutProf Pkts         : 0
```

```
InProf Octets      : 0                    OutProf Octets       : 0
FC EF
InProf Pkts        : 0                    OutProf Pkts         : 0
InProf Octets      : 0                    OutProf Octets       : 0
FC H1
InProf Pkts        : 0                    OutProf Pkts         : 0
InProf Octets      : 0                    OutProf Octets       : 0
FC NC
InProf Pkts        : 0                    OutProf Pkts         : 0
InProf Octets      : 0                    OutProf Octets       : 0
-------------------------------------------------------------------------------
LDP Egress Statistics : 1
===============================================================================
```

fec-originate

Syntax **fec-originate** [*ip-address/mask*] [**operation-type**]
fec-originate [**operation-type**] [*family*]

Context show>router>ldp

Description This command displays LDP static prefix FECs.

Parameters *ip-address/mask* — specifies the IP prefix and prefix length

Values *ipv4-address* a.b.c.d (host bits must be 0)
mask 0 to 32

operation-type — specifies the operation type to display

Values pop | swap

family — the address family filter

Values ipv4 or ipv6

Output The following output is an example of FEC originate information, and Table 42 describes the fields.

Output Example

```
*A:ALU-12# show router ldp fec-originate
===============================================================================
LDP Static Prefix FECs
===============================================================================
Prefix             NHType  NextHop       IngLabel     EgrLabel   OperIngLabel
-------------------------------------------------------------------------------
10.1.0.0/16         Pop     n/a           --           --         0
10.1.0.1/32         Pop     n/a           --           --         0
10.1.0.2/32         Pop     n/a           --           --         0
10.1.0.3/32         Pop     n/a           --           --         0
10.1.0.4/32         Pop     n/a           --           --         0
10.1.0.5/32         Pop     n/a           --           --         0
10.1.0.6/32         Pop     n/a           --           --         0
10.1.0.7/32         Pop     n/a           --           --         0
```

```
10.1.0.8/32         Pop     n/a           --           --        0
10.1.0.9/32         Pop     n/a           --           --        0
...
10.251.0.0/16       Pop     n/a           --           --        0
10.252.0.0/16       Pop     n/a           --           --        0
10.253.0.0/16       Pop     n/a           --           --        0
10.254.0.0/16       Pop     n/a           --           --        0
-------------------------------------------------------------------------------
No. of FECs: 508
===============================================================================

===============================================================================
LDP IPv6 Static Prefix FECs
===============================================================================
Prefix              NHType  NextHop       IngLabel     EgrLabel   OperIngLabel
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:ALU-12#
```

Table 42 **FEC-Originate Field Descriptions**

Label	Description
Prefix	The static prefix FEC
NHType	The type of next hop for this entry: Unknown: the next-hop type has not been set IP Addr: the next hop is an IP address Pop: there is no next hop; label is popped and packet routed Unnumbered: the next hop is an unnumbered interface
Next Hop	The IP address of the next hop, or Unnumbered for unnumbered interfaces
IngLabel	The label that is advertised to the upstream peer. If this variable is set to the default value of 4294967295, the ingress label will be dynamically assigned by the label manager.
EgrLabel	The egress label associated with this next-hop entry. The LSR will swap the incoming label with the configured egress label. If this egress label has a value of 4294967295, the LSR will pop the incoming label.
OperIngLabel	The actual or operational value of the label that was advertised to the upstream peer

interface

Syntax **interface** [*ip-int-name* | *ip-address*] [**detail**]

Context show>router>ldp

Description This command displays configuration information about LDP interfaces.

Parameters *ip-int-name* — specifies an existing interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

ip-address — identifies the LDP neighbor by IP address

detail — displays detailed information

Output The following output is an example of LDP interface information, and Table 43 describes the fields.

Output Example

```
A:ALU-12# show router ldp interface
===============================================================================
LDP Interfaces
===============================================================================
Interface                    Adm/Opr   Hello  Hold  KA     KA      Transport
 Sub-Interface<s>             Adm/Opr  Fctr   Time  Fctr   Time    Address
-------------------------------------------------------------------------------
ip-10.10.1.1                  Up/Up
   ipv4                       Up/Dwn  3      15    3      30      System
   ipv6                       Up/Dwn  3      15    3      30      System
-------------------------------------------------------------------------------
No. of Interfaces: 1
===============================================================================
A:ALU-12#

A:ALU-12>show>router>ldp# interface detail
===============================================================================
LDP Interfaces (Detail)
===============================================================================
-------------------------------------------------------------------------------
Interface "back"
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
BASE
-------------------------------------------------------------------------------
Admin State        : Up                 Oper State       : Down
BFD Status         : ipv4
-------------------------------------------------------------------------------
IPv4
-------------------------------------------------------------------------------
IPv4 Admin State:    Up                 IPv4 Oper State   : Down
IPv4 Oper Down Rea*: interfaceDown
Hold Time          : 1000               Hello Factor     : 15
Keepalive Timeout  : 1000               Keepalive Factor : 15
Transport Addr     : System             Last Modified    : 08/08/2007 09:50:15
Active Adjacencies : 0
```

```
Tunneling          : Disabled
Lsp Name           : None

===============================================================================
A:ALU-12>show>router>ldp#
```

Table 43 **LDP Interface Field Descriptions**

Label	Description
Interface	The interface associated with the LDP instance
Adm	Up — indicates that the LDP is administratively enabled
	Down — indicates that the LDP is administratively disabled
Opr	Up — indicates that the LDP is operationally enabled
	Down — indicates that the LDP is operationally disabled
Hello Fctr	The value by which the hello timeout should be divided to give the hello time; that is, the time interval, in seconds, between LDP Hello messages. LDP uses hello messages to discover neighbors and to detect loss of connectivity with its neighbors.
Hold Time	The time interval, in seconds, that LDP waits before declaring a neighbor to be down. Hold time (also known as Hello time) is local to the system and is sent in the hello messages to a neighbor.
KA Fctr	The value by which the keepalive timeout should be divided to give the keepalive time; that is, the time interval, in seconds, between LDP keepalive messages. LDP keepalive messages are sent to keep the LDP session from timing out when no other LDP traffic is being sent between the neighbors.
KA Time	The time interval, in seconds, that LDP waits before tearing down a session. If no LDP messages are exchanged during this time interval, the LDP session is torn down. Generally the value is configured to be three times the keepalive time (the time interval between successive LDP keepalive messages).
Transport Address	The transport address entity
No. of Interfaces	The total number of LDP interfaces
Oper Down Reason	The reason for the LSP being in the down state
Active Adjacencies	The number of active adjacencies
Last Modified	The time of the last modification to the LDP interface
Lsp Name	The LSP name

parameters

Syntax **parameters**

Context show>router>ldp

Description This command displays configuration information about LDP parameters.

Output The following output is an example of LDP parameters information, and Table 44 describes the fields.

Output Example

```
A:ALU-12# show router ldp parameters
===============================================================================
LDP Parameters (IPv4 LSR ID 10.20.1.1:0)
               (IPv6 LSR ID 3ffe::a14:101[0])
===============================================================================
-------------------------------------------------------------------------------
Graceful Restart Parameters
-------------------------------------------------------------------------------
Graceful Restart   : Disabled
Nbor Liveness Time : 120 sec            Max Recovery Time   : 120
-------------------------------------------------------------------------------
IPv4 Interface Parameters
-------------------------------------------------------------------------------
Keepalive Timeout  : 30 sec             Keepalive Factor    : 3
Hold Time          : 15 sec             Hello Factor        : 3
Transport Address  : system
-------------------------------------------------------------------------------
IPv6 Interface Parameters
-------------------------------------------------------------------------------
Keepalive Timeout  : 30 sec             Keepalive Factor    : 3
Hold Time          : 15 sec             Hello Factor        : 3
Transport Address  : system
-------------------------------------------------------------------------------
Targeted Session Parameters
-------------------------------------------------------------------------------
Import Pfx Policies: None               Export Pfx Policies : None
Prefer Tunl-in-Tunl: Disabled           SDP Auto Targ Sess  : Enabled
-------------------------------------------------------------------------------
IPv4 Targeted Session Parameters
-------------------------------------------------------------------------------
Keepalive Timeout  : 30 sec             Keepalive Factor    : 3
Hold Time          : 15 sec             Hello Factor        : 3
Hello Reduction    : Disabled           Hello Reduction Fctr: 3
-------------------------------------------------------------------------------
IPv6 Targeted Session Parameters
-------------------------------------------------------------------------------
Keepalive Timeout  : 40 sec             Keepalive Factor    : 4
Hold Time          : 45 sec             Hello Factor        : 3
Hello Reduction    : Disabled           Hello Reduction Fctr: 3
===============================================================================
A:ALU-12A#
```

Table 44 **LDP Parameters Field Descriptions**

Label	Description
Graceful Restart Parameters	
Nbor Liveliness Time	The neighbor liveness time
Max Recovery Time	The local maximum recovery time
IPv4 Interface Parameters **IPv6 Interface Parameters**	
Keepalive Timeout	The time interval, in seconds, that LDP waits before tearing down a session. If no LDP messages are exchanged during this time interval, the LDP session is torn down. Generally the value is configured to be three times the keepalive time (the time interval between successive LDP keepalive messages).
Keepalive Factor	The value by which the keepalive timeout should be divided to give the keepalive time; that is, the time interval, in seconds, between LDP keepalive messages. LDP keepalive messages are sent to keep the LDP session from timing out when no other LDP traffic is being sent between the neighbors.
Hold Time	The time interval, in seconds, that LDP waits before declaring a neighbor to be down. Hold time (also known as Hello time) is local to the system and is sent in the hello messages to a neighbor.
Hello Factor	The value by which the hello timeout should be divided to give the hello time; that is, the time interval, in seconds, between LDP Hello messages. LDP uses hello messages to discover neighbors and to detect loss of connectivity with its neighbors.
Propagate Policy	Specifies whether the LSR should generate FECs and which FECs it should generate
	system — indicates that the LDP will distribute label bindings only for the router's system IP address
	interface — indicates that the LDP will distribute label bindings for all LDP interfaces
	all — indicates that the LDP will distribute label bindings for all prefixes in the routing table
	none — indicates that the LDP will not distribute any label bindings

Table 44 **LDP Parameters Field Descriptions (Continued)**

Label	Description
Transport Address	interface — the interface IP address is used to set up the LDP session between neighbors. If multiple interfaces exist between two neighbors, the interface mode cannot be used since only one LDP session is actually set up between the two neighbors.
	system — the system IP address is used to set up the LDP session between neighbors
Label-Distribution	The label distribution method
Label-Retention	liberal — all advertised label mappings are retained whether they are from a valid next hop or not. When the label distribution value is downstream unsolicited, a router may receive label bindings for the same destination for all its neighbors. Labels for the non-next-hops for the FECs are retained in the software but not used. When a network topology change occurs where a non-next-hop becomes a true next hop, the label received earlier is then used.
	conservative — advertised label mappings are retained only if they will be used to forward packets; for example if the label came from a valid next hop. Label bindings received from non-next-hops for each FEC are discarded.
Control Mode	ordered — label bindings are not distributed in response to a label request until a label binding has been received from the next hop for the destination
	independent — label bindings are distributed immediately in response to a label request even if a label binding has not yet been received from the next hop for the destination
Route Preference	The route preference assigned to LDP routes. When multiple routes are available to a destination, the route with the lowest preference will be used. This value is only applicable to LDP interfaces and not for targeted sessions.
IPv4 Targeted Session Parameters **IPv6 Targeted Session Parameters**	
Keepalive Timeout	The factor used to derive the keepalive interval
Keepalive Factor	The time interval, in seconds, that LDP waits before tearing down the session
Hold Time	The time left before a neighbor is declared to be down

Table 44 **LDP Parameters Field Descriptions (Continued)**

Label	Description
Hello Factor	The value by which the hello timeout should be divided to give the hello time; that is, the time interval, in seconds, between LDP Hello messages. LDP uses hello messages to discover neighbors and to detect loss of connectivity with its neighbors.
	Disable — indicates that no authentication is being used
Passive Mode	True — indicates that LDP responds only when it gets a connect request from a peer and will not attempt to actively connect to its neighbors
	False — indicates that LDP actively tries to connect to its peers
Targeted Sessions	Enabled — indicates that targeted sessions are enabled
	Disabled — indicates that targeted sessions are disabled

session

Syntax **session** [*ip-addr* [**:***label-space*]] **local-addresses** [**sent** | **recv**] **ip-addr** *ip-address*
session [*ip-addr* [**:***label-space*]] [**session-type**] [**state** *state*] [**detail** | **summary**]
session [*ip-addr* [**:***label-space*]] **local-addresses** [**sent** | **recv**] [*family*]
session [*ip-addr* [**:***label-space*]] **statistics** [*packet-type*] [**session-type**]
session statistics [*packet-type*] [**session-type**] [*family*]
session [**session-type**] [**state** *state*] [**detail** | **summary**] [*family*]

Context show>router>ldp

Description This command displays configuration information about LDP sessions.

Parameters *ip-addr* — specifies the IP address of the LDP peer

label-space — specifies the label space identifier that the router is advertising on the interface

Values 0 to 65535

detail — displays detailed information

summary — displays summary information

ip-address — specifies the IP address

state — specifies the current operational state of the adjacency

Values established, trying, down

packet-type — specifies the packet type

Values hello, keepalive, init, label, notification, address

family — displays either IPv4 or IPv6 LDP session information

session-type — specifies the session type

Values link, targeted, both

Output The following output is an example of LDP session information, and Table 45 describes the fields.

Output Example

```
ALU-12# show router ldp session
===============================================================================
LDP IPv4 Sessions
===============================================================================
Peer LDP Id           Adj Type State        Msg Sent  Msg Recv  Up Time
-------------------------------------------------------------------------------
10.10.10.104:0        Targeted Established  13943      13947      0d 21:12:41
-------------------------------------------------------------------------------
No. of IPv4 Sessions: 1

===============================================================================
LDP IPv6 Sessions
===============================================================================
Peer LDP Id
 Adj Type             State          Msg Sent       Msg Recv       Up Time
-------------------------------------------------------------------------------
3ffe::a14:102[0]
  Link                Established    1788           1792           0d 01:19:19
3ffe::a14:103[0]
  Link                Established    1789           1788           0d 01:19:19
-------------------------------------------------------------------------------
No. of IPv6 Sessions: 2
===============================================================================
ALU-12#

ALU-12# show router ldp session detail
===============================================================
LDP IPv4 Sessions (Detail)
===============================================================
Session with Peer 10.1.1.33:0
-------------------------------------------------------------------------------
Adjacency Type    : Link           State                 : Established
Up Time           : 0d 00:03:51
Max PDU Length    : 4096           KA/Hold Time Remaining: 26
Link Adjacencies  : 1              Targeted Adjacencies  : 0
Local Address     : 10.1.1.30      Peer Address          : 10.1.1.33
Local TCP Port    : 646            Peer TCP Port         : 50232
Local KA Timeout  : 30             Peer KA Timeout       : 30
Mesg Sent         : 89             Mesg Recv             : 126
FECs Sent         : 3              FECs Recv             : 3
GR State          : Not Capable
Nbr Liveness Time : 0              Max Recovery Time     : 0
Number of Restart : 0              Last Restart Time     : Never
Advertise         : Address
-------------------------------------------------------------------------------
Session with Peer 10.1.1.57:0
-------------------------------------------------------------------------------
```

```
Adjacency Type    : Targeted       State                 : Established
Up Time           : 0d 00:03:49
Max PDU Length    : 4096           KA/Hold Time Remaining: 36
Link Adjacencies  : 0              Targeted Adjacencies  : 1
Local Address     : 10.1.1.30      Peer Address          : 10.1.1.57
Local TCP Port    : 646            Peer TCP Port         : 49574
Local KA Timeout  : 40             Peer KA Timeout       : 40
Mesg Sent         : 55             Mesg Recv             : 61
FECs Sent         : 11             FECs Recv             : 8
GR State          : Not Capable
Nbr Liveness Time : 0              Max Recovery Time     : 0
Number of Restart : 0              Last Restart Time     : Never
Advertise         : Address/Servi*
===============================================================
ALU-12#
```

Table 45 **LDP Session Field Descriptions**

Label	Description
Peer LDP Id	The IP address of the LDP peer
Adj Type	The adjacency type between the LDP peer and LDP session that is targeted
	Link — specifies that this adjacency is a result of a Link Hello
	Targeted — specifies that this adjacency is a result of a Targeted Hello
State	Established — the adjacency is established
	Trying — the adjacency is not yet established
Msg Sent	The number of messages sent
Msg Rcvd	The number of messages received
Up Time	The amount of time the adjacency has been enabled

session-parameters

Syntax **session-parameters** [*family*]
session-parameters [*peer-ip-address*]

Context show>router>ldp

Description This command displays LDP peer information.

Parameters *family* — the address family filter

Values ipv4 or ipv6

peer-ip-address — specifies the peer IP address

Output The following output is an example of LDP session-parameters information.

Output Example

```
A:ALU-12# show router ldp session-parameters
===============================================================================
LDP IPv4 Session Parameters
===============================================================================
-------------------------------------------------------------------------------
Peer : 10.2.3.4
-------------------------------------------------------------------------------
DOD                : Disabled          Adv Adj Addr Only  : Disabled
FEC129             : Disabled
Fec Limit          : 0                 Fec Limit Threshold: 90
Fec Limit Log Only : Disabled
Import Policies    : None              Export Policies    : None
IPv4 Prefix Fec Cap: Enabled           IPv6 Prefix Fec Cap: Enabled
P2MP Fec Cap       : Enabled
Address Export     : None
===============================================================================
No. of IPv4 Peers: 1
===============================================================================
* indicates that the corresponding row element may have been truncated.
===============================================================================
LDP IPv6 Session Parameters
===============================================================================
No Matching Entries Found
===============================================================================
```

status

Syntax **status**

Context show>router>ldp

Description This command displays LDP status information.

Output The following output is an example of LDP status information, and Table 46 describes the fields.

Output Example

```
A:ALU-12# show router ldp status

 ===============================================================================
 LDP Status for IPv4 LSR ID 2.2.2.2
                IPv6 LSR ID ::
 ===============================================================================
 Created at          : 10/18/17 13:08:17
 Last Change         : 10/18/17 13:08:17
 Admin State         : Up
 IPv4 Oper State     : Up                    IPv6 Oper State      : Up
 IPv4 Up Time        : 1d 01:35:18           IPv6 Up Time         : 1d 01:35:18
 IPv4 Oper Down Rea*: n/a                    IPv6 Oper Down Reason: n/a
```

```
IPv4 Oper Down Eve*: 0                    IPv6 Oper Down Events: 0
Tunn Down Damp Time: 3 sec                Weighted ECMP        : Disabled
Label Withdraw Del*: 0 sec                Implicit Null Label  : Disabled
Short. TTL Local   : Enabled              Short. TTL Transit   : Enabled
ConsiderSysIPByPol*: Disabled
Import Policies    : None                 Export Policies      : None
Tunl Exp Policies  : None
FRR                : Disabled             Mcast Upstream FRR   : Disabled
Mcast Upst ASBR FRR: Disabled
MP MBB Time        : 3
Aggregate Prefix   : False                Agg Prefix Policies  : None
Class Forwarding   : Disabled
Legacy LSR Interop : False
Entropy Label Capa*: False
Generate Basic FEC : Disabled
Resolve Via Mcast *: Disabled
-------------------------------------------------------------------------------
Capabilities
-------------------------------------------------------------------------------
Dynamic            : Enabled              P2MP                 : Enabled
IPv4 Prefix Fec    : Enabled              IPv6 Prefix Fec      : Enabled
Service Fec128     : Enabled              Service Fec129       : Enabled
MP MBB             : Enabled              Overload             : Enabled
Unrecognized Notif*: Enabled
===============================================================================
* indicates that the corresponding row element may have been truncated.
```

Table 46 **LDP Status Field Descriptions**

Label	Description
Created at	The date and time that the LDP instance was created
Last Change	The date and time that the LDP instance was last modified
Admin State	Up — indicates that LDP is administratively enabled
	Down — indicates that LDP is administratively disabled
IPv4 Oper State IPv6 Oper State	Up — indicates that LDP is operationally enabled
	Down — indicates that LDP is operationally disabled
IPv4 Up Time IPv6 Up Time	The time, in hundredths of seconds, that the LDP instance has been operationally up
IPv4 Oper Down Time IPv6 Oper Down Time	The time, in hundredths of seconds, that the LDP instance has been operationally down
IPv4 Oper Down Events IPv6 Oper Down Events	The number of times the LDP instance has gone operationally down since the instance was created
Import Policies	The import policy associated with the LDP instance

Table 46 **LDP Status Field Descriptions (Continued)**

Label	Description
Active Adjacencies	The number of active adjacencies (established sessions) associated with the LDP instance
Active Sessions	The number of active sessions (session in some form of creation) associated with the LDP instance
Active Interfaces	The number of active (operationally up) interfaces associated with the LDP instance
Inactive Interfaces	The number of inactive (operationally down) interfaces associated with the LDP instance
Active Peers	The number of active LDP peers
Inactive Peers	The number of inactive LDP peers
Addr FECs Sent	The number of labels that have been sent to the peer associated with this FEC
Addr FECs Recv	The number of labels that have been received from the peer associated with this FEC
Serv FECs Sent	The number of labels that have been sent to the peer associated with this FEC
Serv FECs Recv	The number of labels that have been received from the peer associated with this FEC
Attempted Sessions	The total number of attempted sessions for this LDP instance
No Hello Err	The total number of “Session Rejected” or “No Hello Error” notification messages sent or received by this LDP instance
Param Adv Err	The total number of “Session Rejected” or “Parameters Advertisement Mode Error” notification messages sent or received by this LDP instance
Max PDU Err	The total number of “Session Rejected” or “Parameters Max PDU Length Error” notification messages sent or received by this LDP instance
Label Range Err	The total number of “Session Rejected” or “Parameters Label Range Error” notification messages sent or received by this LDP instance
Bad LDP Id Err	The number of bad LDP identifier fatal errors detected for sessions associated with this LDP instance
Bad PDU Len Err	The number of bad PDU length fatal errors detected for sessions associated with this LDP instance

Table 46 **LDP Status Field Descriptions (Continued)**

Label	Description
Bad Mesg Len Err	The number of bad message length fatal errors detected for sessions associated with this LDP instance
Bad TLV Len Err	The number of bad TLV length fatal errors detected for sessions associated with this LDP instance
Malformed TLV Err	The number of malformed TLV value fatal errors detected for sessions associated with this LDP instance
Keepalive Expired Err	The number of session keepalive timer expired errors detected for sessions associated with this LDP instance
Shutdown Notif Sent	The number of shutdown notifications sent related to sessions associated with this LDP instance
Shutdown Notif Recv	The number of shutdown notifications received related to sessions associated with this LDP instance

targ-peer

Syntax **targ-peer** [*ip-address*] [**detail**]
targ-peer [**detail**] [*family*]

Context show>router>ldp

Description This command displays configuration information about LDP targeted peers.

Parameters *ip-address* — specifies the IP address of the LDP peer

detail — displays detailed information

family — the address family filter

Values ipv4 or ipv6

Output The following output is an example of LDP peer information, and Table 47 describes the fields.

Output Example

```
A:ALU-12# show router ldp targ-peer
===============================================================================
LDP IPv4 Targeted Peers
===============================================================================
Peer                 Adm/   Hello   Hold    KA      KA       Passive   Auto
                     Opr    Fctr    Time    Fctr    Time     Mode      Created
-------------------------------------------------------------------------------
10.10.10.93          Up/Up  3       45      4       40       Disabled  Yes
10.10.10.104         Up/Up  3       45      4       40       Disabled  Yes
```

```
-------------------------------------------------------------------------------
No. of IPv4 Targeted Peers: 2
===============================================================================

===============================================================================
LDP IPv6 Targeted Peers
===============================================================================
Peer                                  Adm/     Hello Hold  KA   KA    Auto
                                      Opr      Fctr  Time  Fctr Time  Created
-------------------------------------------------------------------------------
3ffe::a0a:203                        Up/Up   3     15    3    30    no

-------------------------------------------------------------------------------
No. of IPv6 Targeted Peers: 1
===============================================================================
A:ALU-12#

A:ALU-12# show router ldp targ-peer detail
===============================================================================
LDP IPv4 Targeted Peers (Detail)
===============================================================================
-------------------------------------------------------------------------------
Peer 10.2.3.4
-------------------------------------------------------------------------------
Admin State        : Up              Oper State           : Down
Hold Time          : 45              Hello Factor         : 3
Keepalive Timeout  : 40              Keepalive Factor     : 4
Passive Mode       : Disabled        Last Modified        : 05/01/2008 21:44:17
Active Adjacencies : 0               Auto Created         : No
Tunneling          : None
Lsp Name           : None
===============================================================================
No. of IPv4 Targeted Peers: 1
===============================================================================

===============================================================================
LDP IPv6 Targeted Peers
===============================================================================
No Matching Entries Found
===============================================================================
A:ALU-12#
```

Table 47 LDP Targeted Peer Field Descriptions

Label	Description
Peer	The IP address of the peer
Adm	Up — indicates that LDP is administratively enabled
	Down — indicates that LDP is administratively disabled
Opr	Up — indicates that LDP is operationally enabled
	Down — indicates that LDP is operationally disabled

Table 47 **LDP Targeted Peer Field Descriptions (Continued)**

Label	Description
Hello Factor	The value by which the hello timeout should be divided to give the hello time; that is, the time interval, in seconds, between LDP Hello messages. LDP uses hello messages to discover neighbors and to detect loss of connectivity with its neighbors.
Hold Time	The time interval, in seconds, that LDP waits before declaring a neighbor to be down. Hold time (also known as Hello time) is local to the system and is sent in the hello messages to a neighbor.
Keepalive Factor	The value by which the keepalive timeout should be divided to give the keepalive time; that is, the time interval, in seconds, between LDP keepalive messages. LDP keepalive messages are sent to keep the LDP session from timing out when no other LDP traffic is being sent between the neighbors.
Keepalive Timeout	The time interval, in seconds, that LDP waits before tearing down a session. If no LDP messages are exchanged during this time interval, the LDP session is torn down. Generally the value is configured to be three times the keepalive time (the time interval between successive LDP keepalive messages).
Passive Mode	The mode used to set up LDP sessions. This value is only applicable to targeted sessions and not to LDP interfaces. This mode is always set to False.
	True — indicates that LDP responds only when it gets a connect request from a peer and will not attempt to actively connect to its neighbors
	False — indicates that LDP actively tries to connect to its peers
Auto Create	Specifies whether a targeted peer was automatically created through a Service Manager. For an LDP interface, this value is always false.
No. of Peers	The total number of LDP peers
LSP	The LSP name

tcp-session-parameters

Syntax **tcp-session-parameters** [*family*]
tcp-session-parameters [**keychain** *keychain*]
tcp-session-parameters *transport-peer-ip-address*

Context show>router>ldp

Description This command displays information about the TCP transport session of an LDP peer.

Parameters *family* — displays either IPv4 or IPv6 LDP session information

keychain — specifies the authentication keychain name up to 32 characters in length

Values ipv4 or ipv6

transport-peer-ip-address — specifies the IP address of the transport peer

Output The following output is an example of TCP session parameter information.

Output Example

```
*A:Dut-A# show router ldp tcp-session-parameters
===============================================================================
LDP IPv4 TCP Session Parameters
===============================================================================
-------------------------------------------------------------------------------
Peer Transport: 10.20.1.2
-------------------------------------------------------------------------------
Authentication Key : Disabled Path MTU Discovery : Disabled
Auth key chain : LdpAuth Min-TTL : 0
-------------------------------------------------------------------------------
Peer Transport: 10.20.1.3
-------------------------------------------------------------------------------
Authentication Key : Disabled Path MTU Discovery : Disabled
Auth key chain : LdpAuth Min-TTL : 0
===============================================================================
No. of IPv4 Peers: 2
===============================================================================
===============================================================================
LDP IPv6 TCP Session Parameters
===============================================================================
-------------------------------------------------------------------------------
Peer Transport: 3ffe::a14:102
-------------------------------------------------------------------------------
Authentication Key : Disabled Path MTU Discovery : Disabled
Auth key chain : LdpAuth Min-TTL : 0
-------------------------------------------------------------------------------
Peer Transport: 3ffe::a14:103
-------------------------------------------------------------------------------
Authentication Key : Disabled Path MTU Discovery : Disabled
Auth key chain : LdpAuth Min-TTL : 0
===============================================================================
No. of IPv6 Peers: 2
===============================================================================
```

5.12.2.2.2 Show Router LDP Bindings Commands

bindings

Syntax **bindings**

Context show>router>ldp

Description This command shows LDP bindings information. The **bindings** command can be used with the following keywords:

- active: displays LDP active bindings
- detail: displays details of LDP bindings
- ipv4: displays LDP IPv4 bindings
- ipv6: displays LDP IPv6 bindings
- label-type: displays LDP FEC bindings by matching labels
- p2mp: displays LDP P2MP FEC bindings
- prefixes: displays LDP prefix FEC bindings
- services: displays LDP service FEC bindings
- session: displays LDP FEC bindings by matching peer LSR ID
- summary: displays summary of LDP bindings

Output The following output is an example of LDP bindings parameter information, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>ldp# bindings
===============================================================================
LDP Bindings (IPv4 LSR ID 2.2.2.2)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value),
                                          H - Hpipe Service
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP IPv4 Prefix Bindings
===============================================================================
Prefix                                  IngLbl                    EgrLbl
Peer                                    EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
10.1.1.1/32                                --                     131071
10.1.1.1:0                              1/1/1:100
10.1.1.1
```

```
10.2.2.2/32                                131071U                    --
10.1.1.1:0                                    --
  --
-------------------------------------------------------------------------------
No. of IPv4 Prefix Bindings: 2
===============================================================================
===============================================================================
LDP IPv6 Prefix Bindings
===============================================================================
Prefix                                     IngLbl                     EgrLbl
Peer                                       EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
3ffe::a14:101/128                          262142U                     --
3ffe::a14:102[0]                             --
-------------------------------------------------------------------------------
No. of IPv6 Prefix Bindings: 2
===============================================================================
===============================================================================
LDP Generic IPv4 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                   Interface       IngLbl    EgrLbl
EgrNH                                      EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Generic IPv6 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                   Interface       IngLbl    EgrLbl
EgrNH                                      EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv4 P2MP Bindings
===============================================================================
Source
Group
RootAddr                                   Interface       IngLbl    EgrLbl
EgrNH                                      EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv6 P2MP Bindings
===============================================================================
Source
Group
RootAddr                                   Interface       IngLbl    EgrLbl
EgrNH                                      EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
```

```
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings
===============================================================================
Source
Group                                     RD
RootAddr                                  Interface       IngLbl    EgrLbl
EgrNH                                     EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv6 P2MP Bindings
===============================================================================
Source
Group                                     RD
RootAddr                                  Interface       IngLbl    EgrLbl
EgrNH                                     EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv4 P2MP Bindings
===============================================================================
RootAddr
InnerRootAddr
Source
Group                                     Interface       IngLbl    EgrLbl
EgrNH                                     EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv6 P2MP Bindings
===============================================================================
RootAddr
InnerRootAddr
Source
Group                                     Interface       IngLbl    EgrLbl
EgrNH                                     EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv4 P2MP Bindings
===============================================================================
P2MP-Id                                   RD
RootAddr                                  Interface
InnerRootAddr                                             IngLbl    EgrLbl
EgrNH                                     EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
```

```
LDP VPN Recursive with Generic IPv6 P2MP Bindings
===============================================================================
P2MP-Id                                     RD
RootAddr                                    Interface
InnerRootAddr                                                IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv4 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                    Interface       IngLbl    EgrLbl
InnerRootAddr
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv6 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                    Interface       IngLbl    EgrLbl
InnerRootAddr
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type                                          VCId       SDPId     IngLbl  LMTU
Peer                                          SvcId                EgrLbl  RMTU
-------------------------------------------------------------------------------
?-Eth                                         10         R. Src      --    None
10.1.1.1:0                                    Ukwn                 131070D 1500
-------------------------------------------------------------------------------
No. of VC Labels: 1
===============================================================================
===============================================================================
LDP Service FEC 129 Bindings
===============================================================================
SAII                                            AGII        IngLbl    LMTU
TAII                                            Type        EgrLbl    RMTU
Peer                                            SvcId       SDPId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#
```

Table 48 **LDP Bindings Field Descriptions**

Label	Description	
Legend	U: Label In Use N: Label Not In Use W: Label Withdrawn S: Status Signaled Up D: Status Signaled Down E: Epipe Service V: VPLS Service M: Mirror Service A: Apipe Service F: Fpipe Service	I: IES Service R: VPRN service P: Ipipe Service WP: Label Withdraw Pending C: Cpipe Service BU: Alternate for Fast Re-Route TLV: (Type, Length: Value) H: Hpipe LF: Lower FEC UF: Upper FEC
Type	The service type exchanging labels in the SDP. The possible types displayed are Epipe, Spoke, and Unknown.	
VCId	The value used by each end of an SDP tunnel to identify the VC	
SvcID	Identifies the service in the service domain	
SDPId	Identifies the SDP in the service domain	
Peer	The IP address of the peer	
IngLbl	The ingress LDP label	
	U — indicates that the label is in use	
	R — indicates that the label has been released	
EgrLbl	The egress LDP label	
LMTU	The local MTU value	
RMTU	The remote MTU value	
No. of Prefix Bindings	The total number of LDP bindings on the router	
EgrIntf/LspId	The egress interface LSP ID	
EgrNextHop	The egress next-hop address, or Unnumbered for unnumbered interfaces	
AGI Type	The address group identifier (AGI)	
SAII Peer	The source attachment individual identifier (SAII)	
TAII EgrLbl	The target attachment individual identifier (TAII)	
Prefix	The FEC address	

Table 48 **LDP Bindings Field Descriptions (Continued)**

Label	Description
P2MP-Id	The Internal identifier of Point to Multi-point LSP
RootAddr	The Root Address (only IPV4)
Interface	The Logical Interface ID
EgrNH	The egress next-hop address
Source	The Source Address
Group	The Multicast Group address
InnerRootAddr	The Inner Root Address
No. of VC Labels	The total number of VC labels
No. of Service Bindings	The total number of service bindings
Vc-switching	Not applicable – always indicates No
Egr. Flags	Specifies the egress flags, if any
Egr. Ctl Word	Indicates whether egress control words are used
Egr. Status Bits	Indicates whether egress status bits are supported
Egr If Name	The egress interface name
Ing. Flags	Specifies the ingress flags, if any
Ing. Ctl Word	Indicates whether ingress control words are used
Ing. Status Bits	Indicates whether ingress status bits are supported
Metric	The metric of the LSP
Mtu	The size of the MTU for the global FEC or tunnel to which the LDP binding is applied
Op	The operation performed on the ingress or egress label in the LDP stack (push or pop)

active

Syntax **active detail** [*family*] [**egress-if** *port-id*]
active detail [*family*] [**egress-lsp** *tunnel-id*]
active detail [**egress-nh** *ip-address*] [*family*]
active egress-if *port-id* [**summary** | **detail**] [*family*]
active egress-lsp *tunnel-id* [**summary** | **detail**] [*family*]
active egress-nh [*family*] [**summary** | **detail**] *ip-address*
active ipv4 [**summary** | **detail**] [**egress-if** *port-id*]
active ipv4 [**summary** | **detail**] [**egress-lsp** *tunnel-id*]
active ipv4 [**summary** | **detail**] [**egress-nh** *ip-address*]
active ipv6 [**summary** | **detail**] [**egress-if** *port-id*]
active ipv6 [**summary** | **detail**] [**egress-nh** *ip-address*]
active ipv6 [**summary** | **detail**] [**egress-lsp** *tunnel-id*]
active p2mp p2mp-id *identifier* **root** *ip-address* [**summary** | **detail**] [**egress-if** *port-id*]
active p2mp p2mp-id *identifier* **root** *ip-address* [**summary** | **detail**] [**egress-lsp** *tunnel-id*]
active p2mp p2mp-id *identifier* **root** *ip-address* [**summary** | **detail**] [**egress-nh** *ip-address*]
active p2mp [*family*] [**summary** | **detail**] [**egress-if** *port-id*] [**opaque-type** *opaque-type*]
active p2mp [*family*] [**summary** | **detail**] [**egress-lsp** *tunnel-id*] [**opaque-type** *opaque-type*]
active p2mp [*family*] [**summary** | **detail**] [**egress-nh** *ip-address*] [**opaque-type** *opaque-type*]
active p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**summary** | **detail**] [**egress-if** *port-id*] **inner-root** *ip-address*
active p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**summary** | **detail**] [**egress-lsp** *tunnel-id*] **inner-root** *ip-address*
active p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**summary** | **detail**] [**egress-nh** *ip-address*] **inner-root** *ip-address*
active p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**rd** *rd*] [**summary** | **detail**] [**egress-if** *port-id*]
active p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**rd** *rd*] [**summary** | **detail**] [**egress-lsp** *tunnel-id*]
active p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**rd** *rd*] [**summary** | **detail**] [**egress-nh** *ip-address*]
active p2mp source *ip-address* **group** *mcast-address family* [**rd** *rd*] [**summary** | **detail**] [**innermost-root** *ip-address*]
active prefixes [*family*] [**summary** | **detail**] [**egress-if** *port-id*]
active prefixes [*family*] [**summary** | **detail**] [**egress-lsp** *tunnel-id*]
active prefixes [**egress-nh** *ip-address*] [*family*] [**summary** | **detail**]
active prefixes prefix *ip-prefix*/*ip-prefix-length* [**summary** | **detail**] [**egress-if** *port-id*]
active prefixes prefix *ip-prefix/ip-prefix-length* [**summary** | **detail**] [**egress-lsp** *tunnel-id*]
active prefixes prefix *ip-prefix/ip-prefix-length* [**egress-nh** *ip-address*] [**summary** | **detail**]
active summary [*family*] [**egress-if** *port-id*]
active summary [*family*] [**egress-lsp** *tunnel-id*]
active summary [**egress-nh** *ip-address*] [*family*]

Context show>router>ldp>bindings

Description This command displays information about LDP active bindings.

Parameters **detail** — displays detailed information

summary — displays information in a summarized format

family — displays either IPv4 or IPv6 active LDP information

Values ipv4 or ipv6

egress-if *port-id* — displays LDP active bindings by matching **egress-if**

Values *slot*[/*mda*[/*port*]] or *slot*/*mda*/*port*[.*channel*]
aps-id : **aps**-*group-id*[.*channel*]
group-id : 1 to 24]
mw-link-id **: mw-link**-*link-num*
link-num : 1 to 24

egress-lsp *tunnel-id* — displays LDP active bindings by matching on the egress RSVP-TE LSP *tunnel-id* for LDP FECs that are tunneled over an RSVP-TE LSP. The *tunnel-id* for the RSVP-TE LSP can be found in the output of the **show router mpls lsp detail** command and in the **show router tunnel-table** command. It is not the **Path LSP ID** shown in the output of the **show router mpls lsp path detail** command.

Values 0 to 4294967295

egress-nh *ip-address* — displays LDP active bindings by matching **egress-nh**

Values

ipv4-address	a.b.c.d
ipv6-address	x:x:x:x:x:x:x:x (eight 16-bit pieces)
	x:x:x:x:x:x:d.d.d.d
	x - [0 to FFFF]H
	d - [0 to 255]D

opaque-type *opaque-type* — specifies the type of a multipoint opaque value element

Values generic, ssm, vpn-ssm, recursive-ssm, vpn-recursive, grt-recursive

inner-root *ip-address* — displays recursive FECs whose inner root address matches the specified address

innermost-root *ip-address* — displays recursive FECs whose inner root address matches the specified address and non-recursive FECs that have a root address that matches the specified address

p2mp source *ip-address* — displays LDP active P2MP source bindings

Values

ipv4-address	a.b.c.d
ipv6-address	x:x:x:x:x:x:x:x (eight 16-bit pieces)
	x:x:x:x:x:x:d.d.d.d
	x - [0 to FFFF]H
	d - [0 to 255]D

p2mp-id *identifier* — displays LDP active P2MP identifier bindings

Values 0 to 4294967295

group *mcast-address* — displays the P2MP group multicast address bindings

Values ipv4-mcast-addr or ipv6-mcast-addr

root *ip-address* — displays root IP address information

rd *rd* — displays information for the route distinguisher

Values *rd* : *ip-addr:comm-val* or *2byte-asnumber:ext-comm-val* or *4byte-asnumber:comm-val*

prefix *ip-prefix/ip-prefix-length* — displays information for the specified IP prefix and mask length

Values

ipv4-address	a.b.c.d
ipv4-prefix-length	0 to 32
ipv6-address	x:x:x:x:x:x:x:x (eight 16-bit pieces)
	x:x:x:x:x:x:d.d.d.d
	x - [0 to FFFF]H
	d - [0 to 255]D
ipv6-prefix-length	0 to 128

Output The following output is an example of LDP active bindings information, and Table 48 describes the fields.

Output Example: bindings active

```
*A:Sar18 Dut-B>show>router>ldp# bindings active
===============================================================================
LDP Bindings (IPv4 LSR ID 10.20.1.3:0)
             (IPv6 LSR ID 3ffe::a14:103[0])
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate For Fast Re-Route
        LF - Lower FEC, UF - Upper FEC
        (S) - Static           (M) - Multi-homed Secondary Support
        (B) - BGP Next Hop     (BU) - Alternate Next-hop for Fast Re-Route
        (I) - SR-ISIS Next Hop (O) - SR-OSPF Next Hop
```

```
===============================================================================
LDP IPv4 Prefix Bindings (Active)
===============================================================================
Prefix                                  Op              IngLbl    EgrLbl
EgrNextHop                              EgrIf/LspId
-------------------------------------------------------------------------------
10.20.1.1/32                            Push              --      262143
10.10.2.1                               1/1/1

10.20.1.1/32                            Swap            262141    262143
10.10.2.1                               1/1/1
-------------------------------------------------------------------------------
No. of IPv4 Prefix Active Bindings: 2
===============================================================================
===============================================================================
LDP IPv6 Prefix Bindings (Active)
===============================================================================
Prefix                                     Op              IngLbl    EgrLbl
EgrNextHop                                 EgrIf/LspId
-------------------------------------------------------------------------------
3ffe::a14:101/128                          Push              --      262142
fe80::21                                   1/1/1

3ffe::a14:101/128                          Swap            262136    262142
fe80::21                                   1/1/1
-------------------------------------------------------------------------------
No. of IPv6 Prefix Active Bindings: 2
===============================================================================
===============================================================================
LDP In-Band-SSM IPv6 P2MP Bindings (Active)
===============================================================================
Source
Group                                   Interface
RootAddr                                Op              IngLbl    EgrLbl
EgrNH                                   EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv4 P2MP Bindings (Active)
===============================================================================
RootAddr
InnerRootAddr
Source                                  Interface
Group                                   Op              IngLbl    EgrLbl
EgrNH                                   EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv6 P2MP Bindings (Active)
===============================================================================
RootAddr
InnerRootAddr
Source                                  Interface
Group                                   Op              IngLbl    EgrLbl
EgrNH                                   EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
```

```
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings (Active)
===============================================================================
Source
Group                                     RD              Op
RootAddr                                  Interface       IngLbl    EgrLbl
EgrNH                                     EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv6 P2MP Bindings (Active)
===============================================================================
Source
Group                                     RD              Op
RootAddr                                  Interface       IngLbl    EgrLbl
EgrNH                                     EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
VPN Recursive with Generic IPv4 P2MP Bindings (Active)
===============================================================================
P2MP-Id                                   Interface
RootAddr                                  Op              IngLbl    EgrLbl
InnerRootAddr                             RD
EgrNH                                     EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv6 P2MP Bindings (Active)
===============================================================================
P2MP-Id                                   Interface
RootAddr                                  Op              IngLbl    EgrLbl
InnerRootAddr                             RD
EgrNH                                     EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv4 P2MP Bindings (Active)
===============================================================================
P2MP-Id                                   Interface
RootAddr                                  Op              IngLbl    EgrLbl
InnerRootAddr
EgrNH                                     EgrIf/LspId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv6 P2MP Bindings (Active)
===============================================================================
P2MP-Id                                   Interface
RootAddr                                  Op              IngLbl    EgrLbl
InnerRootAddr
EgrNH                                     EgrIf/LspId
-------------------------------------------------------------------------------
```

```
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#
```

detail

Syntax **detail** [**session** *ip-addr* [*label-space*]] [*family*]

Context show>router>ldp>bindings

Description This command displays details of LDP bindings.

Parameters *family* — displays either IPv4 or IPv6 LDP information

session *ip-addr*[*label-space*] — specifies the IP address and label space identifier

Values

ip-addr[*label-spa**	: *ipv4-address*:*label-space*
	ipv6-address[*label-space*]
label-space	: 0 to 65535]

Output The following output is an example of detailed LDP bindings information, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>ldp# bindings active detail
===============================================================================
LDP Bindings (IPv4 LSR ID 10.20.1.3:0)
             (IPv6 LSR ID 3ffe::a14:103[0])
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate For Fast Re-Route
        (S) - Static       (M) - Multi-homed Secondary Support
        (B) - BGP Next Hop (BU) - Alternate Next-hop for Fast Re-Route
===============================================================================
LDP IPv4 Prefix Bindings (Active)
===============================================================================
-------------------------------------------------------------------------------
Prefix         : 10.20.1.1/32
Op             : Push
Ing Lbl        :   --               Egr Lbl    : 262143
Egr Int/LspId  : 1/1/1
EgrNextHop     : 10.10.2.1
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.10.2.3
Metric         : 1000               Mtu        : 1500
-------------------------------------------------------------------------------
Prefix         : 10.20.1.1/32
Op             : Swap
Ing Lbl        : 262141             Egr Lbl    : 262143
Egr Int/LspId  : 1/1/1
EgrNextHop     : 10.10.2.1
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.10.2.3
```

```
Metric         : 1000               Mtu        : 1500
===============================================================================
No. of IPv4 Prefix Active Bindings: 2
===============================================================================

===============================================================================
LDP IPv6 Prefix Bindings (Active)
===============================================================================
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:101/128
Op             : Push
Ing Lbl        :   --               Egr Lbl    : 262142
Egr Int/LspId  : 1/1/1
EgrNextHop     : fe80::21
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.10.2.3
Metric         : 1000               Mtu        : 1500
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:101/128
Op             : Swap
Ing Lbl        : 262136             Egr Lbl    : 262142
Egr Int/LspId  : 1/1/1
EgrNextHop     : fe80::21
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.10.2.3
Metric         : 1000               Mtu        : 1500
-------------------------------------------------------------------------------
===============================================================================
No. of IPv6 Prefix Active Bindings: 2
===============================================================================

===============================================================================
LDP Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Generic IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv6 P2MP Bindings
===============================================================================
```

```
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type               : ?-Eth               VcId               : 10
SvcId              : Ukwn                SdpId              : R. Src
Peer Address       : 1.1.1.1:0
Vc-switching       : No
LMTU               : None                RMTU               : 1500
Egr. Lbl           : 131070D             Egr. Ctl Word      : No
Egr. Flags         : None                Egr. Status Bits   : Supported (0x1e)
Egr. Flow Label Tx : No                  Egr. Flow Label Rx : No
Egr. PW Status Sig : Enabled
Egr. Vccv CV Bits  : lsp-ping
Egr. Vccv CC Bits  : router-alert-label
Ing. Lbl           :  --                 Ing. Ctl Word      : None
Ing. Flags         : None                Ing. Status Bits   : N/A
Ing. Flow Label Tx : None                Ing. Flow Label Rx : None
Ing. Wdraw Reason  : None
Ing. PW Status Sig : None
Ing. Vccv CV Bits  : None
Ing. Vccv CC Bits  : None
-------------------------------------------------------------------------------
===============================================================================
No. of VC Labels: 1
===============================================================================
===============================================================================
LDP Service FEC 129 Bindings
```

```
===============================================================================
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#
```

ipv4

Syntax **ipv4** [**session** *ip-addr*[*label-space*]] [**summary** | **detail**]

Context show>router>ldp>bindings

Description This command displays LDP active IPv4 bindings.

Parameters *ip-addr*[*label-space*] — specifies the IP address and label space identifier

Values *ip-addr*[*label-spa** : *ipv4-address*:*label-space*
ipv6-address[*label-space*]
label-space : 0 to 65535]

detail — displays detailed information

summary — displays information in a summarized format

Output The following output is an example of LDP active IPv4 bindings information, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>ldp# bindings ipv4
===============================================================================
LDP Bindings (IPv4 LSR ID 10.10.10.10)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value), H -
 Hpipe Service
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP IPv4 Prefix Bindings
===============================================================================
Prefix                                      IngLbl                    EgrLbl
Peer                                        EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
10.10.10.10/32                                --                      131071
10.10.10.10:0                               1/1/1:100
10.1.1.1
10.12.12.12/32                              131071U                     --
10.10.10.10:0                                 --
  --
-------------------------------------------------------------------------------
```

```
No. of IPv4 Prefix Bindings: 2
===============================================================================
===============================================================================
LDP Generic IPv4 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                    Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv4 P2MP Bindings
===============================================================================
Source
Group
RootAddr                                    Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings
===============================================================================
Source
Group                                       RD
RootAddr                                    Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv4 P2MP Bindings
===============================================================================
RootAddr
InnerRootAddr
Source
Group                                       Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv4 P2MP Bindings
===============================================================================
P2MP-Id                                     RD
RootAddr                                    Interface
InnerRootAddr                                               IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv4 P2MP Bindings
```

```
===============================================================================
P2MP-Id
RootAddr                                    Interface       IngLbl    EgrLbl
InnerRootAddr
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#


*A:Sar18 Dut-B>show>router>ldp# bindings  ipv4 session 10.10.10.10:22 summary
 No. of IPv4 Prefix Bindings: 0
 No. of Generic IPv4 P2MP Bindings: 0
 No. of In-Band-SSM IPv4 P2MP Bindings: 0
 No. of In-Band-VPN-SSM IPv4 P2MP Bindings: 0
 No. of Recursive with In-Band-SSM IPv4 P2MP Bindings: 0
 No. of VPN Recursive with Generic IPv4 P2MP Bindings: 0
 No. of GRT Recursive with Generic IPv4 P2MP Bindings: 0
*A:Sar18 Dut-B>show>router>ldp#


*A:Sar18 Dut-B>show>router>ldp# bindings ipv4 detail
===============================================================================
LDP Bindings (IPv4 LSR ID 10.10.10.10)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value), H - Hpipe Se
rvice
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP IPv4 Prefix Bindings
===============================================================================
-------------------------------------------------------------------------------
Prefix         : 10.10.10.10/32
-------------------------------------------------------------------------------
Peer           : 10.10.10.10:0
Ing Lbl        :   --               Egr Lbl    : 131071
Egr Int/LspId  : 10/10/10:100
EgrNextHop     : 10.1.1.1
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : toA
Metric         : 1                  Mtu        : 1554
-------------------------------------------------------------------------------
Prefix         : 10.12.12.12/32
-------------------------------------------------------------------------------
Peer           : 10.10.10.1:0
Ing Lbl        : 131071U            Egr Lbl    :   --
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
===============================================================================
No. of IPv4 Prefix Bindings: 2
===============================================================================
```

```
===============================================================================
LDP Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#
```

ipv6

Syntax **ipv6** [**session** *ip-addr*[*label-space*]] [**summary** | **detail**]

Context show>router>ldp>bindings

Description This command displays LDP active IPv6 bindings.

Parameters *ip-addr*[*label-space*] — specifies the IP address and label space identifier

Values

ip-addr[*label-spa**	:	*ipv4-address*:*label-space*
		ipv6-address[*label-space*]
label-space	:	0 to 65535]

detail — displays detailed information

summary — displays information in a summarized format

Output The following output is an example of LDP active IPv6 bindings information, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B# show router ldp bindings ipv6
===============================================================================
LDP Bindings (IPv4 LSR ID 10.12.12.12)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value), H -
 Hpipe Service
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP IPv6 Prefix Bindings
===============================================================================
Prefix                                      IngLbl                    EgrLbl
Peer                                        EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Generic IPv6 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                    Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv6 P2MP Bindings
===============================================================================
Source
Group
RootAddr                                    Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv6 P2MP Bindings
===============================================================================
Source
Group                                       RD
RootAddr                                    Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv6 P2MP Bindings
===============================================================================
```

```
RootAddr
InnerRootAddr
Source
Group                                       Interface       IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv6 P2MP Bindings
===============================================================================
P2MP-Id                                     RD
RootAddr                                    Interface
InnerRootAddr                                                 IngLbl    EgrLbl
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv6 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                    Interface       IngLbl    EgrLbl
InnerRootAddr
EgrNH                                       EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B#
```

label-type

Syntax **label-type start-label** *start-label* [**end-label** *end-label*] *label-type* [*family*]

Context show>router>ldp>bindings

Description This command displays LDP FEC bindings by matching labels.

Parameters *start-label* — specifies a label value to begin the display

Values 16 to 1048575

end-label — specifies a label value to end the display

Values 17 to 1048575

label-type — specifies a label type to display

Values ingress-label or egress-label

family — displays either IPv4 or IPv6 LDP information

Values ipv4 or ipv6

Output The following output is an example of LDP FEC bindings information by matching labels, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>ldp# bindings label-type start-label 16 end-
label 99 ingress-label
===============================================================================
LDP Bindings (IPv4 LSR ID 10.12.12.12)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate For Fast Re-Route
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP IPv4 Prefix Bindings
===============================================================================
Prefix                                      IngLbl                    EgrLbl
Peer                                        EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP IPv6 Prefix Bindings
===============================================================================
Prefix                                      IngLbl                    EgrLbl
Peer                                        EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type                                          VCId       SDPId     IngLbl  LMTU
Peer                                          SvcId                EgrLbl  RMTU
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
===============================================================================
LDP Service FEC 129 Bindings
===============================================================================
SAII                                            AGII        IngLbl    LMTU
TAII                                            Type        EgrLbl    RMTU
Peer                                            SvcId       SDPId
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#
```

p2mp

Syntax **p2mp p2mp-id** *identifier* **root** *ip-address* [**session** *ip-addr* [*label-space*]] [**summary** | **detail**]
p2mp [**session** *ip-addr* [*label-space*]] [*family*] [**summary** | **detail**] [**opaque-type** *opaque-type*]
p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**session** *ip-addr* [*label-space*]] [*family*] [**summary** | **detail**] **inner-root** *ip-address*
p2mp source *ip-address* **group** *mcast-address* **root** *ip-address* [**rd** *rd*] [**session** *ip-addr* [*label-space*]] [**summary** | **detail**]
p2mp source *ip-address* **group** *mcast-address* [**session** *ip-addr* [*label-space*]] [*family*] [**summary** | **detail**] [**innermost-root** *ip-address*]

Context show>router>ldp>bindings

Description This command displays LDP P2MP FEC bindings.

Parameters **detail** — displays detailed information

summary — displays information in a summarized format

family — displays either IPv4 or IPv6 active LDP information

group *mcast-address* — displays the P2MP group multicast address bindings

inner-root *ip-address* — displays recursive FECs whose inner root address matches the specified address

innermost-root *ip-address* — displays recursive FECs whose inner root address matches the specified address and non-recursive FECs that have a root address that matches the specified address

opaque-type *opaque-type* — specifies the type of a multipoint opaque value element

Values generic, ssm, vpn-ssm, recursive-ssm, vpn-recursive, grt-recursive

p2mp-id *identifier* — displays LDP active P2MP identifier bindings

Values 0 to 4294967295

rd *rd* — displays information for the route distinguisher

Values *ip-addr:comm-val* | *2byte-asnumber:ext-comm-val* | *4byte-asnumber:comm-val*

root *ip-address* — displays root IP address information

session *ip-addr* [*label-space*] — displays information for the LDP session IP address and label space

Values *ipv4-address*:*label-space*
ipv6-address[*label-space*]
label-space: 0 to 65535

source *ip-address* — displays LDP active P2MP source bindings

Values

ipv4-address	a.b.c.d
ipv6-address	x:x:x:x:x:x:x:x (eight 16-bit pieces) x:x:x:x:x:x:d.d.d.d x - [0 to FFFF]H d - [0 to 255]D

Output The following output is an example of LDP P2MP FEC bindings information, and Table 48 describes the fields.

Output Example

```
*A:7705:Dut-F# show router ldp bindings p2mp detail
===============================================================================
LDP Bindings (IPv4 LSR ID 10.20.1.6)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate For Fast Re-Route
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP Generic IPv4 P2MP Bindings
===============================================================================
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.1
-------------------------------------------------------------------------------
Peer           : 10.20.1.4:0
Ing Lbl        : 131062U
Egr Lbl        :   --
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.1
-------------------------------------------------------------------------------
Peer           : 10.20.1.5:0
Ing Lbl        :   --
Egr Lbl        : 131062
Egr Int/LspId  : 1/1/3:0
EgrNextHop     : 10.180.10.5
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.180.10.6
Metric         : 1                  Mtu        : 1496
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.2
-------------------------------------------------------------------------------
Peer           : 10.20.1.4:0
Ing Lbl        : 131064U
Egr Lbl        :   --
Egr Int/LspId  :   --
```

```
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.2
-------------------------------------------------------------------------------
Peer           : 10.20.1.5:0
Ing Lbl        :   --
Egr Lbl        : 131064
Egr Int/LspId  : 1/1/3:0
EgrNextHop     : 10.180.10.5
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.180.10.6
Metric         : 1                  Mtu        : 1496
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.3
-------------------------------------------------------------------------------
Peer           : 10.20.1.4:0
Ing Lbl        : 131063U
Egr Lbl        :   --
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.3
-------------------------------------------------------------------------------
Peer           : 10.20.1.5:0
Ing Lbl        :   --
Egr Lbl        : 131063
Egr Int/LspId  : 1/1/3:0
EgrNextHop     : 10.180.10.5
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.180.10.6
Metric         : 1                  Mtu        : 1496
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.5
-------------------------------------------------------------------------------
Peer           : 10.20.1.4:0
Ing Lbl        :   --
Egr Lbl        : 131065
Egr Int/LspId  : 1/1/1:0
EgrNextHop     : 10.180.9.4
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.180.9.6
Metric         : 1                  Mtu        : 1496
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.5
-------------------------------------------------------------------------------
Peer           : 10.20.1.5:0
Ing Lbl        : 131065U
Egr Lbl        :   --
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
-------------------------------------------------------------------------------
```

```
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.6
-------------------------------------------------------------------------------
Peer           : 10.20.1.4:0
Ing Lbl        :   --
Egr Lbl        : 131061
Egr Int/LspId  : 1/1/1:0
EgrNextHop     : 10.180.9.4
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.180.9.6
Metric         : 1                  Mtu        : 1496
-------------------------------------------------------------------------------
P2MP Type      : 1                  P2MP-Id    : 8193
Root-Addr      : 10.20.1.6
-------------------------------------------------------------------------------
Peer           : 10.20.1.5:0
Ing Lbl        :   --
Egr Lbl        : 131061
Egr Int/LspId  : 1/1/3:0
EgrNextHop     : 10.180.10.5
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.180.10.6
Metric         : 1                  Mtu        : 1496
===============================================================================
No. of Generic IPv4 P2MP Bindings: 10
===============================================================================
===============================================================================
LDP Generic IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Recursive with In-Band-SSM IPv6 P2MP Bindings
===============================================================================
```

```
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP VPN Recursive with Generic IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP GRT Recursive with Generic IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
*A:7705:Dut-F#
```

prefixes

Syntax **prefixes prefix** *ip-prefix/ip-prefix-length* [**summary** | **detail**] [**session** *ip-addr*[*label-space*]]
prefixes [*family*] [**summary** | **detail**] [**session** *ip-addr*[*label-space*]]

Context show>router>ldp>bindings

Description This command displays LDP prefix FEC bindings.

Parameters **prefix** *ip-prefix*/*ip-prefix-length* — specifies information for the specified IP prefix and mask length

Values

ipv4-prefix	a.b.c.d
ipv4-prefix-length	0 to 32
ipv6-address	x:x:x:x:x:x:x:x (eight 16-bit pieces)
	x:x:x:x:x:x:d.d.d.d
	x - [0 to FFFF]H
	d - [0 to 255]D
ipv6-prefix-length	0 to 128

detail — displays detailed information

summary — displays information in a summarized format

family — displays either IPv4 or IPv6 active LDP information

Values ipv4 or ipv6

session *ip-addr* — displays configuration information about LDP sessions

label-space — specifies the label space identifier that the router is advertising on the interface

Values 0 to 65535

Output The following output is an example of LDP prefix FEC bindings information, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>ldp# bindings prefixes
===============================================================================
LDP Bindings (IPv4 LSR ID 10.12.12.2)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate For Fast Re-Route
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP IPv4 Prefix Bindings
===============================================================================
Prefix                                      IngLbl                     EgrLbl
Peer                                        EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
10.10.10.1/32                                   --                      131071
1.1.1.1:0                                   1/1/1:100
10.1.1.1
10.12.12.12/32                              131071U                     --
10.1.1.1:0                                      --
  --
-------------------------------------------------------------------------------
No. of IPv4 Prefix Bindings: 2
===============================================================================
===============================================================================
LDP IPv6 Prefix Bindings
===============================================================================
Prefix                                      IngLbl                     EgrLbl
Peer                                        EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#

*A:Sar18 Dut-B>show>router>ldp# bindings prefixes detail
===============================================================================
LDP Bindings (IPv4 LSR ID 10.12.12.2)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate For Fast Re-Route
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP IPv4 Prefix Bindings
```

```
===============================================================================
-------------------------------------------------------------------------------
Prefix         : 10.10.10.1/32
-------------------------------------------------------------------------------
Peer           : 10.10.10.1:0
Ing Lbl        :   --               Egr Lbl    : 131071
Egr Int/LspId  : 10/10/10:100
EgrNextHop     : 10.1.1.1
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : toA
Metric         : 1                  Mtu        : 1554
-------------------------------------------------------------------------------
Prefix         : 10.12.12.2/32
-------------------------------------------------------------------------------
Peer           : 10.10.10.1:0
Ing Lbl        : 131071U            Egr Lbl    :   --
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
===============================================================================
No. of IPv4 Prefix Bindings: 2
===============================================================================
===============================================================================
LDP IPv6 Prefix Bindings
===============================================================================
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#
```

services

Syntax **services vc-type** *vc-type* **saii** *global-id*:*prefix:ac-id* **taii** [256 chars max] **agi** *agi* [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]

services vc-type *vc-type* **agi** *agi* [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]

services [**vc-type** *vc-type*] [**svc-fec-type**] [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]

services vc-type *vc-type* **vc-id** *vc-id* [**detail**] [**service-id** *service-id*] [**session** *ip-addr*[*label-space*]]

Context show>router>ldp>bindings

Description This command displays LDP service FEC bindings.

Parameters **vc-type** *vc-type* — displays information about the VC type associated with this service FEC

Values ethernet, vlan, mirror, frdlci, atmsdu, atmcell, atmvcc, atmvpc, ipipe, satop-e1, satop-t1, cesopsn, cesopsn-cas

vc-id *vc-id* — displays information about the VC ID associated with this service FEC

Values 1 to 4294967295

saii *global-id*:*prefix*:*ac-id* — specifies the a SAII (source attachment individual identifier)

Values *number*:*number* | a.b.c.d:*number*

taii — specifies the TAII ID, up to 256 characters, associated with this service FEC

svc-fec-type — specifies the FEC type

Values fec128, fec129

agi *agi* — specifies the attachment group identifier TLV associated with this service FEC

Values *ip-addr:comm-val* | *2byte-asnumber:ext-comm-val* | *4byte-asnumber:comm-val*

ip-addr : a.b.c.d
comm-val : 0 to 65535
2byte-asnumber : 1 to 65535
ext-comm-val : 0 to 4294967295
4byte-asnumber : 1 to 4294967295
null - means all value is 0

detail — displays detailed information

service-id — specifies the service ID number to display

Values 1 to 2148007980 | *svc-name* (64 char max)

svc-fec-type — specifies the FEC type

Values fec128, fec129

ip-addr[label-space] — specifies the IP address and the label space identifier that the router is advertising on the interface

Values *ipv4-address*:*label-space*
ipv6-address[*label-space*]
label-space : 0 to 65535

Output The following output is an example of LDP service FEC bindings information, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>ldp# bindings services vc-type ethernet vc-id 999
===============================================================================
LDP Bindings (IPv4 LSR ID 10.2.2.2)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value), H -
 Hpipe Service
        LF - Lower FEC, UF - Upper FEC
```

```
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type                                        VCId       SDPId     IngLbl  LMTU
Peer                                        SvcId                EgrLbl  RMTU
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================


*A:Sar18 Dut-B>show>router>ldp# bindings services vc-type ethernet vc-
id 999 service-id 7777
===============================================================================
LDP Bindings (IPv4 LSR ID 10.2.2.2)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value), H -
         Hpipe Service
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type                                        VCId       SDPId     IngLbl  LMTU
Peer                                        SvcId                EgrLbl  RMTU
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================


*A:Sar18 Dut-B>show>router>ldp# bindings services vc-type ethernet vc-
id 999 service-id 7777 session 10.1.1.1:333
===============================================================================
LDP Bindings (IPv4 LSR ID 10.2.2.2)
             (IPv6 LSR ID ::)
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value), H -
         Hpipe Service
        LF - Lower FEC, UF - Upper FEC
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type                                        VCId       SDPId     IngLbl  LMTU
Peer                                        SvcId                EgrLbl  RMTU
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:Sar18 Dut-B>show>router>ldp#
```

session

Syntax **session** [*family*] [**summary** | **detail**] *ip-addr*[*label-space*]

Context show>router>ldp>bindings

Description This command displays LDP FEC bindings by matching peer LSR ID.

Parameters **detail** — displays detailed information

summary — displays information in a summarized format

family — displays either IPv4 or IPv6 LDP session information

Values ipv4 or ipv6

ip-addr[label-space] — specifies the IP address and the label space identifier that the router is advertising on the interface

Values *ipv4-address*:*label-space*
ipv6-address[*label-space*]
label-space : 0 to 65535

Output The following output is an example of LDP P2MP FEC bindings information by matching peer LSR ID, and Table 48 describes the fields.

Output Example

```
*A:Dut-A# show router ldp bindings session 3ffe::a14:103 summary
 No. of IPv4 Prefix Bindings: 0
 No. of IPv6 Prefix Bindings: 6
 No. of Generic IPv4 P2MP Bindings: 0
 No. of Generic IPv6 P2MP Bindings: 0
 No. of In-Band-SSM IPv4 P2MP Bindings: 0
 No. of In-Band-SSM IPv6 P2MP Bindings: 0
 No. of In-Band-VPN-SSM IPv4 P2MP Bindings: 0
 No. of In-Band-VPN-SSM IPv6 P2MP Bindings: 0
 No. of VC Labels: 0
 No. of FEC 129s: 0


*A:Dut-A# show router ldp bindings session 3ffe::a14:103 detail
===============================================================================
LDP Bindings (IPv4 LSR ID 10.20.1.1:0)
             (IPv6 LSR ID 3ffe::a14:101[0])
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value)
===============================================================================
LDP IPv4 Prefix Bindings
===============================================================================
No Matching Entries Found
===============================================================================
```

```
===============================================================================
LDP IPv6 Prefix Bindings
===============================================================================
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:101/128
-------------------------------------------------------------------------------
Peer           : 3ffe::a14:103[0]
Ing Lbl        : 262142U            Egr Lbl    :   --
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:102/128
-------------------------------------------------------------------------------
Peer           : 3ffe::a14:103[0]
Ing Lbl        : 262136U            Egr Lbl    : 262138
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : n/a
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:103/128
-------------------------------------------------------------------------------
Peer           : 3ffe::a14:103[0]
Ing Lbl        :   --               Egr Lbl    : 262142
Egr Int/LspId  : 1/1/2
EgrNextHop     : fe80::23
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.10.2.1
Metric         : 1000               Mtu        : 1500
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:104/128
-------------------------------------------------------------------------------
Peer           : 3ffe::a14:103[0]
Ing Lbl        : 262132U            Egr Lbl    : 262134
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : n/a
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:105/128
-------------------------------------------------------------------------------
Peer           : 3ffe::a14:103[0]
Ing Lbl        : 262134N            Egr Lbl    : 262132
Egr Int/LspId  : 1/1/2
EgrNextHop     : fe80::23
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : ip-10.10.2.1
Metric         : 2000               Mtu        : 1500
-------------------------------------------------------------------------------
Prefix         : 3ffe::a14:106/128
-------------------------------------------------------------------------------
Peer           : 3ffe::a14:103[0]
Ing Lbl        : 262133U            Egr Lbl    : 262133
Egr Int/LspId  :   --
EgrNextHop     :   --
Egr. Flags     : None               Ing. Flags : None
Egr If Name    : n/a
===============================================================================
```

```
No. of IPv6 Prefix Bindings: 6
===============================================================================
===============================================================================
LDP Generic IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Generic IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-SSM IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP In-Band-VPN-SSM IPv6 P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
No Matching Entries Found
===============================================================================
===============================================================================
LDP Service FEC 129 Bindings
===============================================================================
No Matching Entries Found
===============================================================================
*A:Dut-A#

*A:Dut-A# show router ldp bindings session 10.20.1.3 ipv4
===============================================================================
LDP Bindings (IPv4 LSR ID 10.20.1.1:0)
             (IPv6 LSR ID 3ffe::a14:101[0])
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value)
===============================================================================
LDP IPv4 Prefix Bindings
===============================================================================
Prefix                                  IngLbl                  EgrLbl
```

```
Peer                                    EgrIntf/LspId
EgrNextHop
-------------------------------------------------------------------------------
10.20.1.1/32                            262143U                      --
10.20.1.3:0                               --
  --

10.20.1.2/32                            262141U                   262140
10.20.1.3:0                               --
  --

10.20.1.3/32                              --                        262143
10.20.1.3:0                             1/1/2
10.10.2.3

10.20.1.4/32                            262139U                   262139
10.20.1.3:0                               --
  --

10.20.1.5/32                            262138N                   262137
10.20.1.3:0                             1/1/2
10.10.2.3

10.20.1.6/32                            262135U                   262135
10.20.1.3:0                               --
  --

-------------------------------------------------------------------------------
No. of IPv4 Prefix Bindings: 6
===============================================================================
===============================================================================
LDP Generic IPv4 P2MP Bindings
===============================================================================
P2MP-Id
RootAddr                                Interface       IngLbl    EgrLbl
EgrNH                                   EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================

===============================================================================
LDP In-Band-SSM IPv4 P2MP Bindings
===============================================================================
Source
Group
RootAddr                                Interface       IngLbl    EgrLbl
EgrNH                                   EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================

===============================================================================
LDP In-Band-VPN-SSM IPv4 P2MP Bindings
===============================================================================
Source
Group                                   RD
RootAddr                                Interface       IngLbl    EgrLbl
```

```
EgrNH                                          EgrIf/LspId
Peer
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:Dut-A#
```

summary

Syntax **summary** [**session** *ip-addr*[*label-space*]] [**ipv4** | **ipv6**]

Context show>router>ldp>bindings

Description This command displays a summary of LDP bindings.

Parameters **session** *ip-addr[label-space*] — specifies the IP address and label space identifier

Values *ip-addr[label-spa** : *ipv4-address:label-space*
ipv6-address[label-space]
label-space: 0 to 65535

ipv4 — displays IPv4 summary bindings information

ipv6 — displays IPv6 summary bindings information

Output The following output is an example of summary LDP bindings information, and Table 48 describes the fields.

Output Example

```
*A:Sar18 Dut-B>show>router>ldp# bindings summary
 No. of IPv4 Prefix Bindings: 2
 No. of IPv6 Prefix Bindings: 0
 No. of Generic IPv4 P2MP Bindings: 0
 No. of Generic IPv6 P2MP Bindings: 0
 No. of In-Band-SSM IPv4 P2MP Bindings: 0
 No. of In-Band-SSM IPv6 P2MP Bindings: 0
 No. of In-Band-VPN-SSM IPv4 P2MP Bindings: 0
 No. of In-Band-VPN-SSM IPv6 P2MP Bindings: 0
 No. of Recursive with In-Band-SSM IPv4 P2MP Bindings: 0
 No. of Recursive with In-Band-SSM IPv6 P2MP Bindings: 0
 No. of VPN Recursive with Generic IPv4 P2MP Bindings: 0
 No. of VPN Recursive with Generic IPv6 P2MP Binding: 0
 No. of GRT Recursive with Generic IPv4 P2MP Bindings: 0
 No. of GRT Recursive with Generic IPv6 P2MP Binding: 0
 No. of VC Labels: 1
 No. of FEC 129s: 0
*A:Sar18 Dut-B>show>router>ldp# bindings summary
```

5.12.2.3 Clear Commands

fec-egress-statistics

Syntax **fec-egress-statistics** [*ip-prefix/mask*]

Context clear>router>ldp

Description This command clears LDP FEC statistics.

Note: When LDP FEC statistics are cleared, the current aggregate statistics count is recorded as a baseline and is used to provide a relative count each time the statistics are viewed with the **show** command. Because this baseline number is not reconciled between the active and inactive CSMs, after a CSM activity switch the statistics on the newly active CSM will show the aggregate count as though no clear command has been executed.

Parameters *ip-prefix[/mask]* — the IP prefix and prefix length associated with the prefix FEC

Values

ipv4-prefix:	a.b.c.d
ipv4-prefix-length:	32
ipv6-prefix:	x:x:x:x:x:x:x:x (eight 16-bit pieces)
	x:x:x:x:x:x:d.d.d.d
	x - [0 to FFFF]H
	d - [0 to 255]D
ipv6-prefix-length:	128

instance

Syntax **instance**

Context clear>router>ldp

Description This command resets the LDP instance.

interface

Syntax **interface** *ip-int-name* [**statistics**]

Context clear>router>ldp

Description This command restarts or clears statistics for LDP interfaces.

Parameters *ip-int-name* — specifies an existing interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

statistics — clears only the statistics for an interface

peer

Syntax **peer** *ip-address* [**statistics**]

Context clear>router>ldp

Description This command restarts or clears statistics for LDP targeted peers.

Parameters *ip-address* — specifies a targeted peer

statistics — clears only the statistics for a targeted peer

session

Syntax **session** *ip-addr* [**:***label-space*] [**statistics**]

Context clear>router>ldp

Description This command restarts or clears statistics for LDP sessions.

Parameters *ip-addr* — specifies the IP address of the LDP peer

label-space — specifies the label space identifier that the router is advertising on the interface

Values 0 to 65535

statistics — clears only the statistics for a session

statistics

Syntax **statistics**

Context clear>router>ldp

Description This command clears LDP instance statistics.

5.12.2.4 Debug Commands

The following output shows debug LDP configurations discussed in this section.

```
ALU-12# debug router ldp peer 10.10.10.104
ALU-12>debug>router>ldp# show debug ldp
debug
    router "Base"
        ldp peer 10.10.10.104
            event
                bindings
                messages
            exit
            packet
                hello
                init
                keepalive
                label
            exit
        exit
    exit
exit
ALU-12>debug>router>ldp#
```

ldp

Syntax [**no**] **ldp**

Context debug>router

Description This command configures LDP debugging.

interface

Syntax [**no**] **interface** *interface-name*

Context debug>router>ldp

Description This command configures debugging for a specific LDP interface.

Parameters *interface-name* — specifies an existing interface

peer

Syntax [**no**] **peer** *ip-address*

Context debug>router>ldp

Description This command configures debugging for a specific LDP peer.

Parameters *ip-address* — specifies the LDP peer to debug

event

Syntax [**no**] **event**

Context debug>router>ldp>interface
debug>router>ldp>peer

Description This command configures debugging for specific LDP events.

bindings

Syntax [**no**] **bindings**

Context debug>router>ldp>peer>event

Description This command displays debugging information about addresses and label bindings learned from LDP peers for LDP bindings.

The **no** form of the command disables the debugging output.

messages

Syntax [**no**] **messages**

Context debug>router>ldp>if>event
debug>router>ldp>peer>event

Description This command displays specific information (for example, message type, source, and destination) regarding LDP messages sent to and received from LDP peers.

The **no** form of the command disables debugging output for LDP messages.

packet

Syntax [**no**] **packet**

Context debug>router>ldp>interface
debug>router>ldp>peer

Description This command enables debugging for specific LDP packets.

The **no** form of the command disables the debugging output.

hello

Syntax **hello** [**detail**]
no hello

Context debug>router>ldp>if>packet
debug>router>ldp>peer>packet

Description This command enables debugging for sent and received LDP Hello packets.

The **no** form of the command disables the debugging output.

Parameters **detail** — displays detailed information

init

Syntax **init** [**detail**]
no init

Context debug>router>ldp>peer>packet

Description This command enables debugging for LDP Init packets. The **detail** option displays detailed information on the type length value (TLV) included in mac-flush packets.

The **no** form of the command disables the debugging output.

Parameters **detail** — displays detailed information

keepalive

Syntax [**no**] **keepalive**

Context debug>router>ldp>peer>packet

Description This command enables debugging for LDP keepalive packets.

The **no** form of the command disables the debugging output.

label

Syntax **label** [**detail**]
no label

Context debug>router>ldp neighbor>packet

Description This command enables debugging for LDP label packets.

The **no** form of the command disables the debugging output.

Parameters **detail** — displays detailed information

6 List of Acronyms

Table 49 **Acronyms**

Acronym	Expansion
2G	second generation wireless telephone technology
3DES	triple DES (data encryption standard)
3G	third generation mobile telephone technology
6VPE	IPv6 on Virtual Private Edge Router
7705 SAR	7705 Service Aggregation Router
7750 SR	7750 Service Router
8 PSK	eight phase shift keying
16 QAM	16-state quadrature amplitude modulation
32 QAM	32-state quadrature amplitude modulation
64 QAM	64-state quadrature amplitude modulation
128 QAM	128-state quadrature amplitude modulation
256 QAM	256-state quadrature amplitude modulation
ABR	area border router available bit rate
AC	alternating current attachment circuit
ACK	acknowledge
ACL	access control list
ACR	adaptive clock recovery
AD	auto-discovery
ADM	add/drop multiplexer
ADP	automatic discovery protocol
AES	advanced encryption standard
AFI	authority and format identifier
AIGP	accumulated IGP
AIS	alarm indication signal

Table 49 **Acronyms (Continued)**

Acronym	Expansion
ALG	application level gateway
ANSI	American National Standards Institute
Apipe	ATM VLL
APS	automatic protection switching
ARP	address resolution protocol
A/S	active/standby
AS	autonomous system
ASAP	any service, any port
ASBR	autonomous system boundary router
ASM	any-source multicast autonomous system message
ASN	autonomous system number
ATM	asynchronous transfer mode
ATM PVC	ATM permanent virtual circuit
AU	administrative unit
AUG	administrative unit group
B3ZS	bipolar with three-zero substitution
Batt A	battery A
B-bit	beginning bit (first packet of a fragment)
BBE	background block errors
Bc	committed burst size
Be	excess burst size
BECN	backward explicit congestion notification
Bellcore	Bell Communications Research
BFD	bidirectional forwarding detection
BGP	border gateway protocol
BGP-LS	border gateway protocol link state
BGP-LU	border gateway protocol labeled unicast

Table 49 **Acronyms (Continued)**

Acronym	Expansion
BITS	building integrated timing supply
BMCA	best master clock algorithm
BMU	broadcast, multicast, and unknown traffic Traffic that is not unicast. Any nature of multipoint traffic: • broadcast (that is, all 1s as the destination IP to represent all destinations within the subnet) • multicast (that is, traffic typically identified by the destination address, uses special destination address); for IP, the destination must be 224.0.0.0 to 239.255.255.255 • unknown (that is, the destination is typically a valid unicast address but the destination port/interface is not yet known; therefore, traffic needs to be forwarded to all destinations; unknown traffic is treated as broadcast)
BNM	bandwidth notification message
BOF	boot options file
BoS	bottom of stack
BPDU	bridge protocol data unit
BRAS	Broadband Remote Access Server
BSC	Base Station Controller
BSM	bootstrap message
BSR	bootstrap router
BSTA	Broadband Service Termination Architecture
BTS	base transceiver station
CA	certificate authority
CAS	channel associated signaling
CBN	common bonding networks
CBS	committed buffer space
CC	continuity check control channel
CCM	continuity check message
CCTV	closed-circuit television

Table 49 **Acronyms (Continued)**

Acronym	Expansion
CE	circuit emulation customer edge
CEM	circuit emulation
CES	circuit emulation services
CESoPSN	circuit emulation services over packet switched network
CFM	connectivity fault management
cHDLC	Cisco high-level data link control protocol
CIDR	classless inter-domain routing
CIR	committed information rate
CLI	command line interface
CLP	cell loss priority
CMP	certificate management protocol
C-multicast	customer multicast
CoS	class of service
CPE	customer premises equipment
Cpipe	circuit emulation (or TDM) VLL
CPM	Control and Processing Module (CPM is used instead of CSM when referring to CSM filtering to align with CLI syntax used with other SR products). CSM management ports are referred to as CPM management ports in the CLI.
CPROTO	C prototype
CPU	central processing unit
C/R	command/response
CRC	cyclic redundancy check
CRC-32	32-bit cyclic redundancy check
CRL	certificate revocation list
CRON	a time-based scheduling service (from chronos = time)
CRP	candidate RP
CSM	Control and Switching Module

Table 49 **Acronyms (Continued)**

Acronym	Expansion
CSNP	complete sequence number PDU
CSPF	constrained shortest path first
C-TAG	customer VLAN tag
CV	connection verification customer VLAN (tag)
CW	control word
CWDM	coarse wavelength-division multiplexing
DA/FAN	distribution automation and field area network
DC	direct current
DC-C	DC return - common
DCE	data communications equipment
DC-I	DC return - isolated
DCO	digitally controlled oscillator
DCR	differential clock recovery
DDoS	distributed DoS
DE	discard eligibility
DER	distinguished encoding rules
DES	data encryption standard
DF	do not fragment designated forwarder
DH	Diffie-Hellman
DHB	decimal, hexadecimal, or binary
DHCP	dynamic host configuration protocol
DHCPv6	dynamic host configuration protocol for IPv6
DIS	designated intermediate system
DLCI	data link connection identifier
DLCMI	data link connection management interface
DM	delay measurement

Table 49 **Acronyms (Continued)**

Acronym	Expansion
DNS	domain name server
DNU	do not use
DoS	denial of service
dot1p	IEEE 802.1p bits, in Ethernet or VLAN ingress packet headers, used to map traffic to up to eight forwarding classes
dot1q	IEEE 802.1q encapsulation for Ethernet interfaces
DPD	dead peer detection
DPI	deep packet inspection
DPLL	digital phase locked loop
DR	designated router
DSA	digital signal algorithm
DSCP	differentiated services code point
DSL	digital subscriber line
DSLAM	digital subscriber line access multiplexer
DTE	data termination equipment
DU	downstream unsolicited
DUID	DHCP unique identifier
DUS	do not use for synchronization
DV	delay variation
DVMRP	distance vector multicast routing protocol
e911	enhanced 911 service
EAP	Extensible Authentication Protocol
EAPOL	EAP over LAN
E-bit	ending bit (last packet of a fragment)
E-BSR	elected BSR
ECMP	equal cost multipath
EE	end entity
EFM	Ethernet in the first mile

Table 49 **Acronyms (Continued)**

Acronym	Expansion
EGP	exterior gateway protocol
EIA/TIA-232	Electronic Industries Alliance/Telecommunications Industry Association Standard 232 (also known as RS-232)
EIR	excess information rate
EJBCA	Enterprise Java Bean Certificate Authority
E-LAN	Ethernet local area network
E-Line	Ethernet virtual private line
EL	entropy label
eLER	egress label edge router
ELI	entropy label indicator
E&M	ear and mouth earth and magneto exchange and multiplexer
eMBMS	evolved MBMS
EOP	end of packet
EPC	evolved packet core
EPD	early packet discard
Epipe	Ethernet VLL
EPL	Ethernet private line
EPON	Ethernet Passive Optical Network
EPS	equipment protection switching
ERO	explicit route object
ES	Ethernet segment errored seconds
ESD	electrostatic discharge
ESI	Ethernet segment identifier
ESMC	Ethernet synchronization message channel
ESN	extended sequence number
ESP	encapsulating security payload

Table 49 **Acronyms (Continued)**

Acronym	Expansion
ESPI	encapsulating security payload identifier
ETE	end-to-end
ETH-BN	Ethernet bandwidth notification
ETH-CFM	Ethernet connectivity fault management (IEEE 802.1ag)
EVC	Ethernet virtual connection
EVDO	evolution - data optimized
EVI	EVPN instance
EVPL	Ethernet virtual private link
EVPN	Ethernet virtual private network
EXP bits	experimental bits (currently known as TC)
FC	forwarding class
FCS	frame check sequence
FD	frequency diversity
FDB	forwarding database
FDL	facilities data link
FEAC	far-end alarm and control
FEC	forwarding equivalence class
FECN	forward explicit congestion notification
FeGW	far-end gateway
FEP	front-end processor
FF	fixed filter
FFD	fast fault detection
FIB	forwarding information base
FIFO	first in, first out
FIPS-140-2	Federal Information Processing Standard publication 140-2
FNG	fault notification generator
FOM	figure of merit

Table 49 **Acronyms (Continued)**

Acronym	Expansion
Fpipe	frame relay VLL
FQDN	fully qualified domain name
FR	frame relay
FRG bit	fragmentation bit
FRR	fast reroute
FTN	FEC-to-NHLFE
FTP	file transfer protocol
FXO	foreign exchange office
FXS	foreign exchange subscriber
GFP	generic framing procedure
GigE	Gigabit Ethernet
GLONASS	Global Navigation Satellite System (Russia)
GNSS	global navigation satellite system (generic)
GPON	Gigabit Passive Optical Network
GPRS	general packet radio service
GPS	Global Positioning System
GRE	generic routing encapsulation
GRT	global routing table
GSM	Global System for Mobile Communications (2G)
GTP-U	GPRS tunneling protocol user plane
GW	gateway
HA	high availability
HCM	high capacity multiplexing
HDB3	high density bipolar of order 3
HDLC	high-level data link control protocol
HEC	header error control
HMAC	hash message authentication code

Table 49 **Acronyms (Continued)**

Acronym	Expansion
Hpipe	HDLC VLL
H-QoS	hierarchical quality of service
HSB	hot standby
HSDPA	high-speed downlink packet access
HSPA	high-speed packet access
H-VPLS	hierarchical virtual private line service
IANA	internet assigned numbers authority
IBN	isolated bonding networks
ICB	inter-chassis backup
ICMP	Internet control message protocol
ICMPv6	Internet control message protocol for IPv6
ICP	IMA control protocol cells
IDS	intrusion detection system
IDU	indoor unit
IED	intelligent end device
IEEE	Institute of Electrical and Electronics Engineers
IEEE 1588v2	Institute of Electrical and Electronics Engineers standard 1588-2008
IES	Internet Enhanced Service
IETF	Internet Engineering Task Force
IGMP	Internet group management protocol
IGP	interior gateway protocol
IID	instance ID
IKE	Internet key exchange
iLER	ingress label edge router
ILM	incoming label map
IMA	inverse multiplexing over ATM
IMET-IR	inclusive multicast Ethernet tag—ingress replication

Table 49 **Acronyms (Continued)**

Acronym	Expansion
INVARP	inverse address resolution protocol
IOM	input/output module
IP	Internet Protocol
IPCP	Internet Protocol Control Protocol
IPIP	IP in IP
Ipipe	IP interworking VLL
I-PMSI	inclusive PMSI
IPoATM	IP over ATM
IPS	intrusion prevention system
IPSec	Internet Protocol security
IR	ingress replication
IRB	integrated routing and bridging
ISA	integrated services adapter
ISAKMP	Internet security association and key management protocol
IS-IS	Intermediate System-to-Intermediate System
IS-IS-TE	IS-IS-traffic engineering (extensions)
ISO	International Organization for Standardization
IW	interworking
JP	join prune
KG	key group
LB	loopback
lbf-in	pound force inch
LBM	loopback message
LBO	line buildout
LBR	loopback reply
LCP	link control protocol
LDP	label distribution protocol

Table 49 **Acronyms (Continued)**

Acronym	Expansion
LER	label edge router
LFA	loop-free alternate
LFIB	label forwarding information base
LIB	label information base
LLDP	link layer discovery protocol
LLDPDU	link layer discovery protocol data unit
LLF	link loss forwarding
LLID	loopback location ID
LM	loss measurement
LMI	local management interface
LOS	line-of-sight loss of signal
LSA	link-state advertisement
LSDB	link-state database
LSP	label switched path link-state PDU (for IS-IS)
LSPA	LSP attributes
LSR	label switch router link-state request
LSU	link-state update
LT	linktrace
LTE	long term evolution line termination equipment
LTM	linktrace message
LTN	LSP ID to NHLFE
LTR	link trace reply
MA	maintenance association
MAC	media access control
MA-ID	maintenance association identifier

Table 49 **Acronyms (Continued)**

Acronym	Expansion
MBB	make-before-break
MBGP	multicast BGP multiprotocol BGP multiprotocol extensions for BGP
MBMS	multimedia broadcast multicast service
MBS	maximum buffer space maximum burst size media buffer space
MBSP	mobile backhaul service provider
MCAC	multicast connection admission control
MC-APS	multi-chassis automatic protection switching
MC-MLPPP	multi-class multilink point-to-point protocol
MCS	multicast server multi-chassis synchronization
MCT	MPT craft terminal
MD	maintenance domain
MD5	message digest version 5 (algorithm)
MDA	media dependent adapter
MDDB	multidrop data bridge
MDL	maintenance data link
MDT	multicast distribution tree
ME	maintenance entity
MED	multi-exit discriminator
MEF	Metro Ethernet Forum
MEG	maintenance entity group
MEG-ID	maintenance entity group identifier
MEN	Metro Ethernet network
MEP	maintenance association end point
MFC	multi-field classification

Table 49 **Acronyms (Continued)**

Acronym	Expansion
MHD	multi-homed device
MHF	MIP half function
MHN	multi-homed network
MIB	management information base
MI-IS-IS	multi-instance IS-IS
MIR	minimum information rate
MLD	multicast listener discovery
mLDP	multicast LDP
MLPPP	multilink point-to-point protocol
mLSP	multicast LSP
MoFRR	multicast-only fast reroute
MP	merge point multilink protocol multipoint
MP-BGP	multiprotocol border gateway protocol
MPLS	multiprotocol label switching
MPLSCP	multiprotocol label switching control protocol
MPP	MPT protection protocol
MPR	see Wavence
MPR-e	Microwave Packet Radio (standalone mode)
MPT-HC V2/9558HC	Microwave Packet Transport, High Capacity version 2
MPT-HLC	Microwave Packet Transport, High-Capacity Long-Haul Cubic (ANSI)
MPT-HQAM	Microwave Packet Transport, High Capacity (MPT-HC-QAM) or Extended Power (MPT-XP-QAM) with 512/1024 QAM
MPT-MC	Microwave Packet Transport, Medium Capacity
MPT-XP	Microwave Packet Transport, High Capacity (very high power version of MPT-HC V2/9558HC)
MRAI	minimum route advertisement interval

Table 49 **Acronyms (Continued)**

Acronym	Expansion
MRRU	maximum received reconstructed unit
MRU	maximum receive unit
MSDP	Multicast Source Discovery Protocol
MSDU	MAC Service Data Unit
MSO	multi-system operator
MS-PW	multi-segment pseudowire
MSS	maximum segment size Microwave Service Switch
MTIE	maximum time interval error
MTSO	mobile trunk switching office
MTU	maximum transmission unit multi-tenant unit
M-VPLS	management virtual private line service
MVPN	multicast VPN
MVR	multicast VPLS registration
MW	microwave
MWA	microwave awareness
N·m	newton meter
NAT	network address translation
NAT-T	network address translation traversal
NBMA	non-broadcast multiple access (network)
ND	neighbor discovery
NE	network element
NET	network entity title
NFM-P	Network Functions Manager - Packet (formerly 5620 SAM)
NGE	network group encryption
NG-MVPN	next generation MVPN
NH	next hop

Table 49 **Acronyms (Continued)**

Acronym	Expansion
NHLFE	next hop label forwarding entry
NHOP	next-hop
NLOS	non-line-of-sight
NLPID	network level protocol identifier
NLRI	network layer reachability information
NNHOP	next next-hop
NNI	network-to-network interface
Node B	similar to BTS but used in 3G networks — term is used in UMTS (3G systems) while BTS is used in GSM (2G systems)
NOC	network operations center
NPAT	network port address translation
NRC-F	Network Resource Controller - Flow
NRC-P	Network Resource Controller - Packet
NRC-T	Network Resource Controller - Transport
NRC-X	Network Resource Controller - Cross Domain
NSAP	network service access point
NSD	Network Services Director
NSP	native service processing Network Services Platform
NSSA	not-so-stubby area
NTP	network time protocol
NTR	network timing reference
OADM	optical add/drop multiplexer
OAM	operations, administration, and maintenance
OAMPDU	OAM protocol data units
OC3	optical carrier level 3
OCSP	online certificate status protocol
ODU	outdoor unit

Table 49 **Acronyms (Continued)**

Acronym	Expansion
OIF	outgoing interface
OLT	optical line termination
OMC	optical management console
ONT	optical network terminal
OOB	out-of-band
OPX	off premises extension
ORF	outbound route filtering
OS	operating system
OSI	Open Systems Interconnection (reference model)
OSINLCP	OSI Network Layer Control Protocol
OSPF	open shortest path first
OSPF-TE	OSPF-traffic engineering (extensions)
OSS	operations support system
OSSP	organization specific slow protocol
OTP	one time password
OWAMP	one-way active measurement protocol
P2MP	point to multipoint
PADI	PPPoE active discovery initiation
PADR	PPPoE active discovery request
PAE	port authentication entities
PSB	path state block
PBO	packet byte offset
PBR	policy-based routing
PBX	private branch exchange
PCAP	packet capture
PCC	Path Computation Element Client
PCE	Path Computation Element

Table 49 **Acronyms (Continued)**

Acronym	Expansion
PCEP	Path Computation Element Protocol
PCM	pulse code modulation
PCP	priority code point
PCR	proprietary clock recovery
PDU	power distribution unit protocol data units
PDV	packet delay variation
PDVT	packet delay variation tolerance
PE	provider edge router
PEAPv0	protected extensible authentication protocol version 0
PEM	privacy enhanced mail
PFoE	power feed over Ethernet
PFS	perfect forward secrecy
PHB	per-hop behavior
PHP	penultimate hop popping
PHY	physical layer
PIC	prefix independent convergence
PID	protocol ID
PIM SSM	protocol independent multicast—source-specific multicast
PIR	peak information rate
PKCS	public key cryptography standards
PKI	public key infrastructure
PLAR	private line automatic ringdown
PLCP	Physical Layer Convergence Protocol
PLR	point of local repair
PLSP	path LSP
PMSI	P-multicast service interface
P-multicast	provider multicast

Table 49 **Acronyms (Continued)**

Acronym	Expansion
PoE	power over Ethernet
PoE+	power over Ethernet plus
POH	path overhead
POI	purge originator identification
PoP	point of presence
POS	packet over SONET
PPP	point-to-point protocol
PPPoE	point-to-point protocol over Ethernet
PPS	pulses per second
PRC	primary reference clock
PRS	primary reference source
PRTC	primary reference time clock
PSE	power sourcing equipment
PSK	pre-shared key
PSN	packet switched network
PSNP	partial sequence number PDU
PTA	PMSI tunnel attribute
PTM	packet transfer mode
PTP	performance transparency protocol precision time protocol
PuTTY	an open-source terminal emulator, serial console, and network file transfer application
PVC	permanent virtual circuit
PVCC	permanent virtual channel connection
PW	pseudowire
PWE	pseudowire emulation
PWE3	pseudowire emulation edge-to-edge
Q.922	ITU-T Q-series Specification 922

Table 49 **Acronyms (Continued)**

Acronym	Expansion
QL	quality level
QoS	quality of service
QPSK	quadrature phase shift keying
RADIUS	Remote Authentication Dial In User Service
RAN	Radio Access Network
RBS	robbed bit signaling
RD	route distinguisher
RDI	remote defect indication
RED	random early discard
RESV	reservation
RIB	routing information base
RIP	routing information protocol
RJ-45	registered jack 45
RMON	remote network monitoring
RNC	Radio Network Controller
RP	rendezvous point
RPF RTM	reverse path forwarding RTM
RPS	radio protection switching
RPT	rendezvous-point tree
RR	route reflector
RRO	record route object
RS-232	Recommended Standard 232 (also known as EIA/TIA-232)
RSA	Rivest, Shamir, and Adleman (authors of the RSA encryption algorithm)
RSHG	residential split horizon group
RSTP	rapid spanning tree protocol
RSVP-TE	resource reservation protocol - traffic engineering
RT	receive/transmit

Table 49 **Acronyms (Continued)**

Acronym	Expansion
RTC	route target constraint
RTM	routing table manager
RTN	battery return
RTP	real-time protocol
R&TTE	Radio and Telecommunications Terminal Equipment
RTU	remote terminal unit
RU	rack unit
r-VPLS	routed virtual private LAN service
SA	security association source-active
SAA	service assurance agent
SAFI	subsequent address family identifier
SAP	service access point
SAR-8 Shelf V2	7705 Service Aggregation Router – 8-slot chassis
SAR-18	7705 Service Aggregation Router – 18-slot chassis
SAR-A	7705 Service Aggregation Router – two variants: • passively cooled chassis with 12 Ethernet ports and 8 T1/E1 ports • passively cooled chassis with 12 Ethernet ports and no T1/E1 ports
SAR-Ax	7705 Service Aggregation Router: • passively cooled • DC-powered with a dual-feed DC input that can be connected to a +24/-48/-60 VDC power source • equipped with 12 Ethernet ports (ports 1 to 4 are XOR ports and 5 to 12 are 100/1000 Ethernet SFP ports) • equipped with a factory-installed GPS receiver and GNSS RF faceplate connector
SAR-H	7705 Service Aggregation Router – temperature- and EMC-hardened to the following specifications: IEEE 1613 and IEC 61850-3
SAR-Hc	7705 Service Aggregation Router – compact version of 7705 SAR-H

Table 49 **Acronyms (Continued)**

Acronym	Expansion
SAR-M	7705 Service Aggregation Router – four variants: • actively cooled chassis with 16 T1/E1 ports, 7 Ethernet ports, and 1 hot-insertable module slot • actively cooled chassis with 0 T1/E1 ports, 7 Ethernet ports, and 1 hot-insertable module slot • passively cooled chassis with 16 T1/E1 ports, 7 Ethernet ports, and 0 module slots • passively cooled chassis with 0 T1/E1 ports, 7 Ethernet ports, and 0 module slots
SAR-O	7705 Service Aggregation Router passive CWDM device – three variants: • 2-wavelength CWDM dual-fiber • 4-wavelength CWDM dual-fiber • 8-wavelength CWDM single-fiber Each variant has different models that are used to add and drop different wavelengths
SAR-W	7705 Service Aggregation Router – passively cooled, universal AC and DC powered unit, equipped with five Gigabit Ethernet ports (three SFP ports and two RJ-45 Power over Ethernet (PoE) ports)

Table 49 **Acronyms (Continued)**

Acronym	Expansion
SAR-Wx	7705 Service Aggregation Router – passively cooled, universal AC powered unit; there are six variants: • a unit that is equipped with an AC power input connector, five Gigabit Ethernet data ports (three SFP ports and two RJ-45 Ethernet ports), and an RJ-45 alarm input connector • a unit that is equipped with an AC power input connector, five Gigabit Ethernet data ports (three SFP ports and two RJ-45 Ethernet ports), a GPS receiver, and an RJ-45 alarm input connector • a unit that is equipped with an AC power input connector, five Gigabit Ethernet data ports (three SFP ports, one RJ-45 Ethernet port, and one RJ-45 PoE+ port), and an RJ-45 alarm input connector • a unit that is equipped with an AC power input connector, five Gigabit Ethernet data ports (three SFP ports, one RJ-45 Ethernet port, and one RJ-45 PoE+ port), a GPS receiver, and an RJ-45 alarm input connector • a unit that is equipped with an AC power input connector, four Gigabit Ethernet data ports (three SFP ports and one RJ-45 port), one RJ-45 4-pair xDSL port, and an RJ-45 alarm input connector • a unit that is equipped with an AC power input connector, four Gigabit Ethernet data ports (three SFP ports and one RJ-45 port), one RJ-45 4-pair xDSL port, a GPS receiver, and an RJ-45 alarm input connector
SAR-X	7705 Service Aggregation Router – fan-cooled, rack-mountable, IP20 design, available in two variants: • AC-powered variant with a single-feed AC input that can be connected to a 100 to 240 VAC, 50/60 Hz power source • DC-powered variant with a dual-feed DC input that can be connected to a +24/-48/-60 VDC power source
SAToP	structure-agnostic TDM over packet
SCADA	surveillance, control and data acquisition
SC-APS	single-chassis automatic protection switching
SCP	secure copy
SCTP	Stream Control Transmission Protocol

Table 49 **Acronyms (Continued)**

Acronym	Expansion
SD	signal degrade space diversity
SDH	synchronous digital hierarchy
SDI	serial data interface
SDN	software defined network
SDP	service destination point
SE	shared explicit
SeGW	secure gateway
SES	severely errored seconds
SETS	synchronous equipment timing source
SF	signal fail
SFP	small form-factor pluggable (transceiver)
SFTP	SSH file transfer protocol
(S,G)	(source, group)
SGT	self-generated traffic
SHA-1	secure hash algorithm
SHG	split horizon group
SIR	sustained information rate
SLA	Service Level Agreement
SLARP	serial line address resolution protocol
SLID	subscriber location identifier of a GPON module
SLM	synthetic loss measurement
SNMP	Simple Network Management Protocol
SNPA	subnetwork point of attachment
SNR	signal to noise ratio
SNTP	simple network time protocol
SONET	synchronous optical networking
S-PE	switching provider edge router

Table 49 **Acronyms (Continued)**

Acronym	Expansion
SPF	shortest path first
SPI	security parameter index
S-PMSI	selective PMSI
SPT	shortest path tree
SR	service router (7750 SR) segment routing
SRLG	shared risk link group
SRP	stateful request parameter
SRRP	subscriber routed redundancy protocol
SR-ISIS	segment routing IS-IS
SR-OSPF	segment routing OSPF
SR-TE	segment routing traffic engineering
SSH	secure shell
SSM	source-specific multicast synchronization status messaging
SSU	system synchronization unit
S-TAG	service VLAN tag
STM	synchronous transport module
STM1	synchronous transport module, level 1
STP	spanning tree protocol
STS	synchronous transport signal
SVC	switched virtual circuit
SVEC	synchronization vector
SYN	synchronize
TACACS+	Terminal Access Controller Access-Control System Plus
TC	traffic class (formerly known as EXP bits)
TCP	transmission control protocol
TDA	transmit diversity antenna

Table 49 **Acronyms (Continued)**

Acronym	Expansion
TDEV	time deviation
TDM	time division multiplexing
TE	traffic engineering
TEDB	traffic engineering database
TEID	tunnel endpoint identifier
TEP	tunnel endpoint
TFTP	trivial file transfer protocol
T-LDP	targeted LDP
TLS	transport layer security
TLV	type length value
TM	traffic management
ToD	time of day
ToS	type of service
T-PE	terminating provider edge router
TPID	tag protocol identifier
TPIF	IEEE C37.94 teleprotection interface
TPMR	two-port MAC relay
TPS	transmission protection switching
TSoP	Transparent SDH/SONET over Packet
TTL	time to live
TTLS	tunneled transport layer security
TTM	tunnel table manager
TU	tributary unit
TUG	tributary unit group
TWAMP	two-way active measurement protocol
U-APS	unidirectional automatic protection switching
UAS	unavailable seconds

Table 49 **Acronyms (Continued)**

Acronym	Expansion
UBR	unspecified bit rate
UDP	user datagram protocol
UFD	unidirectional forwarding detection
UMH	upstream multicast hop
UMTS	Universal Mobile Telecommunications System (3G)
UNI	user-to-network interface
uRPF	unicast reverse path forwarding
V.11	ITU-T V-series Recommendation 11
V.24	ITU-T V-series Recommendation 24
V.35	ITU-T V-series Recommendation 35
VC	virtual circuit
VCB	voice conference bridge
VCC	virtual channel connection
VCCV	virtual circuit connectivity verification
VCI	virtual circuit identifier
VID	VLAN ID
VLAN	virtual LAN
VLL	virtual leased line
VM	virtual machine
VoIP	voice over IP
Vp	peak voltage
VP	virtual path
VPC	virtual path connection
VPI	virtual path identifier
VPLS	virtual private LAN service
VPN	virtual private network
VPRN	virtual private routed network

Table 49 **Acronyms (Continued)**

Acronym	Expansion
VRF	virtual routing and forwarding table
VRRP	virtual router redundancy protocol
VSE	vendor-specific extension
VSI	virtual switch instance
VSO	vendor-specific option
VT	virtual trunk virtual tributary
VTG	virtual tributary group
Wavence	formerly 9500 MPR (Microwave Packet Radio)
WCDMA	wideband code division multiple access (transmission protocol used in UMTS networks)
WRED	weighted random early discard
WTR	wait to restore
X.21	ITU-T X-series Recommendation 21
XOR	exclusive-OR
XRO	exclude route object

7 Standards and Protocol Support

This chapter lists the 7705 SAR compliance with EMC, environmental, and safety standards, telecom standards, and supported protocols:

Table 50 EMC Industrial Standards Compliance

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
IEEE 1613:2009 + A1:2011	IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations	✓[1]		✓[3]		✓[2]	✓[1]	✓[3]	✓[3]		
IEEE 1613.1-2013	IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Transmission and Distribution Facilities	✓[4]		✓[7]		✓[5]	✓[6]	✓[7]	✓[7]		
IEEE Std C37.90	IEEE Standard for relays and relay systems associated with Electric Power Apparatus	✓		✓		✓	✓	✓	✓		
IEEE Std C37.90.1	Surge Withstand Capability (SWC) Tests	✓		✓		✓	✓	✓	✓		
IEEE Std C37.90.2	Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers	✓		✓		✓	✓	✓	✓		
IEEE Std C37.90.3	IEEE Standard Electrostatic Discharge Tests for Protective Relays	✓		✓		✓	✓	✓	✓		
EN 50121-4	Electromagnetic Compatibility – Part 4: Emission and Immunity of the Signalling and Telecommunications Apparatus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 62236-4	Electromagnetic Compatibility – Part 4: Emission and Immunity of the Signalling and Telecommunications Apparatus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-6-2	Generic standards – Immunity for industrial environments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-6-4	Generic standards – Emissions standard for industrial environments	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-6-5	Generic standards – immunity for equipment used in power station and substation environment	✓		✓		✓	✓	✓	✓		
IEC 61850-3	Communication networks and systems for power utility automation - Part 3: General requirements	✓		✓		✓	✓[8]	✓	✓		
IEC/AS 60870.2.1	Telecontrol equipment and systems. Operating conditions. Power supply and electromagnetic compatibility	✓		✓		✓	✓	✓	✓		

Notes:

1. Performance Class 1
2. Performance Class 1 (Class 2 with Optics interfaces only)
3. Performance Class 2
4. Zone A; Performance Class 1
5. Zone A; Performance Class 1 (Class 2 with Optics interfaces only)
6. Zone B; Performance Class 1
7. Zone A; Performance Class 2
8. With the exception of DC surges

Table 51 EMC Regulatory and Customer Standards Compliance

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
IEC 61000-4-2	Electrostatic discharge immunity test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-4-3	Radiated electromagnetic field immunity test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-4-4	Electrical fast transient/burst immunity test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-4-5	Surge immunity test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-4-6	Immunity to conducted disturbances	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 61000-4-8	Power frequency magnetic field immunity test	✓		✓		✓	✓	✓	✓		
IEC 61000-4-9	Pulse Magnetic field immunity test	✓		✓		✓	✓	✓	✓		
IEC 61000-4-10	Damped Oscillatory Magnetic Field	✓		✓		✓	✓	✓	✓		
IEC 61000-4-11	Voltage dips, short interruptions and voltage variations immunity tests	✓	✓[1]	✓[1]	✓[1]	✓[1]	✓[1]	✓	✓[1]	✓	✓
IEC 61000-4-12	Oscillatory wave immunity test	✓		✓		✓	✓	✓	✓		
IEC 61000-4-16	Conducted immunity 0 Hz - 150 kHz	✓		✓		✓	✓	✓	✓		
IEC 61000-4-17	Ripple on d.c. input power port immunity test	✓		✓		✓	✓	✓	✓		
IEC 61000-4-18	Damped oscillatory wave immunity test	✓		✓		✓	✓	✓	✓		
IEC 61000-4-29	Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests	✓		✓		✓	✓	✓	✓		
IEC 61000-3-2	Limits for harmonic current emissions (equipment input current <16A per phase)	✓	✓[1]	✓[1]	✓[1]	✓[1]	✓[1]	✓	✓[1]	✓	✓

Table 51 **EMC Regulatory and Customer Standards Compliance (Continued)**

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
IEC 61000-3-3	Limits for voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current <16A	✓	✓[1]	✓[1]	✓[1]	✓[1]	✓[1]	✓	✓[1]	✓	✓
ITU-T K.20 (DC Ports)	Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents	✓	✓	✓	✓	✓	✓	✓	✓		
ITU-T K.44	Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents - Basic Recommendation									✓	✓
ETSI 300 132-2	Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V direct current (dc)	✓	✓	✓	✓	✓	✓	✓	✓	✓	
ETSI 300 132-3	Power supply interface at the input to telecommunications equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400V	✓	✓[1]	✓[1]	✓[1]			✓	✓[1]	✓	✓
EN 300 386	Telecommunication network equipment; ElectroMagnetic Compatibility (EMC)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ES 201 468	Electromagnetic compatibility and Radio spectrum Matters (ERM); Additional ElectroMagnetic Compatibility (EMC) requirements and resistibility requirements for telecommunications equipment for enhanced availability of service in specific applications	✓		✓	✓	✓	✓				✓
EN 55024	Information technology equipment - Immunity characteristics - Limits and methods of measurements	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Telcordia GR-1089-CORE	EMC and Electrical Safety - Generic Criteria for Network Telecommunications Equipment	✓	✓	✓	✓	✓	✓	✓	✓		
AS/NZS CISPR 32	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[3]	✓[3]
FCC Part 15, Subpart B	Radio Frequency devices- Unintentional Radiators (Radiated & Conducted Emissions)	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[3]	✓[3]

Table 51 EMC Regulatory and Customer Standards Compliance (Continued)

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
ICES-003	Information Technology Equipment (ITE) — Limits and methods of measurement	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[3]	✓[3]
EN 55032	Electromagnetic compatibility of multimedia equipment – Emission requirements	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]
CISPR 32	Electromagnetic compatibility of multimedia equipment – Emission requirements	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]	✓[2]
GS7 EMC	Electromagnetic Standard Compatibility (BT standard)	✓		✓	✓	✓	✓	✓			✓
KC Notice Emission (KN32) and Immunity (KN35) (South Korea)	EMS standard: NRRA notice	✓	✓	✓	✓	✓	✓	✓	✓		

Notes:

1. With external AC/DC power supply
2. Class A
3. Class B

Table 52 Environmental Standards Compliance

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
IEEE 1613:2009 + A1:2011	Environmental and Testing Requirements for Communications Networking Devices	✓[1]		✓		✓[1]	✓[1]	✓	✓		
IEC 61850-3	Communication networks and systems for power utility automation - Part 3: General requirements	✓[2]		✓[2]		✓[2]	✓[2]	✓[2]	✓[2]		
IEC 60068-2-1	Environmental testing – Part 2-1: Tests – Test A: Cold	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 60068-2-2	Environmental testing - Part 2-2: Tests - Test B: Dry heat	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC 60068-2-30	Environmental testing - Part 2: Tests. Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 52 Environmental Standards Compliance (Continued)

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
IEC 60255-21-2	Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section Two: Shock and bump tests	✓		✓		✓	✓	✓	✓		
ETSI 300 753 Class 3.2	Acoustic noise emitted by telecommunications equipment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Telcordia GR-63-CORE	NEBS Requirements: Physical Protection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ETSI EN 300 019-2-1 Class 1.2	Specification of environmental tests; Storage	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ETSI EN 300 019-2-2 Class 2.3	Specification of environmental tests; Transportation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ETSI EN 300 019-2-3 Class 3.2	Specification of environmental tests; Stationary use at weatherprotected locations	✓	✓	✓	✓	✓	✓	✓	✓		
ETSI EN 300 019-2-4 Class T4.1	Specification of environmental tests; Stationary use at non-weatherprotected locations									✓	✓
Telcordia GR-3108-CORE	Generic Requirements for Network Equipment in the Outside Plant (OSP)	✓[3]	✓[3]	✓[3]	✓[3]	✓[3]		✓[3]	✓[3]	✓[4]	✓[4]
Telcordia GR-950-CORE	Generic Requirements for ONU Closures and ONU Systems									✓	✓
“GR-3108 Class 3 Section 6.2 IEC 60068-2-52 - Severity 3 MIL-STD-810G Method 509.5 EN 60721-3-3 Class 3C4 EN 60068-2-11: Salt Mist EN 50155 Class ST4”	Conformal Coating [5]	✓			✓	✓		✓	✓		

Notes:

1. Forced air system; uses fans
2. Normal environmental conditions as per IEC 61850-3 ed.2
3. Class 2
4. Class 4
5. Conformal coating is available as an orderable option

Table 53 Safety Standards Compliance

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
UL/CSA 60950-1	Information technology equipment - Safety - Part 1: General requirements	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
IEC/EN 60950-1	Information technology equipment - Safety - Part 1: General requirements	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
UL/CSA 62368-1	Audio/video, information and communication technology equipment - Part 1: Safety requirements			✓		✓	✓				✓
IEC/EN 62368-1	Audio/video, information and communication technology equipment - Part 1: Safety requirements			✓		✓	✓				✓
AS/NZS 60950-1	Information technology equipment - Safety - Part 1: General requirements	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AS/NZS 62368-1	Audio/video, information and communication technology equipment, Part 1: Safety requirements					✓	✓				✓
IEC/EN 60825-1 and 2	Safety of laser products - Part 1: Equipment classification and requirements Part 2: Safety of optical fibre communication systems (OFCS)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
UL/CSA 60950-22	Information Technology Equipment - Safety - Part 22: Equipment to be Installed Outdoors									✓	✓
CSA–C22.2 No.94	Special Purpose Enclosures									✓	✓
UL50	Enclosures for Electrical Equipment, Non-Environmental Consideration									✓	✓
IEC/EN 60950-22	Information technology equipment. Equipment to be installed Outdoors.									✓	✓
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)	✓[1]	✓[2]	✓[2]	✓[1]	✓[1]	✓[1]	✓[2]	✓[2]	✓[3]	✓[3]

Notes:

1. IP20
2. IP40
3. IP65

Table 54 Telecom Interface Compliance

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
IC CS-03 Issue 9	Compliance Specification for Terminal Equipment, Terminal Systems, Network Protection Devices, Connection Arrangements and Hearing Aids Compatibility	✓	✓		✓	✓	✓	✓			
ACTA TIA-968-B	Telecommunications - Telephone Terminal Equipment - Technical Requirements for Connection of Terminal Equipment to the Telephone Network	✓	✓		✓	✓	✓	✓			
AS/ACIF S016 (Australia)	Requirements for Customer Equipment for connection to hierarchical digital interfaces	✓	✓		✓	✓	✓	✓			
ATIS-06000403	Network and Customer Installation Interfaces- DS1 Electrical Interfaces	✓	✓		✓	✓	✓	✓			
ANSI/TIA/EIA-422-B (RS422)	Electrical Characteristics for balanced voltage digital interfaces circuits					✓	✓				
ITU-T G.825	The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)					✓	✓				
ITU-T G.703	Physical/electrical characteristics of hierarchical digital interfaces	✓	✓		✓	✓	✓	✓			
ITU-T G.712 (E&M)	Transmission performance characteristics of pulse code modulation channels					✓	✓				
ITU-T G.957	Optical interfaces for equipments and systems relating to the synchronous digital hierarchy					✓	✓				
ITU-T V.24 (RS232)	List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)					✓	✓	✓	✓		
ITU-T V.28 (V35)	Electrical characteristics for unbalanced double-current interchange circuits					✓	✓				
ITU-T V.36 (V35)	Modems for synchronous data transmission using 60-108 kHz group band circuits					✓	✓				

Table 54 Telecom Interface Compliance (Continued)

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
ITU-T V.11 / X.27 (RS-422)	Electrical characteristics for balanced double current interchange circuits operating at data signalling rates up to 10 Mbit/s					✓	✓				
ITU-T X.21 (RS-422)	Interface between Data Terminal Equipment and Data Circuit-terminating Equipment for synchronous operation on public data networks					✓	✓				
IEEE 802.3at (POE)	Data Terminal Equipment Power via the Media Dependent Interfaces Enhancements				✓			✓	✓	✓	✓

Table 55 Directives, Regional Approvals and Certifications Compliance

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
EU Directive 2014/30/EU (EMC)	Electromagnetic Compatibility (EMC)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EU Directive 2014/35/EU (LVD)	Low Voltage Directive (LVD)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EU Directive 2012/19/EU (WEEE)	Waste Electrical and Electronic Equipment (WEEE)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
EU Directive 2011/65/EU (RoHS)	EU Directive 2011/65/EU Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment (Recast) Directive (including Commission Delegated Directive (EU) 2015/863)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CE Mark		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CRoHS Logo; Ministry of Information Industry order No.39		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
China (MII NAL) Network Access License			✓		✓	✓	✓	✓		✓	

Table 55 **Directives, Regional Approvals and Certifications Compliance (Continued)**

Standard	Title	Platform									
		SAR-X	SAR-A	SAR-Ax	SAR-M	SAR-8	SAR-18	SAR-H	SAR-Hc	SAR-W	SAR-Wx
South Korea (KC Mark)		✓	✓	✓	✓	✓	✓	✓	✓		
Australia (RCM Mark)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Japan (VCCI Mark)		✓	✓	✓	✓	✓	✓	✓			
NEBS Level 3		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
TL9000 certified		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ISO 14001 certified		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ISO 9001:2008 certified		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Security Standards

FIPS 140-2—Federal Information Processing Standard publication 140-2, Security Requirements for Cryptographic Modules

Telecom Standards

ANSI/TIA/EIA-232-C—Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

IEEE 802.1ad—IEEE Standard for Local and Metropolitan Area Networks---Virtual Bridged Local Area Networks

IEEE 802.1ag—Service Layer OAM

IEEE 802.1p/q—VLAN Tagging

IEEE 802.3—10BaseT

IEEE 802.3ab—1000BaseT

IEEE 802.3ah—Ethernet OAM

IEEE 802.3u—100BaseTX

IEEE 802.3x —Flow Control

IEEE 802.3z—1000BaseSX/LX

IEEE 802.3-2008—Revised base standard

IEEE 802.1AX-2008—Link Aggregation Task Force (transferred from IEEE 802.3ad)

IEEE C37.94-2017—N Times 64 Kilobit Per Second Optical Fiber Interfaces Between Teleprotection and Multiplexer Equipment

ITU-T G.704—Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels

ITU-T G.707—Network node interface for the Synchronous Digital Hierarchy (SDH)

ITU-T G.826—End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections

ITU-T G.8032 — Ethernet Ring Protection Switching

ITU-T G.984.1—Gigabit-capable passive optical networks (GPON): general characteristics

ITU-T Y.1564—Ethernet service activation test methodology

ITU-T Y.1731—OAM functions and mechanisms for Ethernet-based networks

Protocol Support

ATM

AF-PHY-0086.001—Inverse Multiplexing for ATM (IMA)

af-tm-0121.000—Traffic Management Specification Version 4.1, March 1999

GR-1113-CORE—Bellcore, Asynchronous Transfer Mode (ATM) and ATM Adaptation Layer (AAL) Protocols Generic Requirements, Issue 1, July 1994

GR-1248-CORE—Generic Requirements for Operations of ATM Network Elements (NEs). Issue 3 June 1996

ITU-T Recommendation I.432.1—B-ISDN user-network interface - Physical layer specification: General characteristics

ITU-T Recommendation I.610—B-ISDN Operation and Maintenance Principles and Functions version 11/95

RFC 2514—Definitions of Textual Conventions and OBJECT_IDENTITIES for ATM Management, February 1999

RFC 2515—Definition of Managed Objects for ATM Management, February 1999

RFC 2684—Multiprotocol Encapsulation over ATM Adaptation Layer 5

BFD

draft-ietf-bfd-mib-00.txt—Bidirectional Forwarding Detection Management Information Base

draft-ietf-bfd-base-o5.txt—Bidirectional Forwarding Detection

draft-ietf-bfd-v4v6-1hop-06.txt—BFD IPv4 and IPv6 (Single Hop)

draft-ietf-bfd-multihop-06.txt—BFD for Multi-hop Paths

BGP

RFC 1397—BGP Default Route Advertisement

RFC 1997—BGP Communities Attribute

RFC 2385—Protection of BGP Sessions via the TCP MD5 Signature Option

RFC 2439—BGP Route Flap Dampening

RFC 2545—Use of BGP-4 Multiprotocol Extensions for IPv6 Inter-Domain Routing

RFC 2918—Route Refresh Capability for BGP-4

RFC 3107—Carrying Label Information in BGP-4

RFC 3392—Capabilities Advertisement with BGP-4

RFC 4271—BGP-4 (previously RFC 1771)

RFC 4360—BGP Extended Communities Attribute

RFC 4364—BGP/MPLS IP Virtual Private Networks (VPNs) (previously RFC 2574bis BGP/MPLS VPNs)

RFC 4456—BGP Route Reflection: Alternative to Full-mesh IBGP (previously RFC 1966 and RFC 2796)

RFC 4486—Subcodes for BGP Cease Notification Message

RFC 4684—Constrained Route Distribution for Border Gateway Protocol/ MultiProtocol Label Switching (BGP/MPLS) Internet Protocol (IP) Virtual Private Networks (VPNs)

RFC 4724—Graceful Restart Mechanism for BGP - GR Helper

RFC 4760—Multi-protocol Extensions for BGP (previously RFC 2858)

RFC 4893—BGP Support for Four-octet AS Number Space

RFC 6513—Multicast in MPLS/BGP IP VPNs

RFC 6514—BGP Encodings and Procedures for Multicast in MPLS/BGP IP VPNs

draft-ietf-idr-add-paths-04.txt—Advertisement of Multiple Paths in BGP

draft-ietf-idr-add-paths-guidelines-00.txt—Best Practices for Advertisement of Multiple Paths in BGP

DHCP/DHCPv6

RFC 1534—Interoperation between DHCP and BOOTP

RFC 2131—Dynamic Host Configuration Protocol (REV)

RFC 2132—DHCP Options and BOOTP Vendor Extensions

RFC 3046—DHCP Relay Agent Information Option (Option 82)

RFC 3315—Dynamic Host Configuration Protocol for IPv6

RFC 3736—Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6

Differentiated Services

RFC 2474—Definition of the DS Field in the IPv4 and IPv6 Headers

RFC 2597—Assured Forwarding PHB Group

RFC 2598—An Expedited Forwarding PHB

RFC 3140—Per-Hop Behavior Identification Codes

Digital Data Network Management

V.35

RS-232 (also known as EIA/TIA-232)

X.21

DSL Modules

IEEE 802.2 LLC/SNAP bridged encapsulation while operating in ATM bonded mode

ITU-T G.991.2 Annex A, B, F and ITU-T G.991.2 Amendment 2 Annex G—SHDSL standards compliance

ITU-T G.991.2 Appendix F and G—Support for up to 5696 Kb/s per pair

ITU-T G.992.1 (ADSL)

ITU-T G.992.3 (G.dmt.bis), Annex A, B, J, M

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