# Alcatel-Lucent

## Service Access Switch | Release 6.1 Rev. 03

### 7210 SAS M, X, R6 OS
### MPLS Guide

**93-0516-01-03**

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# Preface

## About This Guide

Note: This guide is not applicable for 7210 SAS-M devices configured in Access uplink mode.

This guide describes the services and protocol support provided by the 7210 SAS Series and presents examples to configure and implement MPLS, RSVP, and LDP protocols.

This document 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.

## Audience

This manual is intended for network administrators who are responsible for configuring the 7210 SAS M-Series routers. It is assumed that the network administrators have an understanding of networking principles and configurations. Protocols and concepts described in this manual include the following:

- Multiprotocol Label Switching (MPLS)
- Resource Reservation Protocol (RSVP)
- Label Distribution Protocol (LDP)

## List of Technical Publications

The 7210 SAS-M, T, X, R6 documentation set is composed of the following books:

- 7210 SAS-M, T, X, R6 Basic System Configuration Guide

  This guide describes basic system configurations and operations.
- 7210 SAS-M, T, X, R6 System Management Guide

  This guide describes system security and access configurations as well as event logging and accounting logs.
- 7210 SAS-M, T, X, R6 Interface Configuration Guide

  Tis guide describes card, Media Dependent Adapter (MDA), and port provisioning.
- 7210 SAS-M, T, X, R6 OS Router Configuration Guide

  This guide describes logical IP routing interfaces and associated attributes such as an IP address, port, link aggregation group (LAG) as well as IP and MAC-based filtering.
- 7210 SAS-M, X, R6 OS MPLS Guide

  This guide describes how to configure Multiprotocol Label Switching (MPLS), Resource Reservation Protocol (RSVP), and Label Distribution Protocol (LDP).
- 7210 SAS-M, T OS, and 7210 SAS-X, R6 OS Services Guide

  This guide describes how to configure service parameters such as customer information and user services.
- 7210 SAS-M, T, X, R6 OAM and Diagnostic Guide

  This guide describes how to configure features such as service mirroring and Operations, Administration and Management (OAM) tools.
- 7210 SAS-M, T OS and 7210 SAS-X, R6 OS Quality of Service Guide

  This guide describes how to configure Quality of Service (QoS) policy management.

# Technical Support

If you purchased a service agreement for your 7210 SAS M-series 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 an Alcatel-Lucent service agreement, contact your welcome center:

Web: http://www1.alcatel-lucent.com/comps/pages/carrier_support.jhtml

# GETTING STARTED

## In This Chapter

This chapter provides process flow information to configure MPLS, RSVP, and LDP protocols.

## Alcatel-Lucent 7210 SAS-M, X, and R6 Router Configuration Process

Table 1 lists the tasks necessary to configure MPLS applications functions.

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 | Chapter |
|---|---|---|
| Protocol configuration | Configure MPLS protocols: | |
| | • MPLS | MPLS on page 18 |
| | • RSVP | RSVP on page 60 |
| | • LDP | Label Distribution Protocol on page 221 |
| Reference | List of IEEE, IETF, and other proprietary entities. | Standards and Protocol Support (for 7210 SAS-M, 7210 SAS-X, and 7210 SAS-T) on page 293 |

# MPLS and RSVP

## In This Chapter

This chapter provides information to configure MPLS and RSVP.

# MPLS

Multiprotocol Label Switching (MPLS) is a label switching technology that provides the ability to set up connection-oriented paths over a connection less 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 not enabled by default and must be explicitly enabled.

MPLS is independent of any routing protocol but is considered multiprotocol because it works with the Internet Protocol (IP) and frame relay network protocols.

# MPLS Label Stack

MPLS requires a set of procedures to enhance network layer packets with label stacks which thereby turns them into labeled packets. Routers that support MPLS are known as Label Switching Routers (LSRs). In order to transmit a labeled packet on a particular data link, an 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, or swap the label and push one or more labels into 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 some number of other labels may have been above it in the past, or that some number of 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 displays the label placement in a packet.

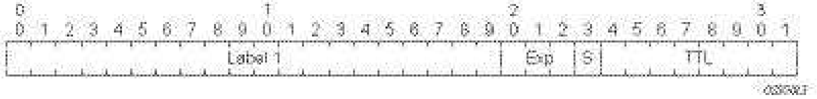


**Figure 1: Label Placement**

**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 TTL 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).

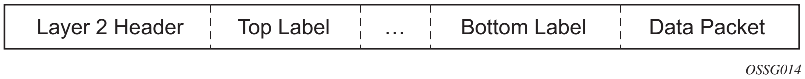


**Figure 2: Label Packet Placement**

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.

Labeled packet processing is independent of the level of hierarchy. Processing is always based on the top label in the stack which includes information about the operations to perform on the packet's label stack.

## Label Values

Packets travelling along an LSP (see Label Switching Routers on page 22) are identified by its label, the 20-bit, unsigned integer. The range is 0 through 1,048,575. Label values 0-15 are reserved and are defined below as follows:

- A value of 0 represents the IPv4 Explicit NULL Label. This Label value is legal only at the bottom of the Label stack. It indicates that the Label stack must be popped, and the packet forwarding must be based on the IPv4 header.
- 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 occur 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. This is a Label that a Label Switching Router (LSR) can assign and distribute, but which never actually appears in the encapsulation. When an LSR would otherwise replace the Label at the top of the stack with a new Label, but the new Label is Implicit NULL, the LSR pops the stack instead of doing the replacement. Although this value may never appear in the encapsulation, it needs to be specified in the RSVP, so a value is reserved.
- Values 4-15 are reserved for future use.

7210 SAS M, X  OS uses labels for MPLS, RSVP-TE, and LDP, as well as packet-based services such as VLL and VPLS.

Label values 16 through 1,048,575 are defined as follows:

- Label values 16 through 31 are reserved for future use.
- Label values 32 through 1,023 are available for static assignment.
- Label values 1,024 through 2,047 are reserved for future use.
- Label values 2,048 through 18,431 are statically assigned for services.
- Label values 32768 through 131,071 are dynamically assigned for both MPLS and services.
- Label values 131,072 through 1,048,575 are reserved for future use.

## Label Switching Routers

LSRs perform the label switching function. LSRs perform different functions based on it’s position in an LSP. Routers in an LSP do one of the following:

- The router at the beginning of an LSP is the ingress label edge router (ILER). The ingress router can encapsulate packets with an MPLS header and forward it to the next router along the path. An LSP can only have one ingress router.
- A Label Switching Router (LSR) can be any intermediate router in the LSP between the ingress and egress routers. An LSR swaps the incoming label with the outgoing MPLS label and forwards the MPLS packets it receives to the next router in the MPLS path (LSP). An LSP can have 0-253 transit routers.
- The router at the end of an LSP is the egress label edge router (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. Each LSP can have only one egress router. The ingress and egress routers in an LSP cannot be the same router.

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

An LSP is confined to one IGP area for LSPs using constrained-path. They cannot cross an autonomous system (AS) boundary.

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

## LSP Types

The following are LSP types:

- Static LSPs — A static LSP specifies a static path. All routers that the LSP traverses must be configured manually with labels. No signaling such as RSVP or LDP is required.
- Signaled LSP — LSPs are set up using a signaling protocol such as RSVP-TE or LDP. The 7210 SAS M supports only RSVP-TE for setting up LSPs. 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.

  There are two signaled LSP types:

  → 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 through other routers (loose). You can control how the path is set up. They are similar to static LSPs but require less configuration. See RSVP on page 60.

→ 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 which satisfies the constraints for the LSP. In turn, CSPF relies on the topology database provided by the extended IGP such as OSPF or IS-IS.

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

If fast reroute is configured, the ingress router signals the routers downstream. Each downstream router sets up a detour for the LSP. If a downstream router does not support fast reroute, the request is ignored and the router continues to support the LSP. This can cause some of the detours to fail, but otherwise the LSP is not impacted.

No bandwidth is reserved for the rerouted 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 the LSP backup LSP establishment.

Hop-limit parameters 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. The hop count is set to 255 by default for the primary and secondary paths. It is set to 16 by default for a bypass or detour LSP path.

## MPLS Fast Re-Route (FRR)

The MPLS facility bypass method of MPLS Fast Re-Route (FRR) functionality is extended to the ingress node.

The behavior of an LSP at an ingress LER with both fast reroute and a standby LSP path configured is as follows:

- When a down stream detour becomes active at a point of local repair (PLR):

  The ingress LER switches to the standby LSP path. If the primary LSP path is repaired subsequently at the PLR, the LSP will switch back to the primary path. If the standby goes down, the LSP is switched back to the primary, even though it is still on the detour at the PLR. If the primary goes down at the ingress while the LSP is on the standby, the detour at the ingress is cleaned up and for one-to-one detours a “path tear” is sent for the detour path. In other words, the detour at the ingress does not protect the standby. If and when the primary LSP is again successfully re-signaled, the ingress detour state machine will be restarted.
- When the primary fails at the ingress:

  The LSP switches to the detour path. If a standby is available then LSP would switch to standby on expiration of **hold-timer**. If **hold-timer** is disabled then switchover to standby would happen immediately. On successful global revert of primary path, the LSP would switch back to the primary path.
- Admin groups are not taken into account when creating detours for LSPs.

## Manual Bypass LSP

The 7210 SAS supports Manual bypass tunnels, on implementation of the Manual bypass feature a LSP can be pre-configured from a PLR which is used exclusively for bypass protection. If a path message for a new LSP requests for bypass protection, the node checks if a manual bypass tunnel satisfying the path constraints exists. If a tunnel is found, it is selected. If no such tunnel exists by default, the 7210 SAS dynamically signals a bypass LSP.

Users can disable the dynamic bypass creation on a per node basis using the CLI.

A maximum of 1000 associations of primary LSP paths can be made with a single manual bypass at the PLR node. If dynamic bypass creation is disabled on the node, it is recommended to configure additional manual bypass LSPs to handle the required number of associations.

## PLR Bypass LSP Selection Rules

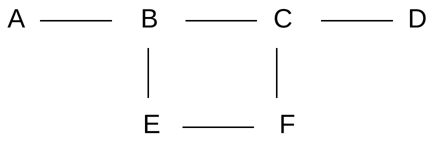


**Figure 3: Bypass Tunnel Nodes**

The PLR uses the following rules to select a bypass LSP among multiple manual and dynamic bypass LSP's at the time of establishment of the primary LSP path or when searching for a bypass for a protected LSP which does not have an association with a bypass tunnel:

1. The MPLS/RSVP task in the PLR node checks if an existing manual bypass satisfies the constraints. If the path message for the primary LSP path indicated node protection desired, which is the default LSP FRR setting at the head end node, MPLS/RSVP task searches for a node-protect' bypass LSP. If the path message for the primary LSP path indicated link protection desired, then it searches for a link-protect bypass LSP.
2. If multiple manual bypass LSPs satisfying the path constraints exist, it will prefer a manual-bypass terminating closer to the PLR over a manual bypass terminating further away. If multiple manual bypass LSPs satisfying the path constraints terminate on the same downstream node, it selects one with the lowest IGP path cost or if in a tie, picks the first one available.
3. If none satisfies the constraints and dynamic bypass tunnels have not been disabled on PLR node, then the MPLS/RSVP task in the PLR will check if any of the already established dynamic bypasses of the requested type satisfies the constraints.
4. If none do, then the MPLS/RSVP 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 desired, and no manual bypass was found after Step 1, and/or no dynamic bypass LSP was found after 3 attempts of performing Step 3, the MPLS/RSVP task will repeat Steps 1-3 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 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 LSP that requested FRR protection but are not currently associated with a bypass tunnel, the PLR node on reception of RESV refresh on the primary LSP path repeats Steps 1-7.

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

If the user configures a bypass tunnel on node B and dynamic bypass tunnels have been disabled, LSPs which have been previously signaled and which were not associated with any manual bypass tunnel, for example, none existed, will be associated with the manual bypass tunnel if suitable. The node checks for the availability of a suitable bypass tunnel for each of the outstanding LSPs every time a 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 which have been previously signaled over dynamic bypass tunnels will not automatically be switched into the manual bypass tunnel even if the manual bypass is a more optimized path. The user will have to perform a make before break at the head end of these LSPs.

If the manual bypass goes into the down state in 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 again the "protection available" flag in the next RESV refresh message for each of these LSPs. If it could not find one, it will keep checking for one every time a RESV message is received for each of the remaining LSPs. When the manual bypass tunnel is back UP, the LSPs which did not find a match will be associated back to this tunnel and the protection available flag is set starting in the next RESV refresh message.

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

## FRR Node-Protection (Facility)

The MPLS Fast Re-Route (FRR) functionality enables PLRs to be aware of the missing node protection and lets them regularly probe for a node-bypass. The following describes an LSP scenario:

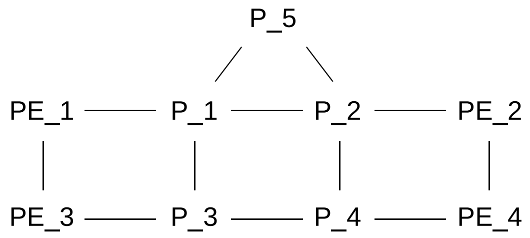


**Figure 4: FRR Node-Protection Example**

Where:

- LSP 1: between PE_1 to PE_2, with CSPF, FRR facility node-protect enabled.
- P_1 protects P_2 with bypass-nodes P_1 -P_3 - P_4 - PE_4 -PE_2.
- If P_4 fails, P_1 tries to establish the bypass-node three times.
- When the bypass-node creation fails, P_1 will protect link P_1-P_2.
- P_1 protects the link to P_2 through P_1 - P_5 - P_2.
- P_4 returns online.

Since LSP 1 had requested node protection, but due to lack of any available path, it could only obtain link protection. Therefore, every 60 seconds the PLR for LSP 1 will search for a new path that might be able to provide node protection. Once P_4 is back online and such a path is available, A new bypass tunnel will be signalled and LSP 1 will get associated with this new bypass tunnel.

## Uniform FRR Failover Time

The failover time during FRR consists of a detection time and a switchover time. The detection time corresponds to the time it takes for the RSVP control plane protocol to detect that a network IP interface is down or that a neighbor/next-hop over a network IP interface is down. The control plane can be informed of an interface down event when event is due to a failure in a lower layer such in the physical layer. The control plane can also detect the failure of a neighbor/next-hop on its own by running a protocol such as Hello, Keep-Alive, or BFD.

The switchover time is measured from the time the control plane detected the failure of the interface or neighbor/next-hop to the time the IOM completed the reprogramming of all the impacted ILM or service records in the data path. This includes the time it takes for the control plane to send a down notification to all IOMs to request a switch to the backup NHLFE.

Uniform Fast-Reroute (FRR) failover enables the switchover of MPLS and service packets from the outgoing interface of the primary LSP path to that of the FRR backup LSP within the same amount of time regardless of the number of LSPs or service records. This is achieved by updating Ingress Label Map (ILM) records and service records to point to the backup Next-Hop Label to Forwarding Entry (NHLFE) in a single operation.

## Configuration Guidelines

Implicit NULL must be enabled for use of Manual Bypass or Dynamic Bypass (FRR facility) if the 7210 is used as a egress LER and/or is a Merge Point.

# MPLS Transport Profile (MPLS-TP)

**Note**: MPLS-TP is supported only on 7210 SAS-R6. It is not supported on 7210 SAS-M and 7210 SAS-X.

MPLS can be used to provide a network layer to support packet transport services. In some operational environments, it is desirable that the operation and maintenance of such an MPLS based packet transport network follow operational models typical in traditional optical transport networks (For example, SONET/SDH), while providing additional OAM, survivability and other maintenance functions targeted at that environment.

MPLS-TP defines a profile of MPLS targeted at transport applications. This profile defines the specific MPLS characteristics and extensions required to meet transport requirements, while retaining compliance to the standard IETF MPLS architecture and label switching paradigm. The basic requirements are architecture for MPLS-TP are described by the IETF in RFC 5654, RFC 5921 and RFC 5960, in order to meet two objectives:

1. To enable MPLS to be deployed in a transport network and operated in a similar manner to existing transport technologies.

2. To enable MPLS to support packet transport services with a similar degree of predictability to that found in existing transport networks.

In order to meet these objectives, MPLS-TP has a number of high level characteristics:

- It does not modify the MPLS forwarding architecture, which is based on existing pseudowire and LSP constructs. Point-to-point LSPs may be unidirectional or bi-directional. Bi-directional LSPs must be congruent (that is, co-routed and follow the same path in each direction). The 7210 SAS supports bidirectional co-routed MPLS-TP LSPs.
- There is no LSP merging.
- OAM, protection and forwarding of data packets can operate without IP forwarding support. When static provisioning is used, there is no dependency on dynamic routing or signaling.
- LSP and pseudowire monitoring is only achieved through the use of OAM and does not rely on control plane or routing functions to determine the health of a path. For example, LDP hello failures, do not trigger protection.
- MPLS-TP can operate in the absence of an IP control plane and IP forwarding of OAM traffic. In 7210 SAS 6.1R1 release, MPLS-TP is only supported on static LSPs and PWs.

The 7210 SAS supports MPLS-TP on LSPs and PWs with static labels. MPLS-TP is not supported on dynamically signalled LSPs and PWs. MPLS-TP is supported for EPIPE, and EPIPE Spoke SDP termination on VPLS. Static PWs may use SDPs that use either static MPLS-TP LSPs or RSVP-TE LSPs.

The following MPLS-TP OAM and protection mechanisms, defined by the IETF, are supported:

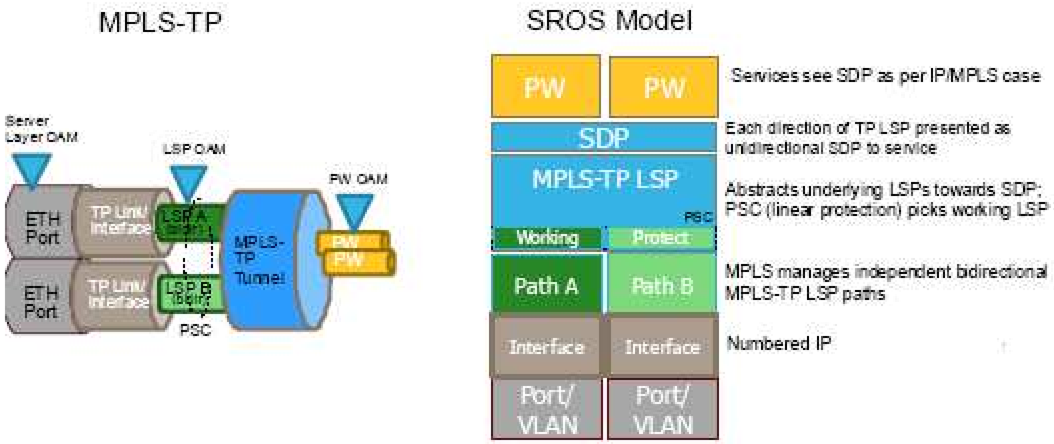
- MPLS-TP Generic Associated Channel for LSPs and PWs (RFC 5586)
- MPLS-TP Identifiers (RFC 6370)
- Proactive CC, CV, and RDI using BFD for LSPs (RFC 6428)
- BFD based CV is not supported in this release.
- On-Demand CV for LSPs and PWs using LSP Ping and LSP Trace (RFC 6426)
- 1-for-1 Linear protection for LSPs (RFC 6378)
- Static PW Status Signaling (RFC 6478)

The 7210 SAS can play the role of an LER and an LSR for static MPLS-TP LSPs, and a PE/T-PE for static MPLS-TP PWs. It can also act an MPLS network that supports both MPLS-TP and dynamic IP/MPLS.

## MPLS-TP Model

Figure 5 shows a high level functional model for MPLS-TP in 7210 SAS. LSP A and LSP B are the working and protect LSPs of an LSP tunnel. These are modelled as working and protect paths of an MPLS-TP LSP in 7210 SAS. MPLS-TP OAM runs in-band on each path. 1:1 linear protection coordinates the working and protect paths, using a protection switching coordination protocol (PSC) that runs in-band on each path over a Generic Associated Channel (G-ACh) on each path. Each path can use an IP numbered, IP unnumbered, or MPLS-TP unnumbered (that is, non-IP) interface.

**Figure 5: MPLS-TP Model**



Note that in 7210 SAS, all MPLS-TP LSPs are bidirectional co-routed, as detailed in RFC5654. That is, the forward and backward directions follow the same route (in terms of links and nodes) across the network. Both directions are setup, monitored and protected as a single entity. Therefore, both ingress and egress directions of the same LSP segment are associated at the LER and LSR and use the same interface (although this is not enforced by the system).

In the above model, an SDP can use one MPLS-TP LSP. This abstracts the underlying paths towards the overlying services, which are transported on pseudowires. Pseudowires are modelled as spoke SDPs and can also use MPLS-TP OAM. PWs with static labels may use SDPs that in-turn use either signaled RSVP-TE LSPs, or one static MPLS-TP LSP.

# MPLS-TP Provider Edge and Gateway

This section describes some example roles for the 7210 SAS in an MPLS-TP network.

## VLL Services

The 7210 SAS may use MPLS TP LSPs, and PWs, to transport point to point virtual leased line services. The 7210 SAS may play the role of a terminating PE or switching PE for VLLs. Epipe is supported.

**Note**: 7210 SAS-R6 supports T-PE functionality only. 7x50 with S-PE functionality is shown in the diagrams below to depict the end-to-end deployment scenario.

Figure 6 illustrates the use of the 7210 SAS as a T-PE for services in an MPLS-TP domain.

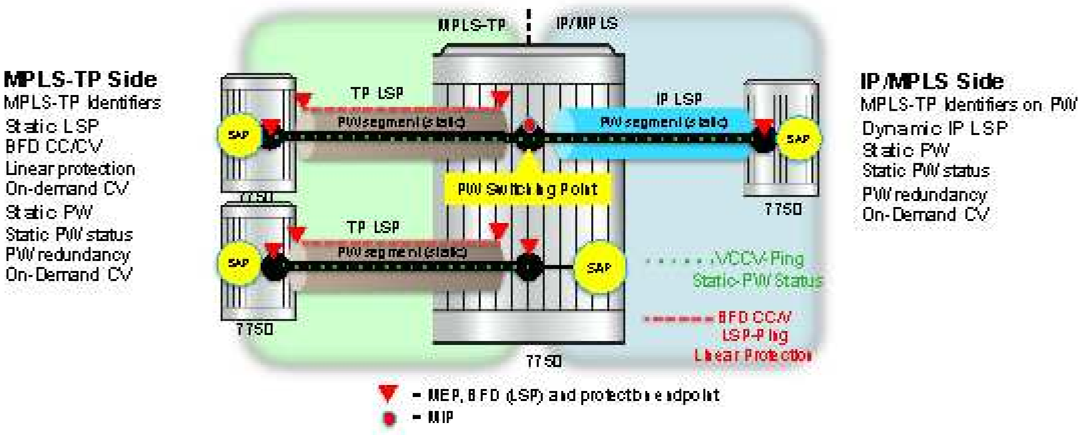


Figure 6: MPLS-TP Provider Edge and Gateway, VLL Services

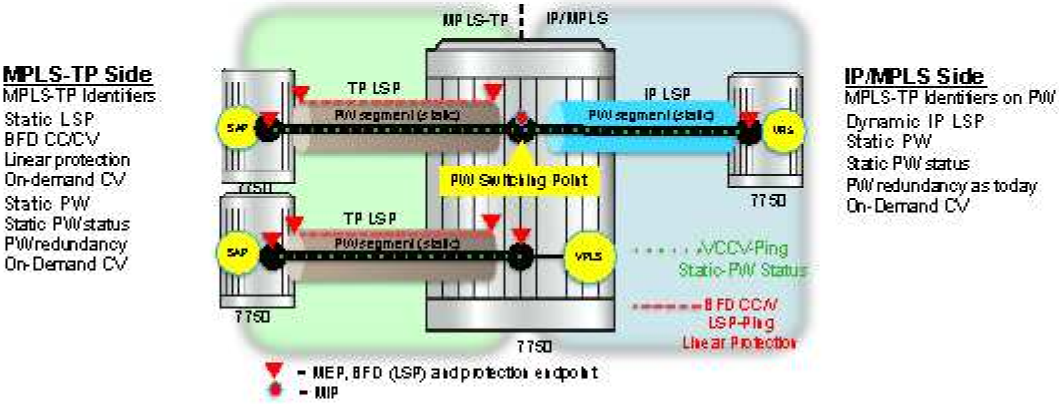


**Figure 7: MPLS-TP Provider Edge and Gateway, spoke-SDP Termination on VPLS**

Note: 7210 SAS-R6 does not support spoke-SDP termination on VPLS, IES and VPRN services. But, 7210 SAS-R6 nodes can be used as T-PE nodes (LER nodes) which originates the Epipe service.

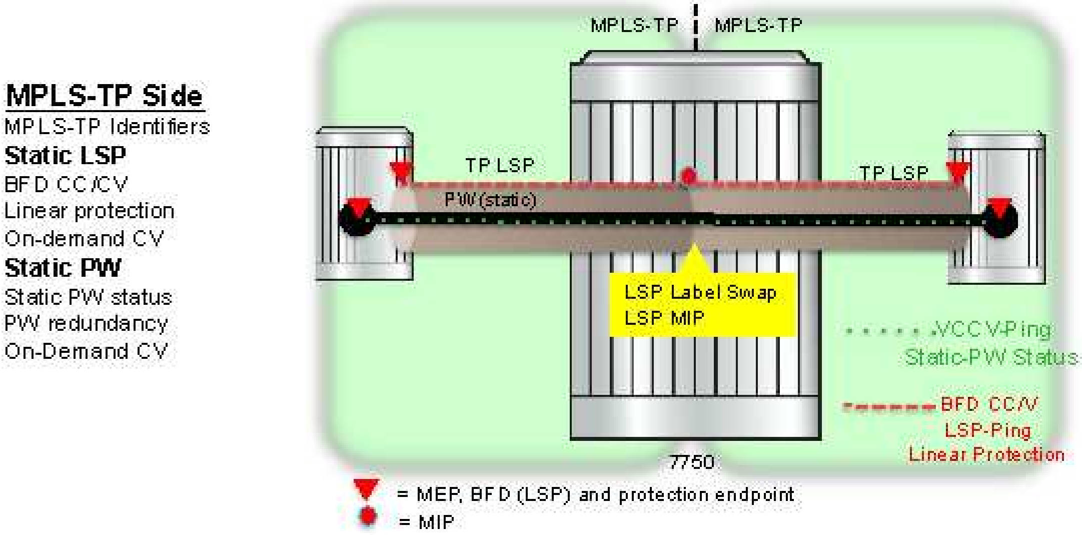


**Figure 8: MPLS-TP LSR**

## Detailed Descriptions of MPLS-TP

## MPLS-TP LSPs

The 7210 SAS supports the configuration of MPLS-TP tunnels, which comprise a working and, optionally, a protect LSP. In 7210 SAS, a tunnel is referred to as an LSP, while an MPLS-TP LSP is referred to as a path. It is then possible to bind an MPLS-TP tunnel to an SDP.

MPLS-TP LSPs (that is, paths) with static labels are supported. MPLS-TP is not supported for signaled LSPs.

Both bi-directional associated (where the forward and reverse directions of a bidirectional LSP are associated at a given LER, but may take different routes through the intervening network) and bidirectional co-routed (where the forward and reverse directions of the LSP are associated at each LSR, and take the same route through the network) are possible in MPLS-TP. However, only bidirectional co-routed LSPs are supported.

It is possible to configure MPLS-TP identifiers associated with the LSP, and MPLS-TP OAM parameters on each LSP of a tunnel. MPLS-TP protection is configured for a tunnel at the level of the protect path level. Both protection and OAM configuration is managed through templates, in order to simplify provisioning for large numbers of tunnels.

The 7210 SAS plays the role of either an LER or an LSR.

## MPLS-TP on Pseudowires

MPLS-TP is supported on PWs with static labels. The provisioning model supports RFC6370-style PW path identifiers for MPLS-TP PWs.

MPLS-TP PWs reuse the static PW provisioning model of previous 7210 SAS releases. The primary distinguishing feature for an “MPLS-TP” PW is the ability to configure MPLS-TP PW path identifiers, and to support MPLS-TP OAM and static PW status signaling.

The 7210 SAS can perform the role of a T-PE for a PW with MPLS-TP.

A spoke-SDP with static PW labels and MPLS-TP identifiers and OAM capabilities can use an SDP that uses either an MPLS-TP tunnel, or that uses regular RSVP-TE LSPs. The control word is supported for all MPLS-TP PWs.

# MPLS-TP Maintenance Identifiers

MPLS-TP is designed for use both with, and without, a control plane. MPLS-TP therefore specifies a set of identifiers that can be used for objects in either environment. This includes a path and maintenance identifier architecture comprising Node, Interface, PW and LSP identifiers, Maintenance Entity Groups (MEGs), Maintenance End Points (MEPs) and Maintenance Intermediate Points (MIPs). These identifiers are specified in RFC6370.

MPLS-TP OAM and protection switching operates within a framework that is designed to be similar to existing transport network maintenance architectures. MPLS-TP introduces concept of maintenance domains to be managed and monitored. In these, Maintenance Entity Group End Points (MEPs) are edges of a maintenance domain. OAM of a maintenance level must not leak beyond corresponding MEP and so MEPs typically reside at the end points of LSPs and PWs. Maintenance Intermediate Points (MIPS) define intermediate nodes to be monitored. Maintenance Entity Groups (MEGs) comprise all the MEPs and MIPs on an LSP or PW.

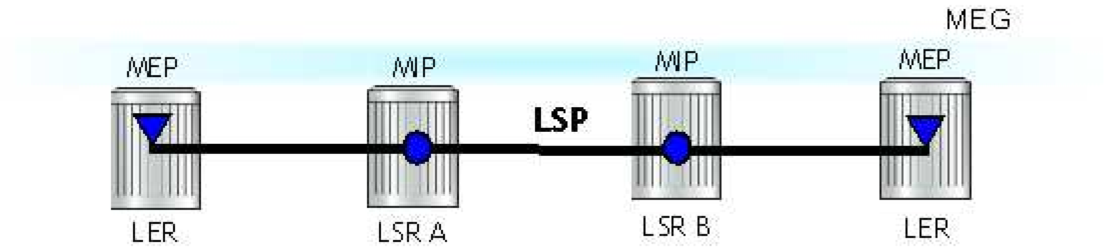


**Figure 9: MPLS-TP Maintenance Architecture**

Both IP-compatible and ICC (ITU-T carrier code) based identifiers for the above objects are specified in the IETF, but only the IP-compatible identifiers defined in RFC6370 are supported.

The 7210 SAS supports the configuration of the following node and interface related identifiers:

- Global_ID: In MPLS-TP, the Global_ID should be set to the AS# of the node. If not explicitly configured, then it assumes the default value of 0. In 7210 SAS, the source Global ID for an MPLS-TP Tunnel is taken to be the Global ID configured at the LER. The destination Global ID is optional in the tunnel configuration. If it is not configured, then it is taken as the same as the source Global ID.
- Node_ID: This is a 32-bit value assigned by the operator within the scope of the Global_ID. The 7210 SAS supports the configuration of an IPv4 formatted address <a.b.c.d> or an unsigned 32-bit integer for the MPLS-TP Node ID at each node. The node ID must be unique within the scope of the global ID, but there is no requirement for it to be a valid IP address. Indeed, a node-id can represent a separate IP-compatible addressing space that may be separate from the IP addressing plan of the underlying network. If no node ID is configured, then the node ID is taken to be the system interface IPv4 address of the node. When configuring a tunnel at an LER, either an IPv4 or an unsigned integer Node ID can be configured as the source and destination identifiers, but both ends must be of the same type.

Statically configured LSPs are identified using GMPLS-compatible identifiers with the addition of a Tunnel_Num and LSP_Num. As in RSVP-TE, tunnels represent, for example, a set of working and protect LSPs. These are GMPLS-compatible because GMPLS chosen by the IETF as the control plane for MPLS-TP LSPs, although this is not supported in 7210 SAS 6.1R1 release. PWs are identified using a PW Path ID which has the same structure as FEC129 AII Type 2.

The 7210 SAS derives the identifiers for MEPs and MIPs on LSPs and PWs based on the configured identifiers for the MPLS-TP Tunnel, LSP or PW Path ID, for use in MPLS-TP OAM and protection switching, as per RFC6370.

The information models for LSPs and PWs supported in 7210 SAS are illustrated in Figure 10 and Figure 11. The figures use the terminology defined in RFC6370.

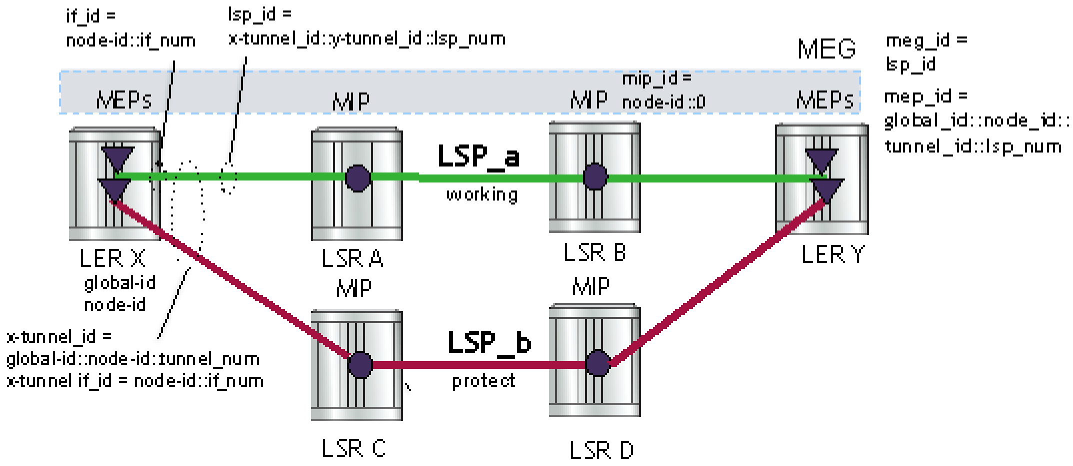
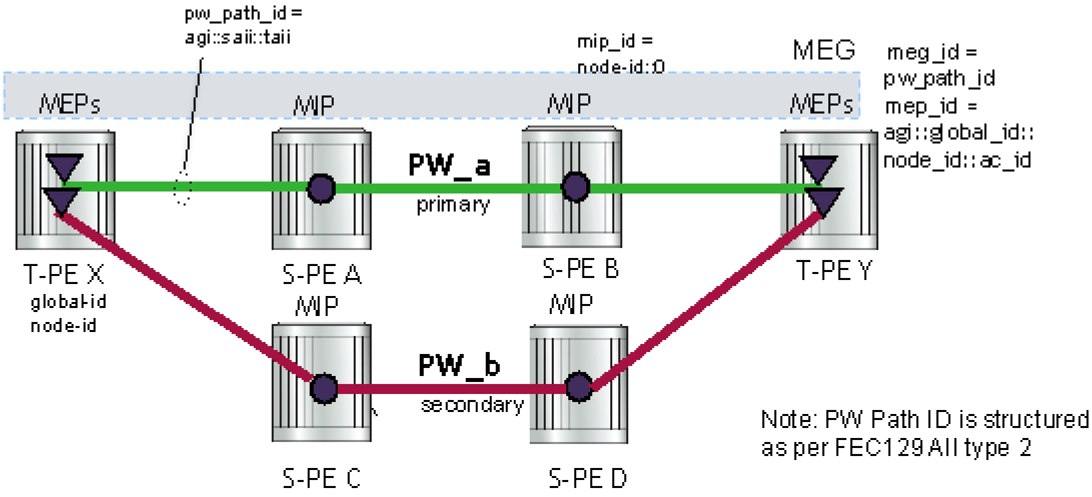


**Figure 10: MPLS-TP LSP and Tunnel Information Model**

The MPLS-TP Tunnel ID and LSP ID are not to be confused with the RSVP-TE tunnel id implemented on the 7210 system. Table 3 shows how these map to the X and Y ends of the tunnel shown in the above figure for the case of co-routed bidirectional LSPs.

**Table 3: Mapping from RSVP-TE to MPLS-TP Maintenance Identifiers**

| RSVP-TE Identifier | MPLS-TP Maintenance Identifier |
|---|---|
| Tunnel Endpoint Address | Node ID (Y) |
| Tunnel ID (X) | Tunnel Num (X) |
| Extended Tunnel ID | Node ID (X) |
| Tunnel Sender Address | Node ID (X) |
| LSP ID | LSP Num |



Note: PW Path ID is structured as per FEC129 AII type 2

**Figure 11: MPLS-TP PW Information Model**

In the PW information model shown in Figure 11, the MS-PW is identified by the PW Path ID that is composed of the full AGI:SAII:TAII. The PW Path ID is also the MEP ID at the T-PEs, so a user does not have to explicitly configure a MEP ID; it is automatically derived by the system. For MPLS-TP PWs with static labels, although the PW is not signaled end-to-end, the directionality of the SAII and TAII is taken to be the same as for the equivalent label mapping message that is, from downstream to upstream. This is to maintain consistency with signaled pseudowires using FEC 129.

On the 7210 SAS, an S-PE for an MS-PW with static labels is configured as a pair of spoke-sdps bound together in an VLL service using the vc-switching command. Therefore, the PW Path ID configured at the spoke-sdp level at an S-PE must contain the Global-ID, Node-ID and AC-ID at the far end T-PEs, not the local S-PE. Note that the ordering of the SAII:TAII in the PW Path ID where static PWs are used should be consistent with the direction of signaling of the egress label to a spoke-SDP forming that segment, if that label were signaled using T-LDP (in downstream unsolicited mode). VCCV Ping will check the PW ID in the VCCV Ping echo request message against the configured PW Path ID for the egress PW segment.

Figure 12 shows an example of how the PW Path IDs can be configured for a simple two-segment MS-PW.

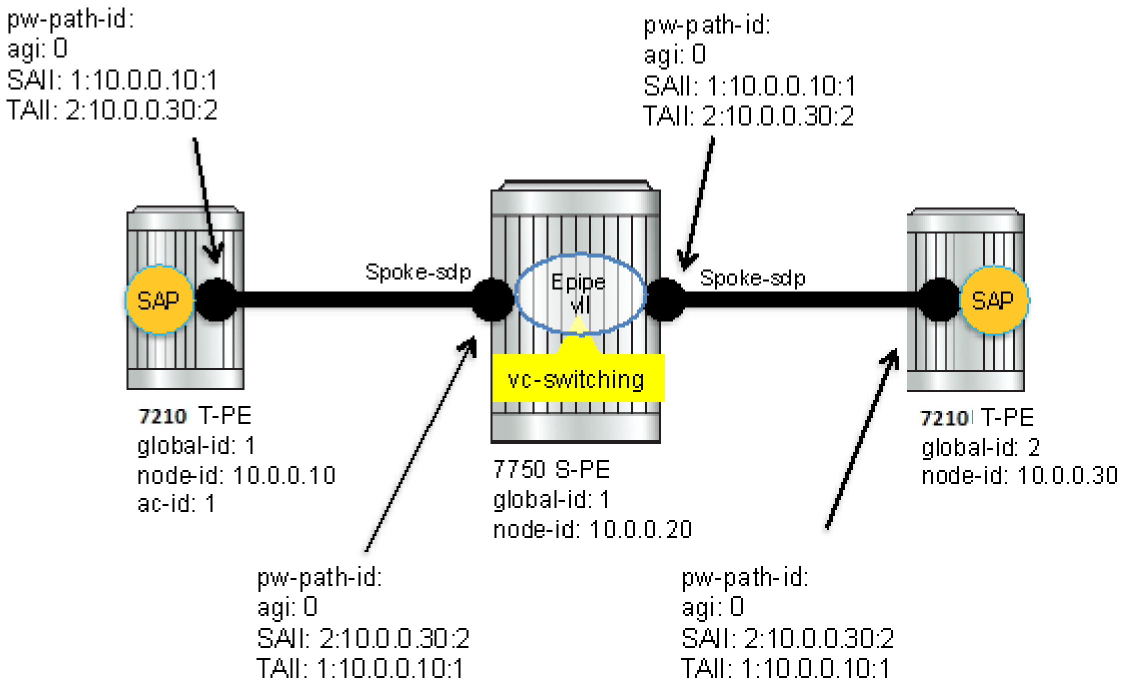


**Figure 12: Example usage of PW Identifiers**

## Generic Associated Channel

MPLS-TP requires that all OAM traffic be carried in-band on both directions of an LSP or PW. This is to ensure that OAM traffic always shares fate with user data traffic. This is achieved by using an associated control channel on an LSP or PW, similar to that used today on PWs. This creates a channel, which is used for OAM, protection switching protocols (for example, LSP linear protection switching coordination), and other maintenance traffic, and is known as the Generic Associated Channel (G-ACh).

RFC5586 specifies mechanisms for implementing the G-ACh, relying on the combination of a reserved MPLS label, the 'Generic-ACH Label (GAL)', as an alert mechanism (value=13) and Generic Associated Channel Header (G-ACH) for MPLS LSPs, and using the Generic Associated Channel Header, only, for MPLS PWs (although the GAL is allowed on PWs). The purpose of the GAL is to indicate that a G-ACH resides at the bottom of the label stack, and is only visible when the bottom non-reserved label is popped. The G-ACH channel type is used to indicate the packet type carried on the G-ACh. Packets on a G-ACh are targeted to a node containing a MEP by ensuring that the GAL is pushed immediately below the label that is popped at the MEP (for example, LSP endpoint or PW endpoint), so that it can be inspected as soon as the label is popped.

A G-ACh packet is targeted to a node containing a MIP by setting the TTL of the LSP or PW label, as applicable, so that it expires at that node, in a similar manner to the SROS implementation of VCCV for MS-PWs.

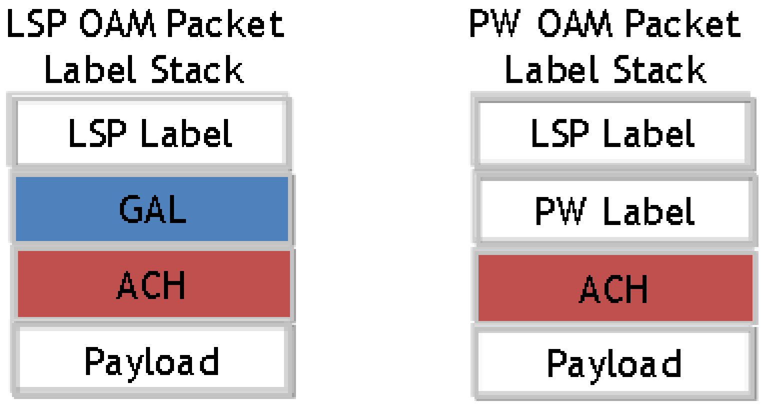


**Figure 13: Label for LSP and PW G-ACh Packets**

7210 SAS supports the G-ACh on static pseudowires and static LSPs.

## MPLS-TP Operations, Administration and Maintenance (OAM)

This section details the MPLS-TP OAM mechanisms that are supported.

### On-Demand Connectivity Verification (CV) using LSP-Ping

MPLS–TP supports mechanisms for on demand CC/CV as well as route tracing for LSPs and PWs. These are required to enable an operator to test the initial configuration of a transport path, or to assist with fault isolation and diagnosis. On demand CC/CV and route tracing for MPLS-TP is based on LSP-Ping and is described in RFC6426. Three possible encapsulations are specified in that RFC:

- IP encapsulation, using the same label stack as RFC4379, or encapsulated in the IPv4 G-ACh channel with a GAL/ACH
- A non-IP encapsulation with GAL/ACH for LSPs and ACH for PWs.

In IP-encapsulation, LSP-Ping packets are sent over the MPLS LSP for which OAM is being performed and contain an IP/UDP packet within them. The On-demand CV echo response message is sent on the reverse path of the LSP, and the reply contains IP/UDP headers followed by the On-demand CV payload.

In non-IP environments, LSP ping can be encapsulated with no IP/UDP headers in a G-ACh and use a source address TLV to identify the source node, using forward and reverse LSP or PW associated channels on the same LSP or PW for the echo request and reply packets. In this case, no IP/UDP headers are included in the LSP-Ping packets.

The 7210 supports the following encapsulations:

- IP encapsulation with ACH for PWs (as per VCCV type 1).
- IP encapsulation without ACH for LSPs using labeled encapsulation
- Non-IP encapsulation with ACH for both PWs and LSPs.

LSP Ping and VCCV Ping for MPLS-TP use two new FEC sub-types in the target FEC stack in order to identify the static LSP or static PW being checked. These are the Static LSP FEC sub-type, which has the same format as the LSP identifier described above, and the Static PW FEC sub-type,. These are used in-place of the currently defined target FEC stack sub-TLVs.

In addition, MPLS-TP uses a source/destination TLV to carry the MPLS-TP global-id and node-id of the target node for the LSP ping packet, and the source node of the LSP ping packet.

LSP Ping and VCCV-Ping for MPLS-TP can only be launched by the LER or T-PE. The replying node therefore sets the TTL of the LSP label or PW label in the reply packet to 255 to ensure that it reaches the node that launched the LSP ping or VCCV Ping request.

### Downstream Mapping Support

RFC4379 specifies four address types for the downstream mapping TLV for use with IP numbered and unnumbered interfaces:

Table 4: Address types for the downstream mapping TLV

| Type # | Address Type | K Octets | Reference | **7210 SAS-R6 support** |
|---|---|---|---|---|
| 1 | IPv4 Numbered | 16 | RFC 4379 | Yes |
| 2 | IPv4 Unnumbered | 16 | RFC 4379 | No |
| 3 | IPv6 Numbered | 40 | RFC 4379 | No |
| 4 | IPv6 Unnumbered | 28 | RFC 4379 | No |

RFC6426 adds address type 5 for use with Non IP interfaces, including MPLS-TP interfaces. In addition, this RFC specifies that type 5 must be used when non-IP ACH encapsulation is used for LSP Trace.

It is possible to send and respond to a DSMAP/DDMAP TLV in the LSP Trace packet for numbered IP interfaces as per RFC4379. In this case, the echo request message contains a downstream mapping TLV with address type 1 (IPv4 address) and the IPv4 address in the DDMAP/DSMAP TLV is taken to be the IP address of the IP interface that the LSP uses. The LSP trace packet therefore contains a DSMAP TLV in addition to the MPLS-TP static LSP TLV in the target FEC stack.

DSMAP/DDMAP is not supported for pseudowires.

## Proactive CC, CV and RDI

Proactive Continuity Check (CC) is used to detect a loss of continuity defect (LOC) between two MEPs in a MEG. Proactive Connectivity Verification (CV) is used to detect an unexpected connectivity defect between two MEPs (For example: mis-merging or disconnection), as well as unexpected connectivity within the MEG with an unexpected MEP. This feature implements both functions using proactive generation of OAM packets by the source MEP that are processed by the peer sink MEP. CC and CV packets are always sent in-band such that they fate share with user traffic, either on an LSP, PW or section and are used to trigger protection switching mechanisms.

Proactive CC/CV based on bidirectional forwarding detection (BFD) for MPLS-TP is described in RFC6428. BFD packets are sent using operator configurable timers and encapsulated without UDP/IP headers on a standardized G-ACh channel on an LSP or PW. CC packets simply consist of a BFD control packet, while CV packets also include an identifier for the source MEP in order that the sink MEP can detect if it is receiving packets from an incorrect peer MEP, thus indicating a mis-connectivity defect. Other defect types (including period mis-configuration defect) should be supported. When a supported defect is detected, an appropriate alarm is generated (for example: log, SNMP trap) at the receiving MEP and all traffic on the associated transport path (LSP or PW) is blocked. This is achieved using linear protection for CC defects, and by blocking the ingress data path for CV defects.

**NOTE**: 7210 SAS-R6 supports only BFD based CC mode. BFD based CC-CV mode is not supported in current release.

Note that when an LSP with CV is first configured, the LSP will be held in the CV defect state for 3.5 seconds after the first valid CV packet is received.

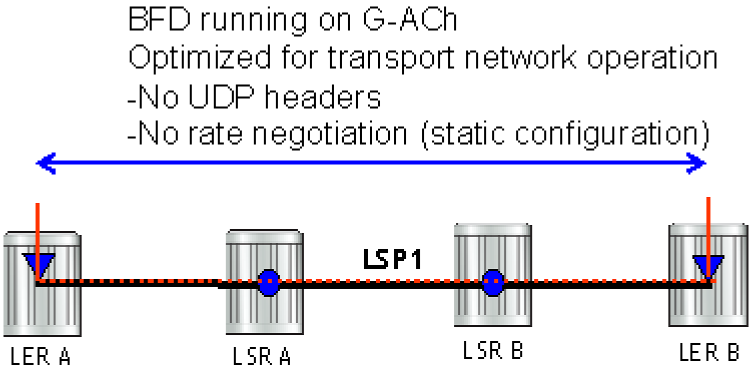

BFD running on G-ACh
Optimized for transport network operation
-No UDP headers
-No rate negotiation (static configuration)
LSP1
LER A
LSR A
LSR B
LER B

**Figure 14: BFD used for proactive CC on MPLS-TP LSP**

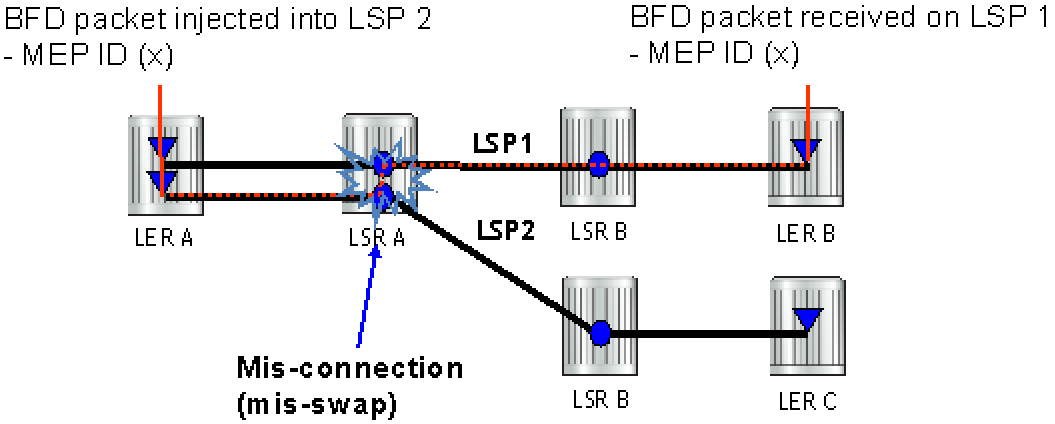


**Figure 15: BFD used for proactive CV on MPLS-TP LSP**

Linear protection switching of LSPs (see below) is triggered based on a CC or CV defect detected by BFD CC/CV.

Note that RFC6428 defines two BFD session modes: Coordinated mode, in which the session state on both directions of the LSP is coordinated and constructed from a single, bidirectional BFD session, and independent mode, in which two independent sessions are bound together at a MEP. Coordinated mode is supported.

BFD is supported on MPLS-TP LSPs. When BFD_CV detects a mis-connectivity on an LSP, the system will drop all incoming non-OAM traffic with the LSP label (at the LSP termination point) instead of forwarding it to the associated SAP or PW segment.

The following G-ACh channel types are supported for the combined CC/CV mode:

- 0x22 for BFD CC with no IP encapsulation
- 0x23 for BFD CV

The following G-ACh channel types are used for the CC-only mode:

- 0x07

### BFD-based RDI

RDI provides a mechanism whereby the source MEP can be informed of a downstream failure on an LSP, and can thus either raise an alarm, or initiate a protection switching operation. In the case of BFD based CC/CV, RDI is communicated using the BFD diagnostic field in BFC CC/CV messages. The following diagnostic codes are supported:

"1 - Control Detection Time Expired”

"9 - mis-connectivity defect”

## PW Control Channel Status Notifications (Static Pseudowire Status Signaling)

MPLS-TP introduces the ability to support a full range of OAM and protection / redundancy on PWs for which no dynamic T-LDP control plane exists. Static PW status signaling is used to advertise the status of a PW with statically configured labels by encapsulating the PW status TLV in a G-ACh on the PW. This mechanism enables OAM message mapping and PW redundancy for such PWs, as defined in RFC6478. This mechanism is known as control channel status signaling in SR OS.

PW control channel status notifications use a similar model to T-LDP status signaling. That is, in general, status is always sent to the nearest neighbor T-PE. To achieve this, the PW label TTL is set to 1 for the G-ACh packet containing the status message.

Control channel status notifications are disabled by default on a spoke-sdp. If they are enabled, then the default refresh interval is set to zero (although this value should be configurable in CLI). That is, when a status bit changes, three control channel status packets will be sent consecutively at one-second intervals, and then the transmitter will fall silent. If the refresh timer interval is non-zero, then status messages will continue to be sent at that interval. The system supports the configuration of a refresh timer of 0, or from 10-65535 seconds. The recommended value is 600 seconds.

In order to constrain the CPU resources consumed processing control channel status messages, the system implements a credit-based mechanism. If a user enables control channel status on a PW[n], then a certain number of credits c_n are consumed from a CPM-wide pool of max_credit credits. The number of credits consumed is inversely proportional to the configured refresh timer (the first three messages at 1 second interval do not count against the credit). If the current_credit <= 0, then control channel status signaling cannot be configured on a PW (but the PW can still be configured and no shutdown).

If a PE with a non-zero refresh timer configured does not receive control channel status refresh messages for 3.5 time the specified timer value, then by default it will time out and assume a PW status of zero.

A trap is generated if the refresh timer times-out.

If PW redundancy is configured, the system will always consider the literal value of the PW status; a time-out of the refresh timer will not impact the choice of the active transit object for the VLL service. The result of this is that if the refresh timer times-out, and a given PW is currently the active PW, then the system will not fail-over to an alternative PW if the status is zero and some lower-layer OAM mechanism for example, BFD has not brought down the LSP due to a connectivity defect. It is recommended that the PW refresh timer be configured with a much longer interval than any proactive OAM on the LSP tunnel, so that the tunnel can be brought down before the refresh timer expires if there is a CC defect.

Note that a unidirectional continuity fault on a RSVP TE LSP may not result in the LSP being brought down before the received PW status refresh timer expires. It is therefore recommended that either bidirectional static MPLS-TP LSPs with BFD CC, or additional protection mechanisms. For example, FRR be used on RSVP-TE LSPs carrying MPLS-TP PWs. This is particularly important in active/standby PW dual homing configurations, where the active / standby forwarding state or operational state of every PW in the redundancy set must be accurately reflected at the redundant PE side for the configuration.

Note that a PW with a refresh timer value of zero is always treated as having not expired.

The 7210 SAS implements a hold-down timer for control-channel-status pw-status bits in order to suppress bouncing of the status of a PW. For a specific spoke-sdp, if the system receives 10 pw-status “change” events in 10 seconds, the system will “hold-down” the spoke-sdp on the local node with the last received non-zero pw-status bits for 20 seconds. It will update the local spoke with the most recently received pw-status. This hold down timer is not persistent across shutdown/no-shutdown events.

## Pseudowire Redundancy and Active / Standby Dual Homing

PW redundancy is supported for static MPLS-TP pseudowires. However, instead of using T-LDP status signaling to signal the forwarding state of a PW, control channel status signaling is used.

The following PW redundancy scenarios are available:

- MC-LAG with single and multi-segment PWs interconnecting the PEs.
- The 7210 SAS-R6 can only act as T-PE when a multi-segment PW is used.
- Dual-homing of a VLL service into redundant IES or VPRN PEs (the IES and VPRN service is configured on the 7750 PEs), with active/standby PWs.
- In this scenario, 7210 SAS originates the Epipe MPLS-TP PWs as a T-PE. 7210 SAS nodes cannot terminate a MPLS-TP PW in a IES or VPRN service.
- Dual-homing of a VLL service into a VPLS with active/standby PWs.
- In this scenario, 7210 SAS originates the Epipe MPLS-TP PWs as a T-PE. 7210 SAS nodes cannot terminate a MPLS-TP PW in a VPLS service.

Note that the active/standby dual-homing into routed VPLS is not supported in for MPLS-TP PWs.

This is because it relies on PW label withdrawal of the standby PW in order to take down the VPLS instance, and hence the associated IP interface. Instead, it is possible to enable BGP multi-homing on a routed VPLS that has MPLS-TP PWs as spokes, and for the PW status of each spoke-SDP to be driven (using control channel status) from the active or standby forwarding state assigned to each PW by BGP.

It is possible to configure inter-chassis backup (ICB) PWs as static MPLS-TP PWs with MPLS-TP identifiers. Only MPLS-TP PWs are supported in the same endpoint. That is, PWs in an endpoint must either be all MPLS-TP, or none of them must be MPLS-TP. This implies that an ICB used in an endpoint for which other PWs are MPLS TP must also be configured as an MPLS-TP PW.

A fail over to a standby pseudowire is initiated based on the existing supported methods (For example, failure of the SDP).

## MPLS-TP LSP Protection

Linear 1-for-1 protection of MPLS-TP LSPs is supported, as defined in RFC 6378. This applies only to LSPs (not PWs).

This is supported edge-to-edge on an LSP, between two LERs, where normal traffic is transported either on the working LSP or on the protection LSP using a logical selector bridge at the source of the protected LSP.

At the sink LER of the protected LSP, the LSP that carries the normal traffic is selected, and that LSP becomes the working LSP. A protection switching coordination (PSC) protocol coordinates between the source and sink bridge, which LSP will be used, as working path and protection path. The PSC protocol is always carried on a G-ACh on the protection LSP.

The 7210 SAS supports single-phased coordination between the LSP endpoints, in which the initiating LER performs the protection switch over to the alternate path and informs the far-end LER of the switch.

Bidirectional protection switching is achieved by the PSC protocol coordinating between the two end points to determine which of the two possible paths (that is, the working or protect path), transmits user traffic at any given time.

It is possible to configure non-revertive or revertive behavior. For non-revertive, the LSP will not switch back to the working path when the PSC switch over requests end, while for revertive configurations, the LSP always returns back to the working path when the switch over requests end.

The following figures illustrate the behavior of linear protection in more detail.

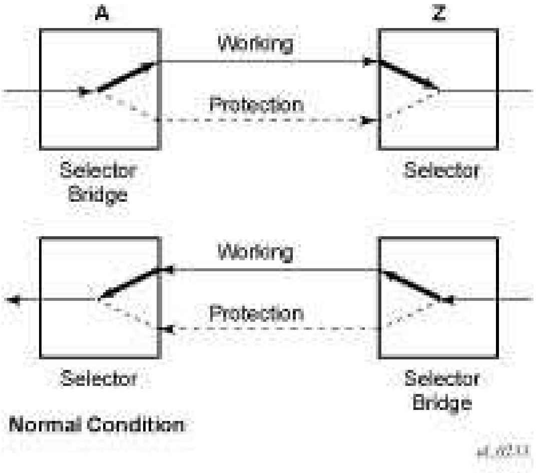


Figure 16: Normal Operation

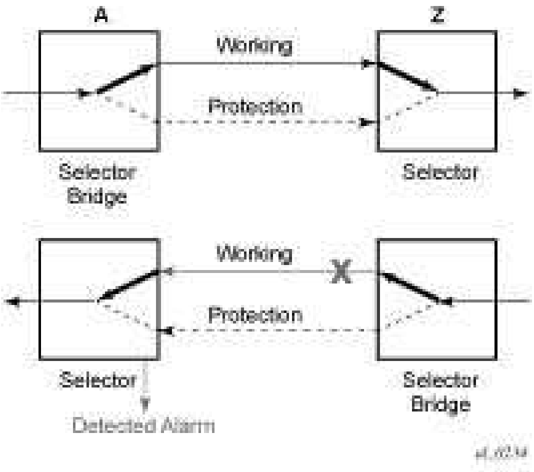


**Figure 17: Failed Condition**

In normal condition, user data packets are sent on the working path on both directions, from A to Z and Z to A.

A defect in the direction of transmission from node Z to node A impacts the working connection Z-to-A, and initiates the detection of a defect at the node A.

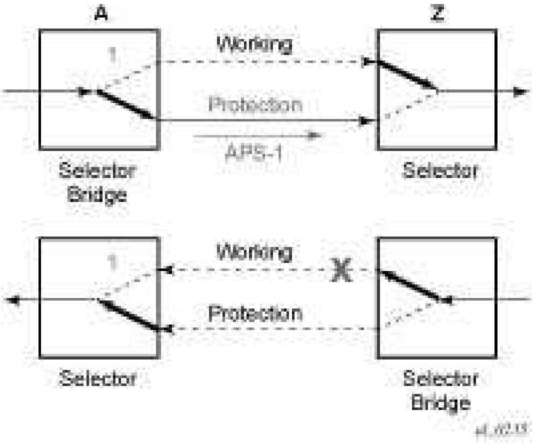


**Figure 18: Failed Condition - Switching at A**

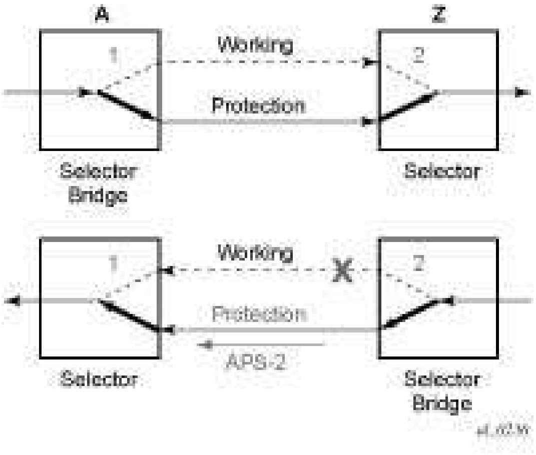


**Figure 19: Failed Condition - Switching at Z**

The unidirectional PSC protocol initiates protection switching: the selector bridge at node A is switched to protection connection A-to-Z and the selector at node A switches to protection connection Z to-A. The PSC packet, sent from node A to node Z, requests a protection switch to node Z.

After node Z validates the priority of the protection switch request, the selector at node Z is switched to protection connection A-to-Z and the selector bridge at the node Z is switched to protection connection Z-to-A. The PSC packet, sent from node Z to node A, is used as acknowledge, informing node A about the switching.

If BFD CC or CC/CV OAM packets are used to detect defects on the working and protection path, they are inserted on both working and protection paths. It should be noted that they are sent regardless of whether the selected as the currently active path.

The 7210 SAS supports the following operator commands:

- Forced Switch
- Manual Switch
- Clear
- Lockout of protection

## Configuring MPLS-TP

This section describes the steps required to configured MPLS-TP.

## Configuration Overview

The following steps must be performed in order to configure MPLS-TP LSPs or PWs.

At the 7210 SAS LER and LSR:

1. Create an MPLS-TP context, containing nodal MPLS-TP identifiers. This is configured under **config>router>mpls>mpls-tp**.
2. Ensure that a sufficient range of labels is reserved for static LSPs and PWs. This is configured under **config>router>mpls-labels>static-labels**.
3. Ensure that a range of tunnel identifiers is reserved for MPLS-TP LSPs under **config>router>mpls-mpls-tp>tp-tunnel-id-range**.
4. A user may optionally configure MPLS-TP interfaces, which are interfaces that no not use IP addressing or ARP for next hop resolution. These can only be used by MPLS-TP LSPs.

At the 7210 SAS LER, configure:

1. OAM Templates. These contain generic parameters for MPLS-TP proactive OAM. An OAM template is configured under **config>router>mpls>mpls-tp>oam-template**.
2. BFD templates. These contain generic parameters for BFD used for MPLS-TP LSPs. A BFD template is configured under **config>router>bfd>bfd-template**.
3. Protection templates. These contain generic parameters for MPLS-TP 1-for-1 linear protection. A protection template is configured under **config>router>mpls>mpls-tp>protection-template**.
4. MPLS-TP LSPs are configured under **config>router>mpls>lsp mpls-tp**
5. Pseudowires using MPLS-TP are configured as spoke-sdps with static PW labels.

At an LSR, a use must configure an LSP transit-path under **config>router>mpls>mpls-tp>transit-path**.

The following sections describe these configuration steps in more detail.

## Node-Wide MPLS-TP Parameter Configuration

Generic MPLS-TP parameters are configured under **config>router>mpls>mpls-tp**. If a user configures **no mpls**, normally the entire mpls configuration is deleted. However, in the case of mpls-tp a check that there is no other mpls-tp configuration for example, services or tunnels using mpls-tp on the node, will be performed.

The mpls-tp context is configured as follows:

```
config
   router
     mpls
       mpls-tp
          global-id <global-id>
          node-id {<ipv4address> | | <1.. .4,294,967,295>}
          [no] shutdown
          exit
```

MPLS-TP LSPs may be configured if the mpls-tp context is administratively down (shutdown), but they will remain down until the mpls-tp context is configured as administratively up. No programming of the data path for an MPLS-TP Path occurs until the following are all true:

- MPLS-TP context is **no shutdown**
- MPLS-TP LSP context is **no shutdown**
- MPLS-TP Path context is **no shutdown**

A **shutdown** of mpls-tp will therefore bring down all MPLS-TP LSPs on the system.

The mpls-tp context cannot be deleted if MPLS-TP LSPs or SDPs exist on the system.

## Node-Wide MPLS-TP Identifier Configuration

MPLS-TP identifiers are configured for a node under the following CLI tree:

```
config
   router
     mpls
       mpls-tp
                global-id 100
                node-id 100.100.100.1
          [no] shutdown
          exit
```

The default value for the global-id is 0. This is used if the global-id is not explicitly configured. If a user expects that inter domain LSPs will be configured, then it is recommended that the global ID should be set to the local ASN of the node. as configured under **config>router**. If two-byte ASNs are used, then the most significant two bytes of the global-id are padded wsith zeros.

The default value of the node-id is the system interface IPv4 address. The MPLS-TP context cannot be administratively enabled unless at least a system interface IPv4 address is configured because MPLS requires that this value is configured.

These values are used unless overridden at the LSP or PW end-points, and apply only to static MPLS-TP LSPs and PWs.

In order to change the values, **config>router>mpls>mpls-tp** must be in the shutdown state. This will bring down all of the MPLS-TP LSPs on the node. New values are propagated to the system when a **no shutdown** is performed.

## Static LSP and pseudowire (VC) Label and Tunnel Ranges

SR OS reserves a range of labels for use by static LSPs, and  a range of labels for use by static pseudowires (SVCs) that is, LSPs and pseudowires with no dynamic signaling of the label mapping. These are configured as follows:

```
config
   router
      mpls-labels
         static-labels max-lsp-labels 991 max-svc-labels 16384
```

The minimum label value for the static LSP label starts at 32 and expands all the way to the maximum number specified. The static VC label range is contiguous with this. The dynamic label range exists above the static VC label range (the label ranges for the respective label type are contiguous). This prevents fragmentation of the label range.

The MPLS-TP tunnel ID range is configured as follows:

```
config
   router
      mpls
         mpls-tp
            [no] tp-tunnel-id-range 1 10
```

The tunnel ID range referred to here is a contiguous range of RSVP-TE Tunnel IDs is reserved for use by MPLS TP, and these IDs map to the MPLS-TP Tunnel Numbers. There are some cases where the dynamic LSPs may have caused fragmentation to the number space such that contiguous range {max-min} is not available. In these cases, the command will fail.

There is no default value for the tunnel id range, and it must be configured to enable MPLS-TP.

If a configuration of the tunnel ID range fails, then the system will give a reason. This could be that the initially requested range, or the change to the allocated range, is not available i.e. tunnel IDs in that range have already been allocated by RSVP-TE. Allocated Tunnel IDs are visible using a show command.

Note that changing the LSP or static VC label ranges does not require a reboot.

Note also that the static label ranges for LSPs, above, apply only to static LSPs configured using the CLI tree for MPLS-TP specified in this section. Different scalability constraints apply to static LSPs configured using the following CLI introduced in earlier SR OS releases:

**config>router>mpls>static-lsp**

**config>router>mpls>interface>label-map**

The scalability applying to labels configured using this CLI is enforced as follows:

- A maximum of 1000 static LSP names may be configured with a PUSH operation.
- A maximum of 1000 LSPs with a POP or SWAP operation may be configured.

These two limits are independent of one another, giving a combined limit of 1000 PUSH and 1000 POP/SAP operations configured on a node.

The static LSP and VC label spaces are contiguous. Therefore, the dimensioning of these label spaces requires careful planning by an operator as increasing the static LSP label space impacts the start of the static VC label space, which may already-deployed

## Interface Configuration for MPLS-TP

It is possible for MPLS-TP paths to use both numbered IP numbered interfaces that use ARP/static ARP, or IP unnumbered interfaces. MPLS-TP requires no changes to these interfaces. It is also possible to use a new type of interface that does not require any IP addressing or next-hop resolution.

Draft-ietf-mpls-tp-next-hop-addressing provides guidelines for the usage of various Layer 2 next-hop resolution mechanisms with MPLS-TP. If protocols such as ARP are supported, then they should be used. However, in the case where no dynamic next hop resolution protocol is used, it should be possible to configure a unicast, multicast or broadcast next-hop MAC address. The rationale is to minimize the amount of configuration required for upstream nodes when downstream interfaces are changes. A default multicast MAC address for use by MPLS-TP point-to-point LSPs has been assigned by IANA (Value: 01-00-5e-90-00-00). This value is configurable on the 7210 to support interoperability with 3rd party implementations that do not default to this value, and this no default value is implemented on the 7210.

In order to support these requirements, a new interface type, known as an unnumbered MPLS-TP interface is introduced. This is an unnumbered interface that allows a broadcast or multicast destination MAC address to be configured. An unnumbered MPLS-TP interface is configured using the **unnumbered-mpls-tp** keyword, as follows:

```
config
   router
      interface <if-name> [unnumbered-mpls-tp]
         port <port-id>[:encap-val]
```

```
mac <local-mac-address>
static-arp <remote-mac-addr>
//ieee-address needs to support mcast and bcast
         exit
```

The **remote-mac-address** may be any unicast, broadcast of multicast address. However, a broadcast or multicast remote-mac-address is only allowed in the **static-arp** command on Ethernet unnumbered interfaces when the **unnumbered-mpls-tp** keyword has been configured. This also allows the interface to accept packets on a broadcast or any multicast MAC address. Note that if a packet is received with a unicast destination MAC address, then it will be checked against the configured <local-mac-address> for the interface, and dropped if it does not match. When an interface is of type **unnumbered-mpls-tp**, only MPLS-TP LSPs are allowed on that interface; other protocols are blocked from using the interface.

An unnumbered MPLS-TP interface is assumed to be point-to-point, and therefore users must ensure that the associated link is not broadcast or multicast in nature if a multicast or broadcast remote MAC address is configured.

The following is a summary of the constraints of an unnumbered MPLS-TP interface:

- It is unnumbered and may borrow/use the system interface address
- It prevents explicit configuration of a borrowed address
- It prevents IP address configuration
- It prevents all protocols except MPLS
- It prevents Deletion if an MPLS-TP LSP is bound to the Interface
- It is allowed only in network chassis mode D

MPLS-TP is only supported over Ethernet ports. The system will block the association of an MPLS-TP LSP to an interface whose port is non-Ethernet.

# LER Configuration for MPLS-TP

## LSP and Path Configuration

MPLS-TP tunnels are configured using the **mpls-tp** LSP type at an LER under the LSP configuration, using the following CLI tree:

```
config
   router
      mpls
         lsp <xyz> [bypass-only|p2mp-lsp|mpls-tp <src-tunnel-num>]
            to node-id {<a.b.c.d> | <1.. .4,294,967,295>}
            dest-global-id <global-id>
             dest-tunnel-number <tunnel-num>
```

```
[no] working-tp-path
   lsp-num <lsp-num>
   in-label <in-label>
   out-label <out-label> out-link <if-name>
             [next-hop <ipv4-address>]
   [no] mep
      [no] oam-template <name>
      [no] bfd-enable [cc | cc_cv]  // defaults to cc
      [no] shutdown
      exit
   [no] shutdown
   exit
[no] protect-tp-path
   lsp-num <lsp-num>
   in-label <in-label>
   out-label <out-label> out-link <if-name>
             [next-hop <ipv4-address> ]
   [no] mep
      [no] protection-template <name>
      [no] oam-template <name>
      [no] bfd-enable [cc | cc_cv]  //defaults to cc
      [no] shutdown
      exit
   [no] shutdown
   exit
```

<*if-name*> could be numbered or unnumbered interface using an Ethernet port.

<*src-tunnel-num*> is a mandatory create time parameter for mpls-tp tunnels, and has to be assigned by the user based on the configured range of tunnel ids. The *src-global-id* used for the LSP ID is derived from the node-wide *global-id* value configured under config>router>mpls>mpls-tp. A tunnel can not be **un shutdown** unless the *global-id* is configured.

The from address of an LSP to be used in the tunnel identifier is taken to be the local node's node-id/global-id, as configured under config>router>mpls>mpls-tp. If that is not explicitly configured, either, then the default value of the system interface IPv4 address is used

The **to node-id** address may be entered in 4-octet IPv4 address format or unsigned 32-bit format. This is the far-end node-id for the LSP, and does do need to be IP addresses.

The **from** and **to** addresses are used as the from and to node-id in the MPLS-TP Tunnel Identifier used for the MEP ID.

Each LSP consists of a working-tp-path and, optionally, a protect-tp-path. The protect-tp-path provides protection for the working-tp-path is 1:1 linear protection is configured (see below). Proactive OAM, such as BFD, is configured under the MEP context of each path. Protection for the LSP is configured under the protect-tp-path mep context.

The ‘to’ global-id is an optional parameter. If it is not entered, then the dest global ID takes the default value of 0. Global ID values of 0 are allowed and indicate that the node's configured Global ID should be used. If the local global id value is 0, then the remote ‘to’ global ID must also be 0. The ‘to’ global ID value cannot be changed if an LSP is in use by an SDP.

The ‘to’ tunnel number is an optional parameter. If it is not entered, then it is taken to be the same value as the source tunnel number.

LSPs are assumed to be bidirectional and co-routed in Relase 11.0. Therefore, system will assume that the incoming interface is the same as the out-link.

The next-hop <ip-address> can only be configured if the out-link if-name refers to a numbered IP interface. In this case, the system will determine the interface to use to reach the configured next-hop, but will check that the user-entered value for the out-link corresponds to the link returned by the system. If they do not correspond, then the path will not come up. Note that if a user changes the physical port referred to in the interface configuration, then BFD, if configured on the LSP, will go down. Users should therefore ensure that an LSP is moved to a different interface with a different port configuration in order to change the port that it uses. This is enforced by blocking the next-hop configuration for an unnumbered interface.

There is no check made that a valid ARP entry exists before allowing a path to be un shut. Therefore, a path will only be held down if BFD is down. If static ARP is not configured for the interface, then it is assumed that dynamic ARP is used. The result is that if BFD is not configured, a path can come up before ARP resolution has completed for an interface. If BFD is not used, then it is recommended that the connectivity of the path is explicitly checked using on-demand CC/CV prior to sending user traffic on it.

The following is a list of additional considerations for the configuration of MPLS-TP LSPs and paths:

- The working-tp-path must be configured before the protect-tp-path.
- Likewise, the protect-tp-path has to be deleted first before the working-tp-path.
- The *lsp-num* parameter is optional. It’s default value is ‘1’ for the working-tp-path and ‘2’ for protect-tp-path.
- The **mep** context must be deleted before a path can be deleted.
- An MPLS interface needs to be created under **config>router>mpls>interface** before using/specifying the out-label/out-link in the Forward path for an MPLS-TP LSP. Creation of the LSP will fail if the corresponding MPLS interface does not exist even though the specified router interface may be valid.
- The system will program the MPLS-TP LSP information upon a '**no shutdown**' of the TP-Path only on the very first **no shutdown**. The Working TP-Path is programmed as the Primary and the Protection TP-Path is programmed as the 'backup'.
- The system will not de-program the IOM on an 'admin shutdown' of the MPLS-TP path. Traffic will gracefully move to the other TP-Path if valid, as determined by the proactive MPLS-TP OAM. This should not result in traffic loss. However it is recommended that the user does moves traffic to the other TP-Path through a tools command before doing 'admin shut' of an Active TP-Path.

- Deletion of the out-label/out-link sub-command under the MPLS-TP Path is not allowed once configured. These can only be modified.
- MPLS will allow the deletion of an 'admin shutdown' TP-Path. This will cause MPLS to de-program the corresponding TP-Path forwarding information from IOM. This can cause traffic loss for certain users that are bound to the MPLS-TP LSP.
- MPLS will not de-program the IOM on a specific interface admin shut/clear unless the interface is a System Interface. However, if mpls informs the TP-OAM module that the mpls interface has gone down, then it triggers a switch to the standby tp-path if the associated interface went down and if it is valid.
- If a MEP is defined and shutdown, then the corresponding path is also operationally down. Note, however, that the MEP admin state is applicable only when a MEP is created from an MPLS-TP path.
- It is not mandatory to configure BFD or protection on an MPLS-TP path in order to bring the LSP up.
- If **bfd-enable cc** is configured, then CC-only mode using ACh channel 0x07 is used. If **bfd-enable cc_v** is configured, then BFD CC packets use channel 0x22 and CV packets use channel 0x23.

The protection template is associated with a LSP as a part of the MEP on the protect path. If only a working path is configured, then the protection template is not configured.

BFD cannot be enabled under the MEP context unless a named BFD template is configured.

## Proactive CC/CV (using BFD) Configuration

Generally applicable proactive OAM parameters are configured using templates.

**NOTE**: The 7210 SAS-R6 supports only BFD based CC mode. BFD based CC-CV mode is not supported in current release.

Proactive CC and CV uses BFD parameters such as Tx/Rx timer intervals, multiplier and other session/fault management parameters which are specific to BFD. These are configured using a BFD Template. The BFD Template may be used for non-MPLS-TP applications of BFD, and therefore contains the full set of possible configuration parameters for BFD. Only a sub-set of these may be used for any given application.

Generic MPLS-TP OAM and fault management parameters are configured in the OAM Template.

Named templates are referenced from the MPLS-TP Path MEP configuration, so different parameter values are possible for the working and protect paths of a tunnel.

The BFD Template is configured as follows:

```
config
```

```
router
   bfd
      [no] bfd-template <name>
         [no] transmit-interval <transmit-interval>
         [no] receive-interval <receive-interval>
         [no] echo-receive <echo-interval>
         [no] multiplier <multiplier>
         [no] type <cpm-np>
         exit
```

The parameters are as follows:

- **transmit-interval** *transmit-interval* and the **rx** *receive-interval*: These are the transmit and receive timers for BFD packets. If the template is used for MPLS-TP, then these are the timers used by CC packets. Values are in milliseconds: 10ms to 100,000ms, with 1ms granularity. Default 10ms for CPM3 or better, 1 sec for other hardware. Note that for MPLS-TP CV packets, a transmit interval of 1 sec is always used.
- **multiplier** *multiplier*: Integer 3 – 20. Default: 3. This parameter is ignored for MPLS-TP combined cc-v BFD sessions, and the default of 3 used, as per RFC6428.
- **echo-receive** *echo-interval*: Sets the minimum echo receive interval, in milliseconds, for a session. Values: 100ms – 100,000ms. Default: 100. This parameter is not used by a BFD session for MPLS-TP.
- **type iom-hw** *type*: This parameter controls the system to use the IOM based hardware BFD session for the local termination point. Hardware based BFD session is enabled by default, when BFD is configured for use with MPLS-TP LSPs.

Note that, if the above BFD timer values are changed in a given template, any BFD sessions on MEPs to which that template is bound will try to renegotiate their timers to the new values. Note that the BFD implementations in some MPLS-TP peer nodes may not be able handle this renegotiation, as allowed by Section 3.7.1 of RFC6428 and may take the BFD session down. This could result in undesired behavior, for example an unexpected protection switching event. It is therefore recommended that in these circumstances, user of 7210 SAS exercises care in modifying the BFD timer values after a BFD session is UP.

Commands within the BFD-template use a begin-commit model. To edit any value within the BFD template, a <begin> needs to be executed once the template context has been entered. However, a value will still be stored temporarily until the commit is issued. Once the commit is issued, values will actually be used by other modules like the mpls-tp module and bfd module.

A BFD template is referenced from the OAM template. The OAM Template is configured as follows:

```
config
   router
      mpls
         mpls-tp
                    oam-template "state-machine-oam-template-prot"
                    bfd-template "state-machine-bfd-template-prot"
                    hold-time-down 0
                    hold-time-up 20
                       exit
```

- **hold-time-down** *interval*: 0-5000 deciseconds, 10ms steps, default 0. This is equivalent to the standardized hold-off timer.
- **hold-time-up** *interval*: 0-500 centiseconds in 100ms steps, default 2 seconds This is an additional timer that can be used to reduce BFD bouncing.
- **bfd-template** *name*: This is the named BFD template to use for any BFD sessions enabled under a MEP for which the OAM template is configured.

An OAM template is then applied to a MEP as described above.

## Protection templates and Linear Protection Configuration

Protection templates defines the generally applicable protection parameters for an MPLS-TP tunnel. Only linear protection is supported, and so the application of a named template to an MPLS-TP tunnel implies that linear protection is used.

A template is configured as follows:

```
config
   router
      mpls
         mpls-tp
            protection-template <name>
              [no] revertive
               [no] wait-to-restore <interval>
               rapid-psc-timer <interval>
               slow-psc-timer <interval>
               exit
```

The allowed values are as follows:

- **wait-to-restore** *interval*: 0-720 seconds, 1 sec steps, default 300 seconds. This is applicable to revertive mode only.
- **rapid-psc-timer** *interval*: [10, 100, 1000ms]. Default 100ms
- **slow-psc-timer** *interval*: 5s-60s. Default: 5s
- **revertive**: Selects revertive behavior. Default: no revertive.

LSP Linear Protection operations are enacted using the following **tools>perform** commands.

```
tools>perform>router>mpls
            tp-tunnel
               clear {<lsp-name> | id <tunnel-id>}
               force {<lsp-name> | id <tunnel-id>}
               lockout {<lsp-name> | id <tunnel-id>}
```

```
                manual {<lsp-name> | id <tunnel-id>}
             exit
          exit
```

To minimize outage times, users should use the “mpls-tp protection command” (e.g. force/manual) to switch all the relevant MPLS-TP paths before executing the following commands:

- clear router mpls  interface <>
- config router mpls interface <> shut

## Intermediate LSR Configuration for MPLS-TP LSPs

The forward and reverse directions of the MPLS-TP LSP Path at a transit LSR are configured using the following CLI tree:

```
config
   router
      mpls
         mpls-tp
            transit-path <path-name>
               [no] path-id {lsp-num <lsp-num>|working-path|protect-path

                  [src-global-id <global-id>]
                  src-node-id {<ipv4address> | <1.. .4,294,967,295>}
                  src-tunnel-num <tunnel-num>
                  [dest-global-id <global-id>]
                  dest-node-id {<ipv4address> | <1.. .4,294,967,295>}
                  [dest-tunnel-num <tunnel-num>]}

               forward-path
                  in-label <in-label> out-label <out-label>
                       out-link <if-name> [next-hop <ipv4-next-hop>]
               reverse-path
                  in-label <in-label> out-label <out-label>
                      [out-link <if-name> [next-hop <ipv4-next-hop>]
               [no] shutdown
```

Note that the *src-tunnel-num* and *dest-tunnel-num* are consistent with the source and destination of a label mapping message for a signaled LSP.

If *dest-tunnel-num* is not entered in CLI, the *dest-tunnel-num* value is taken to be the same as the src-tunnel-num value.

If any of the *global-id* values are not entered, the value is taken to be 0.

If the *src-global-id* value is entered, but the *dest-global-id* value is not entered, *dest-global-id* value is the same as the *src-global-id* value.

Note that the *lsp-num* must match the value configured in the LER for a given path. If no explicit lsp-num is configured, then working-path or protect-path must be specified (equating to 1 or 2 in the system).

The forward path must be configured before the reverse path. The configuration of the reverse path is optional.

The LSP-ID (path-id) parameters apply with respect to the downstream direction of the forward LSP path, and are used to populate the MIP ID for the path at this LSR.

The reverse path configuration must be deleted before the forward path.

The forward-path (and reverse-path if applicable) parameters can be configured with or without the path-id, but they must be configured if MPLS-TP OAM is to be able to identify the LSR MIP.

The transit-path can be no shutdown (as long as the forward-path/reverse-path parameters have been configured properly) with or without identifiers.

The path-id and path-name must be unique on the node. There is a one to one mapping between a given path-name and path-id.

Traffic can not pass through the transit-path if the transit-path is in the **shutdown** state.

# RSVP

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 path(s) of the flows and to establish and maintain state to provide the requested service. RSVP requests generally result in resources reserved in each node along the data path. MPLS leverages this RSVP mechanism to set up traffic engineered LSPs. RSVP is not enabled by default and must be explicitly enabled.

RSVP requests resources for simplex flows. It requests resources only in one direction (unidirectional). Therefore, RSVP 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 is not a routing protocol. RSVP operates with unicast and multicast routing protocols. Routing protocols determine where packets are forwarded. RSVP consults local routing tables to relay RSVP messages.

RSVP uses two message types to set up LSPs, PATH and RESV. Figure 20 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 FEC for which label bindings are desired. PATH messages are used to signal and request 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.

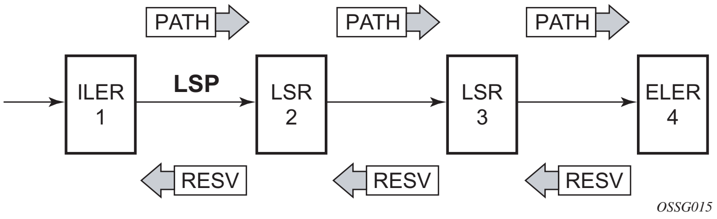


Figure 20: Establishing LSPs

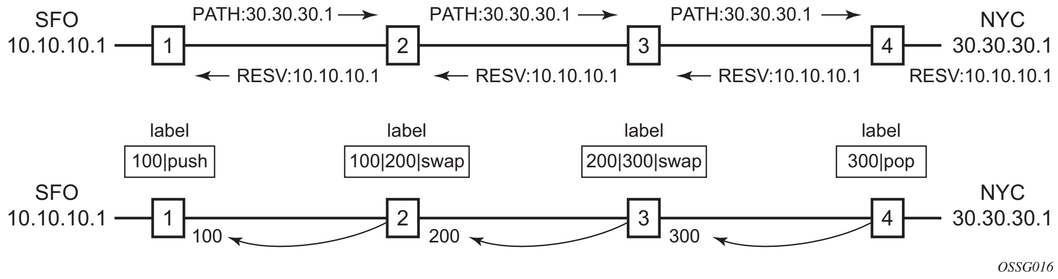


**Figure 21: LSP Using RSVP Path Set Up**

Figure 21 displays an example of an LSP path set up using RSVP. The ingress label edge router (ILER 1) transmits an RSVP 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.

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

- Explicit route object (ERO) — When the ERO is present, the RSVP 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.
- A session attribute object controls the path set up priority, holding priority, and local-rerouting features.

Upon receiving a path message containing a label request object, the ELER transmits a 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.

# Using RSVP for MPLS

Hosts and routers that support both MPLS and RSVP can associate labels with RSVP flows. When MPLS and RSVP 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 FEC which defines the RSVP flow.

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

## RSVP Traffic Engineering Extensions for MPLS

RSVP has been extended for MPLS to support automatic signaling of LSPs. To enhance the scalability, latency, and reliability of RSVP signaling, several extensions have been defined. Refresh messages are still transmitted but the volume of traffic, the amount of CPU utilization, and response latency are reduced while reliability is supported. None of these extensions result in backward compatibility problems with traditional RSVP implementations.

- Hello Protocol on page 62
- MD5 Authentication of RSVP Interface on page 63

### Hello Protocol

The Hello protocol detects the loss of a neighbor node or the reset of a neighbor’s RSVP state information. In standard RSVP, neighbor monitoring occurs as part of RSVP’s soft-state model. The reservation state is maintained as cached information that is first installed and then periodically refreshed by the ingress and egress LSRs. 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 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.

## MD5 Authentication of RSVP Interface

When enabled on an RSVP interface, 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.
- Key used with the authentication algorithm.
- Lifetime of the key. A key is user-generated key using a third party software/hardware and enters the value as static string into CLI configuration of the RSVP interface. The key will continue to be valid until it is removed from that RSVP interface.
- Source Address of the sending system.
- 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 which also contains a Flags field, a Key Identifier field, and a Sequence Number field. The RSVP sender complies to 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.

When a 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 MP node, then the message is discarded since there is no security association with the next-next-hop MP node.

The 7210 SAS MD5 implementation does not support the authentication challenge procedures in RFC 2747.

# Reservation Styles

LSPs can be signaled with explicit reservation styles. 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. SR OS supports two reservation styles:

Note that if FRR option is enabled for the LSP and selects the facility FRR method at the head-end node, only the SE reservation style is allowed. Furthermore, if a 7210 SAS M 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 detour method supports both FF and SE styles.

## RSVP Message Pacing

When a flood of signaling messages arrive because of topology changes in the network, signaling messages can be dropped which results in longer set up times for LSPs. RSVP message pacing controls the transmission rate for RSVP messages, allowing the messages to be sent in timed intervals. Pacing reduces the number of dropped messages that can occur from bursts of signaling messages in large networks.

## RSVP Overhead Refresh Reduction

The RSVP refresh reduction feature consists of the following capabilities implemented in accordance to RFC 2961, *RSVP Refresh Overhead Reduction Extensions*:

- RSVP message bundling — This capability is intended to reduce overall message handling load. The 7210 SAS supports receipt and processing of bundled message only, but no transmission of bundled messages.
- Reliable message delivery: — This capability consists of sending a message-id and returning a message-ack for each RSVP message. It can be used to detect message loss and support reliable RSVP message delivery on a per hop basis. It also helps reduce the refresh rate since the delivery becomes more reliable.
- Summary refresh — This capability consists of refreshing multiples states with a single message-id list and sending negative ACKs (NACKs) for a message_id which could not be matched. The summary refresh capability reduce the amount of messaging exchanged and the corresponding message processing between peers. It does not however reduce the amount of soft state to be stored in the node.

These capabilities can be enabled on a per-RSVP-interface basis are referred to collectively as “refresh overhead reduction extensions”. When the refresh-reduction is enabled on a 7210 SAS RSVP interface, the node indicates this to its peer by setting a refresh-reduction- capable bit in the flags field of the common RSVP header. If both peers of an RSVP interface set this bit, all the above three capabilities can be used. Furthermore, the node monitors the settings of this bit in received RSVP messages from the peer on the interface. As soon as this bit is cleared, the node stops sending summary refresh messages. If a peer did not set the “refresh-reduction-capable” bit, a 7210 SAS node does not attempt to send summary refresh messages.

## Configuring Implicit Null

The implicit null label option allows a 7210 SAS egress LER to receive MPLS packets from the previous hop without the outer LSP label. The operation of the previous hop is referred to as penultimate hop popping (PHP). This option is signaled by the egress LER to the previous hop during the FEC signaling by the LDP control protocol.

The router can be configured to signal the implicit null label value over all RSVP interfaces and for all RSVP LSPs which have this node as the egress LER. In addition, the egress LER can be configured to receive MPLS packet with the implicit null label on a static LSP.

The following CLI command is used to configure the router:

**config>router>ldp>implicit-null-label**

Note: RSVP must be shutdown before changing the implicit null configuration option.

# Traffic Engineering

Without traffic engineering, routers route traffic according to the 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 different (less congested) path other 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 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 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 to reach the destination IP address.

# TE Metric (IS-IS and OSPF)

When the use of the TE metric is selected for an LSP, the shortest path computation after the TE constraints are applied will select an LSP path based on the TE metric instead of the IGP metric. The user configures the TE metric under the MPLS interface. 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 both IGP protocols.

A typical application of the TE metric is to allow CSPF to represent a dual TE topology for the purpose of computing LSP paths.

An LSP dedicated for 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 delay figure, or a combined delay/jitter figure, 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 for 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 figure as required.

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. These constraints include bandwidth, admin-groups, and hop limit. CSPF will then 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. Note that the TE metric is only used in CSPF computations for MPLS paths and not in the regular SPF computation for IP reachability.

## Maintenance of TE links and Nodes

Graceful shutdown is used to maintain selective links and nodes in a TE network. Prior to a shutdown, headend LER nodes are notified of the imminent shutdown of the links or nodes for the purpose of maintenance, so the head-end nodes can move the paths of the LSPs away from the affected resources. Modified TE parameters for the affected links are flooded so all other nodes in the network avoid them in the CSPF calculations.

When the maintenance is over, the operator disables graceful shutdown, which reinstates and floods the user-configured TE parameters. The restored links are available for LSP path establishment.

# Advanced MPLS/RSVP Features

# Shared Risk Link Groups

Shared Risk Link Groups (SRLGs) is a feature that allows the user to establish a backup secondary LSP path or a FRR LSP path which is disjoint from the path of the primary LSP. Links that are members of the same SRLG represent resources sharing the same risk, for example, fiber links sharing the same conduit or multiple wavelengths sharing the same fiber.

When the SRLG option is enabled on a secondary path, CSPF includes the SRLG constraint in the computation of the secondary LSP path. This requires that the primary LSP already be established and up since the head-end LER needs the most current ERO computed by CSPF for the primary path. CSPF would return the list of SRLG groups along with the ERO during primary path CSPF computation. At a subsequent establishment of a secondary path with the SRLG constraint, the MPLS/RSVP task will query again CSPF providing the list of SLRG group numbers to be avoided. CSPF prunes all links with interfaces which belong to the same SRLGs as the interfaces included in the ERO of the primary path. If CSPF finds a path, the secondary is setup. If not, MPLS/RSVP will keep retrying the requests to CSPF.

When the SRLG option is enabled on FRR, CSPF includes the SRLG constraint in the computation of a FRR detour or bypass for protecting the primary LSP path. CSPF prunes all links with interfaces which belong to the same SRLG as the interface which is being protected, for example, the outgoing interface at the PLR the primary path is using. If one or more paths are found, the MPLS/RSVP task will select one based on best cost and will signal the bypass/detour. If not and the user included the strict option, the bypass/detour is not setup and the MPLS/RSVP task will keep retrying the request to CSPF. Otherwise, if a path exists which meets the other TE constraints, other than the SRLG one, the bypass/detour is setup.

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 avoided.

## Enabling Disjoint Backup Paths

A typical application of the SRLG feature is to provide for an automatic placement of secondary backup LSPs or FRR bypass/detour LSPs that minimizes the probability of fate sharing with the path of the primary LSP (Figure 22).

The following details the steps necessary to create shared risk link groups:

- For primary/standby SRLG disjoint configuration:
  - → Create an SRLG-group similar to admin groups.
  - → Link the SRLG-group to MPLS interfaces.

  - → Configure primary and secondary LSP paths and enable SRLG on the secondary LSP path. Note that the SRLG secondary LSP path(s) will *always* perform a strict CSPF query. The **srlg-frr** command is irrelevant in this case (For more information, see srlg-frr on page 116 )

- For FRR detours/bypass SRLG disjoint configuration:
  - → Create an SRLG group, similar to admin groups.
  - → Link the SRLG group to MPLS interfaces.
  - → Enable the **srlg-frr** (strict/non-strict) option, which is a system-wide parameter, and it force every LSP path CSPF calculation, to take the configured SRLG membership(s) (and propagated through the IGP opaque-te-database) into account.
  - → Configure primary FRR (one-to-one/facility) LSP path(s). Consider that each PLR will create a detour/bypass that will only avoid the SRLG membership(s) configured on the primary LSP path egress interface. In a one-to-one case, detour-detour merging is out of the control of the PLR, thus the latter will not ensure that its detour will be prohibited to merge with a colliding one. For facility bypass, with the presence of several bypass type to bind to, the following priority rules will be followed:
    1. Manual bypass disjoint
    2. Manual bypass non-disjoint (eligible only if srlg-frr is non-strict)
    3. Dynamic disjoint
    4. Dynamic non-disjoint (eligible only if srlg-frr is non-strict)

Non-CSPF manual bypass is not considered.

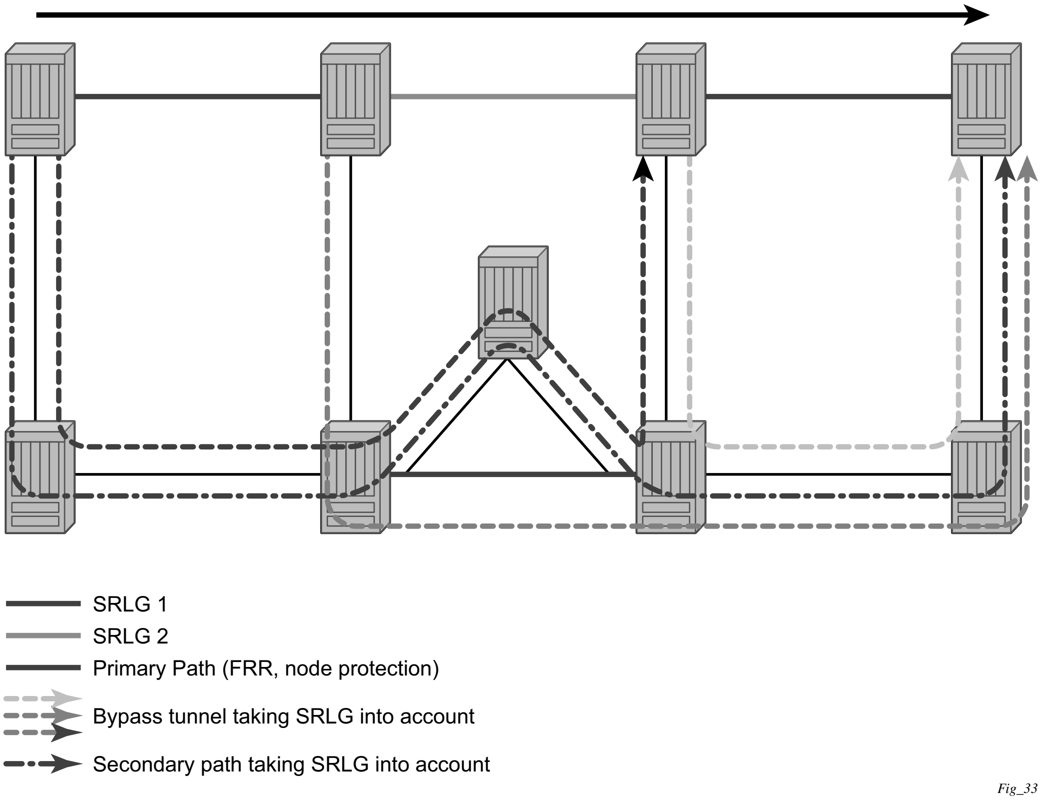

SRLG 1
SRLG 2
Primary Path (FRR, node protection)
Bypass tunnel taking SRLG into account
Secondary path taking SRLG into account
Fig_33

**Figure 22: Shared Risk Link Groups**

This feature is supported on OSPF and IS-IS interfaces on which RSVP is enabled.

## Static Configurations of SRLG Memberships

This feature provides operations with the ability to enter manually the link members of SRLG groups for the entire network at any 7210 SAS node which will need to signal LSP paths (for example, a head-end node).

The operator may explicitly enables the use by CSPF of the SRLG database. In that case, CSPF will not query the TE database for IGP advertised interface SRLG information.

Note, however, that the SRLG secondary path computation and FRR bypass/detour path computation remains unchanged.

There are deployments where the 7210 SAS will interoperate with routers that do not implement the SRLG membership advertisement via IGP SRLG TLV or sub-TLV.

In these situations, the user is provided with the ability to enter manually the link members of SRLG groups for the entire network at any 7210 SAS node which will need to signal LSP paths, for example, a head-end node.

The user enters the SRLG membership information for any link in the network by using the **interface** *ip-int-name* **srlg-group** *group-name* command in the **config>router>mpls> srlg-database>router-id** context. An interface can be associated with up to 5 SRLG groups for each execution of this command. The user can associate an interface with up to 64 SRLG groups by executing the command multiple times. The user must also use this command to enter the local interface SRLG membership into the user SRLG database. The user deletes a specific interface entry in this database by executing the **no** form of this command.

The *group-name* must have been previously defined in the SRLG **srlg-group** *group-name* **value** *group-value* command in the **config>router>mpls**. The maximum number of distinct SRLG groups the user can configure on the system is 1024.

The parameter value for *router-id* must correspond to the router ID configured under the base router instance, the base OSPF instance or the base IS-IS instance of a given node. Note however, that a single user SLRG database is maintained per node regardless if the listed interfaces participate in static routing, OSPF, IS-IS, or both routing protocols. The user can temporarily disable the use by CSPF of all interface membership information of a specific router ID by executing the **shutdown** command in the **config>router>mpls> srlg-database> router-id** context. In this case, CSPF will assume these interfaces have no SRLG membership association. The operator can delete all interface entries of a specific router ID entry in this database by executing the **no router-id** *router-address* command in the **config>router>mpls> srlg-database** context.

CSPF will not use entered SRLG membership if an interface is not listed as part of a router ID in the TE database. If an interface was not entered into the user SRLG database, it will be assumed that it does not have any SRLG membership. CSPF will not query the TE database for IGP advertised interface SRLG information.

The operator enables the use by CSPF of the user SRLG database by entering the user-srlg-db enable command in the **config>router>mpls** context. When the MPLS module makes a request to CSPF for the computation of an SRLG secondary path, CSPF will query the local SRLG and computes a path after pruning links which are members of the SRLG IDs of the associated primary path. Similarly, when MPLS makes a request to CSPF for a FRR bypass or detour path to associate with the primary path, CSPF queries the user SRLG database and computes a path after pruning links which are members of the SRLG IDs of the PLR outgoing interface.

The operator can disable the use of the user SRLG database by entering the user-srlg-db disable in command in the **config>router>mpls** context. CSPF will then resumes queries into the TE database for SRLG membership information. However, the user SRLG database is maintained

The operator can delete the entire SRLG database by entering the **no srlg-database** command in the **config>router>mpls** context. In this case, CSPF will assume all interfaces have no SRLG membership association if the user has not disabled the use of this database.

## TE Graceful Shutdown

Graceful shutdown provides a method to bulk re-route transit LSPs away from the node during software upgrade of a node. A solution is described in RFC 5817, *Graceful Shutdown in MPLS and Generalized MPLS Traffic Engineering Networks*. This is achieved in this draft by using a PathErr message with a specific error code Local Maintenance on TE link required flag. When a LER gets this message, it performs a make-before-break on the LSP path to move the LSP away from the links/nodes which IP addresses were indicated in the PathErr message.

Graceful shutdown can flag the affected link/node resources in the TE database so other routers will signal LSPs using the affected resources only as a last resort. This is achieved by flooding an IGP TE LSA/LSP containing link TLV for the links under graceful shutdown with the traffic engineering metric set to 0xffffffff and 0 as unreserved bandwidth.

# MPLS Service Usage

The 7210 SAS M, X routers enable service providers to deliver virtual private networks (VPNs) and Internet access using MPLS tunnels, with Ethernet interfaces.

# MPLS/RSVP Configuration Process Overview

Figure 23 displays the process to configure MPLS and RSVP parameters.

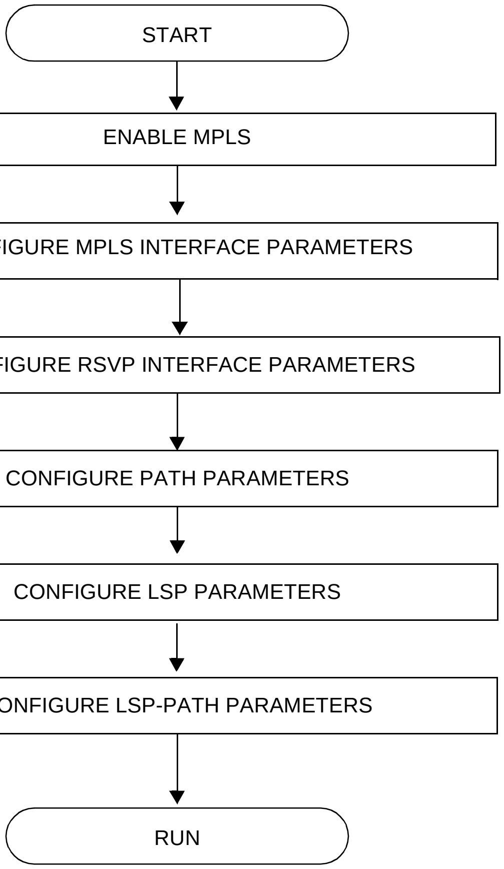

START
ENABLE MPLS
CONFIGURE MPLS INTERFACE PARAMETERS
CONFIGURE RSVP INTERFACE PARAMETERS
CONFIGURE PATH PARAMETERS
CONFIGURE LSP PARAMETERS
CONFIGURE LSP-PATH PARAMETERS
RUN

**Figure 23: MPLS and RSVP Configuration and Implementation Flow**

# Configuration Notes

This section describes MPLS and RSVP 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.

# Configuring MPLS and RSVP with CLI

This section provides information to configure MPLS and RSVP using the command line interface.

Topics in this section include:

# MPLS Configuration Overview

Multiprotocol Label Switching (MPLS) enables routers to forward traffic based on a simple label embedded into the packet header. A router examines the label to determine the next hop for the packet, saving time for router address lookups to the next node when forwarding packets. MPLS is not enabled by default and must be explicitly enabled.

In order to implement MPLS, the following entities must be configured:

- LSPs on page 80
- Paths on page 80
- Router Interface on page 81

## LSPs

To configure MPLS-signaled label-switched paths (LSPs), an LSP must run from an ingress router to an egress router. Configure only the ingress router and configure LSPs to allow the software to make the forwarding decisions or statically configure some or all routers in the path. The LSP is set up by Resource Reservation Protocol (RSVP), through RSVP signaling messages. The 7210 SAS M, X OS automatically manages label values. Labels that are automatically assigned have values ranging from 1,024 through 1,048,575 (see Label Values on page 21).

A static LSP is a manually set up LSP where the nexthop IP address and the outgoing label are explicitly specified.

## Paths

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

## 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.

## Choosing the Signaling Protocol

If only static label switched paths are used in your configurations, then you must manually define the paths through the MPLS network. Label mappings and actions configured at each hop must be specified. You do not need to enable RSVP if you are configuring static LSPs.

If dynamic LSP signaling is implemented in your network, then RSVP must be specified. Enable signaling protocols only on the links where the functionality is required.

In order to implement MPLS, the following entities must be enabled:

- MPLS must be enabled on all routers that are part of an LSP.
- RSVP must be enabled on the same routers.

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

# Basic MPLS Configuration

This section provides information to configure MPLS and configuration examples of common configuration tasks. To enable MPLS on 7210 SAS M, X Series routers, you must configure at least one MPLS interface. The other MPLS configuration parameters are optional. This follow displays an example of an MPLS configuration.

```
A:ALA-1>config>router>mpls# info
------------------------------------------
     admin-group "green" 15
            admin-group "yellow" 20
            admin-group "red" 25
            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 "secondary-path"
                no shutdown
            exit
            path "to-NYC"
                hop 1 10.10.10.104  strict
                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:ALA-1>config>router>mpls#
```

# 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 (for RSVP-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 path parameters for configuring LSP 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 statements under the LSP hierarchy are optional.

# Configuring MPLS Components

Use the MPLS and RSVP CLI syntax displayed below for:

- Configuring Global MPLS Parameters on page 84
- Configuring an MPLS Interface on page 85
- Configuring MPLS Paths on page 86
- Configuring an MPLS LSP on page 87
- Configuring a Static LSP on page 88
- Configuring RSVP Parameters on page 91
- Configuring RSVP Message Pacing Parameters on page 92

# Configuring Global MPLS Parameters

Admin groups can signify link colors, such as red, yellow, or green. MPLS interfaces advertise the link colors it supports. CSPF uses the information when paths are computed for constrained-based LSPs. CSPF must be enabled in order for admin groups to be relevant.

To configure MPLS admin-group parameters, enter the following commands:

**CLI Syntax:**
```
mpls
  admin-group group-name group-value
  frr-object
  resignal-timer minutes
```

The following displays an admin group configuration example:

```
A:ALA-1>config>router>mpls# info
----------------------------------------------
            resignal-timer 500
            admin-group "green" 15
            admin-group "yellow" 20
            admin-group "red" 25
...
----------------------------------------------
A:ALA-1>config>router>mpls#
```

# Configuring an MPLS Interface

Configure the **label-map** parameters if the interface is used in a static LSP.
To configure an MPLS interface on a router, enter the following commands:

**CLI Syntax:**

```
config>router>mpls
  interface
     no shutdown
     admin-group group-name [group-name...(up to 32 max)]
     label-map
        pop
        swap
        no shutdown
     srlg-group group-name [group-name...(up to 5 max)]
     te-metric value
```

The following displays an interface configuration example:

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

# Configuring MPLS Paths

Configure an LSP path to use in MPLS. When configuring an LSP, the IP address of the hops 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 through 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 displays a path configuration example:

```
A:ALA-1>config>router>mpls# info
------------------------------------------
            interface "system"
            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
            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
------------------------------------------
A:ALA-1>config>router>mpls#
```

# Configuring an MPLS LSP

Configure an LSP path for MPLS. When configuring an LSP, you must specify the IP address of the egress router in the **to** statement. 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:ALA-1>config>router>mplp# info
----------------------------------------------
...
            lsp "lsp-to-eastcoast"
                to 192.168.200.41
                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:ALA-1>config>router>mpls#
```

## Configuring a Static LSP

An LSP can be explicitly (statically) configured. Static LSPs are configured on every node along the 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 out-label nexthop ip-addr
     no shutdown
```

The following displays a static LSP configuration example:

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

## Configuring Manual Bypass Tunnels

Consider the following network setup.

```
A----B----C----D
     |    |
     E----F
```

The user first configures the option to disable the dynamic bypass tunnels.

Listed below are the steps to configure the manual bypass tunnels:

1. Configure the option to disable the dynamic bypass tunnels on the 7210 SAS node B (if required). The CLI for this configuration is:
   **config>router>mpls>dynamic-bypass [disable | enable]**
   The dynamic bypass tunnels are enabled by default.

2. Configure an LSP on node B, such as B-E-F-C which is used only as bypass. The user specifies each hop in the path, for example, the bypass LSP has a strict path.

Note that including the bypass-only keyword disables the following options under the LSP configuration:

- bandwidth
- fast-reroute
- secondary

The following LSP configuration options are allowed:

- adaptive
- adspec
- cspf
- exclude
- hop-limit
- include
- metric

The following example displays a bypass tunnel configuration:

```
A:7210 SAS>config>router>mpls>path# info
-------------------------------------------
       ...
       path "BEFC"
               hop 10 10.10.10.11 strict
               hop 20 10.10.10.12 strict
               hop 30 10.10.10.13 strict
               no shutdown
       exit

       lsp "bypass-BC"
               to 10.10.10.15
               primary "BEFC"
               exit
               no shutdown
       ...
-------------------------------------------
A:7210 SAS >config>router>mpls>path#
```

3. Configure an LSP from A to D and indicate fast-reroute bypass protection, select the facility as “FRR method”. (Config>router>mpls>lsp>fast-reroute facility).

   Observe if the following criterions apply:

   → If the LSP passes through B

   → A bypass is requested

   → The next hop is C

   → A manually configured bypass-only tunnel exists from B to C ( excluding link B to C)

**Result:** Node B uses the manually configured bypass-only tunnel from B to C.

# Configuring RSVP Parameters

RSVP is used to set up LSPs. RSVP must be enabled on the router interfaces that are participating in signaled LSPs. The **keep-multiplier** and **refresh-time** default values can be modified in the RSVP context.

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

The following example displays an RSVP configuration example:

```
A:ALA-1>config>router>rsvp# info
------------------------------------------------
     interface "system"
             no shutdown
          exit
          interface to-104
             hello-interval 4000
             no shutdown
          exit
          no shutdown
------------------------------------------------
A:ALA-1>config>router>rsvp#
```

## Configuring RSVP Message Pacing Parameters

RSVP 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 parameters:

**CLI Syntax:**

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

The following example displays a RSVP message pacing configuration example:

```
A:ALA-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:ALA-1>config>router>rsvp#
```

# Configuring Graceful Shutdown

Enable TE graceful shutdown on the maintainence interface using the **config>router>rsvp>interface>graceful-shutdown** command.

Disable graceful shutdown by executing the **no** form of the command at the RSVP interface level or at the RSVP level. This restores the user-configured TE parameters of the maintenance links, and the 7210 SAS maintenance node floods them.

# MPLS Configuration Management Tasks

This section discusses the following MPLS configuration management tasks:

- Modifying MPLS Parameters on page 94
- Modifying MPLS Path Parameters on page 96
- Modifying MPLS Static LSP Parameters on page 97
- Deleting an MPLS Interface on page 98

## 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.

# 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 displays a MPLS LSP configuration example. Refer to the LSP configuration on page 87.

```
A:ALA-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:ALA-1>config>router>mpls#
```

# Modifying MPLS Path Parameters

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

The following displays a path configuration example. Refer to the LSP configuration on page 86.

```
A:ALA-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
...
----------------------------------------------
A:ALA-1>config>router>mpls#
```

# Modifying MPLS Static LSP Parameters

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

The following displays a static LSP configuration example. Refer to the static LSP configuration on page 88.

```
A:ALA-1>config>router>mpls# info
----------------------------------------------
...
            static-lsp "static-LSP"
                to 10.10.10.234
                push 102704 nexthop 10.10.8.114
                no shutdown
            exit
            no shutdown
----------------------------------------------
A:ALA-1>config>router>mpls#
```

# Deleting an MPLS Interface

In order to delete an interface from the MPLS configuration, the interface must be shut down first.

Use the following CLI syntax to delete an interface from the MPLS configuration:

**CLI Syntax:**

```
mpls
  [no] interface ip-int-name
     shutdown
```

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

# RSVP Configuration Management Tasks

This section discusses the following RSVP configuration management tasks:

- Modifying RSVP Parameters on page 99
- Modifying RSVP Message Pacing Parameters on page 100
- Deleting an Interface from RSVP on page 100

## Modifying RSVP Parameters

Only interfaces configured in the MPLS context can be modified in the RSVP context.

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

The following example displays a modified RSVP configuration example:

```
A:ALA-1>config>router>rsvp# info
----------------------------------------------
            keep-multiplier 5
            refresh-time 60
            msg-pacing
                period 400
                max-burst 400
            exit
            interface "system"
            exit
            interface "test1"
                hello-interval 5000
            exit
            no shutdown
----------------------------------------------
A:ALA-1>config>router>rsvp#
```

# Modifying RSVP Message Pacing Parameters

RSVP 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 command usage to modify RSVP parameters:

The following example displays a modified RSVP message pacing configuration example. Refer to the RSVP message pacing configuration on page 91.

```
A:ALA-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:ALA-1>config>router>rsvp#
```

# Deleting an Interface from RSVP

Interfaces cannot be deleted directly from the RSVP configuration. An interface must have been configured in the MPLS context and then the RSVP context. The interface must first be deleted from the MPLS context. This removes the association from RSVP.

See Deleting an MPLS Interface on page 98 for information on deleting an MPLS interface.

# MPLS/RSVP Command Reference

## Command Hierarchies

### MPLS Commands

```
config
    — router
        — [no] mpls
            — admin-group group-name group-value
            — no admin-group group-name
            — dynamic-bypass [enable | disable]
            — [no] frr-object
            — hold-timer seconds
            — no hold-timer
            — [no] interface ip-int-name
                — [no] admin-group group-name [group-name...(up to 5 max)]
                — [no] srlg-group group-name [group-name...(up to 5 max)]
                — te-metric metric
                — no te-metric
            — resignal-timer minutes
            — no resignal-timer
            — [no] shutdown
            — [no] srlg-database
                — [no] router-id router-addr
                    — [no] interface ip-addr srlg-group group-name [group-name..(up
                      to 5 max)]
                — [no] shutdown
            — [no] srlg-frr [strict]
            — srlg-group group-name {value group-value}
            — no srlg-group group-name
            — [no] static-lsp lsp-name
                — no push label
                — push label nexthop ip-address
                — [no] shutdown
```

```
                              — to ip-address
                          — [no] static-lsp-fast-retry seconds
                          — user-srlg-db [enable | disable]
```

## MPLS-TP Commands (Supported only on 7210 SAS-R6)

```
config
    — router
        — [no] mpls
            — [no] mpls-tp
                — global-id global-id
                — no global-id
                — node-id node-id
                — no node-id
                — [no] oam-template name
                    — bfd-template name
                    — no bfd-template
                    — hold-time-down timer
                    — no hold-time-down
                    — hold-time-up timer
                    — no hold-time-up
                — protection-template name
                — no protection-template
                    — rapid-psc-timer interval
                    — no rapid-psc-timer
                    — [no] revertive
                    — slow-psc-timer interval
                    — no slow-psc-timer
                    — wait-to-restore interval
                    — no wait-to-restore
                — [no] shutdown
                — tp-tunnel-id-range start-id end-id
                — no tp-tunnel-id-range
                — transit-path path-name
                — no transit-path
                    — [no] forward-path in-label out-label out-label out-link inter-
                      face name [next-hop ip-address]
                    — path-id {lsp-num lsp-num | working-path | protect-path [src-
                      global-id src-global-id] src-node-id src-node-id src-tunnel-
                      num src-tunnel-num [dest-global-id dest-global-id] dest-node-
                      id dest-node-id [dest-tunnel-num dest-tunnel-num]}
                    — no path-id
                    — [no] reverse-path in-label out-label out-label out-link interface
                      name [next-hop ip-address]
                    — in-label in-label out-label out-label out-link if-name [next-hop
                      next-hop]
                    — no in-label
                    — [no] shutdown
```

## MPLS LSP Commands

```
config
     — router
          — [no] mpls
               — [no] lsp lsp-name [bypass-only | p2mp-lsp | mpls-tp src-tunnel-num]
                    — [no] adaptive
                    — [no] adspec
                    — bgp-transport-tunnel include | exclude
                    — [no] cspf [use-te-metric]
                    — [no] exclude group-name [group-name...(up to 5 max)]
                    — fast-reroute frr-method
                    — no fast-reroute
                         — bandwidth rate-in-mbps
                         — no bandwidth
                         — hop-limit number
                         — no hop-limit
                         — [no] node-protect
                    — from ip-address
                    — hop-limit number
                    — no hop-limit
                    — [no] include group-name [group-name...(up to 5 max)]
                    — [no] ldp-over-rsvp [include | exclude]
                    — metric metric
                    — [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
                    — 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)]
                         — [no] path-preference
                         — [no] record
                         — [no] record-label
                         — [no] shutdown
                         — [no] srlg
                         — [no] standby
                    — [no] shutdown
                    — to ip-address
                    — vprn-auto-bind [include | exclude]
```

## MPLS-TP LSP Commands (Supported only on 7210 SAS-R6)

```
config
     — router
          — [no] mpls
               — [no] lsp lsp-name [bypass-only | p2mp-lsp | mpls-tp src-tunnel-num]
                    — [no] protect-tp-path
                         — in-label in-label
                         — no in-label
                         — lsp-num lsp-number
                         — no lsp-num
                         — [no] mep
                              — bfd-enable [bfd-mode]
                              — no bfd-enable
                              — oam-template [32 chars max]
                              — no oam-template
                              — protection-template 256 chars max
                              — no protection-template
                              — [no] shutdown
                         — out-label out-label out-link if-name [next-hop ip-address]
                         — no out-label
                         — [no] shutdown
                    — [no] working-tp-path
                         — in-label in-label
                         — no in-label
                         — lsp-num lsp-number
                         — no lsp-num
                         — [no] mep
                              — bfd-enable [bfd-mode]
                              — no bfd-enable
                              — oam-template name
                              — no oam-template
                              — [no] shutdown
                         — out-label out-label out-link if-name [next-hop ip-address]
                         — no out-label
                         — [no] shutdown
```

## MPLS Path Commands

```
config
     — router
          — [no] mpls
               — [no] path path-name
                    — hop hop-index ip-address {strict | loose}
                    — no hop hop-index
                    — [no] shutdown
               — [no] static-lsp lsp-name
                    — push label nexthop ip-address
                    — no push out-label
                    — to ip-addr
                    — [no] shutdown
```

## RSVP Commands

```
config
    — router
        — [no] rsvp
            — [no] graceful-shutdown
            — [no] implicit-null-label
            — [no] interface ip-int-name
                — authentication-key [authentication-key | hash-key] [hash | hash2]
                — no authentication-key
                — [no] bfd-enable (for 7210 SAS M in Network Mode)
                — [no] graceful-shutdown
                — hello-interval milli-seconds
                — no hello-interval
                — [no] refresh-reduction
                    — [no] reliable-delivery
                — [no] shutdown
                — subscription percentage
                — no subscription
            — keep-multiplier number
            — no keep-multiplier
            — [no] msg-pacing
                — max-burst number
                — no max-burst
                — period milli-seconds
                — no period
            — rapid-retransmit-time hundred-milliseconds
            — no rapid-retransmit-time
            — rapid-retry-limit number
            — no rapid-retry-limit
            — refresh-time seconds
            — no refresh-time
            — [no] shutdown
```

## Show Commands

```
show
    — router
        — mpls
            — admin-group group-name
            — bypass-tunnel [to ip-address] [protected-lsp name] [dynamic | manual] [detail]
            — interface [ip-int-name|ip-address] [label-map label]
            — interface [ip-int-name|ip-address]
            — label start-label [end-label | in-use | label-owner]
            — label-range
            — lsp [lsp-name] [status {up|down}] [from ip-address| to ip-address] [detail]
            — lsp {transit | terminate} [status {up|down}] [from ip-address | to ip-address | lsp-name name] [detail]
            — lsp count
            — lsp lsp-name activepath
            — lsp [lsp-name] path [path-name] [status {up | down}] [detail]
            — mpls-tp
                — oam-template [template-name] [associations]
                — protection-template [template-name] [associations]
                — status
                — transit-path [path-name] [detail]
            — path [path-name] [lsp-binding]
            — p2mp-info [type {originate|transit|terminate}] [s2l-endpoint ip-address]
            — p2mp-lsp [lsp-name] [detail]
            — p2mp-lsp [lsp-name] p2mp-instance [p2mp-instance-name] [mbb]
            — p2mp-lsp [lsp-name] p2mp-instance [p2mp-instance-name] s2l [s2l-name [to s2l-to-address]][status {up|down}] [detail]
            — p2mp-lsp [lsp-name] p2mp-instance [p2mp-instance-name] s2l [s2l-name[to s2l-to-address]] mbb
            — srlg-database [router-id ip-address] [interface ip-address]
            — srlg-group [group-name]
            — static-lsp [lsp-name]
            — static-lsp {transit | terminate}
            — static-lsp count
            — status
            — tp-lsp [lsp-name] [status {up | down}] [from ip-address | to ip-address] [detail]
            — tp-lsp [lsp-name] path [protecting | working] [detail]
            — tp-lsp [lsp-name] protection

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

## Tools Commands

```
— perform
    — router
        — mpls
            — cspf to ip-addr [from ip-addr] [bandwidth bandwidth] [include-bitmap
              bitmap] [exclude-bitmap bitmap] [hop-limit limit] [exclude-address excl-
              addr [excl-addr...(upto 8 max)]] [use-te-metric] [strict-srlg] [srlggroup
              grp-id...(up to 8 max)] [skip-interface interface-name]
            — force-switch-path [lsp lsp-name] [path path-name]
            — [no] force-switch-path [lsp lsp-name]
            — resignal {lsp lsp-name path path-name | delay minutes}
            — tp-tunnel
                — clear id tunnel-id
                — clear lsp-name
                — force id tunnel-id
                — force lsp-name
                — lockout lsp-name
                — lockout id tunnel-id
                — manual lsp-name
                — manual id tunnel-id
            — trap-suppress number-of-traps time-interval
            — update-path {lsp lsp-name path current-path-name new-path new-path-
              name}
```

## Clear Commands

```
clear
    — router
        — mpls
            — interface [ip-int-name]
            — lsp lsp-name
        — rsvp
            — interface [ip-int-name] [statistics]
            — statistics
```

## Debug Commands

```
debug
    — router
        — mpls [lsp lsp-name] [sender source-address] [endpoint endpoint-address] [tunnel-id tunnel-
          id] [lsp-id lsp-id]
        — no mpls
            — [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
        — rsvp [lsp lsp-name] [sender source-address] [endpoint endpoint-address] [tunnel-id tunnel-
          id] [lsp-id lsp-id] [interface ip-int-name]
        — no rsvp
            — [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
                — all [detail]
                — no all
                — ack
                — 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
```

# MPLS Configuration Commands

# Generic Commands

## shutdown

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

**Context** config>router>mpls
config>router>mpls>interface
config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary

**Description** This command administratively disables an entity. When disabled, an entity does not change, reset, or remove any configuration settings or statistics.

MPLS is not enabled by default and must be explicitely enabled (**no shutdown**).

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 may be deleted.

The **no** form of this command places the entity into an administratively enabled state.

**Default** **no shutdown**

# MPLS Commands

## mpls

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

**Context** config>router

**Description** This command enables the context to configure MPLS parameters. MPLS is not enabled by default and must be explicitely enabled (**no shutdown**). The **shutdown** command administratively disables MPLS.

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

MPLS must be **shutdown** before the MPLS instance can be deleted. If MPLS is not shutdown, when the **no mpls** command is executed, a warning message on the console displays indicating that MPLS is still administratively up.

## admin-group

**Syntax** **admin-group** *group-name group-value*
**no admin-group** *group-name*

**Context** config>router>mpls

**Description** This command is used to define administrative groups or link coloring for an interface. The admin group names can signify link colors, such as red, yellow, or green. MPLS interfaces advertise the link colors the support. CSPF uses the information when paths are computed for constraint-based LSPs. CSPF must be enabled in order for admin groups to be relevant.

Network resources (links) based on zones, geographic location, link location, etc., can be classified using admin groups. MPLS interfaces must be explicitly assigned to an admin group.

Admin groups must be defined in the **config>router>mpls** context before they can be assigned to an MPLS interface. The IGP communicates the information throughout the area.

Up to 32 group names can be defined in the **config>router>mpls** context. The **admin-group** names must be identical across all routers in a single domain.

The **no** form of this command deletes the administrative group. All configuration information associated with this LSP is lost.

**Default** none

**Parameters** *group-name* — Specify the name of the administrative group within a virtual router instance.

*group-value* — Specify the group value associated with this administrative group. This value is unique within a virtual router instance.

**Values** 0 — 31

## dynamic-bypass

**Syntax** **dynamic-bypass** [**enable** | **disable**]
**no dynamic-bypass**

**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.

Note :Implict NULL must be enabled for use of Manual Bypass or Dynamic Bypass (FRR facility) if the 7210 is used as a egress LER and/or is a Merge Point.

Default enable

Note :Implict NULL must be enabled for use of Manual Bypass or Dynamic Bypass (FRR facility) if the 7210 is used as a egress LER and/or is a Merge Point.

## frr-object

**Syntax** [**no**] **frr-object**

**Context** config>router>mpls

**Description** This command specifies whether fast reroute for LSPs using the **facility** bypass method is signalled with or without the fast reroute object using the **one-to-one** keyword. 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 — The value is by default 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 holds before programming its data plane and declaring the LSP up to the service module.

The **no** form of the command disables the hold-timer.

**Default** 1 second

**Parameters** *seconds* — Specifies the time, in seconds, for which the ingress node holds before programming its data plane and declaring the LSP up to the service module.

**Values** 0 — 10

## 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, the software waits before attempting to resignal the LSPs.

When the resignal timer expires, if the new computed path for an LSP has a better metric than the current recorded hop list, an attempt is made to resignal that LSP using the make-before-break 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.

The **no** form of the command disables timer-based LSP resignalling.

**Default** no resignal-timer

**Parameters** *minutes* — The time the software waits before attempting to resignal the LSPs.

**Values** 30 — 10080

## srlg-frr

**Syntax** **srlg-frr** [**strict**]
**no srlg-frr**

**Context** config>router>mpls

**Description** This command enables the use of the Shared Risk Link Group (SRLG) constraint in the computation of FRR bypass or detour to be associated with any primary LSP path on this system.

When this option is enabled, CSPF includes the SRLG constraint in the computation of a FRR detour or bypass for protecting the primary LSP path.

CSPF prunes all links with interfaces which belong to the same SRLG as the interface which is being protected, i.e., the outgoing interface at the PLR the primary path is using. If one or more paths are found, the MPLS/RSVP task will select one based on best cost and will signal the bypass/detour. If not and the user included the strict option, the bypass/detour is not setup and the MPLS/RSVP task will keep retrying the request to CSPF. Otherwise, if a path exists which meets the other TE constraints, other than the SRLG one, the bypass/detour is setup.

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 the primary path is using is checked.

When the MPLS/RSVP task is searching for a SRLG bypass tunnel to associate with the primary path of the protected LSP, it will first check if any configured manual bypass LSP with CSPF enabled satisfies the SLRG constraints. The MPLS/RSVP skips any non-CSPF bypass LSP in the search as there is no ERO returned to check the SLRG constraint. If no path is found, it will check if an existing dynamic bypass LSP satisfies the SLRG and other primary path constraints. If not, then it will make a request to CSPF.

Once the primary path of the LSP is set up and is operationally up, any subsequent changes to the SRLG group membership of an interface the primary path is using would not be considered by the MPLS/RSVP task at the PLR for bypass/detour association until the next opportunity the primary path is re-signaled. The path may be re-signaled due to a failure or to a make-before break operation. Make-before break occurs as a result of a global revertive operation, a timer based or manual re-optimization of the LSP path, or a user change to any of the path constraints.

Once the bypass or detour path is setup and is operationally UP, any subsequent changes to the SRLG group membership of an interface the bypass/detour path is using would not be considered by the MPLS/RSVP task at the PLR until the next opportunity the association with the primary LSP path is re-checked. The association is re-checked if the bypass path is re-optimized. Detour paths are not re-optimized and are re-signaled if the primary path is down.

Enabling or disabling srlg-frr only takes effect after LSP paths are resignaled. This can be achieved by shutting down and re-enabling MPLS. Another option is using the **tools perform router mpls resignal** command. However, note that while the latter might be less service impacting, only originating LSPs can be resignaled with the **tools** command. If also local transit and bypass LSPs are to be resignaled, the **tools** command must be executed on all ingress nodes in the network. The same might be locally achieved by disabling and enabling using the **configure router mpls dynamic-bypass** command, but this can trigger the LSP to go down and traffic loss to occur in case detour or bypass LSP is in use.

An RSVP interface can belong to a maximum of 64 SRLG groups. The user configures the SRLG groups using the command **config>router>mpls>srlg-group**. The user configures the SRLG groups an RSVP interface belongs to 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 the name of the SRLG group within a virtual router instance.

**Values** no slr-frr (default)
srlg-frr (non-strict)
srlg-frr **strict** (strict)

## srlg-group

**Syntax** **srlg-group** *group-name* {**value** *group-value*}
**no srlg-group** *group-name*

**Context** config>router>mpls

**Description** This command is used to define shared risk link groups (SRLGs). An SRLG group represents a set of interfaces which could be subject to the same failures or defects and thus share the same risk of failing.

RSVP interfaces must be explicitly assigned to an SRLG group. SRLG groups must be defined in the **config>router>mpls** context before they can be assigned to an RSVP interface. Two different SRLG group names cannot share the same value. Once an SRLG group has been bound to an MPLS interface, its value cannot be changed until the binding is removed.

The IGP communicates the information throughout the area using the TE link state advertisement. CSPF uses the information when paths are computed for constraint-based LSPs. CSPF must be enabled in order for SRLG groups to be relevant.

Up to 1024 group names can be defined in the **config>router>mpls** context. The SRLG group names must be identical across all routers in a single domain.

The **no** form of this command deletes the SRLG group.

**Default** none

**Parameters** *group-name* — Specifies the name of up to 32 characters of the SRLG group within a virtual router instance.

**value** *group-value* **—** Specifies the group value associated with this SRLG group. This value is unique within a virtual router instance.

**Values** 0 — 4294967295

## user-srlg-db

**Syntax** **user-srlg-db** [**enable | disable**]

**Context** config>router>mpls

**Description** This command enables the use of CSPF by the user SRLG database. When the MPLS module makes a request to CSPF for the computation of an SRLG secondary path, CSPF will query the local SRLG and compute a path after pruning links that are members of the SRLG IDs of the associated primary path. When MPLS makes a request to CSPF for an FRR bypass or detour path to associate with the primary path, CSPF queries the user SRLG database and computes a path after pruning links that are members of the SRLG IDs of the PLR outgoing interface.

If an interface was not entered into the user SRLG database, it is assumed that it does not have any SRLG membership. CSPF will not query the TE database for IGP advertised interface SRLG information.

The disable keyword disables the use of the user SRLG database. CSPF will then resume queries into the TE database for SRLG membership information. The user SRLG database is maintained.

**Default** user-srlg-db disable

## srlg-database

**Syntax** [**no**] **srlg-database**

**Context** config>router>mpls

**Description** This command provides the context for the user to enter manually the link members of SRLG groups for the entire network at any node that needs to signal LSP paths (for example, a head-end node).

The **no** form of the command deletes the entire SRLG database. CSPF will assume all interfaces have no SRLG membership association if the database was not disabled with the command **config>router>mpls>user-srlg-db disable**.

## router-id

**Syntax** [**no**] **router-id** *ip*

**Context** config>router>mpls>srlg-database

**Description** This command provides the context for the user to manually enter the link members of SRLG groups for a specific router in the network. The user must also use this command to enter the local interface SRLG membership into the user SRLG database. Use by CSPF of all interface SRLG membership information of a specific router ID may be temporarily disabled by shutting down the node. If this occurs, CSPF will assume these interfaces have no SRLG membership association.

The **no** form of this command will delete all interface entries under the router ID.

**Parameters** *ip-address* — Specifies the router ID for this system. This must be the router ID configured under the base router instance, the base OSPF instance or the base IS-IS instance.

## interface

**Syntax** **interface** *ip-address* **srlg-group** *group-name* [*group-name*...(up to 5 max)]
**no interface** *ip-address* [**srlg-group** *group-name*...(up to 5 max)]

**Context** config>router>mpls>srlg-database>router-id

**Description** This command allows the operator to manually enter the SRLG membership information for any link in the network, including links on this node, into the user SRLG database.

An interface can be associated with up to 5 SRLG groups for each execution of this command. The operator can associate an interface with up to 64 SRLG groups by executing the command multiple times.

CSPF will not use entered SRLG membership if an interface is not validated as part of a router ID in the routing table.

The **no** form of the command deletes a specific interface entry in this user SRLG database. The **group-name** must already exist in the **config>router>mpls>srlg-group** context.

**Default** none

**Parameters** *ip-int-name* — The name of the network IP interface. An interface name cannot be in the form of an IP address.

**srlg-group** *group-name* — Specifies the SRLG group name. Up to 1024 group names can be defined in the **config>router>mpls** context. The SRLG group names must be identical across all routers in a single domain.

## static-lsp

**Syntax** **[no] static-lsp lsp-name**

**Context** config>router>mpls

**Description** This command is used to configure a static LSP on the ingress router. The static LSP is a manually setup LSP where the nexthop 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 shutdown first in order to delete it. 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* — Name that identifies the LSP.

**Values** Up to 32 alphanumeric characters.

## push

**Syntax** **no push** *label*
**push** *label* **nexthop** *ip-address*

**Context** config>router>mpls>static-lsp

**Description** This command specifies the label to be pushed on 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* — The label to push on the label stack. Label values 16 through 1,048,575 are defined as follows:

Label values 16 through 31 are 7750 SR reserved.

Label values 32 through 1,023 are available for static assignment.

Label values 1,024 through 2,047 are reserved for future use.

Label values 2,048 through 18,431 are statically assigned for services.

Label values 28,672 through 131,071 are dynamically assigned for both MPLS and services.

Label values 131,072 through 1,048,575 are reserved for future use.

**Values** 16 — 1048575

**nexthop** *ip-address* — This command 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 ARP entry does not exist, software sets the operational status of the static LSP to down and continues to ARP for the configured nexthop. Software continuously tries to ARP for the configured nexthop at a fixed interval.

## shutdown

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

**Context** config>router>mpls>static-lsp

**Description** This command is used to administratively disable the static LSP.

The **no** form of this command administratively enables the staticLSP.

**Default** shutdown

## 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. This command is required while creating an LSP. For LSPs that are used as transport tunnels for services, the **to** IP address *must* be the system IP address. If the **to** address does not match the SDP address, the LSP is not included in the SDP definition.

**Parameters** *ip-address* — The system IP address of the egress router.

**Default** none

## static-lsp-fast-retry

**Syntax** **static-lsp-fast-retry seconds**
**[no] static-lsp-fast-retry**

**Context** config>router>mpls

**Description** This command specifies the value used as the fast retry timer for a static LSP.

When a static LSP is trying to come up, the MPLS request for the ARP entry of the LSP next-hop may fail when it is made while the next-hop is still down or unavailable. In that case, MPLS starts a retry timer before making the next request. This enhancement allows the user to configure the retry timer, so that the LSP comes up as soon as the next-hop is up.

The **no** form of the command reverts to the default.

**Default** no static-fast-retry-timer

**Parameters** *seconds* — Specifies the value, in seconds, used as the fast retry timer for a static LSP.

**Values** 1-30

# MPLS Interface Commands

## interface

**Syntax** [**no**] **interface** *ip-int-name*

**Context** config>router>mpls

**Description** This command specifies MPLS protocol support on an IP interface. No MPLS commands are executed on an IP interface where MPLS is not enabled. An MPLS interface must be explicitly enabled (**no shutdown**).

The **no** form of this command deletes all MPLS commands such as **label-map** which are defined under the interface. The MPLS interface must be shutdown first in order to delete the interface definition. If the interface is not shutdown, the **no interface** *ip-int-name* command does nothing except issue a warning message on the console indicating that the interface is administratively up.

**Default** **shutdown**

**Parameters** *ip-int-name* — The name 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.

**Values** 1 to 32 alphanumeric characters.

## admin-group

**Syntax** [**no**] **admin-group** *group-name* [*group-name*...(up to 5 max)]

**Context** config>router>mpls>interface

**Description** This command defines admin groups that this interface supports.

This information is advertised as part of OSPF and IS-IS to help CSPF compute constrained LSPs that must include or exclude certain admin groups. An MPLS interface is assumed to belong to all the admin groups unless the ’admin-group’ command is issued under the interface config. Once an ’admin-group’ command is issued the interface is assumed to belong to only the specifically listed groups for that command.

Each single operation of the admin-group command allows a maximum of 5 groups to be specified at a time. However, a maximum of 32 groups can be specified per inteface through multiple operations.

**Default** no admin-group

**Parameters** *group-name* — 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 defines the association of RSVP interface to an SRLG group. An interface can belong to up to 64 SRLG groups. However, each single operation of the **srlg-group** command allows a maximum of 5 groups to be specified at a time.

The **no** form of this command deletes the association of the interface to the SRLG group.

**Default** none

**Parameters** *group-name* — Specifies the name of the SRLG group within a virtual router instance up to 32 characters.

## 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 IS-IS TE metric is encoded as sub-TLV 18 as part of the extended IS reachability TLV. The metric value is encoded as a 24-bit unsigned integer. 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.

When the use of the TE metric is enabled for an LSP, CSPF will first prune all links in the network topology which 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>cspf>use-te-metric**.

Note that 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

The value of the IGP metric is advertised in the TE metric sub-TLV by IS-IS and OSPF.

**Parameters** *value* — Specifies the metric value.

**Values** 1 — 16777215

# MPLS-TP Commands

## mpls-tp

**Syntax** [**no**] **mpls-tp**

**Context** config>router>mpls

**Description** Generic MPLS-TP parameters and MPLS-TP trabsit paths are configured under this context. If a user configures **no mpls**, normally the entire MPLS configuration is deleted. However, in the case of mpls-tp, a check is made that there is no other mpls-tp configuration (For example, services or LSPs using mpls-tp on the node). The MPLS-TP context cannot be deleted if MPLS-TP LSPs or SDPs exist on the system.

A **shutdown** of mpls-tp will bring down all MPLS-TP LSPs on the system.

**Default** no mpls-tp

## tp-tunnel-id-range

**Syntax** **tp-tunnel-id-range** *start-id end-id*
**no tp-tunnel-id-range**

**Context** config>router>mpls>mpls-tp

**Description** This command configures the range of MPLS tunnel IDs reserved for MPLS-TP LSPs. The maximum difference between the start-id and end-id is 4K.

The tunnel ID referred to here is the RSVP-TE tunnel ID. This maps to the MPLS-TP Tunnel Number. There are some cases where the dynamic LSPs may have caused fragmentation to the number space such that contiguous range [*end-id – start-id*] is not available. In these cases, the command will fail.

There are no default values for the *start-id* and *end-id* of the tunnel id range, and they must be configured to enable MPLS-TP.

**Default** no tunnel-id-range

**Parameters** *start-id* — Specifies the start ID.

**Values** 1 — 61440

*end-id* — Specifies the end ID.

**Values** 1 — 61440

## oam-template

**Syntax** [**no**] **oam-template** *name*

**Context** config>router>mpls>mpls-tp

**Description** This command creates or edits an OAM template Generally applicable proactive OAM parameters are configured using templates. The top-level template is the OAM template.

Generic MPLS-TP OAM and fault management parameters are configured in the OAM Template.

Proactive CC/CV uses BFD and parameters such as Tx/Rx timer intervals, multiplier and other session/fault management parameters specific to BFD are configured using a BFD Template, which is referenced from the OAM template.

**Default** no oam-template

**Parameters** *name* — Specifies a text string name for the template of up to 32 characters in printable 7-bit ASCII, enclosed in double quotes. Named OAM templates are referenced from the MPLS-TP path MEP configuration.

## hold-time-down

**Syntax** **hold-time-down** *timer*
**no hold-time-down**

**Context** config>router>mpls>mpls-tp>oam-template

**Description** This command configures the hold-down dampening timer. It is equivalent to a hold-off timer.

**Default** no hold-time-down

**Parameters** *interval* — Specifies the hold-down dampening timer interval.

**Values** 0 — 5000 deciseconds in 10 ms increments

## hold-time-up

**Syntax** **hold-time-up** *timer*
**no hold-time-up**

**Context** config>router>mpls>mpls-tp>oam-template

**Description** This command configures the hold-up dampening timer. This can be used to provide additional dampening to the state of proactive CC BFD sessions.

**Default** no hold-time-up

**Parameters** *interval* — Specifies the hold-up dampening timer interval.

**Values** 0 — 500 deciseconds, in 100 ms increments

**Default** 2 seconds

## bfd-template

**Syntax** **bfd-template** *name*
**no bfd-template**

**Context** config>router>mpls>mpls-tp>oam-template

**Description** This command configures a named BFD template to be referenced by an OAM template.

**Default** no bfd-template

**Parameters** *name* — Specifies the BFD template name as a text string up to 32 characters in printable 7-bit ASCII, enclosed in double quotes.

**Values**

## protection-template

**Syntax** **protection-template** *name*
**no protection-template**

**Context** config>router>mpls>mpls-tp

**Description** Protection templates are used to define generally applicable protection parameters for MPLS-TP tunnels. Only linear protection is supported, and so the application of a named template to an MPLS-TP LSP implies that linear protection is used. A protection template is applied under the MEP context of the protect-path of an MPLS-TP LSP.

The protection-template command creates or edits a named protection template.

**Default** no protection-template

**Parameters** *name* — Specifies the protection template name as a text string of up to 32 characters in printable 7-bit ASCII, enclosed in double quotes.

## revertive

**Syntax** [**no**] **revertive**

**Context** config>router>mpls>mpls-tp>protection-template

**Description** This command configured revertive behavior for MPLS-TP linear protection. The protect-tp-path MEP must be in the shutdown state for of the MPLS-TP LSPs referencing this protection template in order to change the revertve parameter.

**Default** revertive

## wait-to-restore

**Syntax** **wait-to-restore** *interval*
**no wait-to-restore**

**Context** config>router>mpls>mpls-tp>protection-template

**Description** This command configures the WTR timer. It determines how long to wait until the active path of an MPLS-TP LSP is restored to the working path following the clearing of a defect on the working path. It is appliable to revertive mode, only.

**Default** no wait-to-restore

**Parameters** *interval* — Specifies the WTR timer interval.

**Values** 0 — 720 seconds in 1 second increments

## rapid-psc-timer

**Syntax** **rapid-psc-timer** *interval*
**no rapid-psc-timer**

**Context** config>router>mpls>mpls-tp>protection-template

**Description** This command configures the rapid timer value to be used for protection switching coordination (PSC) packets for MPLS-TP linear protection (RFC 6378).

**Default** no rapid-psc-timer

**Parameters** *interval* — Specifies the rapid timer interval.

**Values** [10, 100, 1000 ms]

**Default** 10 ms

## slow-psc-timer

**Syntax** **slow-psc-timer** *interval*
**no slow-psc-timer**

**Context** config>router>mpls>mpls-tp>protection-template

**Description** This command configures the slow timer value to be used for protection switching coordination (PSC) packets for MPLS-TP linear protection (RFC 6378).

**Default** no rapid-psc-timer

**Parameters** *interval* — Specifies the slow timer interval.

**Values** [10, 100, 1000 ms]

# global-id

**Syntax** **global-id** *global-id*
**no global-id**

**Context** config>router>mpls>mpls-tp

**Description** This command configures the MPLS-TP Global ID for the node. This is used as the 'from' Global ID used by MPLS-TP LSPs originating at this node. If a value is not entered, the Global ID is taken to be Zero. This is used if the global-id is not configured. If an operator expects that inter domain LSPs will be configured, then it is recommended that the global ID should be set to the local ASN of the node, as configured under config>system. If two-byte ASNs are used, then the most significant two bytes of the global-id are padded with zeros.

In order to change the value of the global-id, config>router>mpls>mpls-tp must be in the shutdown state. This will bring down all of the MPLS-TP LSPs on the node. New values a propagated to the system when a no shutdown is performed.

**Default** no global-id

**Parameters** *global-id* — Specifies the global ID for the node.

**Values** 0 — 4294967295

# node-id

**Syntax** **node-id** *node-id*
**no node-id**

**Context** config>router>mpls>mpls-tp

**Description** This command configures the MPLS-TP Node ID for the node. This is used as the 'from' Node ID used by MPLS-TP LSPs originating at this node. The default value of the node-id is the system interface IPv4 address. The Node ID may be entered in 4-octed IPv4 address format, <a.b.c.d>, or as an unsigned 32 bit integer. Note that it is not treated as a routable IP address from the perspective of IP routing, and is not advertised in any IP routing protocols.

The MPLS-TP context cannot be administratively enabled unless at least a system interface IPv4 address is configured because MPLS requires that this value is configured.

**Default** no node-id

**Parameters** *node-id* — Specifies the MPLS-TP node ID for the node.

**Values** <a.b.c.d> or [1— 4294967295]

**Default** System interface IPv4 address

## transit-path

**Syntax** **transit-path** *path-name*
**no transit-path**

**Context** config>router>mpls>mpls-tp

**Description** This command enables the configuration or editing of an MPLS-TP transit path at an LSR.

**Default** no transit-path

**Parameters** *path-name* — Specifies the template of up to 32 characters in printable 7-bit ASCII, enclosed in double quotes.

## path-id

**Syntax** **path-id** {**lsp-num l***sp-num* **| working-path | protect-path** [**src-global-id** *src-global-id*] **src-node-id** *src-node-id* **src-tunnel-num** *src-tunnel-num* [**dest-global-id** *dest-global-id*] **dest-node-id** *dest-node-id* [**dest-tunnel-num** *dest-tunnel-num*]}
**no path-id**

**Context** config>router>mpls>mpls-tp>transit-path

**Description** This command configures path ID for an MPLS-TP transit path at an LSR. The path ID is equivalent to the MPLS-TP LSP ID and is used to generate the maintenance entity group intermediate point (MIP) identifier for the LSP at the LSR. A path-id must be configured for on-demand OAM to verify an LSP at the LSR.

The path-id must contain at least the following parameters: **lsp-num, src-node-id, src-global-id, src-tunnel-num, dest-node-id**.

The path-id must be unique on a node. It is recommended that his is also configured to be a globally unique value.

The **no** form of the command removes the path ID from the configuration.

**Default** no path-id

**Parameters** *lsp-num* — Specifues the LSP number.

**Values** 1 — 65535, or **working path**, or **protect-path**. A **working-path** is equivalent to a lsp-num of 1, and a **protect-path** is an lsp-num of 2.

*src-global-id* — Specifies the source global ID.

**Values** 0 — 4294967295

*src-node-id* — Specifies the source node ID.

**Values** a.b.c.d or 1 — 4294967295

*src-tunnel-num* — Specifies the source tunnel number.

**Values** 1 — 61440

*dest-global-id* — Specifies the destination global ID. If the destination global ID is not entered, then it is set to the same value as the source global ID.

**Values** 0 — 4294967295

*dest-node-id* — Specifies the destination node ID.

**Values** a.b.c.d or 1 — 4294967295

*dest-tunnel-num* — Specifies the destination tunnel number. If the destination tunnel number is not entered, then it is set to the same value as the source tunnel number.

**Values** 1 — 61440

## forward-path

**Syntax** [**no**] **forward-path**

**Context** config>router>mpls>mpls-tp>transit-path

**Description** This command enables the forward path of an MPLS-TP transit path to be created or edited.

The forward path must be created before the reverse path.

The **no** form of this command removes the forward path. The forward path cannot be removed if a reverse exists.

**Default** no forward-path

## reverse-path

**Syntax** [**no**] **reverse-path**

**Context** config>router>mpls>mpls-tp>transit-path

**Description** This command enables the reverse path of an MPLS-TP reverse path to be created or edited.

The reverse path must be created after the forward path.

The **no** form of this command removes the reverse path. The reverse path must be removed before the forward path.

**Default** no reverse-path

## in-label

**Syntax** **in-label** *in-label* **out-label** *out-label* **out-link** *if-name* [**next-hop** *next-hop*]
**no in-label**

**Context** config>router>mpls>mpls-tp>transit-path>forward-path
config>router>mpls>mpls-tp>transit-path>reverse-path

**Description** This command configures the label mapping associated with a forward path or reverse path of an MPLS-TP transit path to be configured.

The incoming label, outgoing label and outgoing interface must be configured, using the **in-label**, **out-label** and **out-link** parameters. If the out-link refers to a numbered IP interface, the user may optionally configure the **next-hop** parameter and the system will determine the interface to use to reach the configured next-hop, but will check that the user-entered value for the *out-link* corresponds to the link returned by the system. If they do not correspond, then the path will not come up.

**Default** no in-label

**Parameters** *in-label* — Specifies the in label.

**Values** 32 — 16415

*out-label* — Specifies the out label.

**Values** 32 — 16415

*if-name* — Specifies the name of the outgoing interface use for the path.

*next-hop* — Specifies the next-hop.

**Values** a.b.c.d

## shutdown

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

**Context** config>router>mpls>mpls-tp>transit-path

**Description** This command administratively enables or disables an MPLS-TP transit path.

**Default** no shutdown

# LSP Commands

## lsp

**Syntax** [**no**] **lsp** *lsp-name* [**bypass-only | p2mp-lsp** | **mpls-tp** *src-tunnel-num***]**

**Context** config>router>mpls

**Description** This command creates an LSP that is signaled dynamically by the 7210 SAS M.

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. Notre that the maximum number of static configurable LSPs is 4.

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 shutdown before it can be deleted.

**Default** none

**Parameters** *lsp-name* — 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 if found, the 7210 selects it. If no manual bypass tunnel is found, the 7210 dynamically signals a bypass LSP in the default behavior. The CLI for this feature includes a knob that provides the user with the option to disable dynamic bypass creation on a per node basis.

**p2mp-lsp —** Defines an LSP as a point-to-multipoint LSP. The following parameters can be used with a P2MP LSP: adaptive, adspec, cspf, exclude, fast-reroute, from, hop-limit, include, metric, retry-limit, retry-timer, resignal-timer. The following parameters cannot be used with a P2MP LSP are primary, secondary and to.

**mpls-tp** *src-tunnel-num* **—** Defines an LSP as an MPLS-TP LSP. The *src-tunnel-num* is a mandatory create time parameter for mpls-tp LSPs, and has to be assigned by the user based on the configured range of tunnel IDs. The following parameters can only be used with an MPLS-TP LSP: to, dest-global-id, dest-tunnel-number, working-tp-path, protect-tp-path. Other parameters defined for the above LSP types cannot be used.

## adaptive

**Syntax** [**no**] **adaptive**

**Context** config>router>mpls>lsp

**Description** This command enables the make-before-break functionality for an LSP or LSP path. When enabled for the LSP, make-before-break will be performed for primary path and all the secondary paths of the LSP.

**Default** adaptive

## adspec

**Syntax** [**no**] **adspec**

**Context** config>router>mpls>lsp

**Description** When enabled, the ADSPEC object will be included in RSVP messages for this LSP. The ADSPEC object is used by the ingress LER to discover the minimum value of the MTU for links in the path of the LSP. By default, the ingress LER derives the LSP MTU from that of the outgoing interface of the LSP path.

Note that a bypass LSP always signals the ADSPEC object since it protects both primary paths which signal the ADSPEC object and primary paths which do not. This means that MTU of LSP at ingress LER may change to a different value from that derived from the outgoing interface even if the primary path has ADSPEC disabled.

**Default** **no adspec —** No ADSPEC objects are included in RSVP messages.

**Parameters**

## bgp-transport-tunnel

**Syntax** **bgp-transport-tunnel** *include* **|** *exclude*

**Context** config>router>mpls>lsp

**Description** This command allows or blocks RSVP-TE LSP to be used as a transport LSP for BGP tunnel routes.

**Default** bgp-transport-tunnel include

**Parameters** *include* — Allows RSVP-TE LSP to be used as transport LSP from the ASBR to local PE router, from ingress PE to ASBR in the local AS or between multi-hop eBGP peers with ASBR to ASBR adjacency.

*exclude* — Blocks RSVP-TE LSP to be used as transport LSP from the ASBR to local PE router, from ingress PE to ASBR in the local AS or between multi-hop eBGP peers with ASBR to ASBR adjacency.

## cspf

**Syntax** [**no**] **cspf** [*use-te-metric*]

**Context** config>router>mpls>lsp

**Description** This command enables Constrained Shortest Path First (CSPF) computation for constrained-path LSPs. Constrained-path LSPs are the ones that take configuration constraints into account. CSPF is also used to calculate the detour routes when fast-reroute is enabled.

Explicitly configured LSPs where each hop from ingress to egress is specified do not use CSPF. The LSP will be set up using RSVP signaling from ingress to egress.

If an LSP is configured with **fast-reroute** *frr-method* specified but does not enable CSPF, then neither global revertive nor local revertive will be available for the LSP to recover.

**Default** no cspf

**Parameters** *use-te-metric* — Specifies to use the use of the TE metric for the purpose of the LSP path computation by CSPF.

## exclude

**Syntax** [**no**] **exclude** *group-name* [*group-name*...(up to 5 max)]

**Context** config>router>mpls>lsp

**Description** This command specifies the admin groups to be excluded when an LSP is set up in the primary or secondary contexts. Each single operation of the exclude command allows a maximum of 5 groups to be specified at a time. However, a maximum of 32 groups can be specified per LSP through multiple operations. The admin groups are defined in the **config>router>mpls>admin-group** context.

Use the **no** form of the command to remove the exclude command.

**Default** no exclude

**Parameters** *group-name* — Specify the existing group-name to be excluded when an LSP is set up.

## fast-reroute

**Syntax** **fast-reroute** *frr-method*
**no fast-reroute**

**Context** config>router>mpls>lsp

**Description** This command creates a pre-computed detour LSP from each node in the path of the LSP. In case of failure of a link or LSP between two nodes, traffic is immediately rerouted on the pre-computed detour LSP, thus avoiding packet-loss.

When **fast-reroute** is enabled, each node along the path of the LSP tries to establish a detour LSP as follows:

- Each upstream node sets up a detour LSP that avoids only the immediate downstream node, and merges back on to the actual path of the LSP as soon as possible.

  If it is not possible to set up a detour LSP that avoids the immediate downstream node, a detour can be set up to the downstream node on a different interface.
- The detour LSP may take one or more hops (see **hop-limit**) before merging back on to 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.

Fast reroute 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 to set up their detours. TE must be enabled for fast-reroute to work.

If an LSP is configured with **fast-reroute** *frr-method* specified but does not enable CSPF, then neither global revertive nor local revertive will be available for the LSP to recover.

The **no** form of the **fast-reroute** command removes the detour 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.

The **no** form of **fast-reroute hop-limit** command reverts to the default value.

**Default** **no fast-reroute** — When fast-reroute is specified, the default fast-reroute method is one-to-one.

**Parameters**

**Values** **one-to-one** — In the one-to-one technique, a label switched path is established which intersects the original LSP somewhere downstream of the point of link or node failure.  For each LSP which is backed up, a separate backup LSP is established.

## bandwidth

**Syntax** **bandwidth** *rate-in-mbps*
**no bandwidth**

**Context** config>router>mpls>lsp>fast-reroute

**Description** This command is used to request reserved bandwidth on the detour path. When configuring an LSP, specify the traffic rate associated with the LSP.

When configuring fast reroute, allocate bandwidth for the rerouted path. The bandwidth rate does not need to be the same as the bandwidth allocated for the LSP.

**Default** no bandwidth — Bandwidth is not reserved for a rerouted path.

**Parameters** *rate-in-mbps* — Specifies the amount of bandwidth in Mbps to be reserved for the LSP path.

## hop-limit

**Syntax** **hop-limit** *limit*
**no hop-limit**

**Context** config>router>mpls>lsp>fast-reroute

**Description** For fast reroute, how many more routers a detour is allowed to traverse compared to the LSP itself. For example, if an LSP traverses four routers, any detour for the LSP can be no more than ten router hops, including the ingress and egress routers.

**Default** 16

**Parameters** *limit* — Specify the maximum number of hops.

**Values** 0 — 255

## node-protect

**Syntax** [**no**] **node-protect**

**Context** config>router>mpls>lsp>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.

**Default** node-protect

## from

**Syntax** **from** *ip-address*

**Context** config>router>mpls>lsp

**Description** This optional 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.

If an interface IP address is specified as the **from** address, and the egress interface of the nexthop 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** The system IP address

**Parameters** *ip-address* — This is 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.

**Default** System IP address

**Values** System IP or network interface IP addresses

## hop-limit

**Syntax** **hop-limit** *number*
**no hop-limit**

**Context** config>router>mpls>lsp
config>router>mpls>lsp>fast-reroute

**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. Software 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 hops of the established LSP, then the LSP is not affected.

The **no** form of this command returns the parameter to the default value.

**Default** **255**

**Parameters** *number* — The number of hops the LSP can traverse, expressed as an integer.

**Values** 2 — 255

## 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

**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, 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.

## ldp-over-rsvp

**Syntax** **[no] ldp-over-rsvp** *[include* **|** *exclude]*

**Context** config>router>mpls>lsp

**Description** This command specifies if this LSP will be included in LDP over RSVP.The no form of the command reverts to default operation.

**Default** no ldp-over-rsvp

**Parameters** *include* — Specifies that this LSP will be included in LDP over RSVP.

*exclude* — Specifies that this LSP will be excluded from LDP over RSVP.

## metric

**Syntax** **metric** *metric*

**Context** config>router>mpls>lsp

**Description** This command specifies the metric for this LSP which is used to select an LSP among a set of LSPs which are destined to the same egress router. The LSP with the lowest metric will be selected.

In LDP-over-RSVP, LDP performs a lookup in the Routing Table Manager (RTM) which provides the next hop to the destination PE and the advertising router (ABR or destination PE itself). If the advertising router matches the targeted LDP peer, LDP then performs a second lookup for the advertising router in the Tunnel Table Manager (TTM). This lookup returns the best RSVP LSP to use to forward packets for an LDP FEC learned through the targeted LDP session. The lookup returns the LSP with the lowest metric. If multiple LSPs have the same metric, then the result of the lookup is to select the first one available in the TTM.

Default 1

**Parameters** *metric* — Specifies the metric for this LSP which is used to select an LSP among a set of LSPs which are destined to the same egress router.

**Values** 1 — 65535

## to

**Syntax** **to** *ip-address*

**Context** config>router>mpls>lsp

**Description** This command specifies the system 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.

**Default** No default

**Parameters** *ip-address* — The system IP address of the egress router.

## vprn-auto-bind

**Syntax** **vprn-auto-bind** [**include** | **exclude**]

**Context** config>router>mpls>lsp

**Description** This command determines whether the associated names LSP can be used or no as part of the auto-bind feature for VPRN services. By default a names LSP is available for inclusion to used for the auto-bind feature.

By configuring the command vprn-auto-bind exclude, the associated LSP will not be used by the auto-bind feature within VPRN services.

The **no** form of the command resets the flag backto the default value.

**Default** include

**Parameters** **include —** Allows an associated LSPto be used by auto-bin for vprn services

**exclude —** Disables the use of the associated LSP to be used with the auto-bind feature for VPRN services.

## retry-limit

**Syntax** **retry-limit** *number*
**no retry-limit**

**Context** config>router>mpls>lsp

**Description** This optional command specifies the number of attempts software should make to re-establish the LSP after it has failed LSP. 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 revert the parameter to the default value.

**Default** 0 (no limit, retries forever)

**Parameters** *number* — The number of times 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 — 10000

## retry-timer

**Syntax** **retry-timer** *seconds*
**no retry-timer**

**Context** config>router>mpls>lsp

**Description** This command configures the time, in seconds, for LSP re-establishment attempts after it has failed.

The **no** form of this command reverts to the default value.

**Default** **30**

**Parameters** *seconds* — The amount of time, in seconds, between attempts to re-establish the LSP after it has failed. Allowed values are integers in the range of 1 to 600.

**Values** 1 — 600

## rsvp-resv-style

**Syntax** **rsvp-resv-style** [*se* | *ff*]

**Context** config>router>mpls>lsp

**Description** This command specifies the RSVP 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

**Description** This command disables the existing LSP including the primary and any standby secondary paths.

To shutdown only the primary enter the **config router mpls lsp** *lsp-name* **primary** *path-name* **shutdown** command.

To shutdown a specific standby secondary enter the **config router mpls lsp** *lsp-name* **secondary** *path-name* **shutdown** command. The existing configuration of the LSP is preserved.

Use the **no** form of this command to restart the LSP. LSPs are created in a shutdown state. Use this command to administratively bring up the LSP.

**Default** **shutdown**

# Primary and Secondary Path Commands

## primary

**Syntax** **primary** *path-name*
**no primary**

**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** *path-name* command, override the LSP attributes.

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 shutdown 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** none

**Parameters** *path-name* — 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 switch over from the primary to the secondary, the 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 eight secondary paths can be specified. All the secondary paths are considered equal and the first available path is used. The software will not switch back among secondary paths.

Software starts the signaling of 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 shutdown 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** none

**Parameters** *path-name* — 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 functionality for an LSP or a primary or secondary LSP path. When enabled for the LSP, make-before-break will be performed for primary path and all the secondary paths of the LSP.

**Default** adaptive

## working-tp-path

**Syntax** [**no**] **working-tp-path**

**Context** config>router>mpls>lsp

**Description** This command creates or edits the working path for an MPLS-TP LSP. At least one working path (but not more than one working path) must be created for an MPLS-TP LSP. If MPLS-TP linear protection is also configured, then this is the path that is used as the default working path for the LSP, and it must be created prior to the protect path. The working-tp-path can only be deleted if no protect-tp-path exists for the LSP.

The following commands are applicable to the working-tp-path: **lsp-num, in-label, out-label, mep, shutdown**.

**Default** no working-tp-path

## protect-tp-path

**Syntax** [**no**] **protect-tp-path**

**Context** config>router>mpls>lsp

**Description** This command creates or edits the protect path for an MPLS-TP LSP. At least one working path must exist before a protect path can be created for an MPLS-TP LSP. If MPLS-TP linear protection is also configured, then this is the path that is used as the default protect path for the LSP. The protect path must be deleted before the wokring path. Only one protect path can be created for each MPLS-TP LSP.

The following commands are applicable to the working-tp-path: **lsp-num, in-label, out-label, mep, and shutdown**.

## lsp-num

**Syntax** **lsp-num** *lsp-num*
**no lsp-num**

**Context** config>mpls>lsp>working-tp-path
config>mpls>lsp>protect-tp-path

**Description** This command configures the MPLS-TP LSP Number for the working TP path or the Protect TP Path.

**Default** no lsp-num

**Parameters** *lsp-num* — Specifies the LSP number.

**Values** 1 — 65535

**Default** 1 for a working path, 2 for a protect path

## in-label

**Syntax** **in-label** *in-label*
**no in-label**

**Context** config>mpls>lsp>working-tp-path
config>mpls>lsp>protect-tp-path

**Description** This command configures the incoming label for the reverse path or the working path or the protect path of an MPLS-TP LSP. MPLS-TP LSPs are bidirectional, and so an incoming label value must be specified for each path.

**Default** no in-label

**Parameters** *in-label* — Specifies the in label.

**Values** 32 — 16415

## out-label

**Syntax** **out-label** *out-label* **out-link** *if-name* [**next-hop** *ip-address*]
**no out-label**

**Context** config>mpls>lsp>working-tp-path
config>mpls>lsp>protect-tp-path

**Description** This command configureds the outgoing label value to use for an MPLS-TP working or protect path. The out-link is the outgoing interface on the node that this path will use, and must be specified. If the out-link refers to a numbered IP interface, the user may optionally configure the **next-hop** parameter and the system will determine the interface to use to reach the configured next-hop, but will check that the user-entered value for the *out-link* corresponds to the link returned by the system. If they do not correspond, then the path will not come up.

**Default** no out-label

**Parameters** *out-label* — Specifies the out label.

**Values** 32 — 16415

*if-name* — Specifies the interface name.

*ip-address* — Specifies the IPv4 address in a.b.c.d

## mep

**Syntax** [**no**] **mep**

**Context** config>mpls>lsp>working-tp-path
config>mpls>lsp>protect-tp-path

**Description** This command creates or edits an MPLS-TP maintenance entity group (MEG) endpoint (MEP) on and MPLS-TP path. MEPs reporesent the termination point for OAM flowing on the path, as well as linear protection for the LSP. Only one MEP can be configured at each end of the path.

The following commands are applicable to a MEP on an MPLS-TP working or protect path: oam-template, bfd-enable, and shutdown. In addition, a protection-template may be configured on a protect path.

The **no** form of the command removes a MEP from an MPLS-TP path.

## oam-template

**Syntax** **oam-template** *name*
**no oam-template**

**Context** config>mpls>lsp>working-tp-path
config>mpls>lsp>protect-tp-path

**Description** This command applies a OAM template to an MPLS-TP working or protect path. It contains configuration paraeters for proactive OAM mechanisms that can be enabled on the path e.g. BFD. Configuration of an OAM template is optional.

The **no** form of the command removes the OAM template from the path.

**Default** no oam-template

**Parameters** *name* — Speciifes a text string name for the template up to 32 characters in printable 7-bit ASCII, enclosed in double quotes.

## shutdown

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

**Context** config>mpls>lsp>working-tp-path>mep
config>mpls>lsp>protect-tp-path>mep
config>mpls>lsp>working-tp-path
config>mpls>lsp>protect-tp-path

**Description** This command disables the existing LSP including the primary and any standby secondary paths.

To shutdown only the primary enter the config router mpls lsp lsp-name primary path-name shutdown command.

To shutdown a specific standby secondary enter the config router mpls lsp lsp-name secondary path-name shutdown command. The existing configuration of the LSP is preserved.

Use the no form of this command to restart the LSP. LSPs are created in a shutdown state. Use this command to administratively bring up the LSP.

**Default** shutdown

## bfd-enable

**Syntax** **bfd-enable** [**bfd-mode**]
**no bfd-enable**

**Context** config>mpls>lsp>working-tp-path
config>mpls>lsp>protect-tp-path

**Description** The command associates the operational state of an MPLS-TP path with a BFD session whose control packets flow on the path. The BFD packets are encapsulated in a generic associated channel (G-ACh) on the path. The timer parameters of the BFD session are taken from the the OAM template of the MEP.

A value of cc means that the BFD session is only used for continuity check of the the MPLS-TP path. In this case, the cc timer parameters of the OAM template apply. A value of cv means that the BFD session is used for both continuity checking and connectivity verification, and the cv timers of the OAM template apply.

This form of the bfd-enable command is only applicable when it is configured under a MEP used on an MPLS-TP working or protect path.

**Default** no bfd-enable

**Parameters** **cc | cc_cv —** cc indicates that BFD runs in CC only mode. This mode uses GACh channel type 0x07. cc_cv indicates that BFD runs in combined CC and CV mode. This mode uses channel type 0x22 for MPLS-TP CC packets, and 0x23 for MPLS-TP CV packets.

## protection-template

**Syntax** **protection-template** *name*
**no protection-template**

**Context** config>mpls>lsp>protect-tp-path

**Description** This command applies a protection template name to an MPLS-TP LSP that the protect path is configured under. If the template is applied, then MPLS-TP 1:1 linear protection is enabled on the LSP, using the parameters specified in the named template.

A named protection template can only be applied to the protect path context of an MPLS-TP LSP.

The no form of the command removes the template and thus disables mpls-tp linear protection on the LSP.

**Default** no protection-template

**Parameters** *name* — Specifies at text string for the template up to 32 characters in printable 7-bit ASCII, enclosed in double quotes.

## 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* — The amount of bandwidth reserved for the LSP path in Mbps. Allowed values are integers in the range of 1 to 100000.

**Values** 0 — 100000

## exclude

**Syntax** [**no**] **exclude** *group-name* [*group-name*...(up to 5 max)]

**Context** config>router>mpls>lsp>primary
config>router>mpls>lsp>secondary

**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**>**mpls**>**admin-group** 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.

## 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 hops of the established LSP, 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 or more than the current hops of the established LSP then the LSP will be unaffected.

The **no** form of this command reverts the values defined under the LSP definition using the **config router mpls lsp** *lsp-name* **hop-limit** command.

**Default** **no hop-limit**

**Parameters** *number* — The number of hops the LSP can traverse, expressed as an integer.

**Values** 2 — 255

## path-preference

**Syntax** [**no**] **path-preference value**

**Context** config>router>mpls>lsp>secondary

**Description** This command enables use of path preference among configured standby secondary paths per LSP. If all standby secondary paths have a default path-preference value then a non-standby secondary path remains an active path, while a standby secondary is available. A standby secondary path configured with highest priority (lowest path-preference value) must be made the active path when the primary is not in use. Path preference can be configured on standby secondary path.

The no form of this command resets the path-preference to the default value.

**Default** **255**

**Parameters** *value* — Specifies an alternate path for the LSP if the primary path is not available.

**Values** 1–255

## 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 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. This requires that the primary LSP already be established and is up since the head-end LER needs the most current ERO computed by CSPF for the primary path. CSPF would return the list of SRLG groups along with the ERO during primary path CSPF computation. At a subsequent establishment of a secondary path with the SRLG constraint, the MPLS/RSVP task will query again CSPF providing the list of SLRG group numbers to be avoided. CSPF prunes all links with interfaces which belong to the same SRLGs as the interfaces included in the ERO of the primary path. If CSPF finds a path, the secondary is setup. If not, MPLS/RSVP will keep retrying the requests to CSPF.

If CSPF is not enabled on the LSP name, then a secondary path of that LSP which has the SRLG constraint included will be shut down and a specific failure code will indicate the exact reason for the failure in **show>router>mpls>lsp>path>detail** output.

At initial primary LSP path establishment, if primary does not come up or primary is not configured, SRLG secondary will not be signaled and will put to down state. A specific failure code will indicate the exact reason for the failure in **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 task will signal it and the LSP use it.

As soon as the primary path is configured and successfully established, MPLS/RSVP moves the LSP to the primary and signals all SRLG secondary paths.

Any time the primary path is re-optimized, has undergone MBB, or has come back up after being down, MPLS/RSVP task checks with CSPF if the SRLG secondary should be re-signaled. If MPLS/RSVP finds that current secondary path is no longer SRLG disjoint, for example, it became ineligible, it puts it on a delayed MBB immediately after the expiry of the retry timer. If MBB fails at the first try, the secondary path is torn down and the path is put on retry.

At the next opportunity the primary goes down, the LSP will use the path of an eligible SRLG secondary if it is UP. If all secondary eligible SLRG paths are Down, MPLS/RSVP will use a non SRLG secondary if configured and UP. If while the LSP is using a non SRLG secondary, an eligible SRLG secondary came back up, MPLS/RSVP will not switch the path of the LSP to it. As soon as primary is re-signaled and comes up with a new SLRG list, MPLS/RSVP will re-signal the secondary using the new SRLG list.

A secondary path which becomes ineligible as a result of an update to the SRLG membership list of the primary path will have the ineligibility status removed on any of the following events:

1. A successful MBB of the standby SRLG path which makes it eligible again.
2. The standby path goes down. MPLS/RSVP puts the standby on retry at the expiry of the retry timer. If successful, it becomes eligible. If not successful after the retry-timer expired or the number of retries reached the number configured under the retry-limit parameter, it is left down.
3. The primary path goes down. In this case, the ineligible secondary path is immediately torn down and will only be re-signaled when the primary comes back up with a new SRLG list.

Once primary path of the LSP is setup and is operationally up, any subsequent changes to the SRLG group membership of an interface the primary path is using would not be considered until the next opportunity the primary path is re-signaled. The primary path may be re-signaled due to a failure or to a make-before-break operation. Make-before-break occurs as a result of a global revertive operation, a timer based or manual re-optimization of the LSP path, or an operator change to any of the path constraints.

One an SRLG secondary path is setup and is operationally UP, any subsequent changes to the SRLG group membership of an interface the secondary path is using would not be considered until the next opportunity secondary path is re-signaled. The secondary path is re-signaled due to a failure, to a re-signaling of the primary path, or to a make before break operation. Make-before break occurs as a result of a timer based or manual re-optimization of the secondary path, or an operator change to any of the path constraints of the secondary path, including enabling or disabling the SRLG constraint itself.

Also, the user-configured include/exclude admin group statements for this secondary path are also checked together 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 once the primary path LSP fails. The **standby** keyword ensures that the secondary path LSP is signaled and maintained indefinitely in a hot-standby state. When the primary path is re-established then the traffic is switched back to the primary path LSP.

The **no** form of this command specifies that the secondary LSP is signaled when the primary path LSP fails.

**Default** none

# LSP Path Commands

## 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 or the system IP address. If the system IP address is specified then 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 shutdown 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** none

**Parameters** *hop-index* — The hop index is used to order the hops specified. The LSP always traverses from the lowest hop index to the highest. The hop index does not need to be sequential.

**Values** 1 — 1024

*ip-address* — 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 then 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.

**loose —** This keyword specifies that the route taken by the LSP from the previous hop to this hop can traverse through other routers. Multiple hop entries with the same IP address are flagged as errors. Either the **loose** *or* **strict** keyword must be specified.

**strict —** This keyword 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 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.

## 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 IGP (best effort) calculated shortest path to the egress router. Paths are created in a **shutdown** state. A path must be shutdown before making any changes (adding or deleting hops) to the path. When a path is shutdown, 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 **shutdown** 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.

**Parameters** *path-name* — Specify a unique case-sensitive alphanumeric name label for the LSP path up to 32 characters in length.

## shutdown

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

**Context** config>router>mpls>path

**Description** 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 administratively enables the path. All LSPs, where this path is defined as primary or defined as standby secondary, are (re)established.

**Default** **shutdown**

# Static LSP Commands

## static-lsp

**Syntax** [**no**] **static-lsp** *lsp-name*

**Context** config>router>mpls

**Description** This command is used to configure a static LSP on the ingress router. The static LSP is a manually set up LSP where the nexthop 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 shutdown first in order to delete it. If the LSP is not shut down, the **no static-lsp** *lsp-name* command does nothing except generate a warning message on the console indicating that the LSP is administratively up.

**Parameters** *lsp-name* — Name that identifies the LSP.

**Values** Up to 32 alphanumeric characters.

## 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 on 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 use of the implicit label value for the push operation.

*label* — The label to push on the label stack. Label values 16 through 1,048,575 are defined as follows:

Label values 16 through 31 are 7210 SAS M reserved.
Label values 32 through 1,023 are available for static assignment.
Label values 1,024 through 2,047 are reserved for future use.
Label values 2,048 through 18,431 are statically assigned for services.
Label values 28,672 through 131,071 are dynamically assigned for both MPLS and services.
Label values 131,072 through 1,048,575 are reserved for future use.

**Values** 16 — 1048575

**nexthop** *ip-address* **—** This command 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 ARP entry does not exist, software sets the operational status of the static LSP to down and continues to ARP for the configured nexthop. Software continuously tries to ARP for the configured nexthop at a fixed interval.

## shutdown

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

**Context** config>router>mpls>static-lsp

**Description** This command is used to administratively disable the static LSP.

The **no** form of this command administratively enables the static LSP.

**Default** **shutdown**

## 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. When creating an LSP this command is required. For LSPs that are used as transport tunnels for services, the **to** IP address ***must*** be the system IP address.

**Parameters** *ip-address* — The system IP address of the egress router.

**Default** none

# RSVP Configuration Commands

# Generic Commands

## shutdown

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

**Context** config>router>rsvp
config>router>rsvp>interface

**Description** This command disables the RSVP protocol instance or the RSVP-related functions for the interface. The RSVP configuration information associated with this interface is retained. When RSVP is administratively disabled, all the RSVP sessions are torn down. The existing configuration is retained.

The **no** form of this command administratively enables RSVP on the interface.

**Default** **shutdown**

# RSVP Commands

## rsvp

**Syntax** [**no**] **rsvp**

**Context** config>router

**Description** This command enables the context to configure RSVP protocol parameters. RSVP is not enabled by default and must be explicitely enabled (**no shutdown**).

RSVP is used to set up LSPs. RSVP should be enabled on all router interfaces that participate in signaled LSPs.

The **no** form of this command deletes this RSVP protocol instance and removes all configuration parameters for this RSVP instance. To suspend the execution and maintain the existing configuration, use the **shutdown** command. RSVP must be shutdown before the RSVP instance can be deleted. If RSVP is not shutdown, the **no rsvp** command does nothing except issue a warning message on the console indicating that RSVP is still administratively enabled.

**Default** no shutdown

The Russian Doll Model (RDM) LSP admission control policy allows bandwidth sharing across Class Types. It provides a hierarchical model by which the reserved bandwidth of a CT is the sum of the reserved bandwidths of the numerically equal and higher CTs.

The RDM model is defined using the following equations:

SUM (Reserved (CTc)) <= BCb,

where the SUM is across all values of c in the range b <= c <= (MaxCT - 1), and BCb is the bandwidth constraint of CTb.

BC0= Max-Reservable-Bandwidth, so that

SUM (Reserved(CTc)) <= Max-Reservable-Bandwidth,

where the SUM is across all values of c in the range 0 <= c <= (MaxCT - 1).

## 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 or all RSVP interfaces on the node if applied at the RSVP level. These are referred to as maintenance interface and maintenance node, respectively.

To initiate a graceful shutdown the maintenance node generates a PathErr message with a specific error sub-code of Local Maintenance on TE Link required for each LSP that is exiting the maintenance interface.

The node performs a single make-before-break attempt for all adaptive CSPF LSPs it originates and LSP paths using the maintenance interfaces. If an alternative path for an affected LSP is not found, then the LSP is maintained on its current path. The maintenance node also tears down and re-signals any detour LSP path using listed maintenance interfaces as soon as they are not active.

The maintenance node floods an IGP TE LSA/LSP containing Link TLV for the links under graceful shutdown with Traffic Engineering metric set to 0xffffffff and Unreserved Bandwidth parameter set to zero (0).

A head-end LER node, upon receipt of the PathErr message performs a single make-before-break attempt on the affected adaptive CSPF LSP. If an alternative path is not found, then 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:

a. 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 which can be found.

b. An adaptive CSPF LSP whose path has explicit hops defined using the listed maintenance interface(s)/node(s).

c. A CSPF LSP with the adaptive option disabled and which current path is over the listed maintenance interfaces in the PathErr message. These are not subject to make-before-break.

d. A non CSPF LSP which current path is over the listed maintenance interfaces in the PathErr message.

The head-end LER node upon receipt of the updates IPG TE LSA/LSP for the maintenance interfaces updates the TE database. This information will be used at the next scheduled CSPF computation for any LSP which path may 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** none

## keep-multiplier

**Syntax** [**no**] **keep-multiplier** *number*
**no keep-multiplier**

**Context** config>router>rsvp

**Description** The **keep-multiplier** *number* is an integer used by RSVP to declare that a reservation is down or the neighbor is down.

The **no** form of this command reverts to the default value.

**Default** 3

**Parameters** *number* — The **keep-multiplier** value.

**Values** 1 — 255

## 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 7210 SAS PLR node or terminating on this 7210 SAS 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 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 messages pertaining to LSP paths tunneled over the bypass. It will also not send Message-ID in RSVP messages. This effectively disables summary refresh.

**Default** disable

## rapid-retransmit-time

**Syntax** **rapid-retransmit-time** *hundred-milliseconds*
**no rapid-retransmit-time**

**Context** config>router>rsvp

**Description** This command defines the value of the Rapid Retransmission Interval. It is used in the re-transmission mechanism to handle unacknowledged message_id objects and is based on an exponential back-off timer.

Re-transmission interval of a RSVP message with the same message_id = 2 * rapid-retransmit-time interval of time.

The node stops re-transmission of unacknowledged RSVP messages:

- If the updated back-off interval exceeds the value of the regular refresh interval.
- If the number of re-transmissions reaches the value of the **rapid-retry-limit** parameter, which-ever 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

**Parameters** *hundred-milliseconds* — Specifies the rapid retransmission interval.

**Values** 1 – 100, in units of 100 msec.

## rapid-retry-limit

**Syntax** **rapid-retry-limit** *limit*
**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 message with the same message_id is retransmitted every 2 * rapid-retransmit-time interval of time. The node will stop retransmission of unacknowledged RSVP 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** *limit* — Specifies the value of the Rapid Retry Limit.

**Values** 1 – 6, integer values

## refresh-time

**Syntax** **refresh-time** *seconds*
**no refresh-time**

**Context** config>router>rsvp

**Description** The **refresh-time** controls the interval, in seconds, between the successive Path and Resv refresh messages. RSVP 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 seconds

**Parameters** *seconds* — The refresh time in seconds.

**Values** 1 — 65535

# Interface Commands

## interface

**Syntax** [**no**] **interface** *ip-int-name*

**Context** config>router>rsvp

**Description** This command enables RSVP protocol support on an IP interface. No RSVP commands are executed on an IP interface where RSVP is not enabled.

The **no** form of this command deletes all RSVP commands such as **hello-interval** and **subscription**, which are defined for the interface. The RSVP interface must be **shutdown** 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.

**Default** **shutdown**

**Parameters** *ip-int-name* — The name 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.

**Values** 1 — 32 alphanumeric characters.

## authentication-key

**Syntax** **authentication-key** [*authentication-key* **|** *hash-key*] [**hash | hash2**]
**no authentication-key**

**Context** config>router>rsvp>interface

**Description** his command specifies the authentication key to be used between RSVP neighbors to authenticate RSVP messages. Authentication uses the MD-5 message-based digest.

When enabled on an RSVP interface, authentication of RSVP messages operates in both directions of the interface.

A 7210 SAS M 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.
- Key used with the authentication algorithm.
- Lifetime of the key. The user-entered key is valid until the user deletes it from the interface.
- Source Address of the sending system.
- Latest sending sequence number used with this key identifier.

A 7210 SAS M 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 which also contains a flags field, a key identifier field, and a sequence number field.

The RSVP sender complies to the procedures for RSVP message generation in RFC 2747, *RSVP Cryptographic Authentication*.

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

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

The **no** form of this command disables authentication.

**Default** **no authentication-key** - The authentication key value is the null string.

**Parameters** *authentication-key* — 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* — 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** parameter 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** parameter 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 bi-directional forwarding (BFD) to control the state of the associated RSVP interface. This causes RSVP 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> interface>bfd** context.

Note that it is possible that the BFD session on the interface was started because of a prior registration with another protocol, for example, OSPF or IS-IS.

The registration of an RSVP interface with BFD is performed at the time of neighbor gets its first session. This means when this node sends or receives a new Path message over the interface. If however the session did not come up, due to not receiving a Resv for a new path message sent after the maximum number of re-tries, the LSP is shutdown and the node de-registers with BFD. In general, the registration of RSVP with BFD is removed as soon as the last RSVP session is cleared.

The registration of an RSVP interface with BFD is performed independent of whether RSVP hello is enabled on the interface or not. However, hello timeout will clear all sessions towards the neighbor and RSVP de-registers with BFD at clearing of the last session.

Note that an RSVP session is associated with a neighbor based on the interface address the path message is sent to. If multiple interfaces exist to the same node, then each interface is treated as a separate RSVP neighbor. The user will have to enable BFD on each interface and RSVP will register with the BFD session running with each of those neighbors independently

Similarly the disabling of BFD on the interface results in removing registration of the interface with BFD.

When a BFD session transitions to DOWN state, the following actions are triggered. For RSVP signaled LSPs, this triggers activation of FRR bypass/detour backup (PLR role), global revertive (head-end role), and switchover to secondary if any (head-end role) for affected LSPs with FRR enabled. It triggers switchover to secondary if any and scheduling of re-tries 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 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 hello messages.

RSVP hello packets are used to detect loss of RSVP connectivity with the neighboring node. Hello packets detect the loss of neighbor far quicker than it would take for the RSVP session to time out based on the refresh interval. After the loss of the of number keep-multiplier 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** milliseconds

**Parameters** *milli-seconds* — Specifies the RSVP hello interval in milliseconds, in multiples of 1000. A 0 (zero) value disables the sending of RSVP hello messages.

**Values** 0 — 60000 milliseconds (in multiples of 1000)

## implicit-null-label

**Syntax** **implicit-null-label** [**enable** | **disable**]
**no implicit-null-label**

**Context** config>router>rsvp

**Description** This command enables the use of the implicit null label for all LSPs.

All LSPs for which this node is the egress LER and for which the path message is received from the previous hop node over this RSVP interface will signal the implicit null label. This means that if the egress LER is also the merge-point (MP) node, then the incoming interface for the path refresh message over the bypass dictates if the packet will use the implicit null label or not. The same for a 1-to-1 detour LSP.

The user must shutdown the RSVP interface before being able to change the implicit null configuration option.

The **no** form of this command returns the RSVP interface to use the RSVP level configuration value.

**Default** disable

**Parameters** **enable —** This parameter enables the implicit null label.

**disable —** This parameter disables the implicit null label.

## refresh-reduction

**Syntax** [**no**] **refresh-reduction**

**Context** config>router>rsvp>interface

**Description** This command enables the use of the RSVP overhead refresh reduction capabilities on this RSVP interface.

The 7210 SAS node accepts bundle RSVP messages from its peer over the interface, performs reliable RSVP message delivery to its peer, and utilizes summary refresh messages to refresh the path and resv states. Reliable message delivery must be explicitly enabled by the user after refresh reduction is enabled.

The other two capabilities are immediately enabled.

A bundle message reduces the overall message handling load, it consists of a bundle header followed by one or more bundle sub-messages. A bundle sub-message is any RSVP message other than a bundle message. A 7210 node only processes the bundled RSVP messages received and does not generate them.

When reliable message delivery is supported by both the node and its peer over the RSVP interface, a RSVP message is sent with a message_id object. A message_id object can be added to any RSVP message or it can be a sub-message of a bundled message.

If a node sets the ack_desired flag in the message_id object , the receiver acknowledges the receipt of the RSVP message by piggy-backing a message_ack object in the next RSVP message it sends to the node. Alternatively, an ACK message can also be used to send the message_ack object. In both cases, more than one message_ack object can be included in the same message.

The 7210 supports only the use of ACK messages to send message_ack object , but it can also process the received message_ack objects piggy-backed to hop-by-hop RSVP messages, such as path and resv.

The 7210 sets the ack_desired flag only in non-refresh RSVP messages and in refresh messages which contain new state information.

A retransmission mechanism based on an exponential backoff timer is supported to handle un-acknowledged message_id objects. A RSVP message with the same message_id is re-transmitted at an interval of 2 * rapid-retransmit-time. The rapid-retransmit-time is referred to as the rapid retransmission interval and it should be lesser than the regular refresh interval configured in the config>router>rsvp>refresh-time context.

Rapid retry limit indicates the maximum number of retransmissions allowed for unacknowledged RSVP messages. The node stops the retransmission of unacknowledged RSVP messages when:

- The updated backoff interval exceeds the regular refresh interval.
- The number of retransmissions reaches the value of the **rapid-retry-limit** parameter, whichever comes first.

These two parameters can be configured on a system in the **config>router>rsvp** context.

Refresh summary consists of sending a summary refresh messages containing message_id list objects.

The fields of the message_id list object are populated with the values from the message_identifier field in the message_id object of a previously sent individual path or resv message. The summary refresh message is sent per refresh regular interval. The interval is 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. If any message_identifier field does not match,the node sends a message_id_nack object to the originator of the message.

The above capabilities are collectively referred to as “Refresh Overhead Reduction Extensions”. When refresh-reduction is enabled on an RSVP interface, the node sets a “refresh-reduction-capable” bit in the flag field of the common RSVP header. If both peers on a RSVP interface set the “refresh-reduction-capable” bit, all the refresh overhead reduction extensions can be implemented. The node monitors the bit in all the RSVP messages received from the peer. The router stops sending summary refresh messages once the bit is cleared ,the node does not send summary refresh messages if the bit is not set by the peer.

A node (with refresh reduction, reliable message delivery enabled) attempts to perform reliable message delivery even if the “refresh-reduction-capable” bit is not set by the peer. If the peer does not support the message_id object, it returns an error message “unknown object class”.The node re-transmits the RSVP message without the message_id object and adopts the same message handling method for all future messages sent to the 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>interface>refresh-reduction

**Description** This command enables reliable delivery of RSVP messages over the RSVP interface. When refresh-reduction is enabled on an interface and reliable-delivery is disabled, then the router will send a message_id and not set ACK desired in the RSVP messages over the interface. Thus 7210 SAS does not expect an ACK and 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 header, the node will enter summary refresh for a specific message_id it sent regardless if it received an ACK or not to this message from the neighbor.

Finally, when ‘reliable-delivery’ option is enabled on any interface, RSVP message pacing is disabled on all RSVP interfaces of the system, for example, the user cannot enable the msg-pacing option in the **config>router>rsvp** context, and error message is returned in CLI. Conversely, 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 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 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 reverts the *percentage* to the default value.

**Default** **100**

**Parameters** *percentage* — The percentage of the interface's bandwidth that RSVP allows to be used for reservations.

**Values** 0 — 1000

# Message Pacing Commands

## msg-pacing

**Syntax** [**no**] **msg-pacing**

**Context** config>router>rsvp

**Description** This command enables RSVP message pacing in which the specified number of RSVP messages, specified in the **max-burst** command, are sent in a configured interval, specified in the **period** command. 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 messages that are sent in the specified period under normal operating conditions.

**Default** 650

**Parameters** *number* —

**Values** 100 — 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, when the router can send the specified number of RSVP messages which is specified in the **max-burst** command.

**Default** 100

**Parameters** *milli-seconds* —

**Values** 100 — 1000 milliseconds in increments of 10 milliseconds

# Show Commands

## admin-group

**Syntax** **admin-group** *group-name*

**Context** show>router>mpls

**Description** This command displays MPLS administrative group information.

**Parameters** *group-name* — Specify a group name up to 32 characters.

**Output** **MPLS Administrative Group Output Fields —** The following table describes MPLS administrative group output fields.

| Label | Description |
|---|---|
| `Group Name` | The name of the group. The name identifies the administrative group within a virtual router instance. |
| `Group Value` | The unique group value associated with the administrative group.<br>If the value displays -1, then the group value for this entry has not been set. |
| `No. of Groups` | The total number of configured admin groups within the virtual router instance. |

### Sample Output

```
A:ALA-1# show router mpls admin-group
=================================================
MPLS Administrative Groups
=================================================
Group Name                         Group Value
-------------------------------------------------
green                              15
red                                25
yellow                             20
-------------------------------------------------
No. of Groups: 3
=================================================
A:ALA-1#
```

## 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 which serves as a backup for a set of LSPs. Such an LSP tunnel is called a bypass tunnel.

**Parameters** *ip-address* — Specify the IP address of the egress router.

*lsp-name* — Specify 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** **MPLS Bypass Tunnel Output Fields —** The following table describes MPLS bypass tunnel output fields.

| | |
|---|---|
| `To` | The system IP address of the egress router. |
| `State` | The LSP’s administrative state. |
| `Out I/F` | Specifies the name of the network IP interface. |
| `Out Label` | Specifies the incoming MPLS label on which to match. |
| `Reserved BW (Kbps)` | Specifies the amount of bandwidth in megabits per second (Mbps) reserved for the LSP. |

### Sample Output

```
*A:Dut-A>show>router>mpls# bypass-tunnel
===============================================================================
MPLS Bypass Tunnels
===============================================================================
Legend :  m - Manual      d - Dynamic
===============================================================================
To               State  Out I/F        Out Label     Reserved   Protected  Type
                                                     BW (Kbps)  LSP Count
-------------------------------------------------------------------------------
10.10.36.3       Up     lag-1:10       131066        0          2          d

10.10.23.2       Up     lag-1:10       130454        0          4          d

10.10.46.4       Up     lag-2          130592        0          4          d

10.10.36.6       Up     lag-2          130591        0          2          d
-------------------------------------------------------------------------------
Bypass Tunnels : 4
===============================================================================
*A:Dut-A>show>router>mpls#
```

## interface

**Syntax** **interface** [*ip-int-name* **|** *ip-address*] [**label-map** *label*]
**interface** [*ip-int-name* **|** *ip-address*]

**Context** show>router>mpls

**Description** This command displays MPLS interface information.

**Parameters** *ip-int-name* — The name 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.

*ip-address* — The system or network interface IP address.

**label-map** *label* — The MPLS label on which to match.

**Values** 32 — 1048575

**Output** **MPLS Interface Output Fields —** The following table describes MPLS interface output fields.

| Label | Description |
|---|---|
| `Interface` | The interface name. |
| `Port-id` | The port ID displayed in the *slot/mda/port* format. |
| `Adm` | Specifies the administrative state of the interface. |
| `Opr` | Specifies the operational state of the interface. |
| `Srlg Groups` | Specifies the shared risk link group (SRLG) name(s). |
| `Te-metric` | Specifies the traffic engineering metric used on the interface. |
| `Interfaces` | The total number of interfaces. |
| `Transmitted` | Displays the number of packets and octets transmitted from the interface. |
| `Received` | Displays the number of packets and octets received. |
| `In Label` | Specifies the ingress label. |
| `In I/F` | Specifies the ingress interface. |
| `Out Label` | Specifies the egress label. |
| `Out I/F` | Specifies the egress interface. |
| `Next Hop` | Specifies the next hop IP address for the static LSP. |
| `Type` | Specifies whether the label value is statically or dynamically assigned. |

```
A:7210SAS# show router mpls interface

===============================================================================
MPLS Interfaces
===============================================================================
Interface                           Port-id           Adm    Opr    TE-metric
-------------------------------------------------------------------------------
system                              system            Up     Up     None
  Admin Groups                      None
  Srlg Groups                       None
ip-10.10.2.3                        1/1/15            Up     Up     None
  Admin Groups                      None
  Srlg Groups                       None
ip-10.10.5.3                        1/1/1             Up     Up     None
  Admin Groups                      None
  Srlg Groups                       None
ip-10.10.11.3                       1/1/3             Up     Up     None
  Admin Groups                      None
  Srlg Groups                       None
ip-10.10.12.3                       lag-1             Up     Up     None
  Admin Groups                      None
  Srlg Groups                       None
-------------------------------------------------------------------------------
Interfaces : 5
===============================================================================
*A:7210SAS#
```

## label

**Syntax** **label** *start-label* [*end-label* **|** *in-use* **|** *label-owner*]

**Context** show>router>mpls

**Description** Displays MPLS labels exchanged.

**Parameters** *start-label* **—** The label value assigned at the ingress router.

*end-label* **—** The label value assigned for the egress router.

*in-use* **—** The number of in-use labels displayed.

**Output** **MPLS Label Output Fields —** The following table describes MPLS label output fields.

| Label | Description |
|---|---|
| `Label` | Displays the value of the label being displayed. |
| `Label Type` | Specifies whether the label value is statically or dynamically assigned. |
| `Label Owner` | The label owner. |
| `In-use labels in entire range` | The total number of labels being used by RSVP. |

**Sample Output**

```
*A:SRU4>config>router>mpls#    show router mpls label 202
=================================================================
MPLS Label 202
=================================================================
Label               Label Type          Label Owner
-----------------------------------------------------------------
```

```
202                 static-lsp          STATIC
-----------------------------------------------------------------
In-use labels in entire range                   : 5057
=================================================================
*A:SRU4>config>router>mpls#
```

## label-range

**Syntax** **label-range**

**Context** show>router>mpls

**Description** This command displays the MPLS label range.

**Output** **MPLS Label Range Output —** The following table describes the MPLS label range output fields.

| Label | Description |
|---|---|
| `Label Type` | Displays the 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 which are transitioning back to the label pool. Labels are aged 15 seconds. |
| `Total Available` | The number of label values available. |

### Sample Output

```
*A:Dut-A# show router mpls label-range
==============================================================================
Label Ranges
==============================================================================
Label Type      Start Label     End Label       Aging          Total Available
------------------------------------------------------------------------------
static-lsp      32              1023            -              992
static-svc      2048            18431           -              16384
dynamic         32768           131071          0              102400
==============================================================================
*A:Dut-A#
```

## lsp

**Syntax** **lsp** *lsp-name* [**status** {**up**|**down**}] [**from** *ip-address* **|** **to** *ip-address*] [**detail**]
**lsp** {**transit** **|** **terminate**} [**status** {**up** **|** **down**}] [**from** *ip-address* **|** **to** *ip-address* **|** **lsp-name** *name*] [**detail**]
**lsp count**
**lsp** *lsp-name* **activepath**
**lsp** *lsp-name* **path** [*path-name*] [**status** {**up** **|down**}] [**detail**]
**lsp** [*lsp-name*] **path** [*path-name*] **mbb**

**Context** show>router>mpls

**Description** This command displays LSP details.

**Parameters** **lsp** *lsp-name* — 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-address* — Displays the IP address of the egress router for the LSP.

**transit —** Displays the number of static LSPs that transit through the router.

**terminate** — Displays the number of static LSPs that terminate at the router.

**lsp** *count* — Displays the total number of LSPs.

**activepath —** Displays the present path being used to forward traffic.

**mbb —** Displays make-before-break (MBB) information.

**detail —** Displays detailed information.

**Output** **MPLS LSP Output —** The following table describes MPLS LSP output fields.

| 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. |
| `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. |
| `Oper State` | `Down` — The path is operationally down. |
|  | `Up` — The path is operationally up. |
| `LSPs` | The total number of LSPs configured. |
| `From` | The IP address of the ingress router for the LSP. |

| Label | Description (Continued) |
|---|---|
| LSP Up Time | The length of time the LSP has been operational. |
| Transitions | The number of transitions that have occurred for the LSP. |
| Retry Limit | The number of attempts that the software should make to re-establish the LSP after it has failed. |
| Signaling | Specifies the signaling style. |
| Hop Limit | The maximum number of hops that an LSP can traverse, including the ingress and egress routers. |
| Fast Reroute/ FastFail Config | enabled — Fast reroute is enabled. In the event of a failure, traffic is immediately rerouted on the pre-computed detour LSP, thus minimizing packet loss. |
| | disabled — There is no detour LSP from each node on the primary path. |
| ADSPEC | enabled — The LSP will include advertising data (ADSPEC) objects in RSVP messages. |
| | disabled — The LSP will not include advertising data (ADSPEC) objects in RSVP messages. |
| Primary | The preferred path for the LSP. |
| Secondary | The alternate path that the LSP will use if the primary path is not available. |
| Bandwidth | The amount of bandwidth in megabits per second (Mbps) reserved for the LSP path. |
| LSP Up Time | The total time in increments that the LSP path has been operational. |
| LSP Tunnel ID | The value which identifies the label switched path that is signaled for this entry. |
| To | The IP address of the egress router for the LSP. |
| LSP Down Time | The total time in increments that the LSP path has not been operational. |
| 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 Timer | The time, in seconds, for LSP re-establishment attempts after an LSP failure. |
| 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. |

| Label | Description (Continued) |
|---|---|
| | `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. |
| `Negotiated MTU` | The size of the maximum transmission unit (MTU) that is negotiated during establishment of the LSP. |
| `FR Hop Limit` | The total number of hops a detour LSP can take before merging back onto the main LSP path. |
| `LastResignalAttempt` | Displays the system up time when the last attempt to resignal this LSP was made. |
| `VprnAutoBind` | Displays the status on VPRN auto-bind feature as enabled or disabled. |

### Sample Output

```
*A:SRU4>config>router>mpls#   show router mpls lsp "to_110_20_1_1_cspf"
===============================================================================
MPLS LSPs (Originating)
===============================================================================
LSP Name                           To                  Fastfail     Adm   Opr
                                                       Config
-------------------------------------------------------------------------------
to_110_20_1_1_cspf                 110.20.1.1          No           Up    Up
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================
*A:SRU4>config>router>mpls#
```

```
*A:Dut-A# show router mpls lsp transit detail
===============================================================================
MPLS LSPs (Transit) (Detail)
===============================================================================
-------------------------------------------------------------------------------
LSP D_B_1::D_B_1
-------------------------------------------------------------------------------
From                 : 10.20.1.4             To            : 10.20.1.2
State                : Up
In Interface         : lag-1:10              In Label      : 130668
Out Interface        : lag-2                 Out Label     : 131065
Previous Hop         : 10.10.14.4            Next Hop      : 10.10.12.2
Reserved BW          : 0 Kbps
-------------------------------------------------------------------------------
*A:Dut-A#
```

```
*===============================================================================
*A:7210-SAS>show>router>mpls# lsp A detail

===============================================================================
MPLS LSPs (Originating) (Detail)
===============================================================================
-------------------------------------------------------------------------------
Type : Originating
-------------------------------------------------------------------------------
LSP Name    : A                                LSP Tunnel ID  : 1
From        : 2.2.2.2                          To             : 100.100.100.100
Adm State   : Up                               Oper State     : Down
LSP Up Time : 0d 00:00:00                      LSP Down Time  : 0d 00:05:42
Transitions : 2                                Path Changes   : 2
Retry Limit : 0                                Retry Timer    : 30 sec
Signaling   : RSVP                             Resv. Style    : SE
Hop Limit   : 255                              Negotiated MTU : 0
Adaptive    : Enabled                          ClassType      : 0
FastReroute : Disabled                         Oper FR        : Disabled
CSPF        : Disabled                         ADSPEC         : Disabled
Metric      : 0
Include Grps:                                  Exclude Grps   :
None                                           None
Type        : RegularLsp                       Least Fill     : Disabled
LdpOverRsvp : Enabled                          VprnAutoBind   : Enabled
Oper Metric : 65535

Primary     : A                                Down Time      : 0d 00:05:42
Bandwidth   : 0 Mbps
===============================================================================
*A:7210-SAS>show>router>mpls# lsp 2 detail


*A:Dut-A# show router mpls lsp A_D_15 path detail
===============================================================================
MPLS LSP A_D_15 Path  (Detail)
===============================================================================
Legend :
    @ - Detour Available              # - Detour In Use
    b - Bandwidth Protected           n - Node Protected
===============================================================================
-------------------------------------------------------------------------------
LSP A_D_15 Path A_D_15
-------------------------------------------------------------------------------
LSP Name    : A_D_15                             Path LSP ID : 19002
From        : 10.20.1.1                          To          : 10.20.1.4
Adm State   : Up                                 Oper State  : Up
Path Name   : A_D_15                             Path Type   : Primary
Path Admin  : Up                                 Path Oper   : Up
OutInterface: lag-1:10                           Out Label   : 130607
Path Up Time: 0d 00:19:18                        Path Dn Time: 0d 00:00:00
Retry Limit : 0                                  Retry Timer : 10 sec
RetryAttempt: 0                                  Next Retry *: 0 sec
Bandwidth   : 10 Mbps                            Oper Bandwi*: 10 Mbps
Hop Limit   : 255
Record Route: Record                             Record Label: Record
Oper MTU    : 9194                               Negotiated *: 9194
Adaptive    : Enabled                            MBB State   : N/A
Include Grps:                                    Exclude Grps:
None                                             None
Path Trans  : 2                                  CSPF Queries: 34
Failure Code: noError                            Failure Node: n/a
ExplicitHops:
    10.20.1.4
Actual Hops :
    10.10.14.1(10.20.1.1) @                      Record Label    : N/A
 -> 10.10.14.4(10.20.1.4)                        Record Label    : 130607
```

```
ComputedHops:
    10.10.14.1      -> 10.10.14.4

Detour Stat*: Standby                            Detour Type : Originate
Detour Avoi*: 10.10.14.4                         Detour Orig*: 10.20.1.1
Detour Acti*: n/a                                Detour Up T*: 0d 00:18:36
In Interface: n/a                                In Label    : n/a
Out Interfa*: lag-2                              Out Label   : 130975
Next Hop    : 10.10.12.2
Explicit Ho*:
    10.10.12.1      -> 10.10.12.2      -> 10.10.23.3      -> 10.10.36.6
 -> 10.10.46.4
```

## oam-template

**Syntax** **oam-template [***template-name***] [associations]**

**Context** show>router>mpls>mpls-tp

**Description** Platforms Supported: 7210 SAS-R6

This command displays MPLS-TP OAM template information.

**Sample Output**

```
*A:7210SAS>show>router>mpls>tp# oam-template

===============================================================================
MPLS-TP OAM Templates
===============================================================================
Template Name : temp1                   Router ID     : 1
BFD Template  : temp1                   Hold-Down Time: 0 centiseconds
                                        Hold-Up Time  : 0 deciseconds
-------------------------------------------------------------------------------
Template Name : temp2                   Router ID     : 1
BFD Template  : temp2                   Hold-Down Time: 0 centiseconds
                                        Hold-Up Time  : 0 deciseconds
-------------------------------------------------------------------------------
Template Name : temp3                   Router ID     : 1
BFD Template  : temp3                   Hold-Down Time: 0 centiseconds
                                        Hold-Up Time  : 0 deciseconds
===============================================================================
*A:7210SAS>show>router>mpls>tp#
```

## protection-template

**Syntax** **protection-template [***template-name***] [associations]**

**Context** show>router>mpls>mpls-tp

**Description** This command displays MPLS-TP protection template information.

### Sample Output

```
*A:7210SAS>show>router>mpls>tp# protection-template

=================================================================
==============
MPLS-TP Protection Templates
=================================================================
==============
Template Name : temp1            Router ID   :
1
Protection Mode: one2one           Direction   :
bidirectional
Revertive   : revertive         Wait-to-Restore:
1sec
Rapid-PSC-Timer: 10ms            Slow-PSC-Timer :
5sec
-----------------------------------------------------------------
--------------
Template Name : temp2            Router ID   :
1
Protection Mode: one2one           Direction   :
bidirectional
Revertive   : revertive         Wait-to-Restore:
1sec
Rapid-PSC-Timer: 10ms            Slow-PSC-Timer :
5sec
-----------------------------------------------------------------
--------------
Template Name : temp3            Router ID   :
1
Protection Mode: one2one           Direction   :
bidirectional
Revertive   : revertive         Wait-to-Restore:
1sec
Rapid-PSC-Timer: 10ms            Slow-PSC-Timer :
5sec
=================================================================
==============
*A:7210SAS>show>router>mpls>tp#
```

## status

**Syntax** **status**

**Context** show>router>mpls>mpls-tp

**Description** This command displays MPLS-TP system configuration information.

### Sample Output

```
*A:mlstp-dutA# show router mpls mpls-tp status

===============================================================================
MPLS-TP Status
===============================================================================
Admin Status  : Up
Global ID     : 42                               Node ID       : 0.0.3.233
Tunnel Id Min : 1                                Tunnel Id Max : 4096
===============================================================================
```

## transit-path

**Syntax** **transit-path** [*path-name*] [**detail**]

**Context** show>router>mpls>mpls-tp

**Description** This command displays MPLS-TP tunnel information.

**Parameters** *path-name* — Specifies the path name, up to 32 characters max.

### Sample Output

```
A:mplstp-dutC# show router mpls mpls-tp transit-path
<path-name>
 "tp-32"   "tp-33"   "tp-34"   "tp-35"   "tp-36"   "tp-37"   "tp-38"   "tp-39"
 "tp-40"   "tp-41"
detail

A:mplstp-dutC# show router mpls mpls-tp transit-path "tp-32"

===============================================================================
MPLS-TP Transit tp-32 Path Information
===============================================================================
Path Name     : tp-32
Admin State   : Up                               Oper State    : Up

------------------------------------------------------------------
Path        NextHop           InLabel   OutLabel  Out I/F
------------------------------------------------------------------
FP                            2080      2081      CtoB_1
RP                            2081      2080      CtoA_1
===============================================================================
A:mplstp-dutC# show router mpls mpls-tp transit-path "tp-32" detail

===============================================================================
MPLS-TP Transit tp-32 Path Information (Detail)
===============================================================================
Path Name     : tp-32
Admin State   : Up                               Oper State    : Up
-------------------------------------------------------------------------------
Path ID configuration
Src Global ID : 42                               Dst Global ID : 42
Src Node ID   : 0.0.3.234                        Dst Node ID   : 0.0.3.233
LSP Number    : 2                                Dst Tunnel Num: 32

Forward Path configuration
In Label      : 2080                             Out Label     : 2081
Out Interface : CtoB_1                           Next Hop Addr : n/a

Reverse Path configuration
In Label      : 2081                             Out Label     : 2080
Out Interface : CtoA_1                           Next Hop Addr : n/a
```

```
===============================================================================
A:mplstp-dutC#
```

## srlg-database

**Syntax** **srlg-database** [**router-id** *ip-address*] [**interface** *ip-address*]

**Context** show>router>mpls

**Description** This command displays MPLS SRLG database information.

**Parameters** **router-id** *ip-address* **—** Specifies a 32-bit integer uniquely identifying the router in the Autonomous System. By convention to ensure uniqueness, this may default to the value of one of the router's IPv4 host addresses, represented as a 32-bit unsigned integer, if IPv4 is configured on the router. The router-id can be either the local one or some remote router.

**interface** *ip-address* **—** Specifies the IP address of the interface.

## 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* — Keyword to display binding information.

**Output** **MPLS Path Output —** The following table describes MPLS Path output fields.

| 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 through other routers. |

| Label | Description (Continued) |
|---|---|
| LSP Name | The name of the LSP used in the path. |
| Binding | Primary — The preferred path for the LSP.<br>Secondary — The standby path for the LSP. |
| Paths | Total number of paths configured. |

**Sample Output**

```
*A:SRU4>config>router>mpls# show router mpls path
===============================================================================
MPLS Path:
===============================================================================
Path Name                        Adm  Hop Index   IP Address       Strict/Loose
-------------------------------------------------------------------------------
to_110_20_1_1                    Up   no hops     n/a              n/a

to_110_20_1_2                    Up   no hops     n/a              n/a

to_110_20_1_3                    Up   no hops     n/a              n/a

to_110_20_1_4                    Up   no hops     n/a              n/a

to_110_20_1_5                    Up   no hops     n/a              n/a

to_110_20_1_6                    Up   no hops     n/a              n/a

to_110_20_1_110                  Up   no hops     n/a              n/a

to_10_8_100_15                   Up   no hops     n/a              n/a

to_10_20_1_20                    Up   no hops     n/a              n/a

to_10_20_1_22                    Up   no hops     n/a              n/a

to_10_100_1_1                    Up   no hops     n/a              n/a
------------------------------------------------------------------------------
Paths : 11
===============================================================================
*A:SRU4>config>router>mpls#
```

## p2mp-info

**Syntax** **p2mp-info** [**type** {**originate | transit | terminate**}] [**s2l-endpoint** *ip-address*]

**Context** show>router>mpls

**Description** This command displays P2MP cross-connect information.

**Parameters** **type —** Specifies the P2MP type.

**Values** **originate** — Specifies to display the static LSPs that originate at this virtual router.
**transit** — Specifies to display the static LSPs that transit through this virtual router.
**terminate** — Specifies to display the static LSPs that terminate at this virtual router.

### Sample Output

```
*A:SetupCLI# show router mpls p2mp-info
========================================================================
MPLS P2MP Cross Connect Information
========================================================================
------------------------------------------------------------------------
S2L 3::1
------------------------------------------------------------------------
Source IP Address    : 200.0.0.61            Tunnel ID     : 4
P2MP ID              : 255                   Lsp ID        : 49152
S2L Name             : 3::1                  To            : 200.0.0.63
In Interface         : 1/1/1:1               In Label      : 131070
Num. of S2ls         : 1
------------------------------------------------------------------------
S2L 3::2
------------------------------------------------------------------------
Source IP Address    : 200.0.0.61            Tunnel ID     : 4
P2MP ID              : 255                   Lsp ID        : 49152
S2L Name             : 3::2                  To            : 200.0.0.65
Out Interface        : 2/1/1:2               Out Label     : 131071
Num. of S2ls         : 2
------------------------------------------------------------------------
S2L 3::2
------------------------------------------------------------------------
Source IP Address    : 200.0.0.61            Tunnel ID     : 4
P2MP ID              : 255                   Lsp ID        : 49152
S2L Name             : 3::2                  To            : 200.0.0.66
Out Interface        : 2/1/1:2               Out Label     : 131071
Num. of S2ls         : 2
------------------------------------------------------------------------
P2MP Cross-connect instances : 3
========================================================================
*A:SetupCLI#
```

## p2mp-lsp

**Syntax** **p2mp-lsp** [*lsp-name*] [**detail**]
**p2mp-lsp** [*lsp-name*] **p2mp-instance** [*p2mp-instance-name*] [**mbb**]
**p2mp-lsp** [*lsp-name*] **p2mp-instance** [*p2mp-instance-name*] **s2l** [*s2l-name* [**to** *s2l-to-address*]] [**status** {**up** | **down**}] [**detail**]
**p2mp-lsp** [*lsp-name*] **p2mp-instance** [*p2mp-instance-name*] **s2l** [*s2l-name* [**to** *s2l-to-address*]] **mbb**

**Context** show>router>mpls

**Description** This command displays MPLS P2MP LSP information.

**Parameters** *lsp-name* — Specifies the name of the LSP used in the path.

**p2mp-instance**[*p2mp-instance-name* **—** Specifies the administrative name for the P2MP instance which must be unique within a virtual router instance.

**mbb —** Specifies to display make-before-break (MBB) information.

**s2l —** Specifies the source-to-leaf (S2L) name.

**to** *s2l-to-address* **—**

**status —** Displays the status of the p2mp LSP.

**Values** up — Displays the total time that this S2l has been operational.
down — Displays the total time that this S2l has not been operational.

### Sample Output

```
A:ALU-25# show router mpls p2mp-lsp lsp_1
========================================================================
MPLS LSPs (Originating)
========================================================================
LSP Name                      To/P2MP ID            Fastfail     Adm   Opr
                                                      Config
------------------------------------------------------------------------
lsp_1                              18                  Yes          Up    Up
------------------------------------------------------------------------
LSPs : 1
========================================================================
A:ALU-25#

A:ALU-25# show router mpls p2mp-lsp Test_p2mp detail
========================================================================
MPLS P2MP LSPs (Originating) (Detail)
========================================================================
------------------------------------------------------------------------
Type : Originating
------------------------------------------------------------------------
LSP Name    : lsp_1                            LSP Tunnel ID  : 1
From       : 10.10.1.1                      P2MP ID       : 18
Adm State   : Up                               Oper State     : Down
LSP Up Time : 0d 00:00:00                      LSP Down Time  : 0d 20:39:48
Transitions : 0                                Path Changes   : 0
Retry Limit : 0                                Retry Timer    : 30 sec
Signaling   : RSVP                             Resv. Style    : FF
Hop Limit   : 255                              Adaptive       : Enabled
FastReroute : Disabled                         Oper FR        : Disabled
FR Method   : Facility                         FR Hop Limit   : 45
FR Bandwidth: 0 Mbps                           FR Node Protect: Disabled
FR Object   : Enabled
CSPF        : Disabled                         ADSPEC         : Disabled
Metric      : 1                                Use TE metric  : Disabled
Include Grps:                                  Exclude Grps   :
None                                           None

P2MPinstance:Test_p2mp                         p2mp-inst-type : primary

S2L Name    :Test-s2l1                         To             : 10.20.1.6
S2L Name    :Test-s2l2                         To             : 10.20.1.5
S2L Name    :Test-s2l3                         To             : 10.20.1.4
```

```
------------------------------------------------------------------------
A:ALU-25#

A:ALU-25# show router mpls p2mp-lsp Test_p2mp
========================================================================
MPLS P2MP Instance (Originating)
========================================================================
------------------------------------------------------------------------
Type : Originating
------------------------------------------------------------------------
LSP Name    : lsp_1                            LSP Tunnel ID  : 1
P2MP ID     : 18                               Path LSP ID    : 18
Adm State   : Up                               Oper State     : Down

P2MPinstance:Test_p2mp                         p2mp-inst-type : primary
Inst Name   : lsp_1                            P2MP Inst ID   : 1
Adm State   : Up                               Oper State     : Down
Inst Up Time: 0d 00:00:00                      Inst Down Time : 0d 20:39:48
Hop Limit   : 255                              Adaptive       : Enabled
Record Route: Record                           Record Label   : Record
Include Grps:                                  Exclude Grps   :
None                                           None
Bandwidth   : 0 Mbps                           Oper Bw        : 0 Mbps

S2L Name    :Test-s2l1                         To             : 10.20.1.6
S2L Name    :Test-s2l2                         To             : 10.20.1.5
S2L Name    :Test-s2l3                         To             : 10.20.1.4
------------------------------------------------------------------------
A:ALU-25#
```

Note that the normal output is in detailed format only. There is no separate detail format.

```
A:ALU-52# show router mpls p2mp-lsp [p2mp-lsp-name] p2mp-instance [p2mp-inst-name]
========================================================================
MPLS P2MP Instance (Originating)
========================================================================
------------------------------------------------------------------------
Type : Originating
------------------------------------------------------------------------
LSP Name    : lsp_1                            LSP Tunnel ID  : 1
P2MP ID     : 18                               Path LSP ID    : 18
Adm State   : Up                               Oper State     : Down

P2MPinstance:Test_p2mp                         p2mp-inst-type : primary
Inst Name   : lsp_1                            P2MP Inst ID   : 1
Adm State   : Up                               Oper State     : Down
Inst Up Time: 0d 00:00:00                      Inst Down Time : 0d 20:39:48
Hop Limit   : 255                              Adaptive       : Enabled
Record Route: Record                           Record Label   : Record
Include Grps:                                  Exclude Grps   :
None                                           None
Bandwidth   : 0 Mbps                           Oper Bw        : 0 Mbps

S2L Name    :Test-s2l1                         To             : 10.20.1.6
S2L Name    :Test-s2l2                         To             : 10.20.1.5
S2L Name    :Test-s2l3                         To             : 10.20.1.4
------------------------------------------------------------------------
A:ALU-52#
```

```
A:ALU-52# show router mpls p2mp-lsp [p2mp-lsp-name] p2mp-instance [p2mp-inst-name]
mbb
========================================================================
MPLS P2MP Instance (Originating)
========================================================================
------------------------------------------------------------------------
Type : Originating
------------------------------------------------------------------------
LSP Name    : lsp_1                              LSP Tunnel ID  : 1
P2MP ID     : 18                                 Path LSP ID    : 18
Adm State   : Up                                 Oper State     : Down

P2MPinstance:Test_p2mp                           p2mp-inst-type : primary
Inst Name   : lsp_1                              P2MP Inst ID   : 1
Adm State   : Up                                 Oper State     : Down
Inst Up Time: 0d 00:00:00                        Inst Down Time : 0d 20:39:48
Hop Limit   : 255                                Adaptive       : Enabled
Record Route: Record                             Record Label   : Record
Include Grps:                                    Exclude Grps   :
None                                             None
Bandwidth   : 0 Mbps                             Oper Bw        : 0 Mbps
Last MBB    :
MBB type    :                                    Mbb State      :
ended at    :                                    Old Metric     :
In Prog MBB :
MBB type    :                                    Next Retry In  :
Started at  :                                    Retry Attempt  :
Failure code:                                    Failure Node   :

S2L Name    :Test-s2l1                           To             : 10.20.1.6
S2l Admin   :                                    S2l Oper       :
Failure code:                                    Failure Node   : 10.12.1.1

S2L Name    :Test-s2l1           To             : 10.20.1.6
S2l Admin   :                                    S2l Oper       :
Failure code:                                    Failure Node   : 10.12.1.1
------------------------------------------------------------------------
A:ALU-52#
```

```
A:ALU-52# show router mpls p2mp-lsp [p2mp-lsp-name] p2mp-instance [p2mp-inst-name]
s2l [s2l-name]
========================================================================
MPLS S2Ls (Originating)
========================================================================
S2L Name                           To             Next Hop     Adm   Opr
------------------------------------------------------------------------
Test-s2l1                          10.20.1.6      10.10.1.2    Up    Up
------------------------------------------------------------------------
LSPs : 1
========================================================================
A:ALU-52#
```

```
A:ALU-52# show router mpls p2mp-lsp [p2mp-lsp-name] p2mp-instance [p2mp-inst-name]
s2l [s2l-name] detail
========================================================================
MPLS S2Ls (Originating) (Detail)
========================================================================
------------------------------------------------------------------------
Type : Originating
```

```
------------------------------------------------------------------------
LSP Name    : lsp_1                            LSP Tunnel ID  : 1
P2MP ID     : 18                               Path LSP ID    : 18
Adm State   : Up                               Oper State     : Down

P2MP Primary Instance:
Inst Name   : lsp_1                            P2MP Inst ID   : 1
Adm State   : Up                               Oper State     : Down

S2L Name    : Test-s2l1                        To             : 10.20.1.6
Adm State   : Up                               Oper State     : Down
OutInterface: 1/1/1                            Out Label      : 131071
S2L Up Time : 0d 00:00:00                      S2L Down Time  : 0d 20:39:48
Transitions : 0                                Path Changes   : 0
Retry Limit : 0                                Retry Timer    : 30 sec
RetryAttempt: 0                                NextRetryIn    : 0 sec
Bandwidth   : No Reservation                   Oper Bw        : 0 Mbps
Hop Limit   : 255                              Adaptive       : Enabled
Record Route: Record                           Record Label   : Record
Oper MTU    : 1496                             Neg MTU        : 1496
FastReroute : Disabled                         Oper FR        : Disabled
FR Method   : Facility                         FR Hop Limit   : 45
FR Bandwidth: 0 Mbps                           FR Node Protect: Disabled
FR Object   : Enabled
CSPF        : Disabled                         ADSPEC         : Disabled
Metric      : 1                                Use TE metric  : Disabled
Include Grps:                                  Exclude Grps   :
None                                           None
CSPF Queries: 9
Failure Code: noError                          Failure Node   : n/a
ExplicitHops:
    No Hops Specified
Actual Hops :
    10.10.1.1(10.20.1.1) @                     Record Label   : N/A
 -> 10.10.1.2(10.20.1.2)                       Record Label   : 131071
ComputedHops:
    10.10.1.1       -> 10.10.1.2
LastResignal: n/a                              CSPF Metric    : 1000
------------------------------------------------------------------------
A:ALU-52#
```

## srlg-group

**Syntax** **srlg-group** [*group-name*]

**Context** show>router>mpls

**Description** This command displays MPLS SRLG groups

**Parameters** *group-name* — Specifies the name of the SRLG group within a virtual router instance.

**Output** **MPLS SRLG Group Output —** The following table describes MPLS SRLG group output fields

| Label | Description |
|---|---|
| Group Name | Displays the name of the SRLG group within a virtual router instance. |
| Group Value | Displays the group value associated with this SRLG group. |

| Label | Description (Continued) |
|---|---|
| `Interface` | Displays the interface where the SRLG groups is associated. |
| `No. of Groups` | Displays the total number of SRLG groups associated with the output. |

### Sample Output

```
*A:SRU4>config>router>mpls# show router mpls srlg-group
===============================================================================
MPLS Srlg Groups
===============================================================================
Group Name                       Group Value   Interfaces
-------------------------------------------------------------------------------
1432                             1432          srl-1
1433                             1433          srl-3
1434                             1434          aps-8
1435                             1435          aps-9
2410                             2410          srr-1
2411                             2411          srr-2
2412                             2412          srr-3
3410                             3410          aps-1
3420                             3420          aps-2
3430                             3430          aps-3
3440                             3440          sr4-1
41.80                            4180          g7600
41104                            41104         germ-1
415.70                           41570         gsr1
420.40                           42040         m160
422.60                           42260         gsr2
44.200                           44200         hubA
45100                            45100         ess-7-1
45110                            45110         ess-7-2
45120                            45120         ess-7-3
4651                             4651          src-1.1
4652                             4652          src-1.2
4653                             4653          src-1.3
4654                             4654          src-1.4
4655                             4655          src-1.5
4656                             4656          src-1.6
4657                             4657          src-1.7
4658                             4658          src-1.8
4659                             4659          src-1.9
4660                             4660          src-1.10
-------------------------------------------------------------------------------
No. of Groups: 30
===============================================================================
*A:SRU4>config>router>mpls#
```

```
*A:SRU4>config>router>mpls# show router mpls srlg-group "1432"
===============================================================================
MPLS Srlg Groups
===============================================================================
Group Name                       Group Value   Interfaces
-------------------------------------------------------------------------------
1432                             1432          srl-1
-------------------------------------------------------------------------------
No. of Groups: 1
```

```
===============================================================================
*A:SRU4>config>router>mpls#
```

## static-lsp

**Syntax** **static-lsp** [*lsp-name*]
**static-lsp** {**transit | terminate**}
**static-lsp count**

**Context** show>router>mpls

**Description** This command displays MPLS static LSP information.

**Output** **MPLS Static LSP Output —** The following table describes MPLS static LSP output fields.

| 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. |
| `In I/F` | The ingress interface. |
| `Out Label` | The egress interface. |
| `Out I/F` | The egress interface. |
| `Adm` | `Down` — The path is administratively disabled. |
|  | `Up` — The path is administratively enabled. |
| `Opr` | `Down` — The path is operationally down. |
|  | `Up` — The path is operationally up. |
| `LSPs` | The total number of static LSPs. |

**Sample Output**

```
A:ALA-12# show router mpls static-lsp
===============================================================================
MPLS Static LSPs (Originating)
===============================================================================
Lsp Name          To              Next Hop        Out Label Out I/F   Adm  Opr
-------------------------------------------------------------------------------
NYC_SJC_customer2 100.20.1.10     10.10.1.4       1020      1/1/1     Up   Up
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================
A:ALA-12#


*A:SRU4>config>router>mpls# show router mpls static-lsp transit
```

```
===============================================================================
MPLS Static LSPs (Transit)
===============================================================================
In Label    In Port     Out Label   Out Port    Next Hop            Adm   Opr
-------------------------------------------------------------------------------
240         aps-1       440         1/1/10      11.22.11.3          Up    Up
241         aps-1       441         1/1/10      11.22.11.3          Up    Up
242         aps-1       442         1/1/10      11.22.11.3          Up    Up
243         aps-1       443         1/1/10      11.22.11.3          Up    Up
244         aps-1       444         1/1/10      11.22.11.3          Up    Up
245         aps-1       445         1/1/10      11.22.11.3          Up    Up
246         aps-1       446         1/1/10      11.22.11.3          Up    Up
247         aps-1       447         1/1/10      11.22.11.3          Up    Up
248         aps-1       448         1/1/10      11.22.11.3          Up    Up
249         aps-1       449         1/1/10      11.22.11.3          Up    Up
250         aps-1       450         1/1/10      11.22.11.3          Up    Up
251         aps-1       451         1/1/10      11.22.11.3          Up    Up
252         aps-1       452         1/1/10      11.22.11.3          Up    Up
253         aps-1       453         1/1/10      11.22.11.3          Up    Up
...
207         3/2/8       407         1/1/9       11.22.10.3          Up    Up
208         3/2/8       408         1/1/9       11.22.10.3          Up    Up
209         3/2/8       409         1/1/9       11.22.10.3          Up    Up
-------------------------------------------------------------------------------
LSPs : 256
===============================================================================
*A:SRU4>config>router>mpls#

A:ALA-12# show router mpls static-lsp terminate
===============================================================================
MPLS Static LSPs (Terminate)
===============================================================================
In Label    In I/F      Out Label   Out I/F     Next Hop            Adm   Opr
-------------------------------------------------------------------------------
1021        1/1/1       n/a         n/a         n/a                 Up    Up
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================
A:ALA-12#
```

## status

**Syntax** **status**

**Context** show>router>mpls

**Description** This command displays MPLS operation information.

**Output** **MPLS Status Output —** The following table describes MPLS status output fields.

| Label | Description |
|---|---|
| `Admin Status` | `Down` — MPLS is administratively disabled.<br>`Up` — MPLS is administratively enabled. |
| `Oper Status` | `Down` — MPLS is operationally down.<br>`Up` — MPLS is operationally up. |
| `LSP Counts` | `Static LSPs` — Displays the count of static LSPs that originate, transit, and terminate on or through the router.<br>`Dynamic LSPs` — Displays the count of dynamic LSPs that originate, transit, and terminate on or through the router.<br>`Detour LSPs` — Displays the count of detour LSPs that originate, transit, and terminate on or through the router. |
| `FR Object` | `Enabled` — Specifies that Fast reroute object is signaled for the LSP.<br>`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.<br>`Disabled` — Specifies that the resignal timer is disabled for the LSP. |
| `Hold Timer` | Displays the amount of time that the ingress node holds before programming its data plane and declaring the LSP up to the service module. |

```
*A:7210SAS# show router mpls status

===============================================================================
MPLS Status
===============================================================================
Admin Status       : Up                  Oper Status        : Up
Oper Down Reason   : n/a
FR Object          : Enabled             Resignal Timer     : Disabled
Hold Timer         : 1 seconds           Next Resignal      : N/A
Srlg Frr           : Disabled            Srlg Frr Strict    : Disabled
Dynamic Bypass     : Enabled             User Srlg Database : Disabled
Least Fill Min Thd.: 5 percent           LeastFill ReoptiThd: 10 percent
Short. TTL Prop Lo*: Enabled             Short. TTL Prop Tr*: Enabled
```

```
AB Sample Multipli*: 1                  AB Adjust Multipli*: 288
Exp Backoff Retry  : Disabled           CSPF On Loose Hop  : Disabled
Lsp Init RetryTime*: 30 seconds
Logger Event Bundl*: Disabled

Sec FastRetryTimer : Disabled           Static LSP FR Timer: 30 seconds
P2P Max Bypass Ass*: 1000
P2PActPathFastRetry: Disabled
In Maintenance Mode: No

LSP Counts          Originate           Transit             Terminate
-------------------------------------------------------------------------------
Static LSPs         0                   0                   0
Dynamic LSPs        0                   0                   1
Detour LSPs         0                   0                   0
===============================================================================
* indicates that the corresponding row element may have been truncated.
*A:7210SAS#
```

# Show RSVP Commands

## interface

**Syntax** **interface** [*ip-int-name* | *ip-address*] **statistics** [**detail**]

**Context** show>router>rsvp

**Description** This command shows RSVP interfaces.

*ip-int-name* — The name 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.

*ip-address* — The system or network interface IP address.

**statistics** — Displays IP address and the number of packets sent and received on an interface-basis.

**detail —** Displays detailed information.

**Output** **RSVP Interface Output —** The following table describes RSVP interface output fields.

| Label | Description |
|---|---|
| `Interface` | The name of the IP interface. |
| `Total Sessions` | The total number of RSVP 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 sessions on this interface. |
| `Total BW (Mbps)` | The amount of bandwidth in megabits per second (Mbps) available to be reserved for the RSVP protocol on the interface. |
| `Resv BW (Mbps)` | The amount of bandwidth in mega-bits per seconds (Mbps) reserved on this interface. A value of zero (0) indicates that no bandwidth is reserved. |
| `Adm` | `Down` — The RSVP interface is administratively disabled.<br>`Up` — The RSVP interface is administratively enabled. |
| `Opr` | `Down` — The RSVP interface is operationally down.<br>`Up` — The RSVP interface is operationally up. |
| `Port ID` | Specifies the physical port bound to the interface. |
| `Active Resvs` | The total number of active RSVP sessions that have reserved bandwidth. |

| Label | Description (Continued) |
|---|---|
| Subscription | Specifies the percentage of the link bandwidth that RSVP can use for reservation. When the value is zero (0), no new sessions are permitted on this interface. |
| Port Speed | Specifies the speed for the interface. |
| Unreserved BW | Specifies the amount of unreserved bandwidth. |
| Reserved BW | Specifies the amount of bandwidth in megabits per second (Mbps) reserved by the RSVP session on this interface. A value of zero (0) indicates that no bandwidth is reserved. |
| Total BW | Specifies the amount of bandwidth in megabits per second (Mbps) available to be reserved for the RSVP protocol on this interface. |
| Hello Interval | Specifies 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. When the value is zero (0), the sending of hello messages is disabled. |
| Refresh Time | Specifies the interval between the successive Path and Resv refresh messages. RSVP declares the session down after it misses ((keep-multiplier + 0.5) * 1.5 * refresh-time)) consecutive refresh messages. |
| Hello Timeouts | The total number of hello messages that timed out on this RSVP interface. |
| Neighbors | The IP address of the RSVP neighbor. |
| Sent | The total number of error free RSVP packets that have been transmitted on the RSVP interface. |
| Recd | The total number of error free RSVP packets received on the RSVP interface. |
| Total Packets | The total number of RSVP packets, including errors, received on the RSVP interface. |
| Bad Packets | The total number of RSVP packets with errors transmitted on the RSVP interface. |
| Paths | The total number of RSVP PATH messages received on the RSVP interface. |
| Path Errors | The total number of RSVP PATH ERROR messages transmitted on the RSVP interface. |
| Path Tears | The total number of RSVP PATH TEAR messages received on the RSVP interface. |
| Resvs | The total number of RSVP RESV messages received on the RSVP interface. |

| Label | Description (Continued) |
|---|---|
| `Resv Confirms` | The total number of RSVP RESV CONFIRM messages received on the RSVP interface. |
| `Resv Errors` | Total RSVP RESV ERROR messages received on RSVP interface. |
| `Resv Tears` | Total RSVP RESV TEAR messages received on RSVP interface. |
| `Refresh Summaries` | Total RSVP RESV summary refresh messages received on interface. |
| `Refresh Acks` | Total RSVP RESV acknowledgement messages received when refresh reduction is enabled on the RSVP interface. |
| `Hellos` | Total RSVP RESV HELLO REQ messages received on the interface. |
| `Bfd Enabled` | Yes — BFD is enabled on the RSVP interface<br>No — BFD is disabled on the RSVP interface. |

### Sample Output

```
*A:7210-SAS>show>router>rsvp# interface detail

===============================================================================
RSVP Interfaces (Detailed)
===============================================================================
-------------------------------------------------------------------------------
Interface : system
-------------------------------------------------------------------------------
Interface         : system
Port ID           : system
Admin State       : Up                  Oper State        : Up
Active Sessions   : 0                   Active Resvs      : 0
Total Sessions    : 0
Subscription      : 100 %               Port Speed        : 0 Mbps
Total BW          : 0 Mbps              Aggregate         : Dsabl
Hello Interval    : 3000 ms             Hello Timeouts    : 0
Authentication    : 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

Percent Link Bandwidth for Class Types
Link Bw CT0       : 100                 Link Bw CT4       : 0
Link Bw CT1       : 0                   Link Bw CT5       : 0
Link Bw CT2       : 0                   Link Bw CT6       : 0
Link Bw CT3       : 0                   Link Bw CT7       : 0

Bandwidth Constraints for Class Types (Kbps)
BC0               : 0                   BC4               : 0
BC1               : 0                   BC5               : 0
BC2               : 0                   BC6               : 0
BC3               : 0                   BC7               : 0

Bandwidth for TE Class Types (Kbps)
TE0->  Resv. Bw   : 0                   Unresv. Bw        : 0
```

```
TE1->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE2->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE3->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE4->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE5->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE6->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE7->  Resv. Bw   : 0                   Unresv. Bw        : 0
No Neighbors.
-------------------------------------------------------------------------------
Interface : ip-10.10.12.3
-------------------------------------------------------------------------------
Interface         : ip-10.10.12.3
Port ID           : 1/1/9
Admin State       : Up                  Oper State        : Up
Active Sessions   : 1                   Active Resvs      : 0
Total Sessions    : 1
Subscription      : 100 %               Port Speed        : 1000 Mbps
Total BW          : 1000 Mbps           Aggregate         : Dsabl
Hello Interval    : 3000 ms             Hello Timeouts    : 0
Authentication    : 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

Percent Link Bandwidth for Class Types
Link Bw CT0       : 100                 Link Bw CT4       : 0
Link Bw CT1       : 0                   Link Bw CT5       : 0
Link Bw CT2       : 0                   Link Bw CT6       : 0
Link Bw CT3       : 0                   Link Bw CT7       : 0

Bandwidth Constraints for Class Types (Kbps)
BC0               : 1000000             BC4               : 0
BC1               : 0                   BC5               : 0
BC2               : 0                   BC6               : 0
BC3               : 0                   BC7               : 0

Bandwidth for TE Class Types (Kbps)
TE0->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE1->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE2->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE3->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE4->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE5->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE6->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE7->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
Neighbors      : 10.10.12.2
-------------------------------------------------------------------------------
Interface : ip-10.10.4.3
-------------------------------------------------------------------------------
Interface         : ip-10.10.4.3
Port ID           : 1/1/8
Admin State       : Up                  Oper State        : Up
Active Sessions   : 1                   Active Resvs      : 0
Total Sessions    : 1
Subscription      : 100 %               Port Speed        : 1000 Mbps
Total BW          : 1000 Mbps           Aggregate         : Dsabl
Hello Interval    : 3000 ms             Hello Timeouts    : 0
Authentication    : 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

Percent Link Bandwidth for Class Types
Link Bw CT0       : 100                 Link Bw CT4       : 0
Link Bw CT1       : 0                   Link Bw CT5       : 0
Link Bw CT2       : 0                   Link Bw CT6       : 0
Link Bw CT3       : 0                   Link Bw CT7       : 0

Bandwidth Constraints for Class Types (Kbps)
BC0               : 1000000             BC4               : 0
BC1               : 0                   BC5               : 0
BC2               : 0                   BC6               : 0
BC3               : 0                   BC7               : 0

Bandwidth for TE Class Types (Kbps)
TE0->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE1->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE2->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE3->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE4->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE5->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE6->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
TE7->  Resv. Bw   : 0                   Unresv. Bw        : 1000000
Neighbors      : 10.10.4.2
-------------------------------------------------------------------------------
Interface : ip-10.10.2.3
-------------------------------------------------------------------------------
Interface         : ip-10.10.2.3
Port ID           : 1/1/4
Admin State       : Up                  Oper State        : Down
Active Sessions   : 0                   Active Resvs      : 0
Total Sessions    : 0
Subscription      : 100 %               Port Speed        : 0 Mbps
Total BW          : 0 Mbps              Aggregate         : Dsabl
Hello Interval    : 3000 ms             Hello Timeouts    : 0
Authentication    : 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

Percent Link Bandwidth for Class Types
Link Bw CT0       : 100                 Link Bw CT4       : 0
Link Bw CT1       : 0                   Link Bw CT5       : 0
Link Bw CT2       : 0                   Link Bw CT6       : 0
Link Bw CT3       : 0                   Link Bw CT7       : 0

Bandwidth Constraints for Class Types (Kbps)
BC0               : 0                   BC4               : 0
BC1               : 0                   BC5               : 0
BC2               : 0                   BC6               : 0
BC3               : 0                   BC7               : 0

Bandwidth for TE Class Types (Kbps)
TE0->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE1->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE2->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE3->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE4->  Resv. Bw   : 0                   Unresv. Bw        : 0
TE5->  Resv. Bw   : 0                   Unresv. Bw        : 0
```

```
TE6->  Resv. Bw   : 0                  Unresv. Bw        : 0
TE7->  Resv. Bw   : 0                  Unresv. Bw        : 0
No Neighbors.
===============================================================================
```

## neighbor

**Syntax** **neighbor** [*ip-address*] [**detail**]

**Context** show>router>rsvp

**Description** This command shows neighbor information.

**Parameters** *ip-address* — Displays RSVP information about the specified IP address.

**detail —** Displays detailed information.

## 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 session information.

**Parameters** **session** *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.

**lsp-name** *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** **RSVP Session Output —** The following table describers RSVP session output fields.

| Label | Description |
|---|---|
| `From` | The IP address of the originating router. |
| `To` | The IP address of the egress router. |
| `Tunnel ID` | The IP address of the tunnel’s ingress node supporting this RSVP session. |

| Label | Description (Continued) |
|---|---|
| LSP ID | The ID assigned by the agent to this RSVP session. |
| Name | The administrative name assigned to the RSVP session by the agent. |
| State | Down — The operational state of this RSVP session is down.<br>Up — The operational state of this RSVP session is up. |

### Sample Output

```
*A:SRU4>show>router>rsvp#   session
===============================================================================
RSVP Sessions
===============================================================================
From            To              Tunnel LSP   Name                         State
                                ID     ID
-------------------------------------------------------------------------------
110.20.1.5      110.20.1.4      18     27648 b4-1::b4-1                   Up
110.20.1.5      110.20.1.4      1      37902 gsr::gsr                     Up
110.20.1.5      10.20.1.22      11     53760 to_10_20_1_22_cspf::to_10_2* Up
110.20.1.4      10.20.1.20      146    17920 to_10_20_1_20_cspf_3::to_10* Up
110.20.1.4      10.20.1.20      145    34816 to_10_20_1_20_cspf_2::to_10* Up
110.20.1.4      10.20.1.20      147    45056 to_10_20_1_20_cspf_4::to_10* Up
110.20.1.4      10.20.1.20      148    6656  to_10_20_1_20_cspf_5::to_10* Up
110.20.1.4      10.20.1.20      149    58880 to_10_20_1_20_cspf_6::to_10* Up
110.20.1.4      10.20.1.20      150    13312 to_10_20_1_20_cspf_7::to_10* Up
110.20.1.4      10.20.1.20      152    40448 to_10_20_1_20_cspf_9::to_10* Up
110.20.1.4      10.20.1.20      154    27648 to_10_20_1_20_cspf_11::to_1* Up
110.20.1.4      10.20.1.20      155    12288 to_10_20_1_20_cspf_12::to_1* Up
110.20.1.4      10.20.1.20      151    46080 to_10_20_1_20_cspf_8::to_10* Up
110.20.1.4      10.20.1.20      153    512   to_10_20_1_20_cspf_10::to_1* Up
110.20.1.4      10.20.1.22      164    62464 to_10_20_1_22_cspf_2::to_10* Up
110.20.1.4      10.20.1.20      156    37888 to_10_20_1_20_cspf_13::to_1* Up
110.20.1.4      10.20.1.20      157    24064 to_10_20_1_20_cspf_14::to_1* Up
110.20.1.4      10.20.1.20      158    19968 to_10_20_1_20_cspf_15::to_1* Up
110.20.1.4      10.20.1.20      161    59904 to_10_20_1_20_cspf_18::to_1* Up
...
110.20.1.3      110.20.1.4      54     23088 to_110_20_1_4_cspf_4::to_11* Up
-------------------------------------------------------------------------------
Sessions : 1976
===============================================================================
* indicates that the corresponding row element may have been truncated.
*A:SRU4>show>router>rsvp#
```

```
A:ALA-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:ALA-12#
```

## statistics

**Syntax** **statistics**

**Context** show>router>rsvp

**Description** This command displays global statistics in the RSVP instance.

**Output** **RSVP Statistics Output —** The following table describes RSVP statistics output fields.

| Label | Description |
|---|---|
| PATH Timeouts | The total number of path timeouts. |
| RESV Timeouts | The total number of RESV timeouts. |

### Sample Output

```
*A:SRU4>show>router>rsvp# statistics
===============================================================================
RSVP Global Statistics
===============================================================================
PATH Timeouts      : 1026               RESV Timeouts      : 182
===============================================================================
*A:SRU4>show>router>rsvp#
```

## status

**Syntax** **rsvp status**

**Context** show>router>rsvp

**Description** This command displays RSVP status.

**Output** **RSVP Status —** The following table describes RSVP status output fields.

| Label | Description |
|---|---|
| Admin Status | `Down` — RSVP is administratively disabled. |
| | `Up` — RSVP is administratively enabled. |
| Oper Status | `Down` — RSVP is operationally down. |
| | `Up` — RSVP is operationally up. |
| Keep Multiplier | Displays the **keep-multiplier** *number* used by RSVP to declare that a reservation is down or the neighbor is down. |
| Refresh Time | Displays the **refresh-time** interval, in seconds, between the successive Path and Resv refresh messages. |
| Message Pacing | `Enabled` — RSVP messages, specified in the **max-burst** command, are sent in a configured interval, specified in the **period** command. |

| Label | Description (Continued) |
|---|---|
| | `Disabled` — Message pacing is disabled. RSVP message transmission is not regulated. |
| `Pacing Period` | Displays the time interval, in milliseconds, when the router can send the specified number of RSVP messages specified in the **rsvp max-burst** command. |
| `Max Packet Burst` | Displays the maximum number of RSVP messages that are sent in the specified period under normal operating conditions. |

### Sample Output

```
*A:SRU4>show>router>rsvp# status
===============================================================================
RSVP Status
===============================================================================
Admin Status       : Up                   Oper Status        : Up
Keep Multiplier    : 3                    Refresh Time       : 30 sec
Message Pacing     : Disabled             Pacing Period      : 100 msec
Max Packet Burst   : 650 msgs             Refresh Bypass     : Disabled
===============================================================================
*A:SRU4>show>router>rsvp#
```

# Tools Commands

## cspf

**Syntax** **cspf to** *ip-addr* [**from** *ip-addr*] [**bandwidth** *bandwidth*] [**include-bitmap** *bitmap*] [**exclude-bitmap** *bitmap*] [**hop-limit** *limit*] [**exclude-address** *excl-addr* [*excl-addr*...(up to 8 max)]] [**use-te-metric**] [**strict-srlg**] [**srlggroup** grp-id...(up to 8 max)] [**skip-interface** *interface-name*]

**Context** tools>perform>router>mpls

**Description** This command computes a CSPF path with specified user constraints.

**Default** none

**Parameters** **to** *ip-addr* **—** Specify the destination IP address.

**from** *ip-addr* **—** Specify the originating IP address.

**bandwidth** *bandwidth* **—** Specifies the amount of bandwidth in mega-bits per second (Mbps) to be reserved.

**include-bitmap** *bitmap* **—** Specifies to include a bit-map that specifies a list of admin groups that should be included during setup.

**exclude-bitmap** *bitmap* **—** Specifies to exclude a bit-map that specifies a list of admin groups that should be included during setup.

**hop-limit** *limit* **—** Specifies the total number of hops a detour LSP can take before merging back onto the main LSP path.

**exclude-address** *ip-addr* **—** Specifies IP addresses, up to 8, that should be included during setup.

**use-te-metric —** Specifies the use of the traffic engineering metric used on the interface.

**strict-srlg —** Specifies whether to associate the LSP with a bypass or signal a detour if a bypass or detour satisfies all other constraints except the SRLG constraints.

**srlg-group** *grp-id* **—** Specifies up to 8 Shared Risk Link Groups (SRLGs). An SRLG group represents a set of interfaces which could be subject to the same failures or defects and therefore, share the same risk of failing.

**Values** 0 — 4294967295

**skip-interface** *interface-name* **—** Specifies an interface name that should be skipped during setup.

## force-switch-path

**Syntax** **force-switch-path** [**lsp** *lsp-name*] [**path** *path-name*]

**Context** tools>perform>router>mpls

**Description** Use this command to move from a standby path to any other standby path regardless of priority.

The **no** form of the command reverts to priority path.

Parameters *lsp-name* — Specifies an existing LSP name to move.

*path-name* — Specifies the path name to which to move the specified LSP.

## trap-suppress

**Syntax** **trap-suppress** *number-of-traps time-interval*

**Context** tools>perform>router>mpls

**Description** This command modifies thresholds for trap suppression. The *time-interval* parameter is used to suppress traps after a certain number of traps have been raised within a period. By executing this command, there will be no more than *number-of-traps* within *time-interval*.

**Parameters** *number-of-traps* — Specifies to suppress the number of traps raised within a period.

**Values** 100 — 1000, in multiples of 100

*time-interval* — Specifies to suppress a certain number of traps raised within a period.

**Values** 1 — 300

## update-path

**Syntax** **update-path** {**lsp** *lsp-name* **path** *current-path-name* **new-path** *new-path-name*}

**Context** tools>perform>router>mpls

**Description** This command enables you to instruct MPLS to replace the path of a primary or secondary LSP. The primary or secondary LSP path is indirectly identified via the *current-path-name* value. The same path name cannot be used more than once in a given LSP name.

This command applies to both CSPF LSP and to a non-CSPF LSP. This command will only work when the specified *current-path-name* has the adaptive option enabled. The adaptive option can be enabled at the LSP level or the path level.

The new path must have been configured in the CLI or provided via SNMP. The CLI command for entering the path is

**configure router mpls path** *path-name*

The command fails if any of the following conditions exist:

- The specified *current-path-name* of this LSP does not have the adaptive option enabled.

- The specified *new-path-name* value does not correspond to a previously defined path.
- The specified *new-path-name* value exists but is being used by any path of the same LSP, including this one.

When you execute this command, MPLS performs the following procedures:

- MPLS performs a single MBB attempt to move the LSP path to the new path.
- If the MBB is successful, MPLS updates the new path
  - MPLS writes the corresponding NHLFE in the data path if this path is the current backup path for the primary.
  - If the current path is the active LSP path, it will update the path, write the new NHLFE in the data path that will cause traffic to switch to the new path.
- If the MBB is not successful, the path retains it current value.
- The update-path MBB has the same priority as the manual re-signal MBB.

## resignal

**Syntax** **resignal** {**lsp** *lsp-name* **path** *path-name* **| delay** *minutes*}

**Context** tools>perform>router>mpls

**Description** This command resignal is a specific LSP path. The *minutes* parameter configures the global timer or all LSPs for resignal. If only lsp-name and path-name are provided, the LSP will be resignaled immediately.

**Parameters** *lsp-name* — Specifies an existing LSP name to resignal.

*path-name* — Specifies an existing path name to resignal.

**delay** *minutes* **—** Configures the global timer or all LSPs to resignal.

## tp-tunnel

**Syntax** tp-tunnel

**Context** tools>perform>router>mpls

**Description** Platforms Supported: 7210 SAS-R6

This command enables the context to perform Linear Protection operations on an MPLS-TP LSP.

## clear

**Syntax** **clear id** *tunnel-id lsp-name*

**Context** tools>perform>router>mpls>tp-tunnel

**Description** Clears all the MPLS-TP linear protection operational commands for the specified LSP that are currently active.

**Parameters** *tunnel-id* — Specifies the tunnel number of the MPLS-TP LSP

**Default** none

**Values** Text name of up to 32 characters

*lsp-name* — Specifies the name of the MPLS-TP LSP.

**Default** none

**Values** 1 - 61440

## force

**Syntax** **force id** *tunnel-id lsp-name*

**Context** tools>perform>router>mpls>tp-tunnel

**Description** Performs a force switchover of the MPLS-TP LSP from the active path to the protect path.

**Parameters** *tunnel-id* — Specifies the tunnel number of the MPLS-TP LSP

**Default** none

**Values** Text name of up to 32 characters

*lsp-name* — Specifies the name of the MPLS-TP LSP.

**Default** none

**Values** 1 - 61440

## lockout

**Syntax** **lockout** *tunnel-id lsp-name*

**Context** tools>perform>router>mpls>tp-tunnel

**Description** Performs a lockout of protection for an MPLS-TP LSP. This prevents a switchover to the protect path.

**Parameters** *tunnel-id* — Specifies the tunnel number of the MPLS-TP LSP

**Default** none

**Values** Text name of up to 32 characters *lsp-name* — Specifies the name of the MPLS-TP LSP.

**Default** none

**Values** 1 - 61440

## manual

**Syntax** **manual** *tunnel-id lsp-name*

**Context** tools>perform>router>mpls>tp-tunnel

**Description** Performs a manual switchover of the MPLS-TP LSP from the active path to the protect path.

**Parameters** *tunnel-id* — Specifies the tunnel number of the MPLS-TP LSP

**Default** none

**Values** Text name of up to 32 characters

*lsp-name* — Specifies the name of the MPLS-TP LSP.

**Default** none

**Values** 1 - 61440

## trap-suppress

**Syntax** **trap-suppress** *number-of-traps time-interval*

**Context** tools>perform>router>mpls

**Description** This command modifies thresholds for trap suppression. The *time-interval* parameter is used to suppress traps after a certain number of traps have been raised within a period. By executing this command, there will be no more than *number-of-traps* within *time-interval*.

**Parameters** *number-of-traps* — Specifies to suppress the number of traps raised within a period.

**Values** 100 — 1000, in multiples of 100

*time-interval* — Specifies to suppress a certain number of traps raised within a period.

**Values** 1 — 300

# Clear Commands

## fec-egress-statistics

**Syntax** fec-egress-statistics [*ip-prefix/mask*]

**Context** clear>router>ldp

**Description** This command resets or clears LDP FEC egress statistics.

**Parameters** *ip-prefix* — Specify information for the specified IP prefix and mask length. Host bits must be "0".

*mask* — Specifies the 32-bit address mask used to indicate the bits of an IP address that are being used for the sub-net address.

**Values** 0 — 32

## interface

**Syntax** **interface** *ip-int-name*

**Context** clear>router>mpls

**Description** This command resets or clears statistics for MPLS interfaces.

**Parameters** *ip-int-name* — The name of an existing IP interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

## lsp

**Syntax** **lsp** *lsp-name*

**Context** clear>router>mpls

**Description** This command resets and restarts an LSP.

**Parameters** *lsp-name* — The name of the LSP to clear up to 64 characters in length.

## interface

**Syntax** **interface** *ip-int-name* **statistics**

**Context** clear>router>rsvp

**Description** This command resets or clears statistics for an RSVP interface.

**Parameters** *ip-int-name* — The name of the IP interface to clear. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

**statistics** — This parameter clears only statistics.

## statistics

**Syntax** **statistics**

**Context** clear>router>rsvp

**Description** This command clears global statistics for the RSVP instance, for example, clears **path** and **resv timeout** counters.

# Debug Commands

## mpls

**Syntax** **mpls** [**lsp** *lsp-name*] [**sender** *source-address*] [**endpoint** *endpoint-address*] [**tunnel-id** *tunnel-id*] [**lsp-id** *lsp-id*]
**no mpls**

**Context** debug>router

**Description** This command enables and configures debugging for MPLS.

**Parameters** **lsp** *lsp-name* — Name that identifies the LSP. The LSP name can be up to 32 characters long and must be unique.

**sender** *source-address* — The system IP address of the sender.

**endpoint** *endpoint-address* — The far-end system IP address.

**tunnel-id** *tunnel-id* — The MPLS SDP ID.

**Values** 0 — 4294967295

**lsp-id** *lsp-id* — The LSP ID.

**Values** 1 — 65535

**interface** *ip-int-name* — Name that identifies the interface. The interface name can be up to 32 characters long and must be unique. 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.

## 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.

## frr

**Syntax** **frr** [**detail**]
**no frr**

**Context** debug>router>mpls>event

**Description** This command debugs fast re-route events.

The **no** form of the command disables the debugging.

**Parameters** **detail —** Displays detailed information about re-route 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** [**lsp** *lsp-name*] [**sender** *source-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** *lsp-name* — Name that identifies the LSP. The LSP name can be up to 32 characters long and must be unique.

**sender** *source-address* — The system IP address of the sender.

**endpoint** *endpoint-address* — The far-end system IP address.

**tunnel-id** *tunnel-id* — The RSVP tunnel ID.

**Values** 0 — 4294967295

**lsp-id** *lsp-id* — The LSP ID.

**Values** 1 — 65535

**interface** *ip-int-name* — The interface name. The interface name can be up to 32 characters long and must be unique. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

## 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 reservation events.

The **no** form of the command disables the debugging.

**Parameters** **detail —** Displays detailed information about RSVP 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 syntax 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.

## 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.

## 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 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 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 resv packets.

The **no** form of the command disables the debugging.

**Parameters** **detail —** Displays detailed information about RSVP Resv events.

## 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.

# Label Distribution Protocol

## In This Chapter

This chapter provides information to enable Label Distribution Protocol (LDP).

Topics in this chapter include:

# Label Distribution Protocol

Label Distribution Protocol (LDP) is a protocol used to distribute labels in non-traffic-engineered applications. LDP allows routers to establish label switched paths (LSPs) through a network by mapping network-layer routing information directly to data link layer-switched paths.

An LSP is defined by the set of labels from the ingress Label Switching Router (LSR) to the egress LSR. 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 LSR 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 as each LSR splices incoming labels for a FEC to the outgoing label assigned to the next hop for the given 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 (DUS).

## LDP and MPLS

LDP performs the label distribution only in MPLS environments. The LDP operation begins with a hello discovery process to find LDP peers in the network. LDP peers are two LSRs 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 (LDP is bi-directional) and to 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 Virtual Private LAN Services (VPLSs) 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 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 are maintained in the forwarding plane that enable fast access and packet identification.

When an unlabeled packet ingresses the 7210 SAS M router, classification policies associate it with a FEC. The appropriate label is imposed on the packet, and the packet is forwarded. Other actions that can take place before a packet is forwarded are imposing additional labels, other encapsulations, learning actions, etc. When 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 preformed on the packet and then the packet is forwarded.

The LDP implementation provides DOD, DUS, ordered control, liberal label retention mode support.

## 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 24. 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 inter-process communication through the event queue, as well as through updates to the various data structures. The primary data structures that LDP maintains are:

- FEC/label database — This database contains all the FEC to label mappings that include, both sent and received. It also contains both address FECs (prefixes and host addresses) as well as service FECs (L2 VLLs and VPLS).
- 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.

## Subsystem Interrelationships

The sections below describe how LDP and the other subsystems work to provide services.

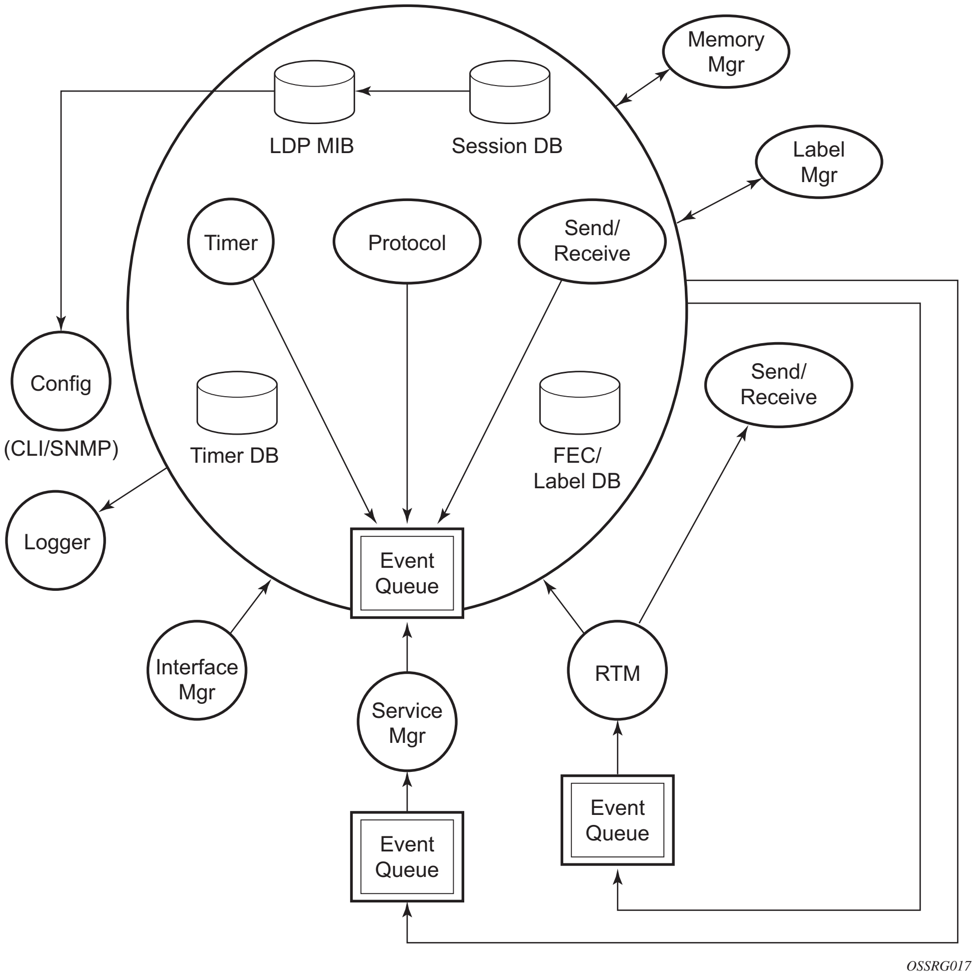


**Figure 24: Subsystem Interrelationships**

## Memory Manager and LDP

LDP does not use any memory until it is instantiated. It pre-allocates 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 larger chunks and managing the memory internally to LDP. When LDP is shut down, it releases all memory allocated to it.

## 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 imply that the system is not functional. The 7210 SAS M uses a label range from 28672 (28K) to 131071 (128K-1) to allocate all dynamic labels, including RSVP allocated labels and VC labels.

## LDP Configuration

The 7210 SAS M 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, LDP targeted sessions can be set up to specific endpoints. Targeted-session parameters are configurable.

## 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.

## 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 service manager of relevant LDP events, such as connection setups and failures, timeouts, labels signaled/withdrawn.

# Execution Flow

LDP activity in 7210 SAS M OS is limited to service-related signaling. Therefore, the configurable parameters are restricted to system-wide parameters, such as hello and keepalive timeouts.

## Initialization

MPLS must be enabled when LDP is initialized. LDP makes sure that the various prerequisites, such as ensuring the system IP interface is operational, the label manager is operational, and there is memory available, are met. It then allocates itself a pool of memory and initializes its databases.

## Session Lifetime

In order for a targeted LDP (T-LDP) session to be established, an adjacency must be created. The LDP extended discovery mechanism requires hello messages to be exchanged between two peers for session establishment. After the adjacency establishment, session setup is attempted.

### 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 liveliness.

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 re-attempted as the back-pressure eases.

# Label Exchange

Label exchange is initiated by the service manager. When an SDP is attached to a service (for example, 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.

## Other Reasons for Label Actions

Other reasons for label actions include:

- MTU changes: LDP withdraws the previously assigned label, and re-signals the FEC with the new 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, it is released.
- VC type unsupported: When an unsupported VC type is received, the received label is released.

## Cleanup

LDP closes all sockets, frees all memory, and shuts down all its tasks when it is deleted, so its memory usage is 0 when it is not running.

## LDP Filters

Both inbound and outbound LDP label binding filtering is supported.

Inbound filtering (import policy) allows configuration of a policy to control the label bindings an

LSR accepts from its peers. Label bindings can be filtered based on:

- Neighbor: Match on bindings received from the specified peer.
- Prefix-list: Match on bindings with the specified prefix/prefixes.

**Note:** The default import behavior is to accept all FECs received from peers. The LDP export policy can be used to explicitly add FECs (or non-LDP routes) for label propagation and does not filter out or stop propagation of any FEC received from neighbors.

Export policy enables configuration of a policy to advertise label bindings based on:

- Direct: All local subnets.
- Prefix-list: Match on bindings with the specified prefix or prefixes.

**Note:** The LDP export policy will not filter out FECs. It is only used to explicitly add FECs (or non-LDP routes) for label propagation.

The default export behavior originates label bindings for system address and propagate all FECs received.

## ECMP Support for LDP

**NOTE**: ECMP is not supported for Label Distribution Protocol (LDP) in 7210 SAS.

# LDP over RSVP Tunnels

LDP over RSVP-TE provides end-to-end tunnels that have two important properties, fast reroute and traffic engineering which are not available in LDP. LDP over RSVP-TE is focused at large networks (over 100 nodes in the network). Simply using end-to-end RSVP-TE tunnels will not scale. While an LER may not have that many tunnels, any transit node will potentially have thousands of LSPs, and if each transit node also has to deal with detours or bypass tunnels, this number can make the LSR overly burdened.

NOTE:

- Use of implicit NULL MPLS lablel must be enabled with use of LDPoRSVP. Use the command configure>router>rsvp> implicit-null-label and configure> router> ldp> implicit-null-label to enable use of Implicit NULL MPLS labels.
- Only FRR one-to-one is supported when LDPoRSVP is used. FRR facility is not supported. This is not blocked in CLI, but operators need to ensure it when configuring the nodes.

LDP over RSVP-TE allows tunneling of user packets using an LDP LSP inside an RSVP LSP.The main application of this feature is for deployment of MPLS based services, for example, VPRN, VLL, and VPLS services, in large scale networks across multiple IGP areas without requiring full mesh of RSVP LSPs between PE routers.

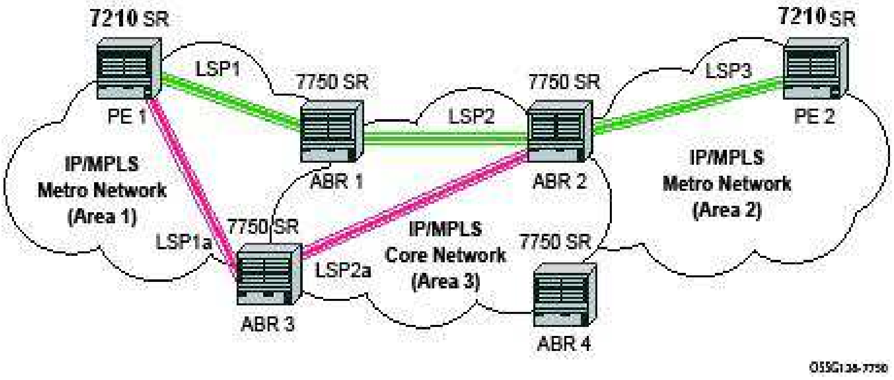


**Figure 25: LDP over RSVP Application**

The network displayed in Figure 25 consists of two metro areas, Area 1 and 2 respectively, and a core area, Area 3. Each area makes use of TE LSPs to provide connectivity between the edge routers. In order to enable services between PE1 and PE2 across the three areas, LSP1, LSP2, and LSP3 are set up using RSVP-TE. There are in fact 6 LSPs required for bidirectional operation but we will refer to each bi-directional LSP with a single name, for example, LSP1. A targeted LDP (T-LDP) session is associated with each of these bidirectional LSP tunnels. That is, a T-LDP adjacency is created between PE1 and ABR1 and is associated with LSP1 at each end. The same is done for the LSP tunnel between ABR1 and ABR2, and finally between ABR2 and PE2. The loopback address of each of these routers is advertised using T-LDP. Similarly, backup bidirectional LDP over RSVP tunnels, LSP1a and LSP2a, are configured via ABR3.

This setup effectively creates an end-to-end LDP connectivity which can be used by all PEs to provision services. The RSVP LSPs are used as a transport vehicle to carry the LDP packets from one area to another. Note that only the user packets are tunneled over the RSVP LSPs. The T-LDP control messages are still sent unlabeled using the IGP shortest path.

Note that in this application, the bi-directional RSVP LSP tunnels are not treated as IP interfaces and are not advertised back into the IGP. A PE must always rely on the IGP to look up the next hop for a service packet. LDP-over-RSVP introduces a new tunnel type, tunnel-in-tunnel, in addition to the existing LDP tunnel and RSVP tunnel types. If multiple tunnels types match the destination PE FEC lookup, LDP will prefer an LDP tunnel over an LDP-over-RSVP tunnel by default.

The design in Figure 25 allows a service provider to build and expand each area independently without requiring a full mesh of RSVP LSPs between PEs across the three areas.

In order to participate in a VPRN service, PE1 and PE2 perform the autobind to LDP. The LDP label which represents the target PE loopback address is used below the RSVP LSP label. Therefore a 3 label stack is required.

In order to provide a VLL service, PE1 and PE2 are still required to set up a targeted LDP session directly between them. Again a 3 label stack is required, the RSVP LSP label, followed by the LDP label for the loopback address of the destination PE, and finally the pseudowire label (VC label).

This implementation supports a variation of the application in Figure 25, in which area 1 is an LDP area. In that case, PE1 will push a two label stack while ABR1 will swap the LDP label and push the RSVP label as illustrated in Figure 26.

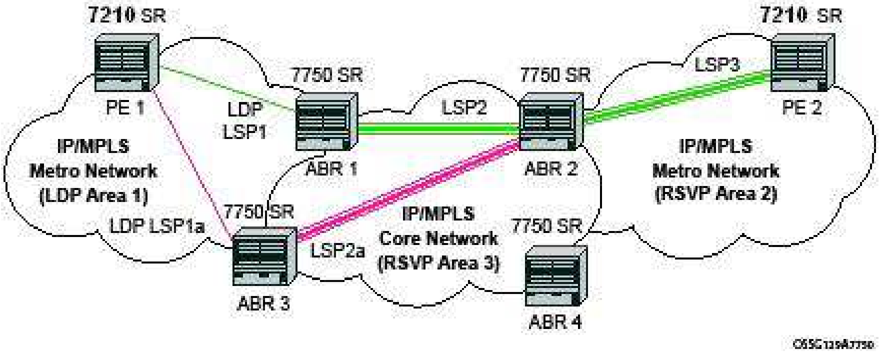


Figure 26: LDP over RSVP Application Variant

## Signaling and Operation

- LDP Label Distribution and FEC Resolution on page 233
- Default FEC Resolution Procedure on page 234

### LDP Label Distribution and FEC Resolution

The user creates a targeted LDP (T-LDP) session to an ABR or the destination PE. This results in LDP hellos being sent between the two routers. These messages are sent unlabeled over the IGP path. Next, the user enables LDP tunneling on this T-LDP session and optionally specifies a list of LSP names to associate with this T-LDP session. By default, all RSVP LSPs which terminate on the T-LDP peer are candidates for LDP-over-RSVP tunnels. At this point in time, the LDP FECs resolving to RSVP LSPs are added into the Tunnel Table Manager as tunnel-in-tunnel type.

Note that if LDP is running on regular interfaces also, then the prefixes LDP learns are going to be distributed over both the T-LDP session as well as regular IGP interfaces. The policy controls which prefixes go over the T-LDP session, for example, only /32 prefixes, or a particular prefix range.

LDP-over-RSVP works with both OSPF and ISIS. These protocols include the advertising router when adding an entry to the RTM. LDP-over-RSVP tunnels can be used as shortcuts for BGP next-hop resolution.

## Default FEC Resolution Procedure

When LDP tries to resolve a prefix received over a T-LDP session, it performs a lookup in the Routing Table Manager (RTM). This lookup returns the next hop to the destination PE and the advertising router (ABR or destination PE itself). If the next-hop router advertised the same FEC over link-level LDP, LDP will prefer the LDP tunnel by default unless the user explicitly changed the default preference using the system wide prefer-tunnel-in-tunnel command. If the LDP tunnel becomes unavailable, LDP will select an LDP-over-RSVP tunnel if available.

When searching for an LDP-over-RSVP tunnel, LDP selects the advertising router(s) with best route. If the advertising router matches the T-LDP peer, LDP then performs a second lookup for the advertising router in the Tunnel Table Manager (TTM) which returns the user configured RSVP LSP with the best metric. If there are more than one configured LSP with the best metric, LDP selects the first available LSP.

If all user configured RSVP LSPs are down, no more action is taken. If the user did not configure any LSPs under the T-LDP session, the lookup in TTM will return the first available RSVP LSP which terminates on the advertising router with the lowest metric.

## FEC Resolution Procedure When prefer-tunnel-in-tunnel is Enabled

When LDP tries to resolve a prefix received over a T-LDP session, it performs a lookup in the Routing Table Manager (RTM). This lookup returns the next hop to the destination PE and the advertising router (ABR or destination PE itself).

When searching for an LDP-over-RSVP tunnel, LDP selects the advertising router(s) with best route. If the advertising router matches the targeted LDP peer, LDP then performs a second lookup for the advertising router in the Tunnel Table Manager (TTM) which returns the user configured RSVP LSP with the best metric. If there are more than one configured LSP with the best metric, LDP selects the first available LSP.

If all user configured RSVP LSPs are down, then an LDP tunnel will be selected if available.

If the user did not configure any LSPs under the T-LDP session, a lookup in TTM will return the first available RSVP LSP which terminates on the advertising router. If none are available, then an LDP tunnel will be selected if available.

## Rerouting Around Failures

Every failure in the network can be protected against, except for the ingress and egress PEs. All other constructs have protection available. These constructs are LDP-over-RSVP tunnel and ABR.

- LDP-over-RSVP Tunnel Protection on page 235
- ABR Protection on page 235

### LDP-over-RSVP Tunnel Protection

An RSVP LSP can deal with a failure in two ways.

- If the LSP is a loosely routed LSP, then RSVP will find a new IGP path around the failure, and traffic will follow this new path. This may involve some churn in the network if the LSP comes down and then gets re-routed. The tunnel damping feature was implemented on the LSP so that all the dependent protocols and applications do not flap unnecessarily.
- If the LSP is a CSPF-computed LSP with the fast reroute option enabled, then RSVP will switch to the detour path very quickly. From that point, a new LSP will be attempted from the head-end (global revertive). When the new LSP is in place, the traffic switches over to the new LSP with make-before-break.

NOTE: Only FRR one-to-one is supported with LDP-over-RSVP with use of implicit NULL label. In other words, implicit NULL label must be enabled to use FRR one-to-one. FRR facility cannot be used. The software does not make any checks to enforce these restrictions. Operators must ensure this by network design and configuration.

### ABR Protection

If an ABR fails, then routing around the ABR requires that a new next-hop LDP-over-RSVP tunnel be found to a backup ABR. If an ABR fails, then the T-LDP adjacency fails. Eventually, the backup ABR becomes the new next hop (after SPF converges), and LDP learns of the new next-hop and can reprogram the new path.

## Configuring Implicit Null Label

The implicit null label option allows a 7210 SAS egress LER to receive MPLS packets from the previous hop without the outer LSP label. The operation of the previous hop is referred to as penultimate hop popping (PHP). This option is signaled by the egress LER to the previous hop during the FEC signaling by the LDP control protocol.

The user can configure to signal the implicit null option for all LDP FECs for which this node is the egress LER using the following command:

**config>router>ldp>implicit-null-label**

When the user changes the implicit null configuration option, LDP withdraws all the FECs and re-advertises them using the new label value.

# LDP over RSVP and ECMP

NOTE: ECMP is not supported for LDP over RSVP.

ECMP for LDP over RSVP is not supported (also see ECMP Support for LDP on page 229). If ECMP applies, all LSP endpoints found over the ECMP IGP path will be installed in the routing table by the IGP for consideration by LDP. It is important to note that IGP costs to each endpoint may differ because IGP selects the farthest endpoint per ECMP path.

LDP will choose the endpoint that is highest cost in the route entry and will do further tunnel selection over those endpoints. If there are multiple endpoints with equal highest cost, then LDP will consider all of them.

# Multi-Area and Multi-Instance Extensions to LDP

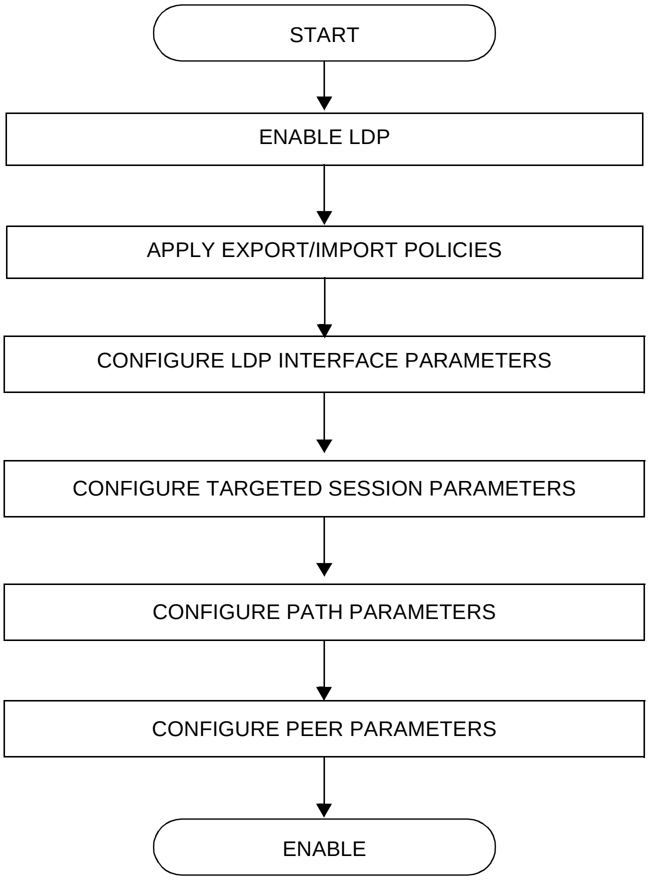
To extend LDP across multiple areas of an IGP instance or across multiple IGP instances, the current standard LDP implementation based on RFC 3036 requires that all the /32 prefixes of PEs be leaked between the areas or instances. This is because an exact match of the prefix in the routing table has to install the prefix binding in the LDP Forwarding Information Base (FIB).

The 7210 SAS performs this function by default, except in cases when the 7210 SAS is configured as Area Border Router (ABR). In this scenario, the convergence of IGP on routers increases when the number of PE nodes scales to thousands of nodes.

Multi-area and multi-instance extensions to LDP provide an optional behavior by which LDP installs a prefix binding in the LDP FIB by simply performing a longest prefix match with an aggregate prefix in the routing table (RIB). The ABR is configured to summarize the /32 prefixes of PE routers. This method is compliant to RFC 5283- LDP Extension for Inter-Area Label Switched Paths (LSPs).

# LDP Process Overview

Figure 27 displays the process to provision basic LDP parameters.


START
ENABLE LDP
APPLY EXPORT/IMPORT POLICIES
CONFIGURE LDP INTERFACE PARAMETERS
CONFIGURE TARGETED SESSION PARAMETERS
CONFIGURE PATH PARAMETERS
CONFIGURE PEER PARAMETERS
ENABLE

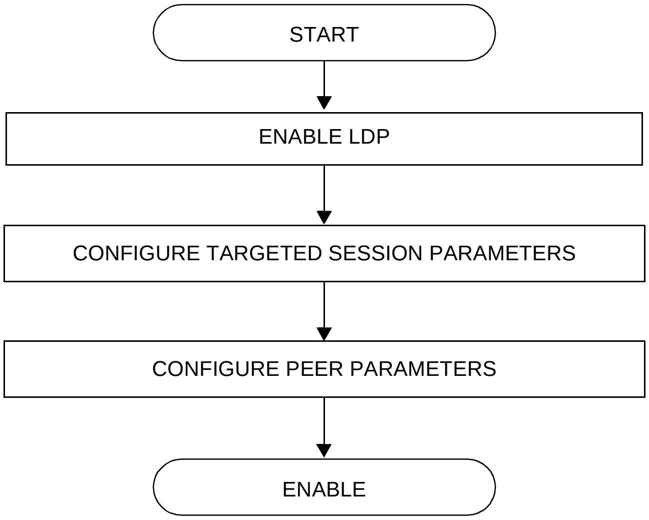

START
ENABLE LDP
CONFIGURE TARGETED SESSION PARAMETERS
CONFIGURE PEER PARAMETERS
ENABLE

**Figure 27: LDP Configuration and Implementation**

# Configuring LDP with CLI

This section provides information to configure LDP using the command line interface.

Topics in this section include:

- LDP Configuration Overview on page 242
- Basic LDP Configuration on page 243
- Common Configuration Tasks on page 244
- LDP Configuration Management Tasks on page 253

# LDP Configuration Overview

When the 7210 SAS M OS 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*.

# Basic LDP Configuration

This chapter provides information to configure LDP and remove configuration examples of common configuration tasks.

The LDP protocol instance is created in the `no shutdown` (enabled) state.

```
A:ALU_SIM11>config>router>ldp# info
----------------------------------------------
            aggregate-prefix-match
                prefix-exclude "sample"
            exit
            graceful-restart
            exit
            peer-parameters
                peer 1.1.1.1
                    ttl-security 1
                exit
            exit
            interface-parameters
                interface "a"
                exit
            exit
            targeted-session
            exit
----------------------------------------------
A:ALU_SIM11>config>router>ldp#
```

# Common Configuration Tasks

This section provides information to configure:

- Enabling LDP on page 244
- Targeted Session Parameters on page 248
- Peer Parameters on page 251

## 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 syntax to enable LDP on a 7210 SAS M OS router:

**CLI Syntax:** `ldp`

**Example:** `config>router#` **`ldp`**

The following displays the enabled LDP configuration.

```
A:ALU_SIM11>config>router>ldp# info
----------------------------------------------
            aggregate-prefix-match
                prefix-exclude "sample"
            exit
            graceful-restart
            exit
            peer-parameters
                peer 1.1.1.1
                    ttl-security 1
                exit
            exit
            interface-parameters
                interface "a"
                exit
            exit
            targeted-session
            exit
----------------------------------------------
A:ALU_SIM11>config>router>ldp#
```

## 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. Alcatel-Lucent's recovery is self-contained and relies on information stored internally to self-heal. This feature is only used to help third-party routers without a self-healing capability to recover.

Maximum recovery time is the time (in seconds) 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) the LSR is willing to retain its MPLS forwarding state. The time should be long enough to allow the neighboring LSRs to re-sync 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
```

## Applying Export and Import Policies

Both inbound and outbound label binding filtering are supported. Inbound filtering allows a route policy to control the label bindings 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:

- Neighbor — Match on bindings received from the specified peer.
- Interface — Match on bindings received from a neighbor or neighbors adjacent over the specified interface.
- Prefix-list — Match on bindings with the specified prefix/prefixes.

Outbound filtering allows a route policy to control the set of LDP label bindings advertised by the LSR. An export policy can control the set of LDP label bindings advertised by the router. By default, label bindings for only the system address are advertised and propagate all FECs that are received.

Matches can be based on:

- Loopback — loopback interfaces.
- All — all local subnets.
- Match — match on bindings with the specified prefix/prefixes.

Use the following syntax to apply import and export policies:

**CLI Syntax:**
```
config>router>ldp
  export policy-name [policy-name...(upto 32 max)]
  import policy-name [policy-name...(upto 32 max)]
```

```
A:ALU_SIM11>config>router>ldp# info
----------------------------------------------
            aggregate-prefix-match
                prefix-exclude "sample"
            exit
            graceful-restart
            exit
            peer-parameters
                peer 1.1.1.1
                    ttl-security 1
                exit
            exit
            interface-parameters
                interface "a"
                exit
            exit
            targeted-session
            exit
----------------------------------------------
```

## Targeted Session Parameters

Use the following 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
            hello timeout factor
            keepalive timeout factor
            no shutdown
```

The following example displays an LDP configuration example:

```
A:ALA-1>config>router>ldp# info
----------------------------------------------
...
            targeted-session
                hello 5000 255
                keepalive 5000 255
                peer 10.10.10.104
                    hello 2500 104
                    keepalive 15 3
                exit
            exit
----------------------------------------------
A:ALA-1>config>router>ldp#
```

## Interface Parameters

Use the following syntax to configure interface parameters:

**CLI Syntax:**

```
config>router# ldp
 interface-parameters
    hello timeout factor
    keepalive timeout factor
    transport-address {system|interface}
    interface ip-int-name
       hello timeout factor
       keepalive timeout factor
       transport-address {system|interface}
       no shutdown
```

The following example displays an interface parameter configuration example:

```
A:ALU_SIM11>config>router>ldp# info
----------------------------------------------
            aggregate-prefix-match
                prefix-exclude "sample"
            exit
            graceful-restart
            exit
            peer-parameters
                peer 1.1.1.1
                    ttl-security 1
                exit
            exit
            interface-parameters
                interface "a"
                exit
            exit
            targeted-session
            exit
----------------------------------------------
```

## Peer Parameters

Use the following syntax to specify interface parameters:

**CLI Syntax:**

```
config>router# ldp
 peer-parameters
    peer ip-address
       auth-keychain name
       authentication-key [authentication-key|hash-key]
       [hash|hash2]
```

```
A:ALA-1>config>router>ldp# info
----------------------------------------------
            peer-parameters
                peer 10.10.10.104
                    authentication-key "3WErEDozxyQ" hash
                exit
            exit
            targeted-session
                hello 5000 255
                keepalive 5000 255
                peer 10.10.10.104
                    hello 2500 100
                    keepalive 15 3
                exit
            exit
----------------------------------------------
A:ALA-1>config>router>ldp#
```

# 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 distribution paths (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 trigger session establishment. The SDP's signaling default enables **tldp**. The service SDP uses the targeted-session parameters configured in the **config>router>ldp>targeted-session** context.

The 7210 SAS M supports only Targeted LDP (TLDP).

The following example displays the command syntax usage to configure enable LDP on an MPLS SDP:

**CLI Syntax:**
```
config>service>sdp#
  signaling {off|tldp}
```

The following displays an example of an SDP configuration showing the signaling default `tldp` enabled.

```
A:ALA-1>config>service>sdp# info detail
----------------------------------------------
            description "MPLS: to-99"
            far-end 10.10.10.99
            lsp A_D_1
            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
----------------------------------------------
A:ALA-1>config>service>sdp#
```

# LDP Configuration Management Tasks

This section discusses the following LDP configuration management tasks:

- Disabling LDP on page 253
- Modifying Targeted Session Parameters on page 254

## 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 command syntax to disable LDP:

**CLI Syntax:**
```
no ldp
  shutdown
```

## Modifying Targeted Session Parameters

The modification of LDP targeted session parameters does not take effect until the next time the session goes down and is re-establishes. Individual parameters cannot be deleted. The no form of a **targeted-session** parameter command reverts modified values back to the default.

The following example displays the command syntax usage to revert targeted session parameters back to the default values:

**Example**:

```
config>router# ldp
config>router>ldp# targeted-session
config>router>ldp>targeted# no authentication-key
config>router>ldp>targeted# no disable-targeted-session
config>router>ldp>targeted# no hello
config>router>ldp>targeted# no keepalive
config>router>ldp>targeted# no peer 10.10.10.99
```

The following output displays the default values:

```
A:ALA-1>config>router>ldp>targeted# info detail
----------------------------------------------
                no disable-targeted-session
                hello 45 3
                keepalive 40 4
----------------------------------------------
A:ALA-1>config>router>ldp>targeted#
```

## Modifying Interface Parameters

The modification of LDP targeted session parameters does not take effect until the next time the session goes down and is re-establishes. Individual parameters cannot be deleted. The **no** form of a **interface-parameter** command reverts modified values back to the defaults.

The following output displays the default values:

```
A:ALU_SIM11>config>router>ldp>targ-session# info detail
----------------------------------------------
                no disable-targeted-session
                hello 45 3
                keepalive 40 4
----------------------------------------------
A:ALU_SIM11>config>router>ldp>targ-session#
```

# LDP Command Reference

## Command Hierarchies

- LDP Commands on page 257
- Show Commands on page 258
- Clear Commands on page 258
- Debug Commands on page 259

### LDP Commands

```
config
    — router
        — [no] ldp
            — [no] aggregate-prefix-match
                — prefix-exclude policy-name  [policy-name...(up to 5 max)]
                — no prefix-exclude
                — [no] shutdown
            — export policy-name [policy-name...(up to 5 max)]
            — no export
            — [no] export-tunnel-table policy-name
            — [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...(u pto 5 max)]
            — interface-parameters
                — hello timeout factor
                — no hello
                — [no] interface ip-int-name
                    — hello timeout factor
                    — no hello
                    — keepalive timeout factor
                    — no keepalive
                    — [no] shutdown
                    — transport-address {system | interface}
                — keepalive timeout factor
                — no keepalive
                — transport-address {system | interface}
            — label-withdrawal-delay seconds
            — peer-parameters
                — peer ip-address
                — no peer [ip-address]
                    — auth-keychain name
                    — authentication-key [authentication-key | hash-key] [hash | hash2]
                    — no authentication-key
                    — ttl-security min-ttl-value
```

```
                                    — [no] ttl-security
                    — [no] shutdown
                    — targeted-session
                            — [no] disable-targeted-session
                            — hello timeout factor
                            — no hello
                            — keepalive timeout factor
                            — no keepalive
                            — peer ip-address
                            — no peer ip-address
                                    — hello timeout factor
                                    — no hello
                                    — keepalive timeout factor
                                    — no keepalive
                                    — [no] shutdown
                    — tunnel-down-damp-time seconds
                    — no tunnel-down-damp-time
```

## Show Commands

```
show
    — router
            — ldp
                    — auth-keychain [keychain]
                    — bindings[fec-type fec-type [detail]] [session ip-addr[:label-space]]
                    — bindings [label-type] [start-label [end-label]
                    — bindings {prefix ip-prefix/mask [detail]}[session ip-addr[:label-space]]
                    — bindings active [prefix ip-prefix/mask]
                    — bindings service-id service-id [detail]
                    — bindings vc-type vc-type [{vc-id vc-id| agi agi} [session ip-addr[:lab el-space]]]
                    — discovery [{peer [ip-address]} | {interface [ip-int-name]}] [state state] [detail]
                    — interface [ip-int-name | ip-address] [detail]
                    — parameters
                    — peer [ip-address] [detail]
                    — peer-parameters peer-ip-address
                    — session [ip-addr[:label-space]] [detail | statistics [packet-type]]
                    — status
```

## Clear Commands

```
clear
    — router
            — ldp
                    — fec-egress-statistics [ip-prefix/mask]
                    — instance
                    — interface [ip-int-name]
                    — peer [ip-address] [statistics]
                    — session [ip-addr[:label-space]] [statistics]
                    — statistics
```

## Debug Commands

```
[no] debug
    — router
        — [no] ldp
            — [no] interface interface-name
                — [no] event
                    — [no] messages
                — [no] packet [detail]
                    — hello [detail]
                    — no hello
            — 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
```

# LDP Configuration Commands

# Generic Commands

## ldp

**Syntax** [**no**] **ldp**

**Context** config>router

**Default** This command creates the context to configure an LDP parameters. LDP is not enabled by default and must be explicitely enabled (**no shutdown**).

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** none (LDP must be explicitly enabled)

## shutdown

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

**Context** config>router>ldp
config>router>ldp>targ-session>peer
config>router>ldp>interface
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 may 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.

The **no** form of the command places an entity in an administratively enabled state.

**Default** no shutdown

## aggregate-prefix-match

**Syntax** [**no**] **aggregate-prefix-match**

**Context** config>router>ldp

**Description** The command enables the use by LDP of the aggregate prefix match procedures.

When this option is enabled, LDP performs the following procedures for all prefixes. When an LSR receives a FEC-label binding from an LDP neighbor for a given specific FEC1 element, it will install the binding in the LDP FIB if:

- It is able to perform a successful longest IP match of the FEC prefix with an entry in the routing table, and
- The advertising LDP neighbor is the next-hop to reach the FEC prefix.

When such a FEC-label binding has been installed in the LDP FIB, then LDP programs an NHLFE entry in the egress data path to forward packets to FEC1. It also advertises a new FEC-label binding for FEC1 to all its LDP neighbors.

When a new prefix appears in the routing table, LDP inspects the LDP FIB to determine if this prefix is a better match (a more specific match) for any of the installed FEC elements. For any FEC for which this is true, LDP may have to update the NHLFE entry for this FEC.

When a prefix is removed from the routing table, LDP inspects the LDP FIB for all FEC elements which matched this prefix to determine if another match exists in the routing table. If so, it updates the NHLFE entry accordingly. If not, it sends a label withdraw message to its LDP neighbors to remove the binding.

When the next hop for a routing prefix changes, LDP updates the LDP FIB entry for the FEC elements which matched this prefix. It also updates the NHLFE entry for these FEC elements accordingly.

The **no** form of this command disables the use by LDP of the aggregate prefix procedures and deletes the configuration. LDP resumes performing 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 procedures. In this case, LDP will perform an exact match of a specific FEC element prefix as opposed to a longest match of one or more LDP FEC element prefixes, against this prefix when it receives a FEC-label binding or when a change to this prefix occurs in the routing table.

The **no** form of this command removes all policies from the configuration.

**Default** no prefix-exclude.

## export

**Syntax** **export** *policy-name* [*policy-name …*upto 5 max]
**no export**

**Context** config>router>ldp

**Description** This command specifies the export route policies used to determine which routes are exported to LDP. Policies are configured in the **config>router>policy-options** context.

If no export policy is specified, non-LDP routes will not be exported from the routing table manager to LDP. LDP-learned routes will be exported to LDP neighbors. Present implementation of export policy (outbound filtering) can be used “only” to add FECs for label propagation. The export policy does not control propagation of FECs that an LSR receives from its 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 **no** form of the command removes all policies from the configuration.

**Default** **no export** — No export route policies specified.

**Parameters** *policy-name* — 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.

The specified name(s) must already be defined.

## export-tunnel-table

**Syntax** **[no] export-tunnel-table** *policy-name*

**Context** config>router>ldp

**Description** This command applies a tunnel table export policy to LDP for the purpose of learning BGP labeled routes from the CPM tunnel table and stitching them to LDP FEC for the same prefix.

The user enables the stitching of routes between LDP and BGP by configuring separately tunnel table route export policies in both protocols and enabling the advertising of RFC 3107, Carrying Label Information in BGP-4, formatted labeled routes for prefixes learned from LDP FECs.

The route export policy in BGP instructs BGP to listen to LDP route entries in the CPM Tunnel Table. If a /32 LDP FEC prefix matches an entry in the export policy, BGP originates a BGP labeled route, stitches it to the LDP FEC, and re-distributes the BGP labeled route to its iBGP neighbors.

The user adds LDP FEC prefixes with the statement ‘from protocol ldp’ in the configuration of the existing BGP export policy at the global level, the peer-group level, or at the peer level using the commands:

- configure>router>bgp>export policy-name
- configure>router>bgp>group>export policy-name
- configure>router>bgp>group>neighbour>export policy-name

To indicate to BGP to evaluate the entries with the ‘from protocol ldp’ statement in the export policy when applied to a specific BGP neighbor, a new argument is added to the existing advertise-label command:

**configure>router>bgp>group>neighbour>advertise-label ipv4 include-ldp-prefix**

Without the new **include-ldp-prefix** argument, only core IPv4 routes learned from RTM are advertised as BGP labeled routes to the neighbor. No stitching of LDP FEC to the BGP labeled route is performed for this neighbor even if the same prefix was learned from LDP.

The tunnel table route export policy in LDP instructs LDP to listen to BGP route entries in the CPM Tunnel Table. If a /32 BGP labeled route matches a prefix entry in the export policy, LDP originates an LDP FEC for the prefix, stitches it to the BGP labeled route, and re-distributes the LDP FEC to its BGP neighbors.

The user can add BGP labeled route prefixes with the statement ‘from protocol bgp’ in the configuration of the LDP tunnel table export policy. Note that the ‘from protocol’ statement has an effect only when the protocol value is ldp. Policy entries with protocol values of rsvp, bgp, or any value other than ldp are ignored at the time the policy is applied to LDP.

The no form of the command removes the policy from the configuration.

**Default** no export-tunnel-table — no tunnel table export route policy is specified.

**Parameters** *policy-name* — The export-tunnel-table 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.

## 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** **no graceful-restart** (**disabled**) — Graceful-restart must be explicitely enabled.

## implicit-null-label

**Syntax** [**no**] **implicit-null-label**

**Context** config>router>ldp

**Description** This command enables the use of the implicit null label. Use this command to signal the IMPLICIT NULL option for all LDP FECs for which this node is the egress LER.

The **no** form of this command disables the signaling of the implicit null label.

**Default** **no implicit-null-label**

## maximum-recovery-time

**Syntax** **maximum-recovery-time** *interval*
**no maximum-recovery-time**

**Context** config>router>ldp

**Description** This command configures the local maximum recovery time.

The **no** form of the command returns the default value.

**Default** 120

**Parameters** *interval* — Specifies the length of time in seconds.

**Values** 15 — 1800

## import

**Syntax** **import** *policy-name* [*policy-name …*upto 5 max]
**no import**

**Context** config>router>ldp

**Description** This command configures import route policies to determine which label bindings (FECs) are accepted from LDP neighbors.  Policies are configured in the **config>router>policy-options** context.

If no import policy is specified, LDP accepts all label bindings 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 **no** form of the command removes all policies from the configuration.

**Default** **no import** — No import route policies specified.

**Parameters** *policy-name* — 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.

The specified name(s) must already be defined.

## label-withdrawal-delay

**Syntax** **label-withdrawal-delay** *seconds*

**Context** config>router>ldp

**Description** This command specifies configures the time interval, in seconds, LDP will delay for the withdrawal of FEC-label binding it distributed to its neighbors when FEC is de-activated. When the timer expires, LDP then sends a label withdrawal for the FEC to all its neighbous. This is applicable only to LDP transport tunnels (IPv4 prefix FECs) and is not applicable to pseudowires (service FECs).

**Default** no label-withdrawal-delay

**Parameters** *seconds* — Specifies the time that LDP delays the withdrawal of FEC-label binding it distributed to its neighbors when FEC is de-activated.

**Values** 3 — 120

## 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 de-activates it, it de-programs 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 users of the LDP tunnel, such as SDPs (all services) and BGP (L3 VPN), will not be notified immediately. Traffic is still blackholed because the IOM NHLFE has been de-programmed.

If the FEC gets resolved before the tunnel-down-damp-time timer expires, then LDP programs the IOM with the new NHLFE and performs a tunnel modify event in TTM updating the dampened entry in 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 TTM which deletes the LDP tunnel.

The **no** form of this command then tunnel down events are not damped.

**Parameters** *seconds* — Specifies the time interval, in seconds, that LDP waits before posting a tunnel down event to the Tunnel Table Manager.

**Values** 0 — 20

## keepalive

**Syntax** **keepalive** *timeout factor*
**no keepalive**

**Context** config>router>ldp>interface-parameters
config>router>ldp>targ-session
config>router>ldp>targ-session>peer
config>router>ldp>if-params>if

**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 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 interface level, sets the **keepalive timeout** and the **keepalive factor** to the value defined under the **interface-parameters** level.

The **no** form of the command, at the peer level, will set the **keepalive timeout** and the **keepalive factor** to the value defined under the **targeted-session** level.

Note that the session needs to be flapped for the new args to operate.

**Default**

| Context | timeout | factor |
|---|---|---|
| config>router>ldp>if-params | 30 | 3 |
| config>router>ldp>targ-session | 40 | 4 |
| config>router>ldp>if-params>if | Inherits values from interface-parameters context. | |
| config>router>ldp>targ-session>peer | Inherits values from targeted-session context. | |

**Parameters** *timeout* — Configures the time interval, expressed in seconds, that LDP waits before tearing down the session.

**Values** 3 — 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 — 255

## interface-parameters

**Syntax** **interface-parameters**

**Context** config>router>ldp

**Description** This command enables the context to configure LDP interfaces and parameters applied to LDP interfaces.

## hello

**Syntax** **hello** *timeout factor*
**no hello**

**Context** config>router>ldp>interface-parameters
config>router>ldp>targ-session
config>router>ldp>targ-session>peer

**Description** This command configures 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 sent in the hello messages to the neighbor. Hold time cannot be less than three times the hello interval.

When LDP session is being set up, the holddown time is negotiated to the lower of the two peers. Once a 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 targeted-session level sets the **hello timeout** and the **hello factor** to the default values.

The **no** form of the command, at the peer level, will set the **hello timeout** and the **hello factor** to the value defined under the targeted-session level.

Note that the session needs to be flapped for the new args to operate.

**Default**

| Context | Timeout | Factor |
|---|---|---|
| config>router>ldp>if-params | 15 | 3 |
| config>router>ldp>targ-session | 45 | 3 |
| config>router>ldp>if-params>if | Inherits values from interface-parameters context. | |
| config>router>ldp>targ-session>peer | Inherits values from targeted-session context. | |

**Parameters** *timeout* — Configures the time interval, in seconds, that LDP waits before a neighbor down.

**Values** 3 — 65535

*factor* — Specifies the number of keepalive messages that should be sent on an idle LDP session in the hello timeout interval.

**Values** 1 — 255

## interface

**Syntax** [**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.

**Parameters** *ip-int-name* — The name of an existing interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

## transport-address

**Syntax** **transport-address** {**interface** | **system**}
**no transport-address**

**Context** config>router>ldp>if-params
config>router>ldp>if-params>if

**Description** This command configures the transport address to be used when setting up the LDP TCP sessions. The transport address can be configured as **interface** or **system**. 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 which 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 situation can not only happen with parallel links, it could be a link and a targeted adjacency since targeted adjacencies request the session to be set up only to the system IP address.

Note that 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 for **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 match the adjacency to the session.

Note that for any given ILDP interface, as the **local-lsr-id** parameters is changed to **interface**, the **transport-address** configuration loses effectiveness. Since it will be ignored and the ILDP session will *always* use the relevant interface IP address as transport-address even though system is chosen.

The **no** form of the command, at the global level, sets the transport address to the default value.
The **no** form of the command, at the interface level, sets the transport address to the value defined under the global level.

**Default** **system** — The system IP address is used.

**Parameters** **interface —** 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 —** The system IP address is used to set up the LDP session between neighbors.

# Peer Parameters Commands

## peer-parameters

**Syntax** **peer-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>peer-parameters

**Description** This command configures parameters for an LDP peer.

**Default** **none**

**Parameters** *ip-addr* — The IP address of the LDP peer in dotted decimal notation.

## auth-keychain

**Syntax** **auth-keychain** *name*

**Context** config>router>ldp>peer-parameters>peer

**Description** This command configures TCP authentication keychain to use for the session.

**Parameters** *name* — Specifies the name of the keychain to use for the specified TCP session or sessions. This keychain allows the rollover of authentication keys during the lifetime of a session up to 32 characters in length. Peer address has to be the TCP session transport address.

## authentication-key

**Syntax** **authentication-key** [*authentication-key* **|** *hash-key*] [**hash | hash2**]
**no authentication-key**

**Context** config>router>ldp>peer-parameters>peer

**Description** This command specifies the authentication key to be used between LDP peers before establishing sessions. Authentication uses the MD-5 message-based digest. Peer address has to be the TCP session transport address.

The **no** form of this command disables authentication.

**Default** **none**

**Parameters** *authentication-key* — The authentication key. The key can be any combination of ASCII characters up to 16 characters in length (unencrypted). If spaces are used in the string, enclose the entire string in quotation marks (“ ”).

*hash-key* — 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** parameter is not used, the less encrypted **hash** form is assumed.

## ttl-security

**Syntax** **ttl-security** *min-ttl-value*
**no ttl-security**

**Context** config>router>ldp>peer-parameters>peer

**Description** This command configures TTL security parameters for incoming packets. When the feature is enabled, BGP/LDP will accept incoming IP packets from a peer only if the TTL value in the packet is greater than or equal to the minimum TTL value configured for that peer. Peer address has to be the TCP session transport address.

The **no** form of the command disables TTL security.

**Default** **no ttl-security**

**Parameters** *min-ttl-value* — Specify the minimum TTL value for an incoming packet.

**Values** 1 — 255

# 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** none

## disable-targeted-session

**Syntax** [**no**] **disable-targeted-session**

**Context** config>router>ldp>targ-session

**Description** This command disables support for SDP triggered automatic generated 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 set up 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** **none**

**Parameters** *ip-address* — The IP address of the LDP peer in dotted decimal notation.

# Show LDP Commands

## auth-keychain

**Syntax** **auth-keychain** [*keychain*]

**Context** show>router>ldp

**Description** This command displays LDP sessions using a particular authentication key-chain.

**Parameters** *keychain* — Specifies an existing keychain name.

### Sample Output

```
*A:ALA-48>config>router>ldp# show router ldp auth-keychain
===============================================================================
LDP Peers
===============================================================================
Peer             TTL Security Min-TTL-Value Authentication Auth key chain
-------------------------------------------------------------------------------
10.20.1.3        Disabled     n/a           Disabled       eta_keychain1
-------------------------------------------------------------------------------
No. of Peers: 1
===============================================================================
*A:ALA-48>config>router>ldp#
```

## bindings

**Syntax**
**bindings** [**fec-type** *fec-type* [**detail**]] [**session** *ip-addr*[:*label-space*]]
**bindings** *label-type start-label* [*end-label*]
**bindings** {**prefix** *ip-prefix/mask* [detail]} [session *ip-addr*[*:label-space*]]
**bindings active** [**prefix** *ip-prefix/mask*]
**bindings service-id** *service-id* [**detail**]
**bindings vc-type** *vc-type* [{**vc-id** *vc-id* **| agi** *agi*} [**session** *ip-addr*[:*lab el-space*]]

**Context** show>router>ldp

**Description** This command displays the contents of the label information base.

**Parameters** **detail —** Displays detailed information.

*label-space* — Specifies the label space identifier that the router is advertising on the interface.

**Values** 0 — 65535

*start-label* — Specifies a label value to begin the display.

**Values** 16 — 1048575

*end-label* — Specifies a label value to end the display.

**Values** 17 — 1048575

*vc-type* — Specifies the VC type to display.

**Values** **ethernet** , **vlan** , **mirror**

*vc-id* — Specifies the VC ID to display.

**Values** 1 — 4294967295

*service-id* — Specifies the service ID number to display.

**Values** 1 — 2147483647

**Output** **LDP Bindings Output —** The following table describes the LDP bindings fields.

| Label | Description | |
|---|---|---|
| `Legend` | U: Label In Use<br>N: Label Not In Use<br>W: Label Withdrawn<br>S: Status Signaled Up<br>D: Status Signaled Down<br>E: Epipe service<br>V: VPLS service<br>M: Mirror service | A: Apipe service<br>F: Fpipe service<br>I: IES service<br>R: VPRN service<br>P: Ipipe service<br>WP: Label Withdraw Pending<br>C: Cpipe service<br>TLV: (Type, Length: Value) |
| `Type` | The service type exchanging labels. The possible types displayed are VPLS, Epipe, Spoke, and Unknown. | |
| `VCId` | The value used by each end of an SDP tunnel to identify the VC. | |
| `SvcID` | The unique service identification number identifying the service in the service domain. | |
| `Peer` | The IP address of the peer. | |
| `EgrIntf/LspId` | Displays the LSP Tunnel ID (not the LSP path ID). | |
| `IngLbl` | The ingress LDP label.<br>U — Label in use.<br>R — Label released. | |
| `EgrLbl` | The egress LDP label. | |
| `LMTU` | The local MTU value. | |
| `RMTU` | The remote MTU value. | |
| `No. of Service Bindings` | The total number of LDP bindings on the router. | |

**Sample Output**

```
*A:Dut-A# show router ldp bindings
===============================================================================
LDP LSR ID: 10.20.1.1
```

```
===============================================================================
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
===============================================================================
LDP Prefix Bindings
===============================================================================
Prefix             Peer            IngLbl  EgrLbl EgrIntf/LspId EgrNextHop
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
LDP Service Bindings
===============================================================================
Type   VCId       SvcId      SDPId  Peer            IngLbl  EgrLbl  LMTU  RMTU
-------------------------------------------------------------------------------
V-Vlan 201        201        1210   10.20.1.2       130604U 131036  1500  1500
V-Vlan 201        201        1410   10.20.1.4       130728U 131016S 1500  1500
V-Vlan 202        202        1210   10.20.1.2       130603U 131035  1500  1500
V-Vlan 202        202        1410   10.20.1.4       130727U 131003S 1500  1500
V-Vlan 203        203        1210   10.20.1.2       130602U 131034  1500  1500
...
===============================================================================
*A:Dut-A#
*A:Dut-A# show router ldp bindings ingress-label 32768 131071
===============================================================================
LDP LSR ID: 10.20.1.1
===============================================================================
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
===============================================================================
LDP Prefix Bindings
===============================================================================
Prefix             Peer            IngLbl  EgrLbl EgrIntf       EgrNextHop
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
LDP Service Bindings
===============================================================================
Type   VCId       SvcId      SDPId  Peer            IngLbl  EgrLbl  LMTU  RMTU
-------------------------------------------------------------------------------
V-Vlan 201        201        1210   10.20.1.2       130604U 131036  1500  1500
V-Vlan 201        201        1410   10.20.1.4       130728U 131016S 1500  1500
V-Vlan 202        202        1210   10.20.1.2       130603U 131035  1500  1500
V-Vlan 202        202        1410   10.20.1.4       130727U 131003S 1500  1500
V-Vlan 203        203        1210   10.20.1.2       130602U 131034  1500  1500
...
===============================================================================
*A:Dut-A#

*A:ALU_SIM11>show>router>ldp# bindings
===============================================================================
LDP LSR ID: 1.1.1.2
===============================================================================
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
        TLV - (Type, Length: Value)
===============================================================================
LDP Prefix Bindings
===============================================================================
Prefix             Peer            IngLbl    EgrLbl EgrIntf/    EgrNextHop
                                                    LspId
-------------------------------------------------------------------------------
1.1.1.1/32         1.1.1.1           --      131071 1/1/1       6.6.6.1
1.1.1.2/32         1.1.1.1         131071U     --     --          --
-------------------------------------------------------------------------------
No. of Prefix Bindings: 2
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type   VCId       SvcId      SDPId  Peer            IngLbl  EgrLbl  LMTU  RMTU
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
LDP Service FEC 129 Bindings
===============================================================================
AGI                                 SAII                    TAII
Type              SvcId      SDPId  Peer            IngLbl  EgrLbl  LMTU  RMTU
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
*A:ALU_SIM11>show>router>ldp#
```

## discovery

**Syntax** **discovery** [{**peer** [*ip-address*]} **|** {**interface** [*ip-int-name*]}] [**state** *state*] [**detail**] [**adjacency-type** *type*]

**Context** show>router>ldp

**Description** This command displays the status of the interfaces participating in LDP discovery.

**Parameters** **peer** *ip-address* — Specifies to display the IP address of the peer.

**interface** *ip-int-name* — The name of an existing interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

**state** *state* — Specifies to display the current operational state of the adjacency.

**Values** established, trying, down

**detail —** Specifies to display detailed information.

**adjacency-type** *type* **—** Specifies to display the adjacency type.

**Values** link, targeted

**Output** **LDP Discovery Output —** The following table describes LDP discovery output fields.

| 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 is targeted. |
| `State` | `Established` — The adjacency is established. |
| | `Trying` — 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 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 sent when this adjacency started up. This configuration sequence number changes when there is a change of configuration. |
| `Local IP Address` | The IP address used locally for the LDP session. |

## 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* — The name of an existing interface. If the string contains special characters (#, $, spaces, etc.), the entire string must be enclosed within double quotes.

*ip-address* — The IP address of the LDP neighbor.

**detail —** Displays detailed information.

**Output** **LDP Interface Output —** The following table describes the LDP interface output fields.

| Label | Description |
|---|---|
| `Interface` | Specifies the interface associated with the LDP instance. |
| `Adm` | `Up` — The LDP is administratively enabled.<br>`Down` — The LDP is administratively disabled. |
| `Opr` | `Up` — The LDP is operationally enabled.<br>`Down` — The LDP is operationally disabled. |
| `Hello Factor` | The value by which the hello timeout should be divided to give the hello time, for example, 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 hello time, also known as hold time. It is the time interval, in seconds, that LDP waits before declaring a neighbor to be down. Hello timeout is local to the system and is sent in the hello messages to a neighbor. |
| `KA Factor` | The value by which the keepalive timeout should be divided to give the keepalive time, for example, 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 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 3 times the keepalive time (the time interval between successive LDP keepalive messages). |
| `Auth` | `Enabled` — Authentication using MD5 message based digest protocol is enabled.<br>`Disabled` — No authentication is used. |
| `No. of Interface` | The total number of LDP interfaces. |

**Sample Output**

```
*A:ALU_SIM11>show>router>ldp# interface
===============================================================================
LDP Interfaces
===============================================================================
Interface                        Adm Opr  Hello  Hold  KA     KA      Transport
                                          Factor Time  Factor Timeout Address
-------------------------------------------------------------------------------
a                                Up  Up   3      15    3      30      System
-------------------------------------------------------------------------------
No. of Interfaces: 1
===============================================================================
*A:ALU_SIM11>show>router>ldp# interface detail
*A:ALU_SIM11>show>router>ldp#
===============================================================================
LDP Interfaces (Detail)
===============================================================================
Interface "a"
-------------------------------------------------------------------------------
Admin State        : Up                   Oper State       : Up
Hold Time          : 15                   Hello Factor     : 3
Keepalive Timeout  : 30                   Keepalive Factor : 3
Transport Addr     : System               Last Modified    : 07/06/2010 10:36:59
Active Adjacencies : 1
Tunneling          : Disabled
Lsp Name           : None
===============================================================================
*A:ALU_SIM11>show>router>ldp#
```

## parameters

**Syntax** **parameters**

**Context** show>router>ldp

**Description** This command displays configuration information about LDP parameters.

**Output** **LDP Parameters Output —** The following table describes the LDP parameters output fields.

| Label | Description |
|---|---|
| `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. |
| `Hello Factor` | The value by which the hello timeout should be divided to give the hello time, for example, 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. |
| `Auth` | `Enabled` — Authentication using MD5 message based digest protocol is enabled.<br>`Disabled` — No authentication is used. |
| `Passive-Mode` | `true` — LDP responds only when it gets a connect request from a peer and will not attempt to actively connect to its neighbors.<br>`false` — LDP actively tries to connect to its peers. |
| `Targeted-Sessions` | `true` — Targeted sessions are enabled.<br>`false` — Targeted sessions are disabled. |

**Sample Output**

```
*A:SRU4>config>router>ldp# show router ldp parameters
===============================================================================
LDP Parameters (LSR ID 110.20.1.4)
===============================================================================
-------------------------------------------------------------------------------
Graceful Restart Parameters
-------------------------------------------------------------------------------
Nbor Liveness Time : 5 sec                Max Recovery Time : 30
-------------------------------------------------------------------------------
Interface Parameters
-------------------------------------------------------------------------------
Keepalive Timeout  : 30 sec               Keepalive Factor  : 3
Hold Time          : 15 sec               Hello Factor      : 3
Propagate Policy   : system               Transport Address : system
Deaggregate FECs   : False                Route Preference  : 9
Label Distribution : downstreamUnsolicited Label Retention   : liberal
Control Mode       : ordered              Loop Detection    : none
-------------------------------------------------------------------------------
Targeted Session Parameters
-------------------------------------------------------------------------------
Keepalive Timeout  : 40 sec               Keepalive Factor  : 4
Hold Time          : 45 sec               Hello Factor      : 3
Passive Mode       : False                Targeted Sessions : Enabled
===============================================================================
*A:SRU4>config>router>ldp#
```

## peer

**Syntax** **peer** [*ip-address*] [**detail**]

**Context** show>router>ldp

**Description** This command displays configuration information about LDP peers.

**Parameters** *ip-address* — The IP address of the LDP peer.

**detail —** Displays detailed information.

**Output** **LDP Peer Output —** The following table describes LDP peer output.

| Label | Description |
|---|---|
| `Peer` | The IP address of the peer. |
| `Adm` | `Up` — The LDP is administratively enabled.<br>`Down` — The LDP is administratively disabled. |
| `Opr` | `Up` — The LDP is operationally enabled.<br>`Down` — The LDP is operationally disabled. |
| `Hello Factor` | The value by which the hello timeout should be divided to give the hello time, for example, 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. |

| Label | Description (Continued) |
|---|---|
| Hold Time | The hello time or hold time. The time interval, in seconds, that LDP waits before declaring a neighbor to be down. Hello timeout is local to the system and is sent in the hello messages to a neighbor. |
| KA Factor | The value by which the keepalive timeout should be divided to give the keepalive time, for example, 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 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 3 times the keepalive time (the time interval between successive LDP keepalive messages). |
| Auth | Enabled — Authentication using MD5 message based digest protocol is enabled.<br>Disabled — No authentication is used. |
| Passive Mode | The mode used to set up LDP sessions. This value is only applicable to targeted sessions and not to LDP interfaces.<br>True — LDP responds only when it gets a connect request from a peer and will not attempt to actively connect to its neighbors.<br>False — LDP actively tries to connect to its peers. |
| Auto Create | Specifies if a targeted peer was automatically created through service manager. For an LDP interface, this value is always false. |
| No. of Peers | The total number of LDP peers. |

### Sample Output

```
*A:SRU4>config>router>ldp# show router ldp peer
===============================================================================
LDP Peers
===============================================================================
Peer              Adm  Opr  Hello   Hold    KA      KA       Passive   Auto
                            Factor  Time    Factor  Timeout  Mode      Created
-------------------------------------------------------------------------------
10.8.100.15       Up   Up   3       45      4       40       Disabled  No
10.20.1.20        Up   Up   3       45      4       40       Disabled  No
10.20.1.22        Up   Up   3       45      4       40       Disabled  No
10.100.1.1        Up   Up   3       45      4       40       Disabled  No
110.20.1.1        Up   Up   3       45      4       40       Disabled  No
110.20.1.2        Up   Up   3       45      4       40       Disabled  No
110.20.1.3        Up   Up   3       45      4       40       Disabled  No
110.20.1.5        Up   Up   3       45      4       40       Disabled  No
110.20.1.6        Up   Up   3       45      4       40       Disabled  No
110.20.1.51       Up   Up   3       45      4       40       Disabled  No
110.20.1.52       Up   Up   3       45      4       40       Disabled  No
```

```
110.20.1.53       Up   Up   3       45      4       40       Disabled  No
110.20.1.55       Up   Up   3       45      4       40       Disabled  No
110.20.1.56       Up   Up   3       45      4       40       Disabled  No
110.20.1.110      Up   Up   3       45      4       40       Disabled  No
110.20.1.150      Up   Up   3       45      4       40       Disabled  No
220.220.1.6       Up   Up   3       45      4       40       Disabled  No
-------------------------------------------------------------------------------
No. of Peers: 17
===============================================================================
*A:SRU4>config>router>ldp#


*A:SRU4>config>router>ldp#  show router ldp peer detail
===============================================================================
LDP Peers (Detail)
===============================================================================
-------------------------------------------------------------------------------
Peer 10.8.100.15
-------------------------------------------------------------------------------
Admin State        : Up              Oper State           : Up
Hold Time          : 45              Hello Factor         : 3
Keepalive Timeout  : 40              Keepalive Factor     : 4
Passive Mode       : Disabled        Last Modified        : 03/03/2010 19:47:34
Active Adjacencies : 1               Auto Created         : No
Tunneling          : Disabled
Lsp Name           : None
Local LSR          : None
BFD Status         : Disabled
-------------------------------------------------------------------------------
Peer 10.20.1.20
-------------------------------------------------------------------------------
Admin State        : Up              Oper State           : Up
Hold Time          : 45              Hello Factor         : 3
Keepalive Timeout  : 40              Keepalive Factor     : 4
Passive Mode       : Disabled        Last Modified        : 03/03/2010 19:47:34
Active Adjacencies : 1               Auto Created         : No
Tunneling          : Disabled
Lsp Name           : None
Local LSR          : None
BFD Status         : Disabled
...
-------------------------------------------------------------------------------
Peer 220.220.1.6
-------------------------------------------------------------------------------
Admin State        : Up              Oper State           : Up
Hold Time          : 45              Hello Factor         : 3
Keepalive Timeout  : 40              Keepalive Factor     : 4
Passive Mode       : Disabled        Last Modified        : 03/03/2010 19:47:34
Active Adjacencies : 0               Auto Created         : No
Tunneling          : Disabled
Lsp Name           : None
Local LSR          : None
BFD Status         : Disabled

===============================================================================
*A:SRU4>config>router>ldp#

*A:SRU4>config>router>ldp#    show router ldp peer 10.8.100.15 detail
===============================================================================
LDP Peers (Detail)
===============================================================================
-------------------------------------------------------------------------------
Peer 10.8.100.15
-------------------------------------------------------------------------------
Admin State        : Up              Oper State           : Up
Hold Time          : 45              Hello Factor         : 3
Keepalive Timeout  : 40              Keepalive Factor     : 4
Passive Mode       : Disabled        Last Modified        : 03/03/2010 19:47:34
Active Adjacencies : 1               Auto Created         : No
Tunneling          : Disabled
Lsp Name           : None
Local LSR          : None
BFD Status         : Disabled
===============================================================================
*A:SRU4>config>router>ldp#
```

## peer-parameters

**Syntax** **peer-parameters** *peer-ip-address*

**Context** show>router>ldp

**Description** This command displays LDP peer information.

**Parameters** *peer-ip-address* — Specify the peer IP address.

**LDP peer-parameters output —** The following table describes LDP peer-parameters output.

| Label | Description |
|---|---|
| `Peer` | The IP address of the peer. |
| `TTL security` | `Enabled` — LDP peering sessions protected. |
| | `Disabled` — LDP peering sessions unprotected. |
| `Min-TTL-Value` | Displays the minimum TTL value for an incoming packet. |
| `Auth` | `Enabled` — Authentication using MD5 message based digest protocol is enabled. |
| | `Disabled` — No authentication is used. |

# session

**Syntax** **session** [*ip-addr*[:*label-space*]] [**detail | statistics** [*packet-type*]] [*session-type*]

**Context** show>router>ldp

**Description** This command displays configuration information about LDP sessions.

**Parameters** *ip-address* — Specify the IP address of the LDP peer.

*label-space* — Specifies the label space identifier that the router is advertising on the interface.

**Values** 0 — 65535

**detail —** Displays detailed information.

**statistics** *packet-type* **—** Specify the packet type.

**Values** hello, keepalive, init, label, notification, address

*session-type* — Specifies to display the session type.

**Values** link, targeted, both

**Output** **LDP Session Output —** The following table describes LDP session output fields.

| Label | Description |
|---|---|
| `Peer LDP ID` | The IP address of the LDP peer. |
| `Adj Type` | The adjacency type between the LDP peer and LDP session is targeted.<br>`Link` — Specifies that this adjacency is a result of a link hello.<br>`Targeted` — Specifies that this adjacency is a result of a targeted hello. |
| `State` | Established — The adjacency is established.<br>Trying — The adjacency is not yet established. |
| `Mesg Sent` | The number of messages sent. |
| `Mesg Rcvd` | The number of messages received. |
| `Up Time` | The amount of time the adjacency has been enabled. |

### Sample Output

```
*A:SRU4>config>router>ldp#   show router ldp session
==============================================================================
LDP Sessions
==============================================================================
Peer LDP Id        Adj Type   State         Msg Sent  Msg Recv  Up Time
------------------------------------------------------------------------------
1.1.1.1:0          Link       Nonexistent   2         1         0d 00:00:04
10.8.100.15:0      Both       Nonexistent   14653     21054     0d 12:48:25
10.20.1.20:0       Both       Established   105187    84837     0d 12:48:27
```

```
10.20.1.22:0       Both       Established   144586    95148     0d 12:48:23
11.22.10.2:0       Link       Nonexistent   4         2         0d 00:00:16
11.22.11.2:0       Link       Nonexistent   4         4         0d 00:00:14
11.22.13.2:0       Link       Nonexistent   5         6         0d 00:00:20
33.66.33.1:0       Link       Nonexistent   6         7         0d 00:00:25
33.66.34.1:0       Link       Nonexistent   2         2         0d 00:00:05
33.66.35.1:0       Link       Nonexistent   4         4         0d 00:00:14
110.20.1.1:0       Targeted   Nonexistent   0         1         0d 00:00:04
110.20.1.3:0       Both       Established   94        97        0d 00:00:55
110.20.1.5:0       Both       Established   230866    286216    0d 12:48:27
110.20.1.110:0     Link       Nonexistent   2         2         0d 00:00:05
200.0.0.1:0        Link       Nonexistent   2         2         0d 00:00:05
-------------------------------------------------------------------------------
No. of Sessions: 15
===============================================================================
*A:SRU4>config>router>ldp#


*A:SRU4>config>router>ldp# show router ldp session 10.20.1.20:0
===============================================================================
LDP Sessions
===============================================================================
Peer LDP Id        Adj Type   State         Msg Sent  Msg Recv  Up Time
-------------------------------------------------------------------------------
10.20.1.20:0       Both       Established   105204    84859     0d 12:49:05
-------------------------------------------------------------------------------
No. of Sessions: 1
===============================================================================
*A:SRU4>config>router>ldp#
```

## status

**Syntax** **status**

**Context** show>router>ldp

**Description** This command displays LDP status information.

**Output** **LDP Status Output —** The following table describes LDP status output fields.

| Label | Description |
|---|---|
| `Admin State` | `Up` — The LDP is administratively enabled.<br>`Down` — The LDP is administratively disabled. |
| `Oper State` | `Up` — The LDP is operationally enabled.<br>`Down` — The LDP is operationally disabled. |
| `Created at` | The date and time when the LDP instance was created. |
| `Up Time` | The time, in hundreths of seconds, that the LDP instance has been operationally up. |
| `Last Change` | The date and time when the LDP instance was last modified. |
| `Oper Down Events` | The number of times the LDP instance has gone operationally down since the instance was created. |
| `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. |

| Label | Description (Continued) |
|---|---|
| `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. |
| `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. |
| `Shutdown Notif Sent` | The number of shutdown notifications sent related to 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 Recv` | The number of shutdown notifications received related to sessions associated with this LDP instance. |

# Clear Commands

## fec-egress-statistics

**Syntax** **fec-egress-statistics** [*ip-prefix/mask*]

**Context** clear>router>ldp

**Description** This command clears LDP FEC egress statistics..

*ip-prefix* — Specify information for the specified IP prefix and mask length. Host bits must be 0.

*mask* — Specifies the 32-bit address mask used to indicate the bits of an IP address that are being used for the subnet address.

**Values** 0 — 32

## instance

**Syntax** **instance**

**Context** clear>router>ldp

**Description** This command resets the LDP instance.

## interface

**Syntax** **interface** [*ip-int-name*]

**Context** clear>router>ldp

**Description** This command restarts or clears statistics for LDP interfaces.

**Parameters** *ip-int-name* — The name of an existing interface. If the string contains special characters (#, $, spaces and other special characters), the entire string must be enclosed within double quotes.

## peer

**Syntax** **peer** [*ip-address*] [**statistics**]

**Context** clear>router>ldp

**Description** This command restarts or clears statistics for LDP targeted peers.

**Parameters** *ip-address* — The IP address of 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** *label-space* — Specifies the label space identifier that the router is advertising on the interface.

**Values** 0 — 65535

**statistics —** Clears only the statistics for a session.

## statistics

**Syntax** **statistics**

**Context** clear>router>ldp

**Description** This command clears LDP instance statistics.

# Debug Commands

The following output shows debug LDP configurations discussed in this section.

```
A:ALA-12# debug router ldp peer 10.10.10.104
A:ALA-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
A:ALA-12>debug>router>ldp#
```

## ldp

**Syntax** [**no**] **ldp**

**Context** debug>router

**Description** Use this command to configure LDP debugging.

## interface

**Syntax** [**no**] **interface** *interface-name*

**Context** debug>router>ldp

**Description** Use this command for debugging an LDP interface.

**Parameters** *interface-name* — The name of an existing interface.

## peer

**Syntax** [**no**] **peer** *ip-address*

**Context** debug>router>ldp

**Description** Use this command for debugging an LDP peer.

**Parameters** ***ip-address*** — The IP address of the LDP peer.

## event

**Syntax** [**no**] **event**

**Context** 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>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** **packet** [**detail**]
**no packet**

**Context** debug>router>ldp>peer

**Description** This command enables debugging for specific LDP packets.

The **no** form of the command disables the debugging output.

**Parameters** **detail —** Displays detailed information.

# hello

**Syntax** **hello** [**detail**]
**no hello**

**Context** debug>router>ldp>peer>packet

**Description** This command enables debugging for 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 **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>peer>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.

# Standards and Protocol Support (for 7210 SAS-M, 7210 SAS-X, and 7210 SAS-T)

**NOTE:** The capabilities available when operating in access-uplink mode/L2 mode and network mode/MPLS mode are different. Correspondingly, not all the standards and protocols listed below are supported in both the modes.

## Standards Compliance

IEEE 802.1ab-REV/D3 Station and Media Access Control Connectivity Discovery
IEEE 802.1D Bridging
IEEE 802.1p/Q VLAN Tagging
IEEE 802.1s Multiple Spanning Tree
IEEE 802.1w Rapid Spanning Tree Protocol
IEEE 802.1X Port Based Network Access Control
IEEE 802.1ad Provider Bridges
IEEE 802.1ah Provider Backbone Bridges
IEEE 802.1ag Service Layer OAM
IEEE 802.3ah Ethernet in the First Mile
IEEE 802.3 10BaseT
IEEE 802.3ad Link Aggregation
IEEE 802.3ae 10Gbps Ethernet
IEEE 802.3u 100BaseTX
IEEE 802.3z 1000BaseSX/LX ITU-T Y.1731 OAM functions and mechanisms for Ethernet based networks draft-ietf-disman-alarm-mib-04.txt IANA-IFType-MIB
IEEE8023-LAG-MIB ITU-T G.8032 Ethernet Ring Protection Switching (version 2)

## Protocol Support

### BGP

RFC 1397 BGP Default Route Advertisement
RFC 1772 Application of BGP in the Internet
RFC 1997 BGP Communities Attribute
RFC 2385 Protection of BGP Sessions via MD5
RFC 2439 BGP Route Flap Dampening
RFC 2547 bis BGP/MPLS VPNs draft-ietf-idr-rfc2858bis-09.txt.
RFC 2918 Route Refresh Capability for BGP-4
RFC 3107 Carrying Label Information in BGP-4
RFC 3392 Capabilities Advertisement with BGP4
RFC 4271 BGP-4 (previously RFC 1771)
RFC 4360 BGP Extended Communities Attribute
RFC 4364 BGP/MPLS IP Virtual Private Networks (VPNs) (previously RFC 2547bis BGP/MPLS VPNs)
RFC 4760 Multi-protocol Extensions for BGP
RFC 4893 BGP Support for Four-octet AS Number Space

### CIRCUIT EMULATION

RFC 4553 Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)
RFC 5086 Structure-Aware Time Division Multiplexed (TDM) Circuit Emulation Service over Packet Switched Network (CESoPSN)
RFC 5287 Control Protocol Extensions for the Setup of Time-Division Multiplexing (TDM) Pseudowires in MPLS Networks

### DHCP

RFC 2131 Dynamic Host Configuration Protocol (REV)
RFC 3046 DHCP Relay Agent Information Option (Option 82)

### DIFFERENTIATED SERVICES

RFC 2474 Definition of the DS Field the IPv4 and IPv6 Headers (Rev)
RFC 2597 Assured Forwarding PHB Group (rev3260)
RFC 2598 An Expedited Forwarding PHB
RFC 2697 A Single Rate Three Color Marker
RFC 2698 A Two Rate Three Color Marker
RFC 4115 A Differentiated Service Two-Rate, Three-Color Marker with Efficient Handling of in-Profile Traffic

### IPv6

RFC 2460 Internet Protocol, Version 6 (IPv6) Specification
RFC 2461 Neighbor Discovery for IPv6
RFC 2462 IPv6 Stateless Address Auto configuration
RFC 2463 Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 Specification
RFC 2464 Transmission of IPv6 Packets over Ethernet Networks
RFC 2740 OSPF for IPv6
RFC 3587 IPv6 Global Unicast Address Format
RFC 4007 IPv6 Scoped Address Architecture
RFC 4193 Unique Local IPv6 Unicast Addresses
RFC 4291 IPv6 Addressing Architecture
RFC 4552 Authentication/Confidentiality for OSPFv3
RFC 5095 Deprecation of Type 0 Routing Headers in IPv6
draft-ietf-isis-ipv6-05
draft-ietf-isis-wg-multi-topology-xx.txt

### IS-IS

RFC 1142 OSI IS-IS Intra-domain Routing Protocol (ISO 10589)
RFC 1195 Use of OSI IS-IS for routing in TCP/IP & dual environments

RFC 2763 Dynamic Hostname Exchange for IS-IS

RFC 2966 Domain-wide Prefix Distribution with Two-Level IS-IS

RFC 2973 IS-IS Mesh Groups

RFC 3373 Three-Way Handshake for Intermediate System to Intermediate System (IS-IS) Point-to-Point Adjacencies

RFC 3567 Intermediate System to Intermediate System (ISIS) Cryptographic Authentication

RFC 3719 Recommendations for Interoperable Networks using IS-IS

RFC 3784 Intermediate System to Intermediate System (IS-IS) Extensions for Traffic Engineering (TE)

RFC 3787 Recommendations for Interoperable IP Networks

RFC 3847 Restart Signaling for IS-IS – GR helper

RFC 4205 for Shared Risk Link Group (SRLG) TLV

### MPLS - LDP

RFC 3037 LDP Applicability

RFC 3478 Graceful Restart Mechanism for LDP — GR helper

RFC 5036 LDP Specification

RFC 5283 LDP extension for Inter-Area LSP

RFC 5443 LDP IGP Synchronization

### MPLS - General

RFC 3031 MPLS Architecture

RFC 3032 MPLS Label Stack Encoding

RFC 4379 Detecting Multi-Protocol Label Switched (MPLS) Data Plane Failures

RFC 4182 Removing a Restriction on the use of MPLS Explicit NULL

### Multicast

RFC 1112 Host Extensions for IP Multicasting (Snooping)

RFC 2236 Internet Group Management Protocol, (Snooping)

RFC 3376 Internet Group Management Protocol, Version 3 (Snooping) [ Only in 7210 SAS-M access-uplink mode ]

### NETWORK MANAGEMENT

ITU-T X.721: Information technology- OSI-Structure of Management Information

ITU-T X.734: Information technology- OSI-Systems Management: Event Report Management Function

M.3100/3120 Equipment and Connection Models

TMF 509/613 Network Connectivity Model

RFC 1157 SNMPv1

RFC 1215 A Convention for Defining Traps for use with the SNMP

RFC 1907 SNMPv2-MIB

RFC 2011 IP-MIB

RFC 2012 TCP-MIB

RFC 2013 UDP-MIB

RFC 2096 IP-FORWARD-MIB

RFC 2138 RADIUS

RFC 2206 RSVP-MIB

RFC 2571 SNMP-FRAMEWORKMIB

RFC 2572 SNMP-MPD-MIB

RFC 2573 SNMP-TARGET-&-NOTIFICATION-MIB

RFC 2574 SNMP-USER-BASEDSMMIB

RFC 2575 SNMP-VIEW-BASEDACM-MIB

RFC 2576 SNMP-COMMUNITY-MIB

RFC 2665 EtherLike-MIB

RFC 2819 RMON-MIB

RFC 2863 IF-MIB

RFC 2864 INVERTED-STACK-MIB

RFC 3014 NOTIFICATION-LOGMIB

RFC 3164 Syslog

RFC 3273 HCRMON-MI

RFC 3411 An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks

RFC 3412 - Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)

RFC 3413 - Simple Network Management Protocol (SNMP) Applications

RFC 3414 - User-based Security Model (USM) for version 3 of the Simple Network Management Protocol (SNMPv3)

RFC 3418 - SNMP MIB

draft-ietf-mpls-lsr-mib-06.txt

draft-ietf-mpls-te-mib-04.txt

draft-ietf-mpls-ldp-mib-07.txt

### OSPF

RFC 1765 OSPF Database Overflow

RFC 2328 OSPF Version 2

RFC 2370 Opaque LSA Support

RFC 3101 OSPF NSSA Option

RFC 3137 OSPF Stub Router Advertisement

RFC 3623 Graceful OSPF Restart – GR helper

RFC 3630 Traffic Engineering (TE) Extensions to  OSPF Version 2

RFC 2740 OSPF for IPv6 (OSPFv3) draft-ietf-ospf-ospfv3-update-14.txt

RFC 4203 Shared Risk Link Group (SRLG) sub-TLV

### MPLS - RSVP-TE

RFC 2430 A Provider Architecture DiffServ & TE

RFC 2702 Requirements for Traffic Engineering over MPLS

RFC2747 RSVP Cryptographic Authentication

RFC3097 RSVP Cryptographic Authentication

RFC 3209 Extensions to RSVP for Tunnels

RFC 4090 Fast reroute Extensions to RSVP-TE for LSP Tunnels

RFC 5817 Graceful Shutdown in MPLS and GMPLS Traffic Engineering Networks

### PSEUDO-WIRE

RFC 3985 Pseudo Wire Emulation Edge-to-Edge (PWE3)

RFC 4385 Pseudo Wire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN

RFC 3916 Requirements for Pseudo-Wire Emulation Edge-to-Edge (PWE3)

RFC 4448 Encapsulation Methods for Transport of Ethernet over MPLS Networks (draft-ietf-pwe3-ethernet-encap-11.txt)

RFC 4446 IANA Allocations for PWE3

RFC 4447 Pseudowire Setup and Maintenance Using LDP (draft-ietf-pwe3-control-protocol-17.txt)

RFC 5085, Pseudowire Virtual Circuit Connectivity Verification (VCCV): A Control Channel for Pseudowires

RFC 5880 Bidirectional Forwarding Detection

RFC 5881 BFD IPv4 (Single Hop)

RFC 5659 An Architecture for Multi-Segment Pseudowire Emulation Edge-to-Edge

RFC6073, Segmented Pseudowire (draft-ietf-pwe3-segmented-pw-18.txt)

draft-ietf-l2vpn-vpws-iw-oam-02.txt

OAM Procedures for VPWS Interworking

draft-ietf-pwe3-oam-msg-map-14-txt, Pseudowire (PW) OAM Message Mapping

Pseudowire Preferential Forwarding Status bit definition

draft-pwe3-redundancy-02.txt

Pseudowire (PW) Redundancy

### RADIUS

RFC 2865 Remote Authentication Dial In User Service

RFC 2866 RADIUS Accounting

### SSH

draft-ietf-secsh-architecture.txt SSH Protocol Architecture

draft-ietf-secsh-userauth.txt SSH Authentication Protocol

draft-ietf-secsh-transport.txt SSH Transport Layer Protocol

draft-ietf-secsh-connection.txt SSH Connection Protocol

draft-ietf-secsh- newmodes.txt SSH Transport Layer Encryption Modes

### TACACS+

draft-grant-tacacs-02.txt

### TCP/IP

RFC 768 UDP

RFC 1350 The TFTP Protocol

RFC 791 IP

RFC 792 ICMP

RFC 793 TCP

RFC 826 ARP

RFC 854 Telnet

RFC 1519 CIDR

RFC 1812 Requirements for IPv4 Routers

RFC 2347 TFTP option Extension

RFC 2328 TFTP Blocksize Option

RFC 2349 TFTP Timeout Interval and Transfer Size option

draft-ietf-bfd-mib-00.txt Bidirectional Forwarding Detection Management Information Base

### Timing

ITU-T G.781 Telecommunication Standardization Section of ITU, Synchronization layer functions, issued 09/2008

ITU-T G.813 Telecommunication Standardization Section of ITU, Timing characteristics of SDH equipment slave clocks (SEC), issued 03/2003.

GR-1244-CORE Clocks for the Synchronized Network: Common Generic Criteria, Issue 3,May 2005

ITU-T G.8261 Telecommunication Standardization Section of ITU, Timing and synchronization aspects in packet networks, issued 04/2008.

ITU-T G.8262 Telecommunication Standardization Section of ITU, Timing characteristics of synchronous Ethernet equipment slave clock (EEC), issued 08/2007.

ITU-T G.8264 Telecommunication Standardization Section of ITU, Distribution of timing information through packet networks, issued 10/ 2008.

IEEE Std 1588™-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.

### VPLS

RFC 4762 Virtual Private LAN Services Using LDP (previously draft-ietf-l2vpn-vpls-ldp-08.txt)

### VRRP

RFC 2787 Definitions of Managed Objects for the Virtual Router Redundancy Protocol

RFC 3768 Virtual Router Redundancy Protocol

### Proprietary MIBs

ALCATEL-IGMP-SNOOPING-MIB.mib

TIMETRA-CAPABILITY-7210-SAS-M-V5v0.mib

(7210 SAS-M Only)

TIMETRA-CAPABILITY-7210-SAS-X-V5v0.mib (7210 SAS-X Only)

TIMETRA-CHASSIS-MIB.mib

TIMETRA-CLEAR-MIB.mib

TIMETRA-DOT3-OAM-MIB.mib

TIMETRA-FILTER-MIB.mib

TIMETRA-GLOBAL-MIB.mib

TIMETRA-IEEE8021-CFM-MIB.mib

TIMETRA-LAG-MIB.mib

TIMETRA-LOG-MIB.mib

TIMETRA-MIRROR-MIB.mib

TIMETRA-NTP-MIB.mib

TIMETRA-OAM-TEST-MIB.mib

TIMETRA-PORT-MIB.mib

TIMETRA-QOS-MIB.mib

TIMETRA-SAS-ALARM-INPUT-MIB.mib

TIMETRA-SAS-FILTER-MIB.mib

TIMETRA-SAS-IEEE8021-CFM-MIB.mib

TIMETRA-SAS-IEEE8021-PAE-MIB.mib

TIMETRA-SAS-GLOBAL-MIB.mib

TIMETRA-SAS-LOG-MIB.mib.mib

TIMETRA-SAS-MIRROR-MIB.mib

TIMETRA-SAS-MPOINT-MGMT-MIB.mib (Only for 7210 SAS-X)

TIMETRA-SAS-PORT-MIB.mib

TIMETRA-SAS-QOS-MIB.mib

TIMETRA-SAS-SDP-MIB.mib

TIMETRA-SAS-SYSTEM-MIB.mib

TIMETRA-SAS-SERV-MIB.mib

TIMETRA-SAS-VRTR-MIB.mib

TIMETRA-SCHEDULER-MIB.mib

TIMETRA-SECURITY-MIB.mib

TIMETRA-SERV-MIB.mib

TIMETRA-SYSTEM-MIB.mib

TIMETRA-TC-MIB.mib

TIMETRA-ISIS-MIB.mib

TIMETRA-ROUTE-POLICY-MIB.mib

TIMETRA-MPLS-MIB.mib

TIMETRA-RSVP-MIB.mib

TIMETRA-LDP-MIB.mib

TIMETRA-VRRP-MIB.mib
TIMETRA-VRTR-MIB.mib

# Standards and Protocol Support for 7210 SAS-R6

### Standards Compliance

IEEE 802.1ab-REV/D3 Station and Media Access Control Connectivity Discovery

IEEE 802.1D Bridging

IEEE 802.1p/Q VLAN Tagging

IEEE 802.1s Multiple Spanning Tree

IEEE 802.1w Rapid Spanning Tree Protocol

IEEE 802.1X Port Based Network Access Control

IEEE 802.1ad Provider Bridges

IEEE 802.1ag Service Layer OAM

IEEE 802.3ah Ethernet in the First Mile

IEEE 802.3 10BaseT

IEEE 802.3ad Link Aggregation

IEEE 802.3ae 10Gbps Ethernet

IEEE 802.3u 100BaseTX

IEEE 802.3z 1000BaseSX/LX

ITU-T Y.1731 OAM functions and mechanisms for Ethernet based networks

draft-ietf-disman-alarm-mib-04.txt

IANA-IFType-MIB

IEEE8023-LAG-MIB

### Protocol Support

### BGP

RFC 1397 BGP Default Route Advertisement

RFC 1772 Application of BGP in the Internet

RFC 1997 BGP Communities Attribute

RFC 2385 Protection of BGP Sessions via MD5

RFC 2439 BGP Route Flap Dampening

RFC 2547bis BGP/MPLS VPNs

draft-ietf-idr-rfc2858bis-09.txt.

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 2547bis BGP/MPLS VPNs)

RFC 4760 Multi-protocol Extensions for BGP

RFC 4893 BGP Support for Four-octet AS Number Space

### DHCP

RFC 2131 Dynamic Host Configuration Protocol

RFC 3046 DHCP Relay Agent Information Option (Option 82)

### DIFFERENTIATED SERVICES

RFC 2474 Definition of the DS Field the IPv4 and IPv6 Headers (Rev)

RFC 2597 Assured Forwarding PHB Group (rev3260)

RFC 2598 An Expedited Forwarding PHB

RFC 2697 A Single Rate Three Color Marker

RFC 2698 A Two Rate Three Color Marker

RFC 4115 A Differentiated Service Two-Rate, Three-Color Marker with Efficient Handling of in-Profile Traffic

### IS-IS

RFC 1142 OSI IS-IS Intra-domain Routing Protocol (ISO 10589)

RFC 1195 Use of OSI IS-IS for routing in TCP/IP & dual environments

RFC 2763 Dynamic Hostname Exchange for IS-IS

RFC 2966 Domain-wide Prefix Distribution with Two-Level IS-IS

RFC 2973 IS-IS Mesh Groups

RFC 3373 Three-Way Handshake for Intermediate System to Intermediate System (IS-IS) Point-to-Point Adjacencies

RFC 3567 Intermediate System to Intermediate System (ISIS) Cryptographic Authentication

RFC 3719 Recommendations for Interoperable Networks using IS-IS

RFC 3784 Intermediate System to Intermediate System (IS-IS) Extensions for Traffic Engineering (TE)

RFC 3787 Recommendations for Interoperable IP Networks

RFC 3847 Restart Signaling for IS-IS – GR helper

RFC 4205 for Shared Risk Link Group (SRLG) TLV

### MPLS - General

RFC 3031 MPLS Architecture

RFC 3032 MPLS Label Stack Encoding

RFC 4379 Detecting Multi-Protocol Label Switched (MPLS) Data Plane Failures

RFC 4182 Removing a Restriction on the use of MPLS Explicit NULL

### MPLS - LDP

RFC 5036 LDP Specification

RFC 3037 LDP Applicability

RFC 3478 Graceful Restart Mechanism for LDP — GR helper

RFC 5283 LDP extension for Inter-Area LSP

RFC 5443 LDP IGP Synchronization

### MPLS - RSVP-TE

RFC 2430 A Provider Architecture Diff-Serv & TE

RFC 2702 Requirements for Traffic Engineering over MPLS

RFC2747 RSVP Cryptographic Authentication

RFC3097 RSVP Cryptographic Authentication

RFC 3209 Extensions to RSVP for Tunnels

RFC 4090 Fast reroute Extensions to RSVP-TE for LSP Tunnels

RFC 5817 Graceful Shutdown in MPLS and GMPLS Traffic Engineering Networks

### MPLS-TP (Transport Profile)

RFC 5586 MPLS Generic Associated Channel

RFC 5921 A Framework for MPLS in Transport Networks
RFC 5960 MPLS Transport Profile Data Plane Architecture
RFC 6370 MPLS-TP Identifiers
RFC 6378 MPLS-TP Linear Protection
RFC 6428 Proactive Connectivity Verification, Continuity Check and Remote Defect indication for MPLS Transport Profile
RFC 6426 MPLS On-Demand Connectivity and Route Tracing
RFC 6478 Pseudowire Status for Static Pseudowires
draft-ietf-mpls-tp-ethernet-addressing-02 MPLS-TP Next-Hop Ethernet Addressing

### NETWORK MANAGEMENT

ITU-T X.721: Information technology-OSI-Structure of Management Information
ITU-T X.734: Information technology-OSI-Systems Management: Event Report Management Function
M.3100/3120 Equipment and Connection Models
TMF 509/613 Network Connectivity Model
RFC 1157 SNMPv1
RFC 1215 A Convention for Defining Traps for use with the SNMP
RFC 1907 SNMPv2-MIB
RFC 2011 IP-MIB
RFC 2012 TCP-MIB
RFC 2013 UDP-MIB
RFC 2096 IP-FORWARD-MIB
RFC 2138 RADIUS
RFC 2206 RSVP-MIB
RFC 2571 SNMP-FRAMEWORKMIB
RFC 2572 SNMP-MPD-MIB
RFC 2573 SNMP-TARGET-&- NOTIFICATION-MIB
RFC 2574 SNMP-USER-BASEDSMMIB
RFC 2575 SNMP-VIEW-BASEDACM-MIB
RFC 2576 SNMP-COMMUNITY-MIB
RFC 2665 EtherLike-MIB
RFC 2819 RMON-MIB
RFC 2863 IF-MIB
RFC 2864 INVERTED-STACK-MIB
RFC 3014 NOTIFICATION-LOGMIB
RFC 3164 Syslog
RFC 3273 HCRMON-MI
RFC 3411 An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks
RFC 3412 - Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)
RFC 3413 - Simple Network Management Protocol (SNMP) Applications
RFC 3414 - User-based Security Model (USM) for version 3 of the Simple Network Management Protocol (SNMPv3)
RFC 3418 - SNMP MIB
draft-ietf-mpls-lsr-mib-06.txt
draft-ietf-mpls-te-mib-04.txt
draft-ietf-mpls-ldp-mib-07.txt

### OSPF

RFC 1765 OSPF Database Overflow
RFC 2328 OSPF Version 2
RFC 2370 Opaque LSA Support
RFC 3101 OSPF NSSA Option
RFC 3137 OSPF Stub Router Advertisement
RFC 3623 Graceful OSPF Restart – GR helper
RFC 3630 Traffic Engineering (TE) Extensions to OSPF Version 2
RFC 4203 Shared Risk Link Group (SRLG) sub-TLV

### PSEUDO-WIRE

RFC 3985 Pseudo Wire Emulation Edge-to-Edge (PWE3)
RFC 4385 Pseudo Wire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN
RFC 3916 Requirements for Pseudo-Wire Emulation Edge-to-Edge (PWE3)
RFC 4448 Encapsulation Methods for Transport of Ethernet over MPLS Networks (draft-ietf-pwe3-ethernet-encap-11.txt)
RFC 4446 IANA Allocations for PWE3
RFC 4447 Pseudowire Setup and Maintenance Using LDP (draft-ietf-pwe3-control-protocol-17.txt)
RFC 5085, Pseudowire Virtual Circuit Connectivity Verification (VCCV): A Control Channel for Pseudowires
RFC 5659 An Architecture for Multi-Segment Pseudowire Emulation Edge-to-Edge
RFC6073, Segmented Pseudowire (draft-ietf-pwe3-segmented-pw-18.txt)
draft-ietf-l2vpn-vpws-iw-oam-02.txt, OAM Procedures for VPWS Interworking
draft-ietf-pwe3-oam-msg-map-14-txt, Pseudowire (PW) OAM Message Mapping
draft-muley-dutta-pwe3-redundancy-bit-03.txt, Pseudowire Preferential Forwarding Status bit definition
draft-pwe3-redundancy-02.txt, Pseudowire (PW) Redundancy

### RADIUS

RFC 2865 Remote Authentication Dial In User Service
RFC 2866 RADIUS Accounting

### SSH

draft-ietf-secsh-architecture.txt SSH Protocol Architecture
draft-ietf-secsh-userauth.txt SSH Authentication Protocol
draft-ietf-secsh-transport.txt SSH Transport Layer Protocol
draft-ietf-secsh-connection.txt SSH Connection Protocol
draft-ietf-secsh- newmodes.txt SSH Transport Layer Encryption Modes

### TACACS+

draft-grant-tacacs-02.txt

### TCP/IP

RFC 768 UDP
RFC 1350 The TFTP Protocol
RFC 791 IP
RFC 792 ICMP
RFC 793 TCP
RFC 826 ARP

RFC 854 Telnet
RFC 1519 CIDR
RFC 1812 Requirements for IPv4 Routers
RFC 2347 TFTP option Extension
RFC 2328 TFTP Blocksize Option
RFC 2349 TFTP Timeout Interval and Transfer Size option
draft-ietf-bfd-mib-00.txt Bidirectional Forwarding Detection Management Information Base
RFC 5880 Bidirectional Forwarding Detection
RFC 5881 BFD IPv4 (Single Hop)

### Timing

ITU-T G.781 Telecommunication Standardization Section of ITU, Synchronization layer functions, issued 09/2008
ITU-T G.813 Telecommunication Standardization Section of ITU, Timing characteristics of SDH equipment slave clocks (SEC), issued 03/2003.
GR-1244-CORE Clocks for the Synchronized Network: Common Generic Criteria, Issue 3,May 2005
ITU-T G.8261 Telecommunication Standardization Section of ITU, Timing and synchronization aspects in packet networks, issued 04/2008.
ITU-T G.8262 Telecommunication Standardization Section of ITU, Timing characteristics of synchronous Ethernet equipment slave clock (EEC), issued 08/2007.
ITU-T G.8264 Telecommunication Standardization Section of ITU, Distribution of timing information through packet networks, issued 10/2008.

### VPLS

RFC 4762 Virtual Private LAN Services Using LDP (previously draft-ietf-l2vpn-vpls-ldp-08.txt)

### VRRP

RFC 2787 Definitions of Managed Objects for the Virtual Router Redundancy Protocol
RFC 3768 Virtual Router Redundancy Protocol

### Proprietary MIBs

ALCATEL-IGMP-SNOOPING-MIB.mib
TIMETRA-CHASSIS-MIB.mib
TIMETRA-CLEAR-MIB.mib
TIMETRA-DOT3-OAM-MIB.mib
TIMETRA-FILTER-MIB.mib
TIMETRA-GLOBAL-MIB.mib
TIMETRA-IEEE8021-CFM-MIB.mib
TIMETRA-LAG-MIB.mib
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