NOKIA

7210 SERVICE ACCESS SYSTEM

7210 SAS-K 2F6C4T, K 3SFP+ 8C MPLS GUIDE

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1 Getting started

This chapter provides process flow information to configure MPLS, RSVP, and LDP protocols. It also provides an overview of the document organization and content, and describes the terminology used in this guide.

1.1 About this guide

> **Note:**
> Unless explicitly noted otherwise, this guide uses 7210 SAS-Dxp to refer to the 7210 SAS-Dxp 12p, 7210 SAS-Dxp 16p, and 7210 SAS-Dxp 24p platforms.

This guide describes system concepts and provides configuration examples to configure the boot option file (BOF) on the following 7210 SAS platforms, operating in one of the modes described in Table 1: Supported modes of operation and configuration methods. If multiple modes of operation apply, they are explicitly noted in the topic:

- 7210 SAS-K 2F6C4T

- 7210 SAS-K 3SFP+ 8C

See section 7210 SAS modes of operation for information about the modes of operation supported by the 7210 SAS product family.

> **Note:**
> Unless explicitly noted otherwise, the phrase "Supported on all 7210 SAS platforms as described in this document" is used to indicate that the topic and CLI commands apply to the following 7210 SAS platforms implicitly operating in the specified modes only:
>
> - access-uplink mode of operation
>
>   7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C
>
> - network mode of operation
>
>   7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C

1.1.1 Document structure and content

This guide uses the following structure to describe features and configuration content:

> **Note:**
> This guide generically covers Release 22.*x*.R*x* content and may include some content that will be released in later maintenance loads. See the 7210 SAS Software Release Notes 22.*x*.R*x*, part number 3HE 18217 000*x* TQZZA, for information about features supported in each load of the Release 22.*x*.R*x* software.

- This guide is organized into functional chapters and provides concepts and descriptions of the implementation flow. Each chapter describes a software area and provides CLI syntax and command usage to configure parameters for the functional area.

- Command outputs shown in this guide are examples only; actual displays may differ depending on supported functionality and user configuration.

- Unless explicitly noted, the CLI commands and their configuration is similar for both network and access-uplink operating modes for features applicable to both modes of operation.

1.2 7210 SAS modes of operation

Unless explicitly noted, the phrase "mode of operation" and "operating mode" refers to the current operating mode of the 7210 SAS router. Each operating mode provides configuration access to a specific group of CLI commands.

> **Note:**
> Not all CLI commands are supported on all 7210 SAS platforms in all modes of operation. Users can only configure CLI commands supported by the current operating mode of the router. See the 7210 SAS Software Release Notes 22.*x*.R*x*, part number 3HE 18217 000*x* TQZZA, and to the appropriate 7210 SAS software user guide for information about features and capabilities supported by a 7210 SAS platform when operating in a specific mode.

The following modes of operation are supported by the 7210 SAS product family:

- **access-uplink**

  In the access-uplink operating mode, the 7210 SAS router uplinks to the network using Layer 2 Ethernet VLAN switching (without IP/MPLS).

  Platforms Supported: 7210 SAS-D, 7210 SAS-Dxp, 7210 SAS-K 2F1C2T, 7210 SAS-K 2F6C4T, 7210 SAS-K 3SFP+ 8C, and 7210 SAS-T.

- **network**

  In the network operating mode, the 7210 SAS router uses IP/MPLS uplinks to the network. The IP routing protocols and MPLS functionality is available; see the appropriate 7210 SAS software user guide for more information about supported features.

  Platforms Supported: 7210 SAS-K 2F6C4T, 7210 SAS-K 3SFP+ 8C, 7210 SAS-Mxp, 7210 SAS-R6, 7210 SAS-R12, 7210 SAS-Sx/S 1/10GE, 7210 SAS-Sx 10/100GE, and 7210 SAS-T.

- **satellite**

  In the satellite operating mode, the 7210 SAS platform uses high-capacity uplinks (for example, 10GE ports on the 7210 SAS-Mxp and 100GE ports on the 7210 SAS-Sx 10/100GE) to connect to the 7750 SR host. The 7210 SAS router is managed by the 7750 SR host. There is no direct CLI access to the satellite node, and all services and protocols are configured on the host.

  Platforms Supported: 7210 SAS-Mxp, 7210 SAS-Sx/S 1/10GE, and 7210 SAS-Sx 10/100GE.

- **standalone**

  In the standalone operating mode, the 7210 SAS platform supports IP/MPLS uplinks. It is operated and managed independently.

  The functionality and features available on the standalone 7210 SAS platform are similar to the network operating mode. The standalone mode is primarily used to differentiate between a node being managed

by the 7750 SR host (in the satellite operating mode), and a node managed independently (standalone operating mode).

Platforms Supported: 7210 SAS-Mxp, 7210 SAS-Sx/S 1/10GE, and 7210 SAS-Sx 10/100GE.

• **standalone-VC**

In the standalone-VC operating mode, a set of 7210 SAS devices are stacked to provide larger 1GE/10GE port density and control-plane redundancy. The stack of nodes is provisioned and managed as a single chassis, and not as individual nodes.

The functionality and features available on the 7210 SAS platform are similar to the network operating mode, with additional capabilities, such as control-plane redundancy with non-stop routing and non-stop services.

Platforms Supported: 7210 SAS-Sx/S 1/10GE

For 7210 SAS platforms that support multiple explicit modes of operation (Table 1: Supported modes of operation and configuration methods), the operating mode must be configured in the Boot Option File (BOF) to ensure the router boots up in the specified mode. For example, the 7210 SAS-T supports access-uplink and network modes of operation, and the 7210 SAS-Sx/S 1/10GE supports satellite, standalone, and standalone-VC mode of operations. In some cases, the 7210 SAS router operates in a specific mode implicitly, and explicit configuration is not required.

See the appropriate *Basic System Configuration Guide* for boot options and information about how to boot the 7210 SAS platform in a specific operating mode.

The following table lists the supported modes of operation and the configuration methods for the 7210 SAS platforms. Unless explicitly noted otherwise, the operating mode is supported on all variants of the specific 7210 SAS platform.

Table 1: Supported modes of operation and configuration methods

7210 SAS platform	Mode of operation and configuration method				
	Network	**Access-uplink**	**Standalone**	**Standalone-VC**	**Satellite**
7210 SAS-D		Implicit	Implicit		
7210 SAS-Dxp		Implicit	Implicit		
7210 SAS-K 2F1C2T		Implicit	Implicit		
7210 SAS-K 2F6C4T [1]	Port Mode Configuration [2]	Port Mode Configuration[2]	Implicit		
7210 SAS-K 3SFP+ 8C [1]	Port Mode Configuration [2]	Port Mode Configuration[2]	Implicit		

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[1] By default, the 7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C boot up in the network mode of operation. These platforms also allow the use of access-uplink port mode (without explicit BOF configuration), which provides the option to use Layer 2 uplinks instead of IP/MPLS uplinks to the network core, similar to the 7210 SAS-K 2F1C2T router.

[2] See section 7210 SAS port modes for information about port mode configuration

7210 SAS platform	Mode of operation and configuration method				
	Network	**Access-uplink**	**Standalone**	**Standalone-VC**	**Satellite**
7210 SAS-Mxp	Implicit [3]		Explicit BOF Configuration		Explicit BOF Configuration
7210 SAS-R6[4]	Implicit		Implicit		
7210 SAS-R12 [4]	Implicit		Implicit		
7210 SAS-Sx/S 1/10GE	Implicit [3]		Explicit BOF Configuration	Explicit BOF Configuration	Explicit BOF Configuration
7210 SAS-Sx 10/100GE	Implicit [3]		Explicit BOF Configuration		Explicit BOF Configuration
7210 SAS-T	Explicit BOF Configuration	Explicit BOF Configuration	Implicit		

1.3 7210 SAS port modes

Unless explicitly noted, the phrase "port mode" refers to the current port configuration of the 7210 SAS node. The 7210 SAS platform supports the configuration of the following port modes:

- **access port mode**

    Access ports are configured for customer-facing traffic if Service Access Points (SAPs) are required. The appropriate encapsulation type must be configured to distinguish the services on the port; services are configured on the port based on the encapsulation value.

    Access ports can be configured on all the 7210 SAS platforms.

- **access-uplink port mode**

    Access-uplink ports provide native Ethernet connectivity in service provider transport or in an infrastructure network. With this option, the encap-type can be configured to only QinQ. Access-uplink SAPs, which are QinQ SAPs, can only be configured on an access-uplink port to allow the operator to differentiate multiple services being carried over a single uplink port.

    This is the default port mode of a 7210 SAS node in the access-uplink mode of operation.

- **network port mode**

    Network ports are configured for network-facing traffic in the service provider transport or infrastructure network, and provide IP/MPLS uplinks.

    This is the default port mode of a 7210 SAS node in the network or standalone mode of operation.

- **hybrid port mode**

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[3] Implicitly operates in network mode when standalone mode of operation is configured

[4] Supports MPLS uplinks only and implicitly operates in network mode

Hybrid ports are configured for access and network facing traffic, and allow a single port to operate in both access and network modes.

Port modes available for configuration on a 7210 SAS node are determined by the current mode of operation of the router.

> **Note:**
> The 7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C are unique; all port modes listed in Table 2: Supported port modes by mode of operation are available for configuration on the router, regardless of the current mode of operation.

The following table lists the port mode configuration support per 7210 SAS mode of operation.

Table 2: Supported port modes by mode of operation

Mode of operation	Supported port mode			
	Access	Network	Hybrid	Access-uplink
Access-uplink	✓			✓
Network	✓	✓	✓	
Satellite [5]				
Standalone	✓	✓	✓	
Standalone-VC	✓	✓	✓	

The following table lists the port mode configuration supported by the 7210 SAS product family. See the appropriate *Interface Configuration Guide* for more information about configuring the port modes for a specific platform.

Table 3: 7210 SAS platforms supporting port modes

Platform	Port mode			
	Access	Network	Hybrid	Access-uplink
7210 SAS-D	Yes	No	No	Yes
7210 SAS-Dxp	Yes	No	No	Yes
7210 SAS-K 2F1C2T	Yes	No	No	Yes
7210 SAS-K 2F6C4T	Yes	Yes	Yes	Yes
7210 SAS-K 3SFP+ 8C	Yes	Yes	Yes	Yes

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[5] Port modes are configured on the 7750 SR host and managed by the host.

Platform	Port mode			
	Access	**Network**	**Hybrid**	**Access-uplink**
7210 SAS-Mxp	Yes	Yes	Yes	No
7210 SAS-R6 IMM-b (IMMv2)	Yes	Yes	Yes	No
7210 SAS-R6 IMM-c 100GE (IMM-c 1CFP4 or IMM-c 1QSFP28)	Yes	Yes	Yes	No
7210 SAS-R12 IMM-b	Yes	Yes	Yes	No
7210 SAS-R12 IMM-c 100GE (IMM-c 1CFP4 or IMM-c 1QSFP28)	Yes	Yes	Yes	No
7210 SAS-Sx/S 1/10GE	Yes	Yes	Yes	No
7210 SAS-Sx 10/100GE	Yes	Yes	Yes	No
7210 SAS-T	Yes	Yes[6]	Yes[7]	Yes[8]

1.4 Nokia 7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C router configuration process

The following table 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 4: Configuration process

Area	Task	Chapter/section
Protocol configuration	Configure MPLS protocols:	
	• MPLS	MPLS
	• RSVP	RSVP
	• LDP	Label Distribution Protocol

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[6] Network ports are supported only if the node is operating in network mode.

[7] Hybrid ports are supported only if the node is operating in network mode.

[8] Access-uplink ports are supported only if the node is operating in access-uplink mode.

Area	Task	Chapter/section
	• PCEP	PCEP
Reference	List of IEEE, IETF, and other proprietary entities	Standards and protocol support

1.5 Conventions

This section describes the general conventions used in this guide.

1.5.1 Precautionary and information messages

The following are information symbols used in the documentation.

DANGER: Danger warns that the described activity or situation may result in serious personal injury or death. An electric shock hazard could exist. Before you begin work on this equipment, be aware of hazards involving electrical circuitry, be familiar with networking environments, and implement accident prevention procedures.

WARNING: Warning indicates that the described activity or situation may, or will, cause equipment damage, serious performance problems, or loss of data.

Caution: Caution indicates that the described activity or situation may reduce your component or system performance.

Note: Note provides additional operational information.

Tip: Tip provides suggestions for use or best practices.

1.5.2 Options or substeps in procedures and sequential workflows

Options in a procedure or a sequential workflow are indicated by a bulleted list. In the following example, at step 1, the user must perform the described action. At step 2, the user must perform one of the listed options to complete the step.

Example: Options in a procedure

1. User must perform this step.

2. This step offers three options. User must perform one option to complete this step:

   • This is one option.

   • This is another option.

   • This is yet another option.

Substeps in a procedure or a sequential workflow are indicated by letters. In the following example, at step 1, the user must perform the described action. At step 2, the user must perform two substeps (a. and b.) to complete the step.

Example: Substeps in a procedure

1. User must perform this step.

2. User must perform all substeps to complete this action:

    a. This is one substep.

    b. This is another substep.

2 MPLS and RSVP

This chapter provides information to configure MPLS and RSVP.

2.1 MPLS

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

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

On the 7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C, is designed to fit into a network using the principles of seamless MPLS architecture which enable access devices with smaller IP routing scale (both control-plane RIB and FIB) and smaller MPLS scale (both control-plane and FIB) to be used to deploy MPLS end-to-end and benefit from the traffic engineering and resiliency mechanism that MPLS provides. The MPLS features and capabilities available on the 7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C are described in this user guide.

2.1.1 MPLS label stack

MPLS requires a set of procedures to enhance network layer packets with label stacks, which turns them into labeled packets. Routers that support MPLS are called Label Switching Routers (LSRs). To transmit a labeled packet on a specific 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. The following figure shows the label placement in a packet. Table 5: Packet/label field description describes the fields.

Figure 1: Label placement
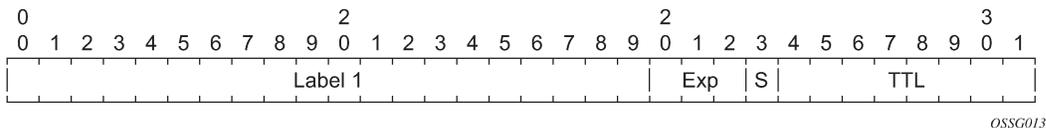
Table 5: Packet/label field description

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 (as shown in the following figure).

Figure 2: Label packet placement
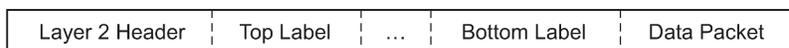
The label value at the top of the stack is looked up when a labeled packet is received. A successful lookup reveals the following:

- 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.

2.1.1.1 Label values

Packets travelling along an LSP (see Label Switching Routers) 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. Because 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 devices use 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 32768through 131,071 are dynamically assigned for both MPLS and services.

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

2.1.2 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.

2.1.2.1 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 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.

  - **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.

    When 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 has 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.

The 7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C support the following functionality:

- MPLS LSR functionality.
- MPLS LER functionality with the following support:
  - Static LSPs.
  - RSVP signaled LSPs with support for both explicit-path LSP and constrained-path LSPs.

- Support for FRR one-to-one and FRR facility bypass for RSVP signaled LSPs.

2.2 MPLS pseudowire hash label support

The MPLS pseudowire hash label allows LSR nodes in a network to load balance labeled packets in a more granular manner than by hashing on the standard label stack. Using the hash label also removes the need to have an LSR inspect the payload below the label stack to check for an IPv4 or IPv6 header.

In packets forwarded over an LSP, an MPLS hash label is inserted by the ingress LER at the bottom of the label stack. The label value is the result of the hash of the packet headers (the packet header fields that are used depend on the capability of the ingress LER node). The ingress LER hash routine guarantees that the spraying of packets by an LSR hashing on the extended label stack, which includes the hash label, maintains packet ordering within a conversation. LSR hashing pertains to multiple LDP ECMP paths or multiple paths over a LAG network port.

Note:

- On 7210 SAS devices, the ingress node does not use the pseudowire hash label for ECMP hashing and LAG hashing. It is available for use by the transit MPLS LSR nodes. See the *7210 SAS-D, Dxp, K 2F1C2T, K 2F6C4T, K 3SFP+ 8C Interface Configuration Guide* for a description of the fields used by the ingress LER for ECMP and LAG hashing.

- The pseudowire hash label is supported for VLL services with spoke-SDP, VPLS services with spoke-SDP and mesh SDP, and RVPLS services with spoke-SDP.

- When a hash label is added at the ingress LER, it is marked with an LSP EXP value of 0.

- The pseudowire hash label is not accounted for the in the total number of MPLS transport and service labels that the node pushes and pops.

2.3 MPLS facility bypass method of 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 switches 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 is 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.

2.3.1 Manual bypass LSP

The 7210 SAS supports Manual bypass tunnels, on implementation of the Manual bypass feature a LSP can be preconfigured 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.

2.3.1.1 PLR bypass LSP selection rules

The following figure shows the bypass tunnel nodes.

Figure 3: Bypass tunnel nodes
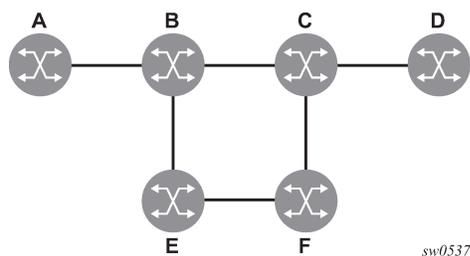
The PLR uses the following rules to select a bypass LSP among multiple manual and dynamic bypass LSPs at the time of establishment of the primary LSP path or when searching for a bypass for a protected LSP which does not have an association with a bypass tunnel:

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 is needed, 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 is needed, then it searches for a link-protect bypass LSP.

2. If multiple manual bypass LSPs satisfying the path constraints exist, it prefers 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 checks if any of the already established dynamic bypasses of the requested type satisfies the constraints.

4. If none do, then the MPLS/RSVP task asks CSPF to check if a new dynamic bypass of the requested type, node-protect or link-protect, can be established.

5. If the path message for the primary LSP path indicated node protection is needed, and no manual bypass was found after Step 1, or no dynamic bypass LSP was found after 3 attempts of performing Step 3, the MPLS/RSVP task repeats Steps 1-3 looking for a suitable link-protect bypass LSP. If none are found, the primary LSP has no protection and the PLR node must clear the "local protection available" flag in the IPv4 address sub-object of the RRO starting in the next Resv refresh message it sends upstream.

6. If the path message for the primary LSP path indicated link protection is needed, and no manual bypass was found after step 1, or no dynamic bypass LSP was found after performing Step 3, the primary LSP has 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 does 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 occurs on the protected LSP. Furthermore, if no manual bypass exist that satisfy the constraints of the protected LSP, the LSP remains 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, are 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 are not automatically switched into the manual bypass tunnel even if the manual bypass is a more optimized path. The user has 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) clears the "protection available" flag in the RRO IPv4 sub-object in the next RESV refresh message for each affected LSP. It then tries to associate each of these LSPs with one of the manual bypass tunnels that are still up. If it finds one, it makes the association and sets the "protection available" flag again in the next RESV refresh message for each of these LSPs. If it could not find one, it keeps 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 are 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 automatically signals 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 only signals 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 does not switch the protected LSPs from the dynamic bypass tunnel into the manual bypass tunnel.

2.3.1.2 FRR node-protection (facility)

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

Figure 4: FRR node-protection example

sw0538
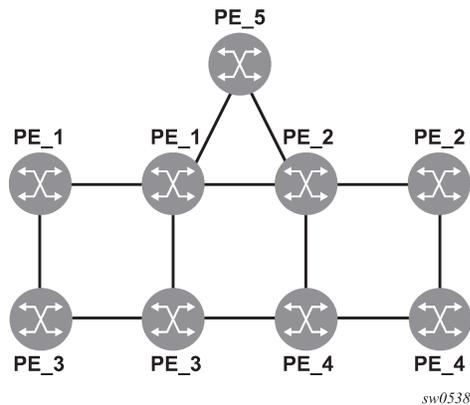
Where:

- 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 protects link P_1-P_2
- P_1 protects the link to P_2 through P_1 - P_5 - P_2
- P_4 returns online

As LSP 1 had requested node protection, but because of a lack of any available path, it could only obtain link protection. Therefore, every 60 seconds the PLR for LSP 1 searches for a new path that may be able to provide node protection. When P_4 is back online and such a path is available, a new bypass tunnel is signaled and LSP 1 is associated with this new bypass tunnel.

2.3.1.3 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 the event is because of 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 datapath. 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.

2.4 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 paths 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 datapath. 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 5: Establishing LSPs shows the process to establish an LSP as follows:

- 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 needed. 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 5: Establishing LSPs
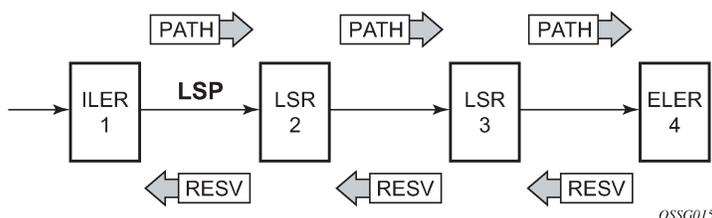
The following figure shows an example of an LSP path set up using RSVP. The ingress label edge router (ILER 1) transmits an RSVP path message (path: 30.30.30.1) downstream to the egress label edge router (ELER 4). The path message contains a label request object that requests intermediate LSRs and the ELER to provide a label binding for this path.

Figure 6: LSP using RSVP path set up
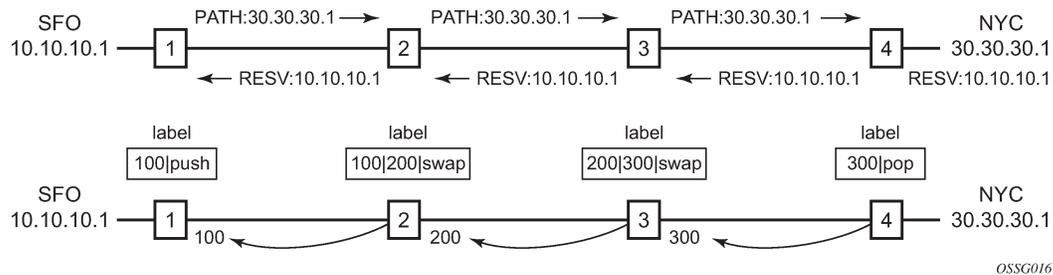
In addition to the label request object, an RSVP PATH message can also contain a number of optional objects:

- **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 toward 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.

2.4.1 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. When 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.

2.4.1.1 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.

2.4.1.1.1 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 the RSVP soft-state model. The reservation state is maintained as cached information that is first installed and then periodically refreshed by the ingress and egress 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.

2.4.1.1.2 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 continues 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 because there is no security association with the next-next-hop MP node.

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

2.4.2 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 PLR node receives a path message with fast-reroute requested with facility method and the FF reservation style, it rejects the reservation. The one-to-one detour method supports both FF and SE styles.

2.4.2.1 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.

2.4.3 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 because 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 reduces 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 an 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, the node does not attempt to send summary refresh messages.

2.4.3.1 Configuring implicit null

The implicit null label option allows a router 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 LSP signaling with RSVP control protocol. In addition, the egress LER can be configured to receive MPLS packet with the implicit null label on a static LSP.

The user can configure your router to signal the implicit null label value over all RSVP interfaces and for all RSVP LSPs for which this node is the egress LER using the implicit-null-label command in the **config>router>rsvp** context. The user must shutdown RSVP before being able to change the implicit null configuration option.

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 signals 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 uses the implicit null label or not. The same applies for a 1-to-1 detour LSP.

The implicit null label option is also supported on a static label LSP. The following commands can be used to cause the node to push or to swap to an implicit null label on the MPLS packet:

config>router>mpls>static-lsp>push implicit-null-label nexthop ip-address

config>router>mpls>if>label-map>swap implicit-null-label nexthop ip-address

2.4.4 Using unnumbered Point-to-Point interface in RSVP

This feature introduces the use of unnumbered IP interface as a Traffic Engineering (TE) link for the signaling of RSVP P2P LSP.

An unnumbered IP interface is identified uniquely on a router in the network by the tuple {router-id, ifIndex}. Each side of the link assigns a system-wide unique interface index to the unnumbered interface. IS-IS, OSPF, RSVP, and OAM modules use this tuple to advertise the link information, signal LSP paths over this unnumbered interface, or send and respond to an MPLS echo request message over an unnumbered interface.

The interface-borrowed IP address is used exclusively as the source address for IP packets that originates from the interface and needs to be configured to an address different from system interface for the FRR bypass LSP to come up at the ingress LER.

The borrowed IP address for an unnumbered interface is configured using the following CLI command, with a default value set to the system interface address:

configure>router>interface>unnumbered [*ip-int-name* | *ip-address*].

The support of unnumbered TE link in IS-IS consists of adding a new sub-TLV of the extended IS as per RFC 5307 reachability TLV, which encodes the Link Local and Link Remote Identifiers as defined in RFC 5307.

The support of unnumbered TE link in OSPF consists of adding a new sub-TLV, which encodes the same Link Local and Link Remote Identifiers in the Link TLV of the TE area opaque LSA and sends the local Identifier in the Link Local Identifier TLV in the TE link local opaque LSA as per RFC 4203.

The support of unnumbered TE link in RSVP implements the signaling of unnumbered interfaces in ERO/RRO as per RFC 3477 and the support of IF_ID RSVP_HOP object with a new C-Type as per Section 8.1.1 of RFC 3473. The IPv4 Next/Previous Hop Address field is set to the borrowed IP interface address.

The unnumbered IP is advertised by IS-IS TE and OSPF TE, and CSPF can include them in the computation of a path for a P2P LSP. This feature does not, however, support defining an unnumbered interface as a hop in the path definition of an LSP.

A router creates an RSVP neighbor over an unnumbered interface using the tuple {router-id, ifIndex}. The router-id of the router which advertised a specific unnumbered interface index is obtained from the TE database. As as result, if traffic engineering is disabled in IS-IS or OSPF, a non-CSPF LSP with the next-hop for its path is over an unnumbered interface does not come up at the ingress LER because the router-id of the neighbor which has the next-hop of the path message cannot be looked up. In this case, the LSP

path remains in the operationally down state with the reason "noRouteToDestination". If a PATH message is received at the LSR in which traffic engineering was disabled and the next-hop for the LSP path is over an unnumbered interface, a PathErr message is sent back to the ingress LER with the Routing Problem error code 24 and an error value of 5 "No route available toward destination".

This feature supports all of the MPLS features available for numbered IP interfaces, with the following exceptions:

- Configuring a router-id with a value other than system.

- Signaling an LSP path with an ERO based loose/strict hop using an unnumbered TE link in the path hop definition.

- Signaling of one-to-one detour LSP over unnumbered interface.

- Soft preemption of LSP path using unnumbered interface.

- Inter-area LSP.

- Unnumbered RSVP interface registration with BFD.

- RSVP Hello and all Hello-related capabilities, such as Graceful-restart helper.

- The user SRLG database feature. The **user-srlg-db** option under MPLS allows the user to manually enter the SRLG membership of any link in the network in a local database at the ingress LER. The user cannot enter an unnumbered interface into this database and therefore all unnumbered interfaces will be considered as having no SRLG membership if the user has enabled the **user-srlg-db** option.

This feature also extends the support of lsp-ping, lsp-trace, and P2P LSPs that have unnumbered TE links in their path.

2.4.4.1 Operation of RSVP FRR facility backup over unnumbered interface

When the Point-of-Local Repair (PLR) node activates the bypass LSP by sending a PATH message to refresh the path state of protected LSP at the Merge-Point (MP) node, it must use an IPv4 tunnel sender address in the sender template object which is different than the one used by the ingress LER in the PATH message. These are the procedures specified in RFC 4090 and which are followed in the node implementation.

The node uses the address of the outgoing interface of the bypass LSP as the IPv4 tunnel sender address in the sender template object. This address will be different from the system interface address used in the sender template of the protected LSP by the ingress LER and therefore there are no conflicts when the ingress LER acts as a PLR.

> **Note:**
> When the PLR is the ingress LER node and the outgoing interface of the bypass LSP is unnumbered, it is required that the user assigns to the interface a borrowed IP address which is different from the system interface. If not, the bypass LSP will not come up.

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

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

- change in C-Type of the RSVP_HOP object

- C-Type is IF_ID RSVP_HOP and did not change but IF_ID TLV is different

- change in IPv4 Next/Previous Hop Address in RSVP_HOP object regardless of the C-Type value

These procedures at PLR and MP nodes are followed in both link-protect and node-protect FRR.

> **Note:**
> If the MP node is running a pre-R9.0 R4 implementation, it will reject the new IF_ID C-Type and drop the PATH over bypass. This will result in the protected LSP state expiring at the MP node, which will tear down the path. This would be the case in general when node-protect FRR is enabled and the MP node does not support unnumbered RSVP interface.

2.4.5 PCEP support for RSVP-TE LSPs

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

The 7210 SAS operates as a PCE Client (PCC) only, supporting PCC capabilities for RSVP-TE LSPs.

The following MPLS-level and LSP-level CLI commands are used to configure RSVP-TE LSPs in a router acting as a PCC.

- **config>router>mpls>**

  pce-report rsvp-te {enable | disable}

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

  path-profile *profile-id* [**path-group** *group-id*]

  pce-computation

  pce-control

  pce-report {enable | disable | inherit}

2.5 MPLS 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 the mapping of traffic flows 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.

2.5.1 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 used by default. The TE metric is only used in CSPF computations for MPLS paths and not in the regular SPF computation for IP reachability.

2.6 Advanced MPLS/RSVP features

2.6.1 LSP path change

The **tools perform router mpls update-path** {**lsp** *lsp-name* **path** *current-pathname* **new-path** *new-path-name*} command instructs MPLS to replace the path of the primary or secondary LSP.

The primary or secondary LSP path is indirectly identified via the current-path-name value. In existing implementation, the same path name cannot be used more than once in a given LSP name.

This command is also supported on an SNMP interface.

This command applies to both CSPF LSP and to a non-CSPF LSP. However, it will only be honored when the specified current-path-name has the adaptive option enabled. The adaptive option can be enabled the LSP level or at the path level.

The new path must be first configured in CLI or provided via SNMP. The **config router mpls path** *path-name* CLI command is used to enter the path.

The command fails if any of the following conditions are satisfied:

- 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 the command is executed, 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 datapath 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 datapath, which 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.

2.6.2 Manual LSP path switch

This feature provides a new command to move the path of an LSP from a standby secondary to another standby secondary.

The base version of the command allows the path of the LSP to move from a standby (or an active secondary) to another standby of the same priority. If a new standby path with a higher priority or a primary path comes up after the tools perform command is executed, the path re-evaluation command runs and the path is moved to the path specified by the outcome of the re-evaluation.

The CLI command for the base version is:

tools perform router mpls switch-path lsp *lsp-name* **path** *path-name*

The sticky version of the command can be used to move from a standby path to any other standby path regardless of priority. The LSP remains in the specified path until this path goes down or the user performs the no form of the tools perform command.

The CLI commands for the sticky version are:

tools perform router mpls force-switch-path lsp *lsp-name* **path** *path-name*

tools perform router mpls no force-switch-path lsp *lsp-name*

2.6.3 Make-Before-Break (MBB) procedures for LSP/Path parameter configuration change

When an LSP is switched from an existing working path to a new path, it is desirable to perform this in a hitless fashion. The Make-Before-Break (MBB) procedure consist of first signaling the new path when it is up, and having the ingress LER move the traffic to the new path. Only then the ingress LER tears down the original path.

MBB procedure is raised during the following operations:

- timer based and manual re-signal of an LSP path

- Fast-ReRoute (FRR) global revertive procedures

- Traffic-Engineering (TE) graceful shutdown procedures

2.6.4 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.

2.6.4.1 Disjoint backup paths

This section provides information about the steps necessary to create shared risk link groups for primary/standby SRLG disjoint configuration and for FRR detours/bypass SRLG disjoint configuration. Non-CSPF manual bypass is not considered.

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 (shown in the following figure).

Figure 7: Shared Risk Link Groups
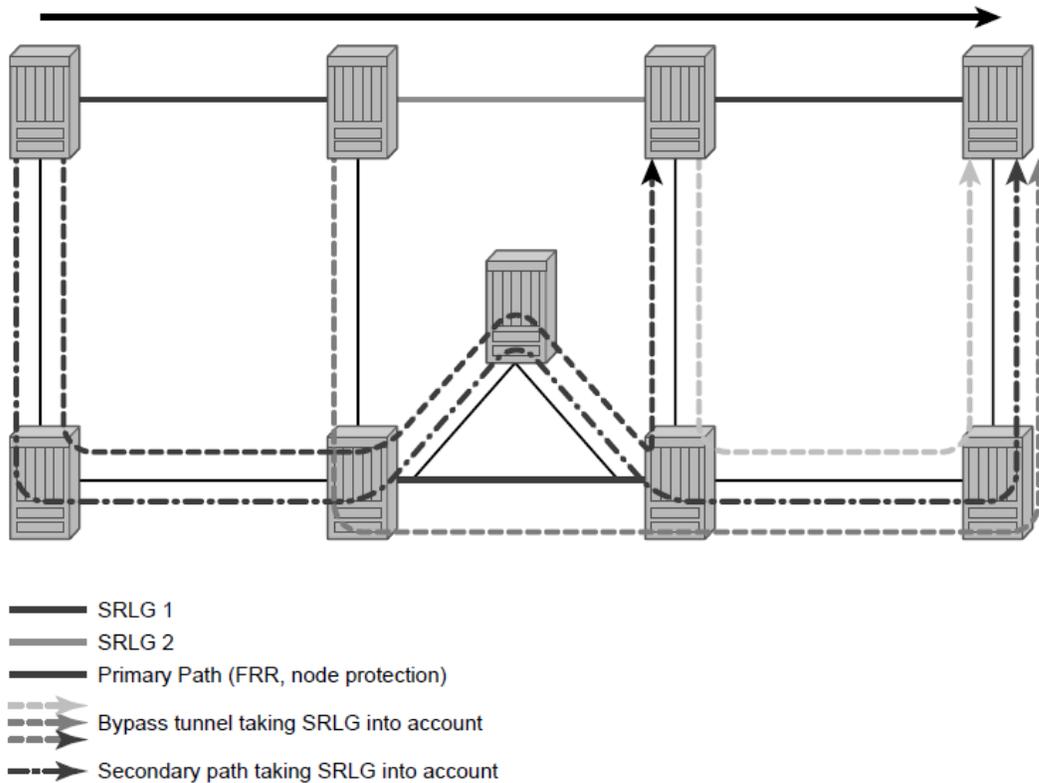
This feature is supported on OSPF and IS-IS interfaces on which RSVP is enabled.

2.6.4.1.1 Enabling disjoint backup paths for primary and standby SRLG disjoint configuration

About this task

The following details the steps necessary to create shared risk link groups for primary/standby SRLG disjoint configuration.

Procedure

Step 1. Create an SRLG-group similar to admin groups.

Step 2. Link the SRLG-group to MPLS interfaces.

Step 3. Configure primary and secondary LSP paths and enable SRLG on the secondary LSP path. Note that the SRLG secondary LSP paths will always perform a strict CSPF query. The **srlg-frr** command is irrelevant in this case (For more information, see srlg-frr).

2.6.4.1.2 Enabling disjoint backup paths for FRR detours and bypass SRLG disjoint configuration

About this task

The following details the steps necessary to create shared risk link groups for FRR detours/bypass SRLG disjoint configuration.

Procedure

Step 1. Create an SRLG group, similar to admin groups.

Step 2. Link the SRLG group to MPLS interfaces.

Step 3. Enable the **srlg-frr** (strict/non-strict) option, which is a system-wide parameter, and it forces every LSP path CSPF calculation, to take the configured SRLG memberships (and propagated through the IGP opaque-te-database) into account.

Step 4. Configure primary FRR (one-to-one/facility) LSP paths. Consider that each PLR will create a detour/bypass that will only avoid the SRLG memberships 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, therefore 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 types to bind to, the following priority rules will be followed:

    a. manual bypass disjoint

    b. manual bypass non-disjoint (eligible only if srlg-frr is non-strict)

    c. dynamic disjoint

    d. dynamic non-disjoint (eligible only if srlg-frr is non-strict)

2.6.4.2 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 interpret with routers that do not implement the SRLG membership advertisement through 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** context. 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 specific 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.

2.6.5 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.

2.7 MPLS/RSVP configuration process overview

The following figure shows the process to configure MPLS and RSVP parameters.

Figure 8: MPLS and RSVP configuration and implementation flow

```
                    ┌──────────────┐
                    │    Start     │
                    └──────┬───────┘
                           │
         ┌─────────────────▼─────────────────┐
         │           Enable MPLS             │
         └─────────────────┬─────────────────┘
                           │
         ┌─────────────────▼─────────────────┐
         │  Configure MPLS interface parameters │
         └─────────────────┬─────────────────┘
                           │
         ┌─────────────────▼─────────────────┐
         │  Configure RSVP interface parameters │
         └─────────────────┬─────────────────┘
                           │
         ┌─────────────────▼─────────────────┐
         │     Configure path parameters     │
         └─────────────────┬─────────────────┘
                           │
         ┌─────────────────▼─────────────────┐
         │     Configure LSP parameters      │
         └─────────────────┬─────────────────┘
                           │
         ┌─────────────────▼─────────────────┐
         │  Configure LSP-path parameters    │
         └─────────────────┬─────────────────┘
                           │
                    ┌──────▼───────┐
                    │     Run      │
                    └──────────────┘
```

sw0539
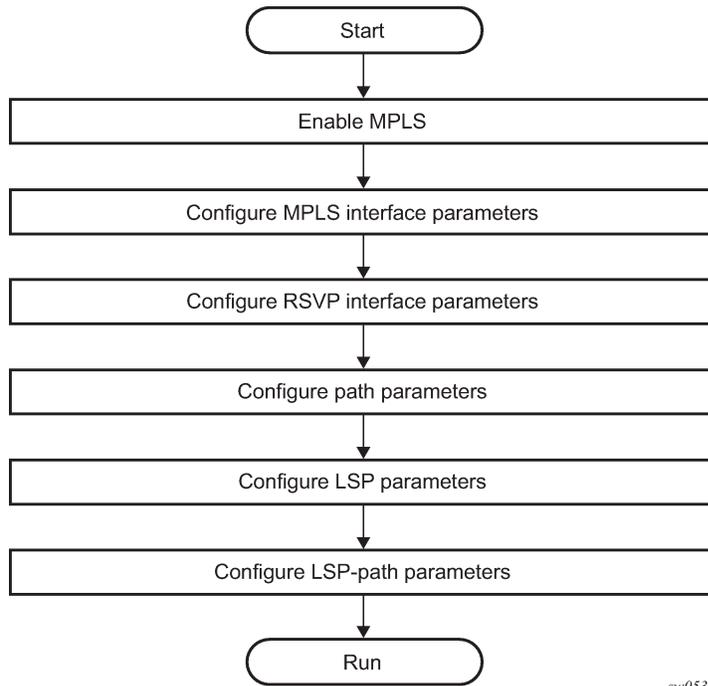
2.8 Configuration notes

This following information describes MPLS and RSVP guidelines and restrictions:

- 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 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.

2.9 Configuring MPLS and RSVP with CLI

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

2.10 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.

2.10.1 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 automatically manages label values. Labels that are automatically assigned have values ranging from 1,024 through 1,048,575. See section Label values for more information.

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

2.10.2 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.

2.10.3 Router interface

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

2.10.4 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.

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.

2.11 Basic MPLS configuration

This section provides information to configure MPLS and configuration examples of common configuration
tasks. To enable MPLS on routers, you must configure at least one MPLS interface. The other MPLS
configuration parameters are optional.

Example: MPLS configuration output

```
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#
```

2.12 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 as follows:

- 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.

2.12.1 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.

Use the following syntax to configure MPLS admin-group parameters.

```
mpls
admin-group group-name group-value
frr-object
resignal-timer minutes
```

Example: Admin group configuration output

```
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#
```

2.12.2 Configuring an MPLS interface

Configure the **label-map** parameters if the interface is used in a static LSP. Use the following syntax to configure an MPLS interface on a router.

```
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
```

Example: MPLS interface configuration output

```
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#
```

2.12.3 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 syntax to configure a path.

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

Example: Path configuration output

```
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#
```

2.12.4 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.

Example: MPLS LSP configuration output

```
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#
```

2.12.4.1 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 syntax to configure a static LSP.

```
config>router>mpls
static-lsp lsp-name
to ip-address
push out-label nexthop ip-addr
no shutdown
```

Example: Static LSP configuration output

```
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#
```

2.12.5 Configuring manual bypass tunnels

About this task

Consider the network setup in the following figure that shows nodes A through F.

Figure 9: Manual bypass tunnels
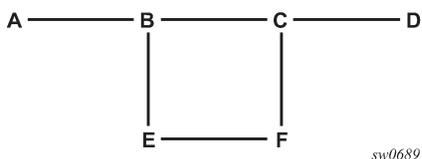
The user first configures the option to disable the dynamic bypass tunnels.

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

Procedure

Step 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.

Step 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

Example

Bypass tunnel configuration output

```
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#
```

Step 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 criteria 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)

Expected outcome

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

2.13 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.

Example: RSVP configuration output

```
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#
```

2.13.1 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 syntax to configure RSVP parameters.

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

Example: RSVP message pacing configuration output

```
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#
```

2.13.2 Configuring graceful shutdown

Enable TE graceful shutdown on the maintenance 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.

2.14 MPLS configuration management tasks

This section discusses the MPLS configuration management tasks.

2.14.1 Modifying MPLS parameters

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

2.14.2 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.

Example: MPLS LSP configuration output

```
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#
```

2.14.3 Modifying MPLS path parameters

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

Example: Path configuration output

```
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#
```

2.14.4 Modifying MPLS static LSP parameters

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

Example: Static LSP configuration

See the static LSP configuration on Configuring a static LSP.

```
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#
```

2.14.5 Deleting an MPLS interface

To delete an interface from the MPLS configuration, the interface must be shut down first.

Use the following syntax to delete an interface from the MPLS configuration output.

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

Example: MPLS configuration output

```
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#
```

2.15 RSVP configuration management tasks

This section describes the RSVP configuration management tasks.

2.15.1 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.

Example: Modified RSVP configuration output

```
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#
```

2.15.2 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.

Example: Modified RSVP message pacing configuration output

```
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#
```

2.15.3 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 for information about deleting an MPLS interface.

2.16 MPLS/RSVP command reference

2.16.1 Command hierarchies

- Configuration commands
  - MPLS commands
  - MPLS LSP commands
  - MPLS Path commands
  - RSVP commands
- Show commands
- Tools commands
- Clear commands
- Debug commands

2.16.1.1 Configuration commands

2.16.1.1.1 MPLS commands

```
config
    - router
        - [no] mpls
            - 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)]
                - label-map in-label
                - no label-map in-label
                    - no pop
                    - pop
                    - no shutdown
                    - shutdown
                    - swap out-label nexthop ip-address
                    - swap implicit-null-label nexthop ip-address
                    - no swap
                - no shutdown
                - shutdown
                - [no] srlg-group group-name [group-name...(up to 5 max)]
                - te-metric metric
                - no te-metric
            - pce-report rsvp-te {enable | disable}
            - 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]
            - [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]
```

2.16.1.1.2 MPLS LSP commands

```
config
    - router
        - [no] mpls
            - [no] lsp lsp-name [bypass-only]
                    - [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)]
                    - path-profile profile-id [path-group group-id]
                    - no path-profile profile-id
                    - [no] pce-computation
                    - [no] pce-control
                    - pce-report {enable | disable | inherit}
                    - [no] primary path-namex
                        - [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
```

2.16.1.1.3 MPLS Path commands

```
config
    - router
        - [no] mpls
            - [no] p2p-active-path-fast-retry
            - [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
```

2.16.1.1.4 RSVP commands

```
config
    - router
        - [no] rsvp
            - [no] implicit-null-label
            - [no] interface ip-int-name
                - authentication-key [authentication-key | hash-key] [hash | hash2]
                - no authentication-key
                - [no] bfd-enable
                - 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
```

2.16.1.2 Show commands

```
show
    - router
        - mpls
```

```
                - 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]
                - srlg-database [router-id ip-address] [interface ip-address]
                - static-lsp  [lsp-name]
                - static-lsp  {transit | terminate}
                - static-lsp  count
                - status
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
```

2.16.1.3 Tools commands

```
tools
    - 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...(up to 8
 max)]] [use-te-metric] [strict-srlg] [srlggroup
grp-id...(up to 8 max)] [skip-interface interface-name]
                - resignal {lsp lsp-name path path-name | delay minutes}
                - switch-path [lsp lsp-name] [path path-name]
```

2.16.1.4 Clear commands

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

2.16.1.5 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
```

2.16.2 Command descriptions

- MPLS configuration commands
- RSVP configuration commands
- Show commands
- Tools commands
- Clear commands
- Debug commands

2.16.2.1 MPLS configuration commands

- Generic commands
- MPLS commands
- MPLS interface commands
- LSP commands
- Primary and secondary path commands
- LSP path commands
- Static LSP commands

2.16.2.1.1 Generic commands

shutdown

Syntax

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

Context

config>router>mpls

config>router>mpls>interface

config>router>mpls>lsp>primary

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

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 explicitly 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

2.16.2.1.2 MPLS commands

mpls

Syntax

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

Context

config>router

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure MPLS parameters. MPLS is not enabled by default and must be explicitly enabled (**no shutdown**). The **shutdown** command administratively disables MPLS.

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

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

dynamic-bypass

Syntax

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

no dynamic-bypass

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

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:**
> Implicit NULL must be enabled for the use of Manual Bypass or Dynamic Bypass (FRR facility) if the 7210 SAS is used as an egress LER or is a merge point.

Default

dynamic bypass

frr-object

Syntax

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

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command specifies whether fast reroute for LSPs using the **facility** bypass method is signaled 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.

By default, the value is inherited by all LSPs.

Default

frr-object

hold-timer

Syntax

hold-timer *seconds*

no hold-timer

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the amount of time that the ingress node waits before programming its data plane and declaring to the service module that the LSP is up.

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

Default

1 second

Parameters

seconds

Specifies the hold time, in seconds.

Values   0 to 10

pce-report

Syntax

pce-report rsvp-te {**enable** | **disable**}

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the reporting mode for RSVP-TE LSPs.

The PCC LSP database is synchronized with the PCE LSP database using the PCEP PCRpt (PCE report) message for PCC-controlled, PCE-computed, and PCE-controlled LSPs.

The global MPLS-level **pce-report** command enables or disables PCE reporting for all RSVP-TE LSPs during PCE LSP database synchronization. The PCC reports both CSPF and non-CSPF LSPs.

The LSP-level **pce-report** command (in the **config>router>mpls>lsp>pce-report** context) overrides the global configuration for reporting an LSP to the PCE. The default configuration, which inherits the global MPLS-level configuration, is disabled (using the **pce-report rsvp-te disable** command).

The default configuration controls the introduction of a PCE into an existing network and allows the user to decide whether all RSVP-TE LSPs should be reported. If PCE reporting for an LSP is disabled, either because of the inheritance of the global MPLS configuration or because of LSP-level configuration, enabling the **pce-control** option for the LSP has no effect.

Default

pce-report rsvp-te disable

Parameters

rsvp-te

Specifies PCE reporting for all RSVP-TE LSPs.

enable — Keyword to enable PCE reporting.

disable — Keyword to disable PCE reporting.

Values   enable, disable

resignal-timer

Syntax

resignal-timer *minutes*

no resignal-timer

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the value for the LSP resignal timer. The resignal timer is the wait time, in minutes, before the software attempts 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 continues to use the existing path and a resignal is attempted the next time the timer expires.

The **no** form of this command disables timer-based LSP resignaling.

Default

no resignal-timer

Parameters

minutes

Specifies the time the software waits before attempting to resignal the LSPs.

Values   30 to 10080

srlg-frr

Syntax

srlg-frr [**strict**]

no srlg-frr

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables or disables the use of the Shared Risk Link Group (SRLG) constraint in the computation of an FRR bypass or detour LSP for any primary LSP path on the system.

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

CSPF prunes all links with interfaces that belong to the same SRLG as the interface being protected, where the interface being protected is the outgoing interface at the PLR used by the primary path. If one or more paths are found, the MPLS/RSVP task selects one path based on best cost and signals the setup of the FRR bypass or detour LSP. If no path is found and the user included the **strict** option, the FRR bypass or detour LSP is not set up and the MPLS/RSVP task keeps retrying the request to CSPF. If a path exists that meets the other TE constraints, other than the SRLG one, the bypass or detour LSP is set up.

An FRR bypass or detour LSP is not guaranteed to be SRLG disjoint from the primary path. This is because only the SRLG constraint of the outgoing interface at the PLR that the primary path is using is checked.

When the MPLS/RSVP task is searching for a SRLG bypass tunnel to associate with the primary path of the protected LSP, the task performs the following steps.

- First, the task checks for any configured manual bypass LSP that has CSPF enabled and that satisfies the SLRG constraints.

- The task then skips any non-CSPF bypass LSP in the search because there is no ERO returned with which to check the SLRG constraint.

- If no path is found, the task checks for an existing dynamic bypass LSP that satisfies the SLRG and other primary path constraints.

- If no bypass path is found, the task makes a request to CSPF to create one.

When the primary path of the LSP is set up and is operationally up, any subsequent changes to the SRLG group membership of an interface that the primary path is using will not be considered by the MPLS/RSVP task at the PLR for bypass or detour LSP association until the next opportunity that the primary path is resignaled. The path may be resignaled because of a failure or a make-before-break (MBB) operation. An MBB operation occurs as a result of a global revertive operation, a reoptimization of the LSP path (timer-based or manual), or a user change to any of the path constraints.

When the bypass or detour path is set up and is operationally up, subsequent changes to the SRLG group membership of an interface that the bypass or detour LSP path is using would not be considered by the MPLS/RSVP task at the PLR until the next opportunity that the association with the primary LSP path is rechecked. The association is rechecked if the bypass path is reoptimized. Detour paths are not reoptimized and are resignaled if the primary path is down.

Enabling or disabling the **srlg-frr** command takes effect only after LSP paths are resignaled, which is done by shutting down and reenabling MPLS. Another option is using the **tools perform router mpls resignal** command. While using the **tools** command may have less service impact, only originating LSPs can be

resignaled using the **tools** command. If local transit and bypass LSPs must also be resignaled, the **tools** command must be executed on all ingress nodes in the network. The same may 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 when the detour or bypass LSP is in use.

An RSVP interface can belong to a maximum of 64 SRLG groups. Configure the SRLG groups using the **config router mpls srlg-group** command. Configure the SRLG groups that an RSVP interface belongs to using the **srlg-group** command in the **config>router>mpls>interface** context.

The **no** form of this 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   default: no slr-frr

non-strict: srlg-frr

strict: srlg-frr **strict**

user-srlg-db

Syntax

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

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

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 queries the local SRLG and computes 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 then resumes queries into the TE database for SRLG membership information. The user SRLG database is maintained.

Default

user-srlg-db disable

Parameters

enable

Keyword to enable the use of the user SRLG database.

disable

Keyword to disable the use of the user SRLG database.

srlg-database

Syntax

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

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context manually enter 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 this command deletes the entire SRLG database. CSPF assumes all interfaces have no SRLG membership association if the database was not disabled using the **config router mpls user-srlg-db disable** command.

router-id

Syntax

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

Context

config>router>mpls>srlg-database

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command manually enters 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 assumes these interfaces have no SRLG membership association.

The **no** form of this command deletes 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.

Values a.b.c.d

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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enable the user 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 five 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.

CSPF does 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 this 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.

Parameters

ip-int-name

Specifies 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.

label-map

Syntax

[**no**] **label-map** *in-label*

Context

config>router>mpls>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command is used on transit routers when a static LSP is defined. The static LSP on the ingress router is initiated using the **config router mpls static-lsp** *lsp-name* command. An *in-label* can be associated with either a **pop** or **swap** action, but not both. If both actions are specified, the last action specified takes effect.

The **no** form of this command deletes the static LSP configuration associated with the *in-label*.

Parameters

in-label

Specifies the incoming MPLS label on which to match.

Values   32 to 1023

pop

Syntax

[**no**] **pop**

Context

config>router>mpls>if>label-map

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command specifies that the incoming label must be popped (removed). No label stacking is supported for a static LSP. The service header follows the top label. After the label is popped, the packet is forwarded based on the service header.

The **no** form of this command removes the **pop** action for the *in-label*.

shutdown

Syntax

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

Context

config>router>mpls>if>label-map

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command disables the label map definition. This drops all packets that match the *in-label* specified in the **label-map** command.

The **no** form of this command administratively enables the defined label map action.

Default

no shutdown

swap

Syntax

swap *out-label* **nexthop** *ip-address*

swap implicit-null-label nexthop *ip-address*

no swap

Context

config>router>mpls>interface>label-map

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command swaps the incoming label and specifies the outgoing label and next-hop IP address on an LSR for a static LSP.

The **no** form of this command removes the swap action associated with the *in-label*.

Parameters

implicit-null-label

Keyword to specify the use of the implicit label value for the outgoing label of the swap operation.

out-label

Specifies the label value to be swapped with the in-label. Label values 16 through
1,048,575 are defined as follows.

- Label values16 through 31 are 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 to 1048575

nexthop *ip-address*

Specifies the IP address to forward to. If an ARP entry for the next hop exists, the static
LSP is marked operational. If an ARP entry does not exist, the operational status of the
static LSP is set to down and the software continuously tries to ARP for the configured next
hop at fixed intervals.

static-lsp

Syntax

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

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures a static LSP on the ingress router. The static LSP is a manually set up LSP
where the next-hop IP address and the outgoing label (push) must be specified.

The **no** form of this command deletes this static LSP and associated information.

The LSP must be shut down first 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

Specifies a name that identifies the LSP, up to 32 alphanumeric characters.

push

Syntax

no push *label*

push *label* **nexthop** *ip-address*

Context

config>router>mpls>static-lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

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 label to push on the label stack. Label values 16 through 1048575 are defined as follows.

- Label values16 through 31 are reserved.

- Label values 32 through 1023 are available for static assignment.

- Label values 1024 through 2047 are reserved for future use.

- Label values 2048 through 18431 are statically assigned for services.

- Label values 28672 through 131071 are dynamically assigned for both MPLS and services.

- Label values 131072 through 1048575 are reserved for future use.

Values   16 to 1048575

nexthop *ip-address*

Specifies the IP address of the next hop toward the LSP egress router. If an ARP entry for the next hop exists, the static LSP is marked operational.

If ARP entry does not exist, software sets the operational status of the static LSP to down and continuously tries to ARP for the configured next hop at a fixed interval.

shutdown

Syntax

[no] **shutdown**

Context

config>router>mpls>static-lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command administratively disables 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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

Specifies the system IP address of the egress router.

static-lsp-fast-retry

Syntax

static-lsp-fast-retry seconds

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

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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 functionality 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 this command reverts to the default value.

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 to 30

2.16.2.1.3 MPLS interface commands

interface

Syntax

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

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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**, that are defined under the interface. The MPLS interface must be shut down first to delete the interface definition. 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

Specifies the name of the network IP interface, up to 32 alphanumeric characters. An interface name cannot be in the form of an IP address. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

admin-group

Syntax

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

Context

config>router>mpls>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command associates admin groups with the interface.

The user can apply admin groups to an IES, VPRN, network IP, or MPLS interface. Each single operation of the **admin-group** command allows a maximum of five groups to be specified at a time. However, a maximum of 32 groups can be added to a specific interface through multiple operations.

After an admin group is bound to one or more interfaces, its value cannot be changed until all bindings are removed. The configured admin-group membership is applied in all levels and areas the interface is participating in. The same interface cannot have different memberships in different levels or areas.

Only the admin groups bound to an MPLS interface are advertised in TE link TLVs and sub-TLVs when the traffic-engineering option is enabled in IS-IS or OSPF. IES and VPRN interfaces do not have their attributes advertised in TE TLVs.

The user can also delete all memberships of an interface by not specifying a group name.

The **no** form of this command deletes the association of this interface with one or more of the admin groups.

Default

no admin-group

Parameters

group-name

Specifies the name of the group, up to 32 characters. The association of group name and value should be unique within an IP/MPLS domain.

srlg-group

Syntax

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

Context

config>router>mpls>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

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 five groups to be specified at a time.

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

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

Platforms

Supported on all 7210 SAS platforms as described in this document

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 first prunes all links in the network topology that do not meet the constraints specified for the LSP path. Such constraints include bandwidth, admin-groups, and hop limit. Then, CSPF runs an SPF on the remaining links. The shortest path among the all SPF paths is 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 **config router mpls lsp cspf use-te-metric** command.

The TE metric is only used in CSPF computations for MPLS paths and not in the regular SPF computation for IP reachability. The value of the IGP metric is advertised in the TE metric sub-TLV by IS-IS and OSPF.

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

Default
no te-metric

Parameters
value

Specifies the metric value.

Values 1 to 16777215

2.16.2.1.4 LSP commands

lsp

Syntax
[**no**] **lsp** *lsp-name* [**bypass-only**]

Context
config>router>mpls

Platforms
Supported on all 7210 SAS platforms as described in this document

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

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.

Parameters

lsp-name

Specifies a name that identifies the LSP. The LSP name can be up to 32 characters and must be unique.

bypass-only

Keyword to specify an LSP as a manual bypass LSP exclusively. When a path message for a new LSP requests bypass protection, the PLR first checks if a manual bypass tunnel satisfying the path constraints exists. If one is found, the 7210 SAS selects it. If no manual bypass tunnel is found, the 7210 SAS dynamically signals a bypass LSP in the default behavior. The CLI for this feature includes a command that provides the option to disable dynamic bypass creation on a per-node basis.

adaptive

Syntax

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

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the make-before-break (MBB) functionality for an LSP or LSP path. When enabled for the LSP, MBB is performed for the primary path and all the secondary paths of the LSP.

Default

adaptive

adspec

Syntax

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

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command specifies that the advertised data (ADSPEC) object is 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.

A bypass LSP always signals the ADSPEC object because it protects both primary paths that signal the ADSPEC object and primary paths that do not. The 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

bgp-transport-tunnel

Syntax

bgp-transport-tunnel {include | exclude}

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables or disables RSVP-TE LSP to be used as a transport LSP for BGP tunnel routes.

Default

bgp-transport-tunnel exclude

Parameters

include

Keyword that enables RSVP-TE LSP to be used as transport LSP from ingress PE to ASBR in the local AS.

exclude

Keyword that disables RSVP-TE LSP to be used as transport LSP from ingress PE to ASBR in the local AS.

cspf

Syntax

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

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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 the **fast-reroute** command 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, neither global revertive nor local revertive is available for the LSP to recover.

Default

no cspf

Parameters

use-te-metric

Keyword to specify 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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 five groups to be specified at a time. However, a maximum of 32 groups can be specified per LSP by using multiple operations. The admin groups are defined in the **config>router>mpls>admin-group** context.

The **no** form of this command removes the **exclude** command.

Default

no exclude

Parameters

group-name

Specifies the existing group-name to be excluded when an LSP is set up.

fast-reroute

Syntax

fast-reroute *frr-method*

no fast-reroute

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures a precomputed 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 precomputed detour LSP, which avoids packet loss.

When the **fast-reroute** command 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 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 signals all intermediate routers using RSVP to set up their detours. TE must be enabled for **fast-reroute** to work.

CSPF must be enabled for fast rerouter to work. If an LSP is configured with **fast-reroute** *frr-method* specified but without CSPF enabled, neither global revertive nor local revertive is available for the LSP to recover.

The **no** form of this **fast-reroute** command removes the detour LSP from each node on the primary path. This command also removes 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

Parameters

ffr-method

Specifies the fast reroute method to use.

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

bandwidth

Syntax

bandwidth *rate-in-mbps*

no bandwidth

Context

config>router>mpls>lsp>fast-reroute

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures reserved bandwidth on the detour path. When configuring an LSP, specify the traffic rate associated with the LSP.

When configuring the **fast-reroute** command, 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

Parameters

rate-in-mbps

Specifies the amount of bandwidth, in Mb/s, to be reserved for the LSP path.

hop-limit

Syntax

hop-limit *limit*

no hop-limit

Context

config>router>mpls>lsp>fast-reroute

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures how many more routers a detour can traverse compared to the LSP itself on a fast reroute. 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.

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

Default

16

Parameters

limit

Specifies the maximum number of hops.

Values   0 to 255

node-protect

Syntax

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

Context

config>router>mpls>lsp>fast-reroute

Platforms

Supported on all 7210 SAS platforms as described in this document

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 reaches its destination even if the neighboring router fails.

Default

node-protect

from

Syntax

from *ip-address*

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

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 next-hop IP address is a different interface, the LSP is not signaled. As the egress interface changes because of changes in the routing topology, an LSP recovers if the **from** IP address is the system IP address and not a specific interface IP address.

Only one **from** address can be configured.

Default

system IP address

Parameters

ip-address

Specifies the IP address of the ingress router. This can be either the interface or the system IP address. If the IP address is local, the LSP must egress through that local interface, which ensures local strictness.

Values   system IP or network interface IP addresses

Default   system IP address

hop-limit

Syntax

hop-limit *number*

no hop-limit

Context

config>router>mpls>lsp

config>router>mpls>lsp>fast-reroute

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the maximum number of hops that an LSP can traverse, including the ingress and egress routers. An LSP is not set up if the hop limit is exceeded. This value can be changed dynamically for an LSP that is already set up with the following implications.

- If the new value is less than the current number of hops of the established LSP, the LSP is brought down. The 7210 SAS 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, the LSP is not affected.

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

Default

255

Parameters

number

Specifies the number of hops the LSP can traverse, expressed as an integer.

Values   2 to 255

include

Syntax

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

Context

config>router>mpls>lsp

config>router>mpls>lsp>primary

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the admin groups to be included when an LSP is set up. Up to five groups per operation can be specified, up to 32 maximum.

The **no** form of this 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.

metric

Syntax

metric *metric*

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the metric for this LSP, which is used to select an LSP among a set of LSPs that are destined for the same egress router. The LSP with the lowest metric is selected.

Default

1

Parameters

metric

Specifies the metric for this LSP.

Values   1 to 65535

path-profile

Syntax

path-profile *profile-id* [**path-group** *group-id*]

no path-profile *profile-id*

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the PCE path profile and path group ID.

The PCE supports the computation of disjoint paths for two LSPs originating or terminating on the same or different PE routers. To indicate this constraint to the PCE, the user configures the PCE path profile ID and path group ID to which the PCE-computed or PCE-controlled LSP belongs. Because the PCC passes these parameters transparently to the PCE, the parameters are opaque data to the router.

The association of the optional path group ID allows the PCE to determine the profile ID to use with this path group ID. Although one path group ID is allowed for each profile ID, you can execute the **path-profile** command multiple times and enter the same path group ID with multiple profile IDs. A maximum of five **path-profile** *profile-id* [**path-group** *group-id*] entries can be associated with the same LSP.

Parameters

profile-id

Specifies the profile ID.

Values   1 to 4294967295

group-id

Specifies the path group ID.

Values   0 to 4294967295

pce-computation

Syntax

[**no**] **pce-computation**

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the PCE-computed LSP mode of operation for an RSVP-TE LSP.

The user can grant only path computation requests (PCE-computed) or both path computation requests and path updates (PCE-controlled) to a PCE for a specific LSP.

The **pce-computation** command sends the path computation request to the PCE instead of the local CSPF. Enabling this option allows the PCE to perform path computations for the LSP at the request of the PCC router only. This is used in cases where the user wants to use the PCE-specific path computation algorithm instead of the local router CSPF algorithm.

The enabling of the **pce-computation** requires that the **cspf** option first be enabled; otherwise, this configuration is rejected. Conversely, an attempt to disable the **cspf** option on an RSVP-TE LSP that has the **pce-computation** command or **pce-control** command enabled is rejected.

Default

no pce-computation

pce-control

Syntax

[**no**] **pce-control**

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the PCE-controlled LSP mode of operation for an RSVP-TE LSP.

Using the **pce-control** command, the PCC router delegates full control of the LSP to the PCE (PCE-controlled). As a result, PCE acts in an active stateful mode for this LSP. The PCE can reroute the path following a failure or reoptimize the path and update the router without an update request from the PCC router.

The user can delegate CSPF and non-CSPF LSPs, or LSPs that have the **pce-computation** option enabled or disabled. The LSP maintains the latest active path computed by the PCE or the PCC router at the time it is delegated. The PCE only updates the path at the next network event or reoptimization.

The enabling of the **pce-control** command requires that the **cspf** option first be enabled; otherwise, this configuration is rejected. Conversely, an attempt to disable the **cspf** option on an RSVP-TE LSP that has the **pce-control** command or **pce-computation** command enabled is rejected.

If PCE reporting is disabled for the LSP, either because of inheritance from the MPLS-level configuration or because of LSP-level configuration, enabling the **pce-control** option for the LSP has no effect.

Default

no pce-control

pce-report

Syntax

pce-report {**enable** | **disable** | **inherit**}

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the reporting mode to a PCE for an RSVP-TE LSP.

The PCC LSP database is synchronized with the PCE LSP database using the PCEP PCRpt (PCE Report) message for PCC-controlled, PCE-computed, and PCE-controlled LSPs.

Use the global MPLS-level **pce-report** command (**config>router>mpls>pce-report**) to enable or disable PCE reporting for all RSVP-TE LSPs during PCE LSP database synchronization.

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

Default

pce-report inherit

Parameters

enable

Keyword to enable PCE reporting.

disable

Keyword to disable PCE reporting.

inherit

Keyword to inherit the global configuration for PCE reporting.

to

Syntax

to *ip-address*

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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.

Parameters

ip-address

Specifies the system IP address of the egress router.

retry-limit

Syntax

retry-limit *number*

no retry-limit

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

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 reverts to the default value.

Default

0

Parameters

number

Specifies the number of times the 7210 SAS attempts to re-establish the LSP after it has failed. Allowed values are integers; 0 indicates to retry forever.

Values   0 to 10000

retry-timer

Syntax

retry-timer *seconds*

no retry-timer

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

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

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

Default

30

Parameters

seconds

Specifies the amount of time, in seconds, between attempts to re-establish the LSP after it has failed.

Values   1 to 600

rsvp-resv-style

Syntax

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

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

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

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

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

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

Default

shutdown

2.16.2.1.5 Primary and secondary path commands

primary

Syntax

primary *path-name*

no primary

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures a preferred path for the LSP. This command is optional only if the **secondary** *path-name* is included in the LSP definition. Only one primary path can be defined for an LSP.

Some of the attributes of the LSP, such as the bandwidth and hop-limit, can be optionally specified as the attributes of the primary path. The attributes specified in the *primary path-name* command override the 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 first shut down to delete it.

The **no** form of this command results in no action except a warning message on the console indicating that the primary path is administratively up.

Parameters

path-name

Specifies the case-sensitive alphanumeric name label for the LSP path, up to 32 characters.

secondary

Syntax

[**no**] **secondary** *path-name*

Context

config>router>mpls>lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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 7210 SAS 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 7210 SAS software does not switch back between secondary paths.

The 7210 SAS software starts the signaling of all non-standby secondary paths at the same time. Retry counters are maintained for each unsuccessful attempt. When the retry limit is reached on a path, the 7210 SAS software does 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 to delete it.

The **no secondary** *path-name* command results in no action except a warning message on the console indicating that the secondary path is administratively up.

Parameters

path-name

Specifies the case-sensitive alphanumeric name label for the LSP path, up to 32
characters.

adaptive

Syntax

[no] **adaptive**

Context

config>router>mpls>lsp>primary

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the MBB functionality for an LSP or a primary or secondary LSP path. When
enabled for the LSP, an MBB operation is performed for primary path and all the secondary paths of the
LSP.

Default

adaptive

bandwidth

Syntax

bandwidth *rate-in-mbps*

no bandwidth

Context

config>router>mpls>lsp>primary

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

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

Parameters

rate-in-mbps

Specfies the amount of bandwidth reserved for the LSP path in Mb/s.

Values   0 to 100000

exclude

Syntax

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

Context

config>router>mpls>lsp>primary

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

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.

The **no** form of this command removes 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command overrides the **config router mpls lsp 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, the LSP is unaffected.

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

Default

no hop-limit

Parameters

number

Specifies the number of hops the LSP can traverse, expressed as an integer.

Values   2 to 255

path-preference

Syntax

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

Context

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the use of path preference among configured standby secondary paths per LSP.

If all standby secondary paths have a default **path-preference** *value*, 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 reverts to the default value.

Default

255

Parameters

value

Specifies an alternate path for the LSP if the primary path is not available.

Values   1 to 255

record

Syntax

[**no**] **record**

Context

config>router>mpls>lsp>primary

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

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, because 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 specified 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables recording of all the labels at each node that an LSP path traverses. Enabling the **record-label** command also enables 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

Platforms

Supported on all 7210 SAS platforms as described in this document

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. CSPF requires that the primary LSP already be established and in the up state, because 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 queries CSPF again, which provides the list of SLRG group numbers to be avoided. CSPF prunes all links with interfaces that belong to the same SRLGs as the interfaces included in the ERO of the primary path. If CSPF finds a path, the secondary is set up. If CSPF does not find a path, MPLS/RSVP keeps retrying the requests to CSPF.

If CSPF is not enabled on the LSP, a secondary path of that LSP that includes the SRLG constraint is shut down and a specific failure code indicates the exact reason for the failure in the **show router mpls lsp path detail** command output.

At initial primary LSP path establishment, if primary does not come up or primary is not configured, SRLG secondary is not signaled and is put in the down state. A specific failure code indicates the exact reason for the failure in **show router mpls lsp path detail** command output. However, if a non-SRLG secondary path was configured, such as a secondary path with the SRLG option disabled, the MPLS/RSVP task signals 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 reoptimized, has undergone MBB, or has come back up after being down, the MPLS/RSVP task checks with CSPF if the SRLG secondary should be resignaled. If MPLS/RSVP finds that the current secondary path is no longer SRLG disjoint, for example, it became ineligible and 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 that the primary path goes down, the LSP uses the path of an eligible SRLG secondary if it is in the up state. If all secondary eligible SLRG paths are in the down state, MPLS/RSVP uses a non SRLG secondary if configured and in the up state. If while the LSP is using a non SRLG secondary, an eligible SRLG secondary came back up, MPLS/RSVP does not switch the path of the LSP to it. As soon as primary is resignaled and comes up with a new SLRG list, MPLS/RSVP resignals the secondary using the new SRLG list.

A secondary path that becomes ineligible as a result of an update to the SRLG membership list of the primary path has the ineligibility status removed when any of the following occurs.

- A successful MBB of the standby SRLG path, which makes it eligible again.

- 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 expires or the number of retries reaches the number configured under the retry-limit parameter, it is left down.

- The primary path goes down. In this case, the ineligible secondary path is immediately torn down and is resignaled only when the primary comes back up with a new SRLG list.

When 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 until the next opportunity the primary path is resignaled. The primary path may be resignaled because of a failure or an MBB operation. MBB occurs as a result of a global revertive operation, a timer-based or manual reoptimization of the LSP path, or an operator change to any of the path constraints.

When an SRLG secondary path is set up 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 the secondary path is resignaled. The secondary path is resignaled because of a failure, a resignaling of the primary path, or an MBB operation. MBB occurs as a result of a timer-based or manual reoptimization 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.

Also, the user-configured include or exclude admin group statements for this secondary path are also checked together with the SRLG constraints by CSPF.

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

Default

no srlg

standby

Syntax

[**no**] **standby**

Context

config>router>mpls>lsp>secondary

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

The secondary path LSP is normally signaled when the primary path LSP fails. The **standby** command ensures that the secondary path LSP is signaled and maintained indefinitely in a hot-standby state. When the primary path is re-established, the traffic is switched back to the primary path LSP.

The **no** form of this command specifies that the secondary LSP is signaled when the primary path LSP fails.

2.16.2.1.6 LSP path commands

hop

Syntax

hop *hop-index ip-address* {**strict** | **loose**}

no hop *hop-index*

Context

config>router>mpls>path

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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, the LSP can choose the best available interface.

Optionally, the LSP ingress and egress IP address can be included as the first and the last hop. A hop list can include the ingress interface IP address, the system IP address, and the egress IP address of any of the hops being specified.

The **no** form of this command deletes hop list entries for the path. All the LSPs currently using this path are affected. Additionally, all services actively using these LSPs are affected. The path must be shut down first to delete the hop from the hop list. The **no hop** *hop-index* command results in no action except a warning message on the console indicating that the path is administratively up.

Parameters

hop-index

Specifies the hop index, which is used to order the specified hops. The LSP always traverses from the lowest hop index to the highest. The hop index does not need to be sequential.

Values 1 to 1024

ip-address

> Specifies the system or network interface IP address of the transit router. The IP address can be the interface IP address or the system IP address. If the system IP address is specified, the LSP can choose the best available interface. A hop list can also include the ingress interface IP address, the system IP address, and the egress IP address of any of the specified hops.

loose

> Keyword that specifies 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

> Keyword that specifies 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, 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, 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.

p2p-active-path-fast-retry

Syntax

p2p-active-path-fast-retry *seconds*

no p2p-active-path-fast-retry

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures a global parameter to apply a shorter retry timer for the first try after an active LSP path went down because of a local failure or the receipt of a RESVTear. This timer is used only on the first try. Subsequent retries continue to be governed by the existing LSP level retry timer.

Default

0 (disabled)

Parameters

seconds

> Specifies the retry timer, in seconds.

> **Values**   1 to 10 seconds

path

Syntax
[**no**] **path** *path-name*

Context
config>router>mpls

Platforms
Supported on all 7210 SAS platforms as described in this document

Description
This command configures 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 shut down before making any changes (adding or deleting hops) to the path. When a path is shut down, any LSP using the path becomes operationally down.

To create a strict path from the ingress to the egress router, the ingress and 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 are affected. All the services that are actively using these LSPs are also 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 results in no action except a warning message on the console indicating that the path may be in use.

Parameters
path-name

> Specifies a unique case-sensitive alphanumeric name label for the LSP path, up to 32 characters.

shutdown

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

Context
config>router>mpls>path

Platforms
Supported on all 7210 SAS platforms as described in this document

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 as standby secondary are established or re-established.

Default

shutdown

2.16.2.1.7 Static LSP commands

static-lsp

Syntax

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

Context

config>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures a static LSP on the ingress router. The static LSP is a manually set up LSP where the next-hop IP address and the outgoing label (push) must be specified.

The LSP must be shut down first 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.

The **no** form of this command deletes this static LSP and associated information.

Parameters

lsp-name

Specifies the name that identifies the LSP, up to 32 alphanumeric characters.

push

Syntax

push *label* **nexthop** *ip-address*

no push *label*

Context

config>router>mpls>static-lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command specifies the label to be pushed onto the label stack and the next-hop IP address for the static LSP.

The **no** form of this command removes the association of the label to push for the static LSP.

Parameters

label

Specifies the label to push on the label stack. Label values 16 through 1,048,575 are defined as follows.

- Label values16 through 31 are reserved.
- Label values 32 through 1023 are available for static assignment.
- Label values 1024 through 2047 are reserved for future use.
- Label values 2048 through 18431 are statically assigned for services.
- Label values 28672 through 131071 are dynamically assigned for both MPLS and services.
- Label values 131072 through 1048575 are reserved for future use.

Values   16 to 1048575

nexthop *ip-address*

Specifies the IP address of the next hop toward the LSP egress router. If an ARP entry for the next hop exists, the static LSP is marked operational. If an ARP entry does not exist, the software sets the operational status of the static LSP to down and continues to send an ARP request for the configured next hop at fixed intervals.

shutdown

Syntax

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

Context

config>router>mpls>static-lsp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command administratively disables 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the system IP address of the egress router for the static LSP. This command is required when creating an LSP. For LSPs that are used as transport tunnels for services, the **to** IP address must be the system IP address.

Parameters

ip-address

Specifies the system IP address of the egress router.

2.16.2.2 RSVP configuration commands

- Generic commands
- RSVP commands
- Interface commands
- Message pacing commands

2.16.2.2.1 Generic commands

shutdown

Syntax

[no] **shutdown**

Context

config>router>rsvp

config>router>rsvp>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

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

2.16.2.2.2 RSVP commands

rsvp

Syntax

[**no**] **rsvp**

Context

config>router

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure RSVP protocol parameters. RSVP is not enabled by default and must be explicitly 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 shut down before the RSVP instance can be deleted. If RSVP is not shut down, the **no rsvp** command does nothing except issue a warning message on the console indicating that RSVP is still administratively enabled.

Default

no shutdown

bfd-enable

Syntax

[**no**] **bfd-enable**

Context

config>router>rsvp>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the use of bidirectional 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.

Configure the BFD session parameters, such as *transmit-interval*, *receive-interval*, and *multiplier*, under the IP interface in the **config>router>interface>bfd** context.

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 the neighbor gets its first session, which is when this node sends or receives a new Path message over the interface. However, if the session does not come up, because of not receiving a Resv for a new path message sent after the maximum number of retries, the LSP is shut down and the node deregisters with BFD. In general, the registration of RSVP 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 an RSVP hello is enabled on the interface. However, **hello** *timeout* clears all sessions toward the neighbor and RSVP deregisters with BFD at the clearing of the last session.

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, each interface is treated as a separate RSVP neighbor. The user must enable BFD on each interface, and RSVP registers 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 the down state, the following actions are triggered:

- for RSVP signaled LSPs, 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

- switchover to secondary, if any, and scheduling of retries for signaling the primary path of the non-FRR-affected LSPs (head-end role).

> **Note:**
> For more information about the list of protocols that support BFD, see the *7210 SAS-D, Dxp, K 2F1C2T, K 2F6C4T, K 3SFP+ 8C Router Configuration Guide*.

The **no** form of this command removes BFD from the associated RSVP protocol adjacency.

Default

no bfd-enable

graceful-shutdown

Syntax

[no] graceful-shutdown

Context

config>router>rsvp

config>router>rsvp>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command initiates a graceful shutdown of the specified RSVP interface (maintenance interface) or all RSVP interfaces on the node (maintenance node), if applied at the RSVP level.

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 MBB 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, the LSP is maintained on its current path. The maintenance node also tears down and resignals 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 the TE metric set to 0xffffffff and the unreserved bandwidth parameter set to zero.

A head-end LER node, upon receipt of the PathErr message, performs a single MBB attempt on the affected adaptive CSPF LSP. If an alternative path is not found, the LSP is maintained on its current path.

A node does not take any action on the paths of the following originating LSPs after receiving the PathErr message:

- an adaptive CSPF LSP for which the PathErr indicates a node address in the address list and the node corresponds to the destination of the LSP. In this case, there are no alternative paths that can be found.

- an adaptive CSPF LSP whose path has explicit hops defined using the listed maintenance interfaces or nodes.

- a CSPF LSP with the adaptive option disabled and where the current path is over the listed maintenance interfaces in the PathErr message. These are not subject to MBB.

- a non-CSPF LSP where the 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 is used at the next scheduled CSPF computation for any LSP with a path that traverses any of the maintenance interfaces.

The **no** form of this command disables the graceful shutdown operation at the RSVP interface level or the RSVP level. The configured TE parameters of the maintenance links are restored and the maintenance node floods the links.

keep-multiplier

Syntax

keep-multiplier *number*

no keep-multiplier

Context

config>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command specifies 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

Specifies the **keep-multiplier** value.

Values   1 to 255

refresh-reduction-over-bypass

Syntax

refresh-reduction-over-bypass [**enable** | **disable**]

Context

config>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

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 command is disabled. Because 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. The node 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the value of the rapid retransmission interval. This is used in the retransmission mechanism based on an exponential backoff timer to handle unacknowledged message_id objects.

The RSVP-TE message with the same message-id is retransmitted every 2 × **rapid-retransmit-time** interval.

The node stops the retransmission of unacknowledged RSVP messages in the following cases when the updated backoff interval exceeds the value of the regular refresh interval or when the number of retransmissions reaches the value of the **rapid-retry-limit** parameter, whichever comes first.

The rapid retransmission Interval must be smaller than the regular refresh interval configured using the **config router rsvp refresh-time** command.

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

Default

5

Parameters

hundred-milliseconds

Specifies the rapid retransmission interval.

Values   1 to 100, in units of 100 msec

rapid-retry-limit

Syntax

rapid-retry-limit *limit*

no rapid-retry-limit

Context

config>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the value of the rapid retry limit. This is used in the retransmission mechanism based on an exponential backoff timer to handle unacknowledged message_id objects. The RSVP message with the same message_id is retransmitted every 2 × **rapid-retransmit-time** interval.

The node stops the 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** command, 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 to 6, integer values

refresh-time

Syntax

refresh-time *seconds*

no refresh-time

Context

config>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the interval between the successive Path and Resv refresh messages. RSVP declares the session down after it misses the consecutive refresh messages value configured in the **keep-multiplier** command.

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

Default

30 seconds

Parameters

seconds

Specifies the refresh time, in seconds.

Values   1 to 65535

2.16.2.2.3 Interface commands

interface

Syntax

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

Context

config>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

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**, that are defined for the interface. The RSVP interface must be **shutdown** before it can be deleted. If the interface is not shut down, the **no interface** *ip-int-name* command does nothing except issue a warning message on the console indicating that the interface is administratively up.

Default

shutdown

Parameters

ip-int-name

Specifies 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, and so on), the entire string must be enclosed within double quotes.

Values   1 to 32 alphanumeric characters

authentication-key

Syntax

authentication-key [*authentication-key* | *hash-key*] [**hash** | **hash2**]

no authentication-key

Context

config>router>rsvp>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the authentication key 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 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:

- 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

An RSVP sender transmits an authenticating digest of the RSVP message, computed using the shared authentication key and a keyed-hash algorithm. The message digest is included in an integrity object that also contains a flags field, a key identifier field, and a sequence number field. The RSVP sender complies with the procedures for RSVP message generation in RFC 2747, *RSVP Cryptographic Authentication*.

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

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

Parameters

authentication-key

Specifies the authentication key. The key can be any combination of ASCII characters up to 16 characters in length (unencrypted). If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

hash-key

Specifies the hash key. The key can be any combination of up 33 alphanumeric characters. If spaces are used in the string, enclose the entire string in quotation marks (" ").

This is useful when a user must configure the parameter, but for security purposes the actual unencrypted key value is not provided.

hash

Keyword to specify 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

Keyword to specify the key is entered in a more complex encrypted form. If the **hash2** parameter is not used, the less encrypted **hash** form is assumed.

hello-interval

Syntax

hello-interval *milli-seconds*

no hello-interval

Context

config>router>rsvp>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the time interval between RSVP hello messages.

RSVP hello packets detect loss of RSVP connectivity with the neighboring node. Hello packets detect the loss of the neighbor more quickly than it would take for the RSVP session to time out based on the refresh interval. After the loss of the of **keep-multiplier** *number* consecutive hello packets, the neighbor is declared to be in a down state.

The **no** form of this command reverts to the default value. 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 to 60000 milliseconds (in multiples of 1000)

implicit-null-label

Syntax

implicit-null-label [**enable** | **disable**]

no implicit-null-label

Context

config>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the use of the implicit null label for all LSPs signaled by RSVP on the node.

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 signals the implicit null label. If the egress LER is also the merge-point (MP) node, the incoming interface for the path refresh message over the bypass dictates whether the packet uses the implicit null label. The same is true for a 1-to-1 detour LSP.

The RSVP interface must be shut down before changing the **implicit-null-label** command.

The **no** form of this command reverts the RSVP interface to using the RSVP level configuration value.

Default

disable

Parameters

enable

Keyword to enable the implicit null label.

disable

Keyword to disable the implicit null label.

refresh-reduction

Syntax

[**no**] **refresh-reduction**

Context

config>router>rsvp>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the use of the RSVP overhead refresh reduction capabilities on this RSVP interface.

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

Default

no refresh-reduction

reliable-delivery

Syntax

[**no**] **reliable-delivery**

Context

config>router>rsvp>interface>refresh-reduction

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures reliable delivery of RSVP messages over the RSVP interface. When the **refresh-reduction** command is enabled on an interface and the **reliable-delivery** command is disabled, the router sends a message_id and not set ACK desired in the RSVP messages over the interface. The router does not expect an ACK but accepts it if received. The node also accepts message IDs and replies 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 enters summary refresh for a specific message_id it sent regardless of whether it received an ACK to this message from the neighbor.

Finally, when the **reliable-delivery** command is enabled on any interface, RSVP message pacing is disabled on all RSVP interfaces on the system; for example, the user cannot enable the **msg-pacing** option in the **config>router>rsvp** context, and an error message is returned in the CLI. When the **msg-pacing** option is enabled, the user cannot enable the reliable delivery option on any interface on this system. An error message is also generated in the CLI after such an attempt.

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

Default

no reliable-delivery

subscription

Syntax

subscription *percentage*

no subscription

Context

config>router>rsvp>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

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* value is exceeded, the reservation is rejected and a log message is generated.

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

Default

100

Parameters

percentage

Specifies the percentage of the interface bandwidth that RSVP allows to be used for reservations.

Values   0 to 1000

2.16.2.2.4 Message pacing commands

msg-pacing

Syntax

[no] **msg-pacing**

Context

config>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures 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 are dropped because the output queue for the interface used for message pacing is full.

Default

no msg-pacing

max-burst

Syntax

max-burst *number*

no max-burst

Context

config>router>rsvp>msg-pacing

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the maximum number of RSVP messages that are sent in the specified period under normal operating conditions.

Default

650

Parameters

number

Specifies the maximum number of RSVP messages.

Values   100 to 1000, in increments of 10

period

Syntax

period *milli-seconds*

no period

Context

config>router>rsvp>msg-pacing

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the time interval, in milliseconds, during which the router can send the specified number of RSVP messages, as specified in the **max-burst** command.

Default

100

Parameters

milli-seconds

Specifies the time period during which the router can send RSVP messages.

Values   100 to 1000 milliseconds, in increments of 10 milliseconds

2.16.2.3 Show commands

- Show MPLS commands
- Show RSVP commands

2.16.2.3.1 Show MPLS commands

bypass-tunnel

Syntax

bypass-tunnel [**to** *ip-address*] [**protected-lsp** [*lsp-name*]] [**dynamic** | **manual**] [**detail**]

Context

show>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

If fast reroute is enabled on an LSP and the facility method is selected, instead of creating a separate LSP for every LSP that is to be backed up, a single LSP is created that serves as a backup for a set of LSPs. Such an LSP tunnel is called a bypass tunnel.

Parameters

ip-address
Specifies the IP address of the egress router.

lsp-name
Specifies the name of the LSP protected by the bypass tunnel.

dynamic
Displays dynamically assigned labels for bypass protection.

manual
Displays manually assigned labels for bypass protection.

detail
Displays detailed information.

Output

The following output is an example of MPLS bypass tunnel information, and Table 6: Output fields: MPLS bypass tunnel describes the output fields.

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#
```

Table 6: Output fields: MPLS bypass tunnel

Label	Description
To	The system IP address of the egress router
State	The LSP administrative state
Out I/F	Specifies the name of the network IP interface
Out Label	Specifies the incoming MPLS label on which to match

Label	Description
Reserved BW (Kbps)	Specifies the amount of bandwidth in kilobytes per second (Kb/s) reserved for the LSP

interface

Syntax

interface [*ip-int-name* | *ip-address*] [**label-map** *label*]

interface [*ip-int-name* | *ip-address*]

Context

show>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays MPLS interface information.

Parameters

ip-int-name

> Specifies 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, and so on), the entire string must be enclosed within double quotes.

ip-address

> Specifies the system or network interface IP address.

label

> Specifies the MPLS label on which to match.

> > **Values** 32 to 1048575

Output

The following output is an example of MPLS interface information, and Table 7: Output fields: MPLS interface describes the output fields.

Sample output

```
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#
```

Table 7: Output fields: MPLS interface

Label	Description
Interface	The interface name
Port-id	The port ID displayed in *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) names
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

label

Syntax

label *start-label* [*end-label* | **in-use** | *label-owner*]

Context

show>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays MPLS labels exchanged.

Parameters

start-label

Specifies the label value assigned at the ingress router.

end-label

Specifies the label value assigned for the egress router.

in-use

Specifies the number of in-use labels displayed.

label-owner

Specifies the owner of the label.

Output

The following output is an example of MPLS label information, and Table 8: Output fields: MPLS label describes the output fields.

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#
```

Table 8: Output fields: MPLS label

Label	Description
Label	Displays the value of the label
Label Type	Specifies whether the label value is statically or dynamically assigned
Label Owner	The label owner
In-use labels in entire range	The total number of labels being used by RSVP

label-range

Syntax

label-range

Context

show>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays the MPLS label range.

Output

The following output is an example of MPLS label range information, and Table 9: Output fields: MPLS label describes the output fields.

Sample output

```
*A:Dut-A# show router mpls-labels label-range

===========================================================================
Label Ranges
===========================================================================
Label Type      Start Label End Label   Aging       Available   Total
---------------------------------------------------------------------------
Static          32          18431       -           18399       18400
Dynamic         18432       131071      0           112635      112640
    Seg-Route   0           0           -           0           112640
===========================================================================
*A:Dut-A#
```

Table 9: Output fields: MPLS label

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 that are transitioning back to the label pool. Labels are aged 15 seconds.
Total Available	The number of label values available

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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays LSP details.

Parameters

lsp *lsp-name*

Specifies the name of the LSP used in the path.

status up

Displays an LSP that is operationally up.

status down

Displays an LSP that is operationally down.

from ip-address

    Displays the IP address of the ingress router for the LSP.

to ip-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.

name

    Specifies the IP address of the named LSP.

lsp count

    Displays the total number of LSPs.

activepath

    Displays the present path being used to forward traffic.

path-name

    Specifies the name of the path carrying the LSP.

mbb

    Displays make-before-break (MBB) information.

detail

    Displays detailed information.

Output

The following output is an example of MPLS LSP information, and Table 10: Output fields: MPLS LSP describes the output fields.

Sample output

```
*A:SRU4>config>router>mpls#   show router mpls lsp "to_10_20_1_1_cspf"
===============================================================================
MPLS LSPs (Originating)
===============================================================================
LSP Name                         To               Fastfail     Adm   Opr
                                                  Config
-------------------------------------------------------------------------------
to_10_20_1_1_cspf                10.20.1.1        No           Up    Up
-------------------------------------------------------------------------------
LSPs : 1
===============================================================================
*A:SRU4>config>router>mpls#


===============================================================================
*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             : 10.100.100.100
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
```

Table 10: Output fields: MPLS LSP

Label	Description
LSP Name	The name of the LSP used in the path
To	The system IP address of the egress router for the LS.
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
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

Label	Description
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 precomputed detour LSP, which minimizes packet loss.
	disabled — There is no detour LSP from each node on the primary path
ADSPEC	enabled — The LSP includes advertising data (ADSPEC) objects in RSVP messages
	disabled — The LSP does not include advertising data (ADSPEC) objects in RSVP messages
Primary	The preferred path for the LSP
Secondary	The alternate path that the LSP uses 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 that 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.
	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.

Label	Description
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
LastResignal Attempt	Displays the system up time when the last attempt to resignal this LSP was made
VprnAutoBind	Displays the status on the VPRN auto-bind feature as enabled or disabled

srlg-database

Syntax

srlg-database [**router-id** *ip-address*] [**interface** *ip-address*]

Context

show>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays MPLS SRLG database information.

Parameters

router-id *ip-address*

Specifies a 32-bit integer that uniquely identifies the router in the AS. 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 a remote router.

interface *ip-address*

Specifies the IP address of the interface.

path

Syntax

path [*path-name*] [*lsp-binding*]

Context

show>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays MPLS paths.

Parameters

path-name

Specifies the unique name label for the LSP path.

lsp-binding

Displays binding information.

Output

The following output is an example of MPLS path information, and Table 11: Output fields: MPLS path describes the output fields.

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#
```

Table 11: Output fields: MPLS path

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
LSP Name	The name of the LSP used in the path
Binding	`Primary` — the preferred path for the LSP `Secondary` — the standby path for the LSP
Paths	Total number of paths configured

static-lsp

Syntax

> **static-lsp** [*lsp-name*]
>
> **static-lsp** [*lsp-type* {**transit** | **terminate**}]
>
> **static-lsp count**

Context

> show>router>mpls

Platforms

> Supported on all 7210 SAS platforms as described in this document

Description

> This command displays MPLS static LSP information.

Parameters

> *lsp-name*

Specifies a name that identifies the LSP.

lsp-type

Specifies the type that identifies the LSP.

transit — Displays the number of static LSPs that transit the router.

terminate — Displays the number of static LSPs that terminate at the router.

Values transit, terminate

count

Displays the number of static LSPs that originate and terminate at the router.

Output

The following output is an example of MPLS static LSP information, and Table 12: Output fields: MPLS static LSP describes the output fields.

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 10.20.1.10      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     10.22.11.3        Up    Up
241        aps-1      441        1/1/10     10.22.11.3        Up    Up
242        aps-1      442        1/1/10     10.22.11.3        Up    Up
243        aps-1      443        1/1/10     10.22.11.3        Up    Up
244        aps-1      444        1/1/10     10.22.11.3        Up    Up
245        aps-1      445        1/1/10     10.22.11.3        Up    Up
246        aps-1      446        1/1/10     10.22.11.3        Up    Up
247        aps-1      447        1/1/10     10.22.11.3        Up    Up
248        aps-1      448        1/1/10     10.22.11.3        Up    Up
249        aps-1      449        1/1/10     10.22.11.3        Up    Up
250        aps-1      450        1/1/10     10.22.11.3        Up    Up
251        aps-1      451        1/1/10     10.22.11.3        Up    Up
252        aps-1      452        1/1/10     10.22.11.3        Up    Up
253        aps-1      453        1/1/10     10.22.11.3        Up    Up
...
207        3/2/8      407        1/1/9      10.22.10.3        Up    Up
208        3/2/8      408        1/1/9      10.22.10.3        Up    Up
209        3/2/8      409        1/1/9      10.22.10.3        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#
```

Table 12: Output fields: MPLS static LSP

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 label
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

status

Syntax

status

Context

show>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays MPLS operation information.

Output

The following output is an example of MPLS status information, and Table 13: Output fields: MPLS status describes the output fields.

Sample output

```
*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#
```

Table 13: Output fields: MPLS status

Label	Description
Admin Status	Down — MPLS is administratively disabled Up — MPLS is administratively enabled
Oper Status	Down — MPLS is operationally down 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. Dynamic LSPs — Displays the count of dynamic LSPs that originate, transit, and terminate on or through the router Detour LSPs — Displays the count of detour LSPs that originate, transit, and terminate on or through the router

Label	Description
FR Object	Enabled — Specifies that Fast reroute object is signaled for the LSP
	Disabled — Specifies that Fast reroute object is not signaled for the LSP
Resignal Timer	Enabled — Specifies that the resignal timer is enabled for the LSP
	Disabled — Specifies that the resignal timer is disabled for the LSP
Hold Timer	Displays the amount of time that the ingress node holds before programming its data plane and declaring the LSP up to the service module

2.16.2.3.2 Show RSVP commands

interface

Syntax

interface [*ip-int-name* | *ip-address*] **statistics** [**detail**]

Context

show>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command shows RSVP interfaces.

Parameters

ip-int-name

Specifies 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, and so on), the entire string must be enclosed within double quotes.

ip-address

Specifies 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

The following output is an example of RSVP interface information, and Table 14: Output fields: RSVP interface describes the fields.

Sample output

```
*A:A:ALA-1>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.
=========================================================================
```

Table 14: Output fields: RSVP interface

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	The amount of bandwidth in megabits per second (mbps) available to be reserved for the RSVP protocol on the interface

Label	Description
Resv BW	The amount of bandwidth in mega-bits per seconds (mbps) reserved on this interface A value of zero indicates that no bandwidth is reserved.
Adm	Down — The RSVP interface is administratively disabled Up — The RSVP interface is administratively enabled
Opr	Down — The RSVP interface is operationally down 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
Subscription	Specifies the percentage of the link bandwidth that RSVP can use for reservation When the value is zero, 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 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, 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

Label	Description
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
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 acknowledgment 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 No — BFD is disabled on the RSVP interface

neighbor

Syntax
neighbor [*ip-address*] [**detail**]

Context

show>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

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

Platforms

Supported on all 7210 SAS platforms as described in this document

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

Displays a session that is operationally up.

status down

Displays a session that is operationally down.

detail

Displays detailed information.

Output

The following output is an example of RSVP session information, and Table 15: Output fields: RSVP session describes the output fields.

Sample output

```
*A:SRU4>show>router>rsvp#   session
===============================================================================
RSVP Sessions
===============================================================================
From            To              Tunnel LSP    Name                        State
                                ID     ID
-------------------------------------------------------------------------------
10.20.1.5       10.20.1.4       18     27648 b4-1::b4-1                    Up
10.20.1.5       10.20.1.4       1      37902 gsr::gsr                      Up
10.20.1.5       10.20.1.22      11     53760 to_10_20_1_22_cspf::to_10_2* Up
10.20.1.4       10.20.1.20      146    17920 to_10_20_1_20_cspf_3::to_10* Up
10.20.1.4       10.20.1.20      145    34816 to_10_20_1_20_cspf_2::to_10* Up
10.20.1.4       10.20.1.20      147    45056 to_10_20_1_20_cspf_4::to_10* Up
10.20.1.4       10.20.1.20      148    6656  to_10_20_1_20_cspf_5::to_10* Up
10.20.1.4       10.20.1.20      149    58880 to_10_20_1_20_cspf_6::to_10* Up
10.20.1.4       10.20.1.20      150    13312 to_10_20_1_20_cspf_7::to_10* Up
10.20.1.4       10.20.1.20      152    40448 to_10_20_1_20_cspf_9::to_10* Up
10.20.1.4       10.20.1.20      154    27648 to_10_20_1_20_cspf_11::to_1* Up
10.20.1.4       10.20.1.20      155    12288 to_10_20_1_20_cspf_12::to_1* Up
10.20.1.4       10.20.1.20      151    46080 to_10_20_1_20_cspf_8::to_10* Up
10.20.1.4       10.20.1.20      153    512   to_10_20_1_20_cspf_10::to_1* Up
10.20.1.4       10.20.1.22      164    62464 to_10_20_1_22_cspf_2::to_10* Up
10.20.1.4       10.20.1.20      156    37888 to_10_20_1_20_cspf_13::to_1* Up
10.20.1.4       10.20.1.20      157    24064 to_10_20_1_20_cspf_14::to_1* Up
10.20.1.4       10.20.1.20      158    19968 to_10_20_1_20_cspf_15::to_1* Up
10.20.1.4       10.20.1.20      161    59904 to_10_20_1_20_cspf_18::to_1* Up
...
10.20.1.3       10.20.1.4       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#
```

Table 15: Output fields: RSVP session

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
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 Up — the operational state of this RSVP session is up

statistics

Syntax

statistics

Context

show>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays global statistics in the RSVP instance.

Output

The following output is an example of RSVP statistics information, and Table 16: Output fields: RSVP statistics describes the output fields.

Sample output

```
*A:SRU4>show>router>rsvp# statistics
===============================================================================
RSVP Global Statistics
===============================================================================
PATH Timeouts     : 1026              RESV Timeouts     : 182
===============================================================================
*A:SRU4>show>router>rsvp#
```

Table 16: Output fields: RSVP statistics

Label	Description
PATH Timeouts	The total number of path timeouts
RESV Timeouts	The total number of RESV timeouts

status

Syntax

rsvp status

Context

show>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays RSVP status.

Output

The following output is an example of RSVP status information, and Table 17: Output fields: RSVP status describes the output fields.

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#
```

Table 17: Output fields: RSVP status

Label	Description
Admin Status	Down — RSVP is administratively disabled Up — RSVP is administratively enabled
Oper Status	Down — RSVP is operationally down

Label	Description
	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 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

2.16.2.4 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**] [**srlg-group** grp-id...(up to 8 max)] [**skip-interface** *interface-name*]

Context

tools>perform>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command computes a CSPF path with specified user constraints.

Parameters

    to *ip-addr*

        Specifies the destination IP address.

    from *ip-addr*

Specifies 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 to 4294967295

skip-interface *interface-name*

Specifies an interface name that should be skipped during setup.

Output

The following output is an example of MPLS CSPF information.

Sample output

```
*A:Dut-C# tools perform router mpls cspf to 10.20.1.6

Req CSPF for all ECMP paths
    from: this node to: 10.20.1.6 w(no Diffserv) class: 0 , setup Priority 7, Hold
Priority 0 TE Class: 7


CSPF Path
To        : 10.20.1.6
Path 1    : (cost 2000)
   Src:   10.20.1.3   (= Rtr)
   Egr:   unnumbered lnkId 4            -
> Ingr:   unnumbered lnkId 2              Rtr:   10.20.1.5        (met 1000)
   Egr:   unnumbered lnkId 3            -
> Ingr:   unnumbered lnkId 3              Rtr:   10.20.1.6        (met 1000)
```

```
    Dst:   10.20.1.6   (= Rtr)

Path 2    : (cost 2000)
   Src:   10.20.1.3   (= Rtr)
   Egr:   unnumbered lnkId 5            -
 > Ingr:  unnumbered lnkId 5            Rtr:   10.20.1.4       (met 1000)
   Egr:   unnumbered lnkId 3            -
 > Ingr:  unnumbered lnkId 2            Rtr:   10.20.1.6       (met 1000)
   Dst:   10.20.1.6   (= Rtr)

*A:Dut-C#
```

resignal

Syntax

resignal {**lsp** *lsp-name* **path** *path-name* | **delay** *minutes*}

Context

tools>perform>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command resignals a specific LSP path. The *minutes* parameter configures the global timer of all LSPs for resignal. If only *lsp-name* and *path-name* are provided, the LSP is resignaled immediately.

Parameters

lsp-name

Specifies an existing LSP name to resignal.

path-name

Specifies an existing path name to resignal.

delay *minutes*

Sets the global timer of all LSPs to resignal.

switch-path

Syntax

switch-path [**lsp** *lsp-name*] [**path** *path-name*]

Context

tools>perform>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command moves a standby (or an active secondary) path to another standby path of the same priority. If a new standby path with a higher priority or a primary path comes up after the **tools perform** command is executed, the path re-evaluation command runs and the path is moved to the path specified by the outcome of the re-evaluation.

Parameters

lsp-name

Specifies the name of an existing LSP to move.

path-name

Specifies the path name to which to move the specified LSP.

2.16.2.5 Clear commands

interface

Syntax

interface *ip-int-name*

Context

clear>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command resets or clears statistics for MPLS interfaces.

Parameters

ip-int-name

Specifies the name of an existing IP interface. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

lsp

Syntax

lsp *lsp-name*

Context

clear>router>mpls

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command resets and restarts an LSP.

Parameters

lsp-name

Specifies the name of the LSP to clear, up to 64 characters.

statistics

Syntax

statistics

Context

clear>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command clears global statistics for the RSVP instance; for example, the command clears **path** and **resv timeout** counters.

2.16.2.6 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables and configures debugging for MPLS.

Parameters

lsp-name

Specifies the name that identifies the LSP, which can be up to 32 characters and must be unique.

source-address

Specifies the system IP address of the sender.

endpoint-address

Specifies the far-end system IP address.

tunnel-id

Specifies the MPLS SDP ID.

Values   0 to 4294967295

lsp-id

Specifies the LSP ID.

Values   1 to 65535

ip-int-name

Specifies th name that identifies the interface. The interface name can be up to 32 characters and must be unique. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

event

Syntax

[**no**] **event**

Context

debug>router>mpls

debug>router>rsvp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables debugging for specific events.

The **no** form of this command disables the debugging.

all

Syntax

all [**detail**]

no all

Context

debug>router>mpls>event

debug>router>rsvp>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs all events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about all events.

auth

Syntax

auth

no auth

Context

debug>router>rsvp>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs authentication events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about authentication events.

frr

Syntax

frr [**detail**]

no frr

Context

debug>router>mpls>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs fast reroute events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about reroute events.

iom

Syntax

iom [**detail**]

no iom

Context

debug>router>mpls>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs MPLS IOM events.

The **no** form of this 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs LSP setup events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about LSP setup events.

mbb

Syntax

mbb [**detail**]

no mbb

Context

debug>router>mpls>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs the state of the most recent invocation of the make-before-break (MBB)
functionality.

The **no** form of this 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs miscellaneous events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about miscellaneous events.

XC

Syntax

xc [**detail**]

no xc

Context

debug>router>mpls>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs cross connect events.

The **no** form of this 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables and configures debugging for RSVP.

Parameters

lsp-name

    Specifies the name that identifies the LSP, which can be up to 32 characters and must be unique.

source-address

    Specifies the system IP address of the sender.

endpoint-address

    Specifies the far-end system IP address.

tunnel-id

    Specifies the RSVP tunnel ID.

        Values   0 to 4294967295

lsp-id

    Specifies the LSP ID.

        Values   1 to 65535

ip-int-name

    Specifies the interface name. The interface name can be up to 32 characters and must be unique. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

nbr

Syntax

nbr [**detail**]

no nbr

Context

debug>router>rsvp>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs neighbor events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about neighbor events.

path

Syntax

path [**detail**]

no path

Context

debug>router>rsvp>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs path-related events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about path-related events.

resv

Syntax

resv [**detail**]

no resv

Context

debug>router>rsvp>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs RSVP reservation events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about RSVP reservation events.

rr

Syntax

rr

no rr

Context

debug>router>rsvp>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs refresh reduction events.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about refresh reduction events.

packet

Syntax

[**no**] **packet**

Context

debug>router>rsvp>

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs packets.

The **no** form of this command disables the debugging.

ack

Syntax

ack [**detail**]

no ack

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs ACK packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about RSVP ACK packets.

bundle

Syntax

bundle [**detail**]

no bundle

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs bundle packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about RSVP bundle packets.

all

Syntax

all [**detail**]

no all

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs all packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about all RSVP packets.

hello

Syntax

hello [**detail**]

no hello

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs hello packets.

The **no** form of this command disables the debugging.

Parameters
detail
Displays detailed information about hello packets.

path

Syntax
path [**detail**]
no path

Context
debug>router>rsvp>packet

Platforms
Supported on all 7210 SAS platforms as described in this document

Description
This command enables debugging for RSVP path packets.

The **no** form of this command disables the debugging.

Parameters
detail
Displays detailed information about path-related events.

patherr

Syntax
patherr [**detail**]
no patherr

Context
debug>router>rsvp>packet

Platforms
Supported on all 7210 SAS platforms as described in this document

Description
This command debugs path error packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about path error packets.

pathtear

Syntax

pathtear [**detail**]

no pathtear

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs path tear packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about path tear packets.

resv

Syntax

resv [**detail**]

no resv

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables debugging for RSVP RESV packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about RSVP RESV events.

resverr

Syntax

resverr [**detail**]

no resverr

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs ResvErr packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about ResvErr packets.

resvtear

Syntax

resvtear [**detail**]

no resvtear

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs ResvTear packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about ResvTear packets.

srefresh

Syntax

srefresh [detail]

no srefresh

Context

debug>router>rsvp>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs srefresh packets.

The **no** form of this command disables the debugging.

Parameters

detail

Displays detailed information about RSVP srefresh packets.

3 Label Distribution Protocol

This chapter provides information to enable Label Distribution Protocol (LDP).

3.1 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 allow 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 specific 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).

3.1.1 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 bidirectional) 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 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, and so on. 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 supports DUS, ordered control, and the liberal label retention mode.

3.1.2 LDP architecture

LDP comprises a few processes that handle the protocol PDU transmission, timer-related issues, and protocol state machine. The number of processes is kept to a minimum to simplify the architecture and to allow for scalability. Scheduling within each process prevents starvation of any particular LDP session, while buffering alleviates TCP-related congestion issues.

The LDP subsystems and their relationships to other subsystems are illustrated in Figure 10: Subsystem interrelationships. This illustration shows the interaction of the LDP subsystem with other subsystems, including memory management, label management, service management, SNMP, interface management, and routing table management (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.

3.1.3 Subsystem interrelationships

The sections below describe how LDP and the other subsystems work to provide services.

Figure 10: Subsystem interrelationships

OSSRG017
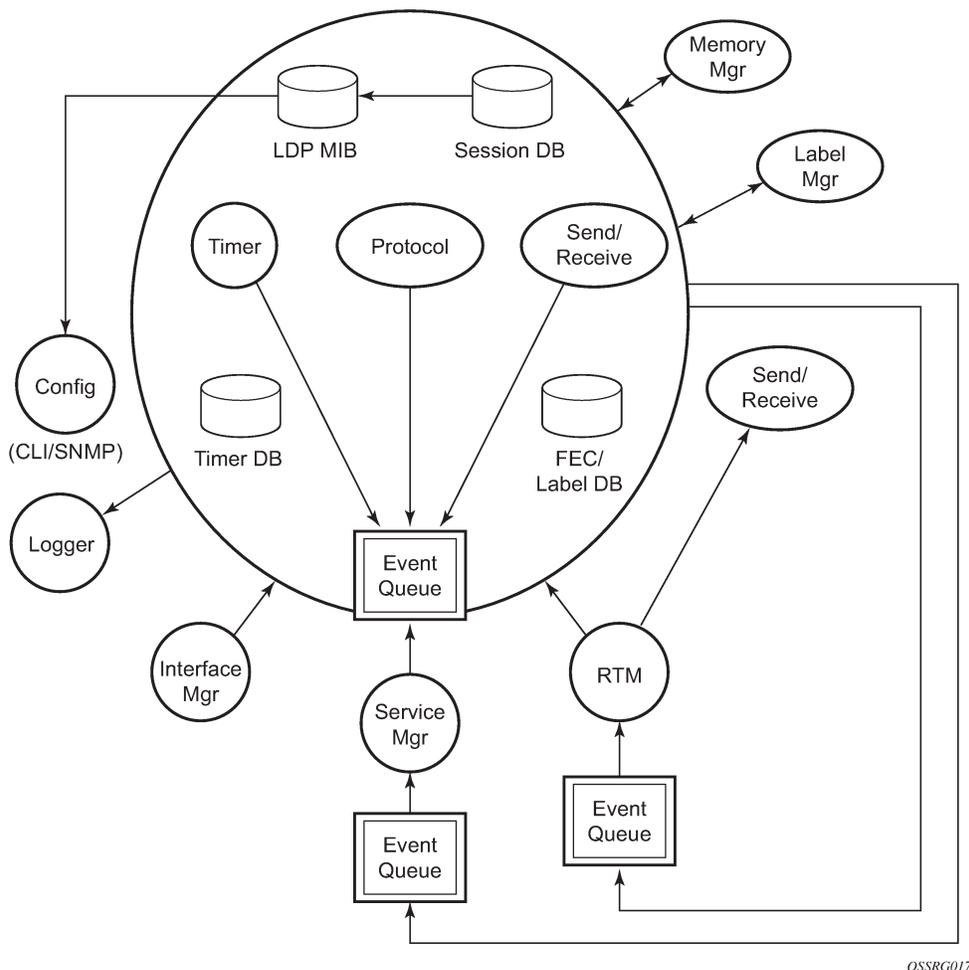
3.1.3.1 Memory manager and LDP

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.

3.1.3.2 Label manager

LDP assumes that the label manager is up and running. LDP will abort initialization if the label manager is not running. The label manager is initialized at system boot-up; therefore, anything that causes it to fail will likely imply that the system is not functional. The 7210 devices uses a label range from 28672 (28K) to 131071 (128K-1) to allocate all dynamic labels, including RSVP allocated labels and VC labels.

3.1.3.3 LDP configuration

The 7210 devices 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.

3.1.3.4 Logger

LDP uses the logger interface to generate debug information relating to session setup and teardown, LDP events, label exchanges, and packet dumps. Per-session tracing can be performed.

3.1.3.5 Service manager

All interaction occurs between LDP and the service manager, becasue 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.

3.1.4 Execution flow

LDP activity is limited to service-related signaling. Therefore, the configurable parameters are restricted to system-wide parameters, such as hello and keepalive timeouts.

3.1.4.1 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.

3.1.4.2 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.

3.1.4.2.1 Adjacency establishment

In the router, the adjacency management is done through the establishment of a Service Distribution Path (SDP) object, which is a service entity in the Nokia service model. The Nokia service model uses logical entities that interact to provide a service. The service model requires the service provider to create configurations for four main entities:

- customers
- services

- Service Access Paths (SAPs) on the local routers

- Service Distribution Points (SDPs) that connect to one or more remote routers

An SDP is the network-side termination point for a tunnel to a remote router. An SDP defines a local entity that includes the system IP address of the remote routers and a path type. Each SDP comprises the following:

- SDP ID

- transport encapsulation type, MPLS

- far-end system IP address

If the SDP is identified as using LDP signaling, then an LDP extended hello adjacency is attempted.

If another SDP is created to the same remote destination, and if LDP signaling is enabled, no further action is taken, because only one adjacency and one LDP session exists between the pair of nodes.

An SDP is a unidirectional object, so a pair of SDPs pointing at each other must be configured in order for an LDP adjacency to be established. When an adjacency is established, it is maintained through periodic hello messages.

3.1.4.2.2 Session establishment

When the LDP adjacency is established, the session setup follows as per the LDP specification. Initialization and keep-alive 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. Because 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.

3.1.5 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.

3.1.5.1 Other reasons for label actions

Other reasons for label actions include the following:

- **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.

3.1.5.2 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.

3.1.5.3 Configuring implicit null label

The implicit null label option allows an egress LER to receive MPLS packets from the previous hop without the outer LSP label. The user can configure to signal the implicit 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.

Enable the use of 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.

3.1.5.4 Global LDP filters

Outbound filtering is performed by way of the configuration of an export policy. The Global LDP export policy can be used to explicitly originate label bindings for local interfaces. The Global LDP export policy does not filter out or stop propagation of any FEC received from neighbors. Use the LDP peer export prefix policy for this purpose.

The system IP address AND static FECs cannot be blocked using an export policy.

Finally, the 'neighbor interface' statement inside a global import policy is not considered by LDP.

3.1.5.4.1 Per LDP peer FEC import and export policies

The FEC prefix export policy provides a way to control which FEC prefixes received from prefixes received from other LDP and T-LDP peers are re-distributed to this LDP peer.

The user configures the FEC prefix export policy using the following command:

config>router>ldp>session-params>peer>export-prefixes policy-name

By default, all FEC prefixes are exported to this peer.

The FEC prefix import policy provides a mean of controlling which FEC prefixes received from this LDP peer are imported and installed by LDP on this node. If resolved these FEC prefixes are then re-distributed to other LDP and T-LDP peers.

The user configures the FEC prefix export policy using the following command:

config>router>ldp>session-params>peer>import-prefixes policy-name

By default, all FEC prefixes are imported from this peer.

3.1.6 ECMP support for LDP

This feature performs load balancing for LDP-based LSPs by supporting multiple outgoing next-hops for a specific IP prefix on ingress and transit LSRs.

An LSR that has multiple equal cost paths to a specific IP prefix can receive an LDP label mapping for this prefix from each downstream next-hop peer. The LDP implementation uses the liberal label retention mode to retain all the labels for an IP prefix received from multiple next-hop peers.

Without ECMP support, only one of these next-hop peers is selected and installed in the forwarding plane. The the next-hop peer selection algorithm looks up the route information obtained from the routing table manager (RTM) for this prefix and finds the first valid LDP next-hop peer (for example, the first neighbor in the RTM entry from which a label mapping was received). If the outgoing label to the installed next-hop is no longer valid (for example, if the session to the peer is lost or the peer withdraws the label), a new valid LDP next-hop peer is selected from the existing next-hop peers, and LDP reprograms the forwarding plane to use the label sent by this peer.

With ECMP support, all the valid LDP next-hop peers (peers that sent a label mapping for a specific IP prefix) are installed in the forwarding plane. In ingress LER and transit LSR, an ingress label is mapped to the next-hops that are in the RTM and from which a valid mapping label has been received. The forwarding plane then uses an internal hashing algorithm to determine how traffic will be distributed amongst these multiple next-hops, assigning each flow to a specific next-hop.

For more information about hash algorithms at LER and transit LSR, see "LAG hashing" in the *7210 SAS-D, Dxp, K 2F1C2T, K 2F6C4T, K 3SFP+ 8C Interface Configuration Guide*.

> **Note:**
> LDP ECMP and LDP LFA are mutually exclusive.

3.1.6.1 Label operations

If an LSR is the ingress for a specific IP prefix, LDP programs a push operation for the prefix in the forwarding engine and creates an LSP ID for the mapped next-hop label forwarding entry (NHLFE) (LTN) and an LDP tunnel entry in the forwarding plane. LDP also informs the tunnel table manager (TTM) of this tunnel. Both the LTN entry and the tunnel entry have an NHLFE for the label mapping that the LSR received from each of its next-hop peers.

If the LSR behaves as a transit for a specific IP prefix, LDP programs a swap operation for the prefix in the forwarding engine. Programming a swap operation results in the creation of an incoming label map (ILM) entry in the forwarding plane. The ILM entry must map an incoming label to multiple NHLFEs. If the LSR is an egress for a specific IP prefix, LDP programs a POP entry in the forwarding engine. Programming a POP entry results in the creation of an ILM entry in the forwarding plane, but NHLFE entries are not created.

When unlabeled packets arrive at the ingress LER, the forwarding plane consults the LTN entry and uses a hashing algorithm to map the packet to one of the NHLFEs (push label), and forwards the packet to the corresponding next-hop peer. For labeled packets arriving at a transit or egress LSR, the forwarding plane consults the ILM entry and either uses a hashing algorithm to map it to one of the NHLFEs (swap label), or routes the packet if there are no NHLFEs (pop label).

A static FEC swap is not activated unless there is a matching route in the system route table that also matches the user-configured static FEC next hop.

3.1.7 Unnumbered interface support in LDP

This feature allows LDP to establish a Hello adjacency and to resolve unicast FECs over unnumbered LDP interfaces.

This feature also extends lsp-ping support to include testing an LDP unicast resolved over an unnumbered LDP interface.

3.1.7.1 Feature configuration

This feature does not introduce a new CLI command for adding an unnumbered interface into LDP. Instead, the **fec-originate** command is extended to specify the interface name, because an unnumbered interface does not have an IP address of its own. The user can, however, specify an interface name for numbered interfaces.

See the CLI command reference for the changes to the **fec-originate** command.

3.1.7.2 Operation of LDP over an unnumbered IP interface

Consider the setup shown in the following figure.

Figure 11: LDP adjacency and session over unnumbered interface
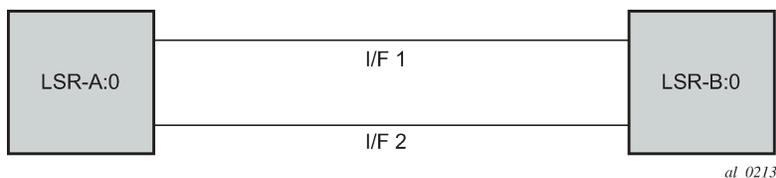
LSR A and LSR B have the following LDP identifiers respectively:

- <LSR Id=A> : <label space id=0>
- <LSR Id=B> : <label space id=0>

There are two P2P unnumbered interfaces between LSR A and LSR B. These interfaces are identified on each system with their unique local link identifier. In other words, the combination of {Router-ID, Local Link Identifier} uniquely identifies the interface in OSPF or IS-IS throughout the network.

A borrowed IP address is also assigned to the interface to be used as the source address of IP packets which need to be originated from the interface. The borrowed IP address defaults to the system loopback interface address (A and B respectively in this setup). The user can change the borrowed IP interface to any configured IP interface, loopback or not, by applying the following command:

config>router>if>unnumbered [*ip-int-name* | *ip-address*]

When the unnumbered interface is added into LDP, it will have the behavior described in the following sections.

3.1.7.2.1 Link LDP

1. Hello adjacency will be brought up using link Hello packet with source IP address set to the interface borrowed IP address and a destination IP address set to 224.0.0.2.

2. As a consequence of item 1, Hello packets with the same source IP address should be accepted when received over parallel unnumbered interfaces from the same peer LSR-ID. The corresponding Hello adjacencies would be associated with a single LDP session.

3. The transport address for the TCP connection, which is encoded in the Hello packet, will always be set to the LSR-ID of the node regardless if the user enabled the interface option under **config>router>ldp>if-params>if> ipv4>transport-address**.

4. The user can configure the **local-lsr-id** option on the interface and change the value of the LSR-ID to either the local interface or to some other interface name, loopback or not, numbered or not. If the local interface is selected or the provided interface name corresponds to an unnumbered IP interface, the unnumbered interface-borrowed IP address will be used as the LSR-ID. In all cases, the transport address for the LDP session will be updated to the new LSR-ID value but the link Hello packets will continue to use the interface-borrowed IP address as the source IP address.

5. The LSR with the highest transport address, that is., LSR-ID in this case, will bootstrap the TCP connection and LDP session.

6. Source and destination IP addresses of LDP packets are the transport addresses; that is, LDP LSR-IDs of systems A and B in this case.

3.1.7.2.2 Targeted LDP

1. Source and destination addresses of targeted Hello packet are the LDP LSR-IDs of systems A and B.

2. The user can configure the **local-lsr-id** option on the targeted session and change the value of the LSR-ID to either the local interface or to some other interface name, loopback or not, numbered or not. If the local interface is selected or the provided interface name corresponds to an unnumbered IP interface, the unnumbered interface-borrowed IP address will be used as the LSR-ID. In all cases, the transport address for the LDP session and the source IP address of targeted Hello message will be updated to the new LSR-ID value.

3. The LSR with the highest transport address (that is, LSR-ID in this case) will bootstrap the TCP connection and LDP session.

4. Source and destination IP addresses of LDP messages are the transport addresses; that is, LDP LSR-IDs of systems A and B in this case.

3.1.7.2.3 FEC resolution

1. LDP will advertise/withdraw unnumbered interfaces using the Address/Address-Withdraw message. The borrowed IP address of the interface is used.

2. A FEC can be resolved to an unnumbered interface in the same way as it is resolved to a numbered interface. The outgoing interface and next-hop are looked up in the RTM cache. The next-hop consists of the router-id and link identifier of the interface at the peer LSR.

3. LDP FEC ECMP next-hops over a mix of unnumbered and numbered interfaces is supported.

4. All LDP FEC types are supported.

5. The **fec-originate** command is supported when the next-hop is over an unnumbered interface.

All LDP features are supported except for the following:

1. BFD cannot be enabled on an unnumbered LDP interface. This is a consequence of the fact that BFD is not supported on unnumbered IP interface on the system.

2. As a consequence of item 1, LDP FRR procedures will not be triggered via a BFD session timeout but only by physical failures and local interface down events.

3. Unnumbered IP interfaces cannot be added into LDP global and peer prefix policies.

3.1.8 LDP Fast-Reroute for IS-IS and OSPF prefixes

LDP Fast Re-Route (FRR) is a feature which allows the user to provide local protection for an LDP FEC by precomputing and downloading to IOM both a primary and a backup NHLFE for this FEC.

The primary NHLFE corresponds to the label of the FEC received from the primary next-hop as per standard LDP resolution of the FEC prefix in RTM. The backup NHLFE corresponds to the label received for the same FEC from a Loop-Free Alternate (LFA) next-hop.

The LFA next-hop precomputation by IGP is described in RFC 5286, *Basic Specification for IP Fast Reroute: Loop-Free Alternates*. LDP FRR relies on using the label-FEC binding received from the LFA next-hop to forward traffic for a specific prefix as soon as the primary next-hop is not available. This means that a node resumes forwarding LDP packets to a destination prefix without waiting for the routing convergence. The label-FEC binding is received from the loop-free alternate next-hop ahead of time and is stored in the Label Information Base (LIB) because LDP on the router operates in the liberal retention mode.

This feature requires that IGP performs the Shortest Path First (SPF) computation of an LFA next-hop, in addition to the primary next-hop, for all prefixes used by LDP to resolve FECs. IGP also populates both routes in the Routing Table Manager (RTM).

3.1.8.1 LDP FRR configuration

The user enables Loop-Free Alternate (LFA) computation by SPF under the IS-IS or OSPF routing protocol level:

config>router>isis>loopfree-alternate

config>router>ospf>loopfree-alternate

The above commands instruct the IGP SPF to attempt to precompute both a primary next-hop and an LFA next-hop for every learned prefix. When found, the LFA next-hop is populated into the RTM along with the primary next-hop for the prefix.

Next the user enables the use by LDP of the LFA next-hop by configuring the following option:

config>router>ldp>fast-reroute

When this command is enabled, LDP will use both the primary next-hop and LFA next-hop, when available, for resolving the next-hop of an LDP FEC against the corresponding prefix in the RTM. This will result in LDP programming a primary NHLFE and a backup NHLFE into the IOMXCM for each next-hop of a FEC prefix for the purpose of forwarding packets over the LDP FEC.

Note that because LDP can detect the loss of a neighbor/next-hop independently, it is possible that it switches to the LFA next-hop while IGP is still using the primary next-hop. To avoid this situation, it is recommended to enable IGP-LDP synchronization on the LDP interface:

config>router>interface>ldp-sync-timer *seconds*

3.1.8.1.1 Reducing the scope of the LFA calculation by SPF

The user can instruct IGP to not include all interfaces participating in a specific IS-IS level or OSPF area in the SPF LFA computation. This provides a way of reducing the LFA SPF calculation where it is not needed.

config>router>isis>level>loopfree-alternate-exclude

config>router>ospf>area>loopfree-alternate-exclude

Note that if IGP shortcut are also enabled in LFA SPF, LSPs with destination address in that IS-IS level or OSPF area are also not included in the LFA SPF calculation.

The user can also exclude a specific IP interface from being included in the LFA SPF computation by IS-IS or OSPF:

config>router>isis>interface>loopfree-alternate-exclude

config>router>ospf>area>interface>loopfree-alternate-exclude

Note that when an interface is excluded from the LFA SPF in IS-IS, it is excluded in both level 1 and level 2. When the user excludes an interface from the LFA SPF in OSPF, it is excluded in all areas. However, the above OSPF command can only be executed under the area in which the specified interface is primary and once enabled, the interface is excluded in that area and in all other areas where the interface is secondary. If the user attempts to apply it to an area where the interface is secondary, the command will fail.

3.1.8.2 LDP FRR procedures

The LDP FEC resolution when LDP FRR is not enabled operates as follows. When LDP receives a "FEC, label" binding for a prefix, it will resolve it by checking if the exact prefix, or a longest match prefix when the **aggregate-prefix-match option** is enabled in LDP, exists in the routing table and is resolved against a next-hop which is an address belonging to the LDP peer that advertised the binding, as identified by its LSR-id. When the next-hop is no longer available, LDP deactivates the FEC and deprograms the NHLFE in the datapath. LDP will also immediately withdraw the labels it advertised for this FEC and deletes the ILM in the datapath unless the user configured the **label-withdrawal-delay** option to delay this operation. Traffic that is received while the ILM is still in the datapath is dropped. When routing computes and populates the routing table with a new next-hop for the prefix, LDP resolves again the FEC and programs the datapath accordingly.

When LDP FRR is enabled and an LFA backup next-hop exists for the FEC prefix in RTM, or for the longest prefix the FEC prefix matches to when **aggregate-prefix-match** option is enabled in LDP, LDP will resolve the FEC as above but will program the datapath with both a primary NHLFE and a backup NHLFE for each next-hop of the FEC.

In order perform a switchover to the backup NHLFE in the fast path, LDP follows the uniform FRR failover procedures which are also supported with RSVP FRR.

When any of the following events occurs, LDP instructs in the fast path the IOM to enable the backup NHLFE for each FEC next-hop impacted by this event. The IOM do that by simply flipping a single state bit associated with the failed interface or neighbor/next-hop:

- An LDP interface goes operationally down, or is admin shutdown. In this case, LDP sends a neighbor/next-hop down message to the IOM for each LDP peer it has adjacency with over this interface.

- An LDP session to a peer went down as the result of the Hello or Keep-Alive timer expiring over a specific interface. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only.

- The TCP connection used by a link LDP session to a peer went down, due say to next-hop tracking of the LDP transport address in RTM, which brings down the LDP session. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only.

- A BFD session, enabled on a T-LDP session to a peer, times-out and as a result the link LDP session to the same peer and which uses the same TCP connection as the T-LDP session goes also down. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only.

- A BFD session enabled on the LDP interface to a directly connected peer, times-out and brings down the link LDP session to this peer. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only. BFD support on LDP interfaces is a new feature introduced for faster tracking of link LDP peers. See Section 1.2.1 for more details.

The tunnel-down-damp-time option or the label-withdrawal-delay option, when enabled, does not cause the corresponding timer to be activated for a FEC as long as a backup NHLFE is still available.

3.1.8.2.1 Link LDP Hello adjacency tracking with BFD

LDP can only track an LDP peer with which it established a link LDP session with using the Hello and Keep-Alive timers. If an IGP protocol registered with BFD on an IP interface to track a neighbor, and the BFD session times out, the next-hop for prefixes advertised by the neighbor are no longer resolved. This however does not bring down the link LDP session to the peer because the LDP peer is not directly tracked by BFD. More importantly the LSR-id of the LDP peer may not coincide with the neighbor's router-id IGP is tracking by way of BFD.

To properly track the link LDP peer, LDP needs to track the Hello adjacency to its peer by registering with BFD. This way, the peer next-hop is tracked.

The user enables Hello adjacency tracking with BFD by enabling BFD on an LDP interface:

config>router>ldp>interface-parameters>interface>bfd-enable

The parameters used for the BFD session, in other words, transmit-interval, receive-interval, and multiplier, are those configured under the IP interface in existing implementation:

config>router>interface>bfd

When multiple links exist to the same LDP peer, a Hello adjacency is established over each link but only a single LDP session will exist to the peer and will use a TCP connection over one of the link interfaces. Also, a separate BFD session should be enabled on each LDP interface. If a BFD session times out on a specific link, LDP will immediately bring down the Hello adjacency on that link. In addition, if the there are FECs which have their primary NHLFE over this link, LDP triggers the LDP FRR procedures by sending to IOM the neighbor/next-hop down message. This will result in moving the traffic of the impacted FECs to an LFA next-hop on a different link to the same LDP peer or to an LFA backup next-hop on a different LDP peer depending on the lowest backup cost path selected by the IGP SPF.

As soon as the last Hello adjacency goes down because of the BFD timing out, the LDP session goes down and the LDP FRR procedures will be triggered. This will result in moving the traffic to an LFA backup next-hop on a different LDP peer.

3.1.8.2.2 LDP FRR and RSVP shortcut (IGP shortcut)

When an RSVP LSP is used as a shortcut by IGP, it is included by SPF as a P2P link and can also be optionally advertised into the rest of the network by IGP. Thus the SPF is able of using a tunneled next-hop

as the primary next-hop for a specific prefix. LDP is also able of resolving a FEC to a tunneled next-hop when the IGP shortcut feature is enabled.

> **Note:**
> Use of RSVP shortcut is supported only with LDR FRR LFA. It is not supported in the main SFP.

When both IGP shortcut and LFA are enabled in IS-IS or OSPF, and LDP FRR is also enabled, then the following additional LDP FRR capabilities are supported:

- A FEC which is resolved to a direct primary next-hop can be backed up by a LFA tunneled next-hop.
- A FEC which is resolved to a tunneled primary next-hop will not have an LFA next-hop. It will rely on RSVP FRR for protection.

The LFA SPF is extended to use IGP shortcuts as LFA next-hops as described in IS-IS and OSPF support for Loop-Free Alternate calculation.

3.1.8.3 IS-IS and OSPF support for Loop-Free Alternate calculation

SPF computation in IS-IS and OSPF is enhanced to compute LFA alternate routes for each learned prefix and populate it in RTM.

The following figure illustrates a simple network topology with point-to-point (P2P) interfaces and highlights three routes to reach router R5 from router R1.

Figure 12: Topology with primary and LFA routes
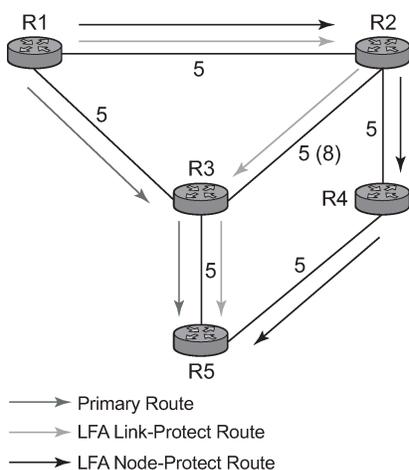
al_0215

The primary route is by way of R3. The LFA route by way of R2 has two equal cost paths to reach R5. The path by way of R3 protects against failure of link R1-R3. This route is computed by R1 by checking that the cost for R2 to reach R5 by way of R3 is lower than the cost by way of routes R1 and R3. This condition is referred to as the *loop-free criterion*. R2 must be loop-free with respect to source node R1.

The path by way of R2 and R4 can be used to protect against the failure of router R3. However, with the link R2-R3 metric set to 5, R2 sees the same cost to forward a packet to R5 by way of R3 and R4. Thus R1 cannot guarantee that enabling the LFA next-hop R2 will protect against R3 node failure. This means that the LFA next-hop R2 provides link-protection only for prefix R5. If the metric of link R2-R3 is changed to 8, then the LFA next-hop R2 provides node protection since a packet to R5 will always go over R4. In other

words it is required that R2 becomes loop-free with respect to both the source node R1 and the protected node R3.

Consider the case where the primary next-hop uses a broadcast interface as illustrated in the following figure.

Figure 13: Example topology with broadcast interfaces
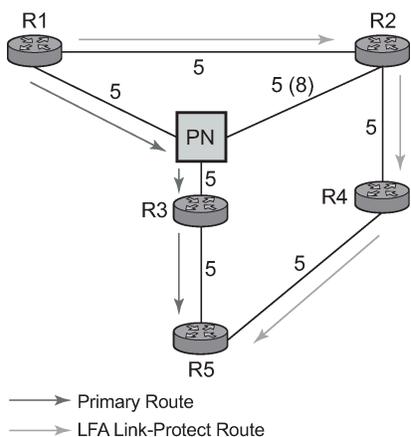
In order for next-hop R2 to be a link-protect LFA for route R5 from R1, it must be loop-free with respect to the R1-R3 link's Pseudo-Node (PN). However, since R2 has also a link to that PN, its cost to reach R5 by way of the PN or router R4 are the same. Thus R1 cannot guarantee that enabling the LFA next-hop R2 will protect against a failure impacting link R1-PN since this may cause the entire subnet represented by the PN to go down. If the metric of link R2-PN is changed to 8, then R2 next-hop will be an LFA providing link protection.

The following are the detailed rules for this criterion as provided in RFC 5286:

- **rule 1**

  Link-protect LFA backup next-hop (primary next-hop R1-R3 is a P2P interface):

  `Distance_opt(R2, R5) < Distance_opt(R2, R1) + Distance_opt(R1, R5)`

  `Distance_opt(R2, R5) >= Distance_opt(R2, R3) + Distance_opt(R3, R5)`

- **rule 2**

  Node-protect LFA backup next-hop (primary next-hop R1-R3 is a P2P interface):

  `Distance_opt(R2, R5) < Distance_opt(R2, R1) + Distance_opt(R1, R5)`

  `Distance_opt(R2, R5) < Distance_opt(R2, R3) + Distance_opt(R3, R5)`

- **rule 3**

  Link-protect LFA backup next-hop (primary next-hop R1-R3 is a broadcast interface):

  `Distance_opt(R2, R5) < Distance_opt(R2, R1) + Distance_opt(R1, R5)`

  `Distance_opt(R2, R5) < Distance_opt(R2, PN) + Distance_opt(PN, R5)`

  where; PN stands for the R1-R3 link Pseudo-Node.

For the case of P2P interface, if SPF finds multiple LFA next-hops for a specific primary next-hop, it follows the following selection algorithm:

1. It will pick the node-protect type in favor of the link-protect type.

2. If there is more than one LFA next-hop within the selected type, then it will pick one based on the least cost.

3. If more than one LFA next-hop with the same cost results from item 2, then SPF will select the first one. This is not a deterministic selection and will vary following each SPF calculation.

For the case of a broadcast interface, a node-protect LFA is not necessarily a link protect LFA if the path to the LFA next-hop goes over the same PN as the primary next-hop. Similarly, a link protect LFA may not guarantee link protection if it goes over the same PN as the primary next-hop.

The selection algorithm when SPF finds multiple LFA next-hops for a specific primary next-hop is modified as follows:

1. The algorithm splits the LFA next-hops into two sets:

   • The first set consists of LFA next-hops which *do not* go over the PN used by primary next-hop.

   • The second set consists of LFA next-hops which *do* go over the PN used by the primary next-hop.

2. If there is more than one LFA next-hop in the first set, it will pick the node-protect type in favor of the link-protect type.

3. If there is more than one LFA next-hop within the selected type, then it will pick one based on the least cost.

4. If more than one LFA next-hop with equal cost results from item 3, SPF will select the first one from the remaining set. This is not a deterministic selection and will vary following each SPF calculation.

5. If no LFA next-hop results from Step 4, SPF will rerun items 2-4 using the second set.

Note this algorithm is more flexible than strictly applying rule 3 above; the link protect rule in the presence of a PN and specified in RFC 5286. A node-protect LFA which does not avoid the PN; does not guarantee link protection, can still be selected as a last resort. The same thing, a link-protect LFA which does not avoid the PN may still be selected as a last resort. Both the computed primary next-hop and LFA next-hop for a specific prefix are programmed into RTM.

3.1.8.3.1 Loop-Free Alternate calculation in the presence of IGP shortcuts

To expand the coverage of the LFA backup protection in a network, RSVP LSP based IGP shortcuts can be placed selectively in parts of the network and be used as an LFA backup next-hop.

When IGP shortcut is enabled in IS-IS or OSPF on a specific node, all RSVP LSP originating on this node and with a destination address matching the router-id of any other node in the network are included in the main SPF by default. Use of RSVP tunnel as an IGP shortcut in the main SFP is not supported on the 7210 SAS-K 2F6C4T or 7210 SAS-K 3SFP+ 8C.

To limit the time it takes to compute the LFA SPF, the user must explicitly enable the use of an IGP shortcut as LFA backup next-hop using one of a couple of new optional argument for the existing LSP level IGP shortcut command:

config>router>mpls>lsp>igp-shortcut [**lfa-only**]

The **lfa-only** option allows an LSP to be included in the LFA SPFs only such that the introduction of IGP shortcuts does not impact the main SPF decision. For a specific prefix, the main SPF always selects a direct primary next-hop. The LFA SPF will select a an LFA next-hop for this prefix but will prefer a direct LFA next-hop over a tunneled LFA next-hop. Only this option is supported on the 7210 SAS-K 2F6C4T and 7210 SAS-K 3SFP+ 8C to improve coverage.

Thus the selection algorithm in Section 1.3 when SPF finds multiple LFA next-hops for a specific primary next-hop is modified as follows:

- The algorithm splits the LFA next-hops into two sets:
    - The first set consists of direct LFA next-hops.
    - The second set consists of tunneled LFA next-hops. after excluding the LSPs which use the same outgoing interface as the primary next-hop.
- The algorithms continues with first set if not empty, otherwise it continues with second set.
- If the second set is used, the algorithm selects the tunneled LFA next-hop which endpoint corresponds to the node advertising the prefix.
    - If more than one tunneled next-hop exists, it selects the one with the lowest LSP metric.
    - If still more than one tunneled next-hop exists, it selects the one with the lowest tunnel-id.
    - If none is available, it continues with rest of the tunneled LFAs in second set.
- Within the selected set, the algorithm splits the LFA next-hops into two sets:
    - The first set consists of LFA next-hops which do not go over the PN used by the primary next-hop.
    - The second set consists of LFA next-hops which go over the PN used by the primary next-hop.
- If there is more than one LFA next-hop in the selected set, it will pick the node-protect type in favor of the link-protect type.
- If there is more than one LFA next-hop within the selected type, then it will pick one based on the least total cost for the prefix. For a tunneled next-hop, it means the LSP metric plus the cost of the LSP endpoint to the destination of the prefix.
- If there is more than one LFA next-hop within the selected type (ecmp-case) in the first set, it will select the first direct next-hop from the remaining set. This is not a deterministic selection and will vary following each SPF calculation.
- If there is more than one LFA next-hop within the selected type (ecmp-case) in the second set, it will pick the tunneled next-hop with the lowest cost from the endpoint of the LSP to the destination prefix. If there remains more than one, it will pick the tunneled next-hop with the lowest tunnel-id.

3.1.8.3.2 Loop-Free Alternate Shortest Path First (LFA SPF) policies

An LFA SPF policy allows the user to apply specific criteria, such as admin group and SRLG constraints, to the selection of a LFA backup next-hop for a subset of prefixes that resolve to a specific primary next-hop. See more details in the section titled "Loop-Free Alternate Shortest Path First (LFA SPF) Policies" in the Routing Protocols Guide.

3.1.9 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).

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 with RFC 5283, *LDP Extension for Inter-Area Label Switched Paths (LSPs)*.

3.2 LDP process overview

The following figure shows the basic LDP parameter provisioning process.

Figure 14: Basic LDP parameter provisioning
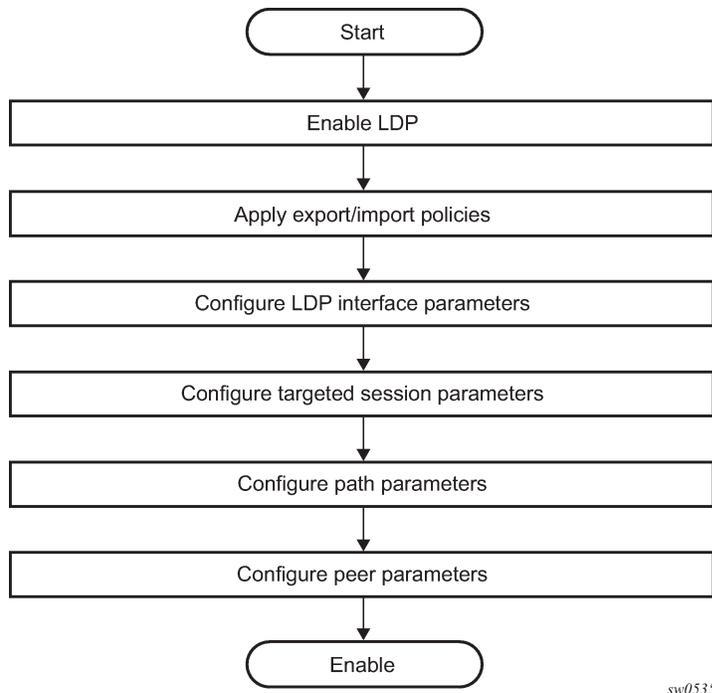
The following figure shows the LDP configuration and implementation process.

Figure 15: LDP configuration and implementation
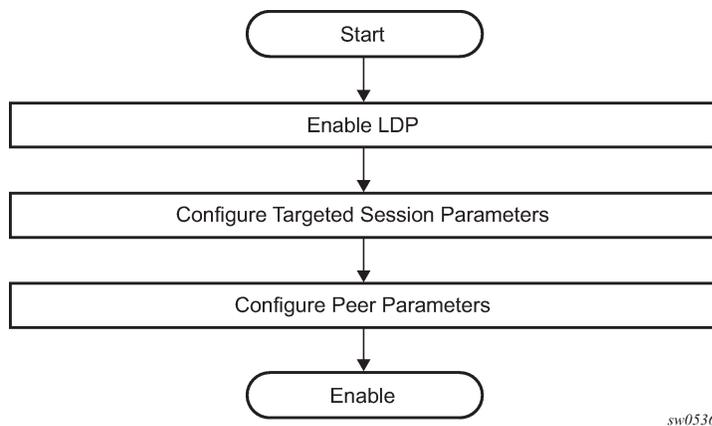
3.3 Configuring LDP with CLI

This section provides information to configure LDP using the command line interface.

3.4 LDP configuration overview

When the 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*.

3.5 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.

3.6 Common configuration tasks

3.6.1 Enabling LDP

LDP must be enabled in order for the protocol to be active. MPLS must also be enabled. MPLS is enabled in the `config>router>mpls` context.

Use the **ldp** command to enable LDP on a router.

Example: LDP syntax

```
config>router# ldp
```

3.6.2 Configuring graceful-restart helper parameters

Graceful-restart helper advertises to its LDP neighbors by carrying the fault tolerant (FT) session TLV in the LDP initialization message, assisting the LDP in preserving its IP forwarding state across the restart. Nokia'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.

```
config>router>ldp
[no] graceful-restart
    [no] maximum-recovery-time interval
    [no] neighbor-liveness-time interval
```

3.6.3 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.

```
config>router>ldp
export policy-name [policy-name...(upto 32 max)]
import policy-name [policy-name...(upto 32 max)]
```

3.6.4 Targeted session parameters

Use the following syntax to specify **targeted-session** parameters.

```
config>router# ldp
targeted-session
disable-targeted-session
hello timeout factor
keepalive timeout factor
peer ip-address
    no bfd-enable
    hello timeout factor
    keepalive timeout factor
    no shutdown
```

Example: LDP configuration output

```
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#
```

3.6.5 Interface parameters

Use the following syntax to configure interface parameters.

```
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
```

Example: Interface parameter configuration output

```
A:ALU_SIM11>config>router>ldp# info
----------------------------------------------
    aggregate-prefix-match
        prefix-exclude "sample"
        exit
    graceful-restart
        exit
    session-parameters
    peer 1.1.1.1
            ttl-security 1
        exit
    exit
    interface-parameters
            interface "a"
        exit
    exit
    targeted-session
    exit
----------------------------------------------
```

3.6.6 Session parameters

Use the following syntax to specify session parameters.

```
config>router# ldp
session-parameters
peer ip-address
  auth-keychain name
  authentication-key [authentication-key|hash-key] [hash|hash2]
```

Example: Session parameter configuration output

```
A:ALA-1>config>router>ldp# info
----------------------------------------------
    session-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
    no bfd-enable
        hello 2500 100
        keepalive 15 3
        exit
    exit
----------------------------------------------
A:ALA-1>config>router>ldp#
```

3.6.7 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.

Use the following syntax to configure enable LDP on an MPLS SDP.

```
config>service>sdp#
signaling {off|tldp}
```

Example: SDP configuration output

The following example displays the SDP configuration output with 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#
```

3.7 LDP configuration management tasks

This section describes the LDP configuration management tasks.

3.7.1 Disabling LDP

The **no ldp** command disables the LDP protocol on the router. All parameters revert to the default settings. LDP must be shut down before it can be disabled.

Use the following command syntax to disable LDP.

```
no ldp
shutdown
```

3.7.2 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.

Example: Command usage to revert targeted session parameters back to the default values

```
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
```

Example: Default values output for targeted session parameters

```
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#
```

3.7.3 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.

3.8 LDP command reference

3.8.1 Command hierarchies

- LDP commands
- Show commands
- Clear commands
- Debug commands
- Tools commands

3.8.1.1 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
            - fast-reroute
            - no fast-reroute
            - fec-originate ip-prefix/mask [advertised-label in-label] [swap-label out-label]
 interface interface-name
            - fec-originate ip-prefix/mask [advertised-label in-label] next-hop ip-address
[swap-label out-label]
            - fec-originate ip-prefix/mask [advertised-label in-label] next-hop ip-address
[swap-label out-label] interface interface-name
            - fec-originate ip-prefix/mask [advertised-label in-label] pop
            - no fec-originate ip-prefix/mask interface interface-name
            - no fec-originate ip-prefix/mask next-hop ip-address
            - no fec-originate ip-prefix/mask next-hop ip-address interface interface-name
            - no fec-originate ip-prefix/mask pop
            - [no] graceful-restart
                - maximum-recovery-time interval
                - no maximum-recovery-time
                - neighbor-liveness-time interval
                - no neighbor-liveness-time
            - [no] implicit-null-label
            - import policy-name [policy-name...(up to 5 max)]
            - interface-parameters
                - [no] interface ip-int-name
                    - bfd-enable
                    - no bfd-enable
```

```
                        - ipv4
                            - fec-type-capability
                                - prefix-ipv4 {enable | disable}
                            - hello timeout factor
                            - no hello
                            - keepalive timeout factor
                            - no keepalive
                            - [no] shutdown
                            - transport-address {system | interface}
                - label-withdrawal-delay seconds
                - session-parameters
                    - [no] peer ip-address
                        - export-addresses policy-name [policy-name ... (up to 5 max)]
                        - no export-addresses
                        - export-prefixes policy-name [policy-name ... (up to 5 max)]
                        - no export-prefixes
                        - fec-type-capability
                            - prefix-ipv4 {enable | disable}
                            - fec129-cisco-interop {enable | disable}
                        - import-prefixes policy-name [policy-name ... (up to 5 max)]
                        - no import-prefixes
                - [no] shutdown
                - targeted-session
                    - [no] disable-targeted-session
                    - ipv4
                        - hello timeout factor
                        - no hello
                        - hello-reduction {enable factor | disable}
                        - no hello-reduction
                        - keepalive timeout factor
                        - no keepalive
                    - peer ip-address
                    - no peer ip-address
                        - hello timeout factor
                        - no hello
                        - keepalive timeout factor
                        - no keepalive
                        - local-lsr-id interface-name
                        - no local-lsr-id
                        - [no] shutdown
```

3.8.1.2 Show commands

```
show
    - router
        - ldp
            - auth-keychain [keychain]
            - bindings active [fec-type prefixes] [prefix ip-prefix/mask] [egress-nh ip-address
| egress-if port-id | egress-lsp tunnel-id] [summary]
            - bindings active
            - bindings active prefixes [family] [{summary | detail}] [egress-if port-id]
            - bindings active prefixes [family] [{summary | detail}] [egress-lsp tunnel-id]
            - bindings active prefixes [egress-nh ip-address] [family] [{summary | detail}]
            - bindings active prefixes prefix ip-prefix/ip-prefix-length [{summary | detail}]
[egress-if port-id]
            - bindings active prefixes prefix ip-prefix/ip-prefix-length [{summary | detail}]
[egress-lsp tunnel-id]
            - bindings active prefixes prefix ip-prefix/ip-prefix-length [egress-nh ip-address]
[{summary | detail}]
            - bindings fec-type {prefixes|services} [session ip-addr 4c5]] [summary| detail]
            - 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 prefixes prefix ip-prefix/ip-prefix-length [{summary | detail}]
  [session ip-addr[:label-space]]
                   - bindings prefixes [family] [{summary | 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]
                   - parameters
                   - session [ip-addr[label-space]] [session-type] [state state] [summary | detail]
                   - session [ip-addr[label-space]] local-addresses [sent | recv] [family]
                   - session [ip-addr[label-space]][sent | recv] overload [fec-type fec-type]
                   - session [sent | recv] overload [fec-type fec-type] [family]
                   - session [ip-addr[label-space]] statistics [packet-type] [session-type]
                   - session statistics [packet-type] [session-type] [family]
                   - session [session-type] [state state] [summary | detail] [family]
                   - session-parameters [family]
                   - session-parameters peer-ip-address
                   - statistics
                   - status
                   - targ-peer [ip-address] [detail]
                   - targ-peer [detail] family
                   - targ-peer resource-failures [family]
                   - targ-peer-template [peer-template]
                   - targ-peer-template-map [template-name [peers]]
                   - tcp-session-parameters [family]
                   - tcp-session-parameters [keychain keychain]
                   - tcp-session-parameters [transport-peer-ip-address]
```

3.8.1.3 Clear commands

```
clear
    - router
        - ldp
            -
            - instance
            - interface [ip-int-name]
            - peer [ip-address] [statistics]
            - session [ip-addr[:label-space]] [statistics]
            - statistics
```

3.8.1.4 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
```

3.8.1.5 Tools commands

```
tools
    - dump
        - ldp-treetrace {prefix ip-prefix/mask | manual-prefix ip-prefix/mask}[path-
destination ip-address] [trace-tree]
        - router
            - ldp
                - instance
                - interface ip-int-name
                - memory-usage
                - peer ip-address
                - session ip-addr[label-space] [connection | peer | adjacency]
                - sockets
                - timers [session ip-addr[label-space]]
            - static-route ldp-sync-status
    - perform
        - router
            - isis
                - ldp-sync-exit
                - run-manual-spf
            - ospf
                - ldp-sync-exit
                - refresh-lsas [lsa-type] [area-id]
                - run-manual-spf [externals-only]
```

3.8.2 Command descriptions

- Configuration commands

- Show commands

- Clear commands

- Debug commands

- Tools commands

3.8.2.1 Configuration commands

- Generic commands

- LDP global commands

- Session parameters commands

- Targeted session commands

3.8.2.1.1 Generic commands

shutdown

Syntax

[no] **shutdown**

Context

config>router>ldp

config>router>ldp>targ-session>peer

config>router>ldp>interface-parameters>interface>ipv4

config>router>ldp>interface-parameters>ipv4

config>router>ldp>aggregate-prefix-match

Platforms

Supported on all 7210 SAS platforms as described in this document

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.

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 this command places an entity in an administratively enabled state.

Default

no shutdown

3.8.2.1.2 LDP global commands

ldp

Syntax

[no] **ldp**

Context

config>router

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure LDP parameters. LDP is not enabled by default and must be explicitly enabled (**no shutdown**).

To suspend the LDP protocol, use the **shutdown** command. Configuration parameters are not affected. The LDP instance must first be disabled using the **shutdown** command before being deleted.

The **no** form of this command deletes the LDP protocol instance, removing all associated configuration parameters.

aggregate-prefix-match

Syntax

[no] **aggregate-prefix-match**

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

The command enables LDP to use the aggregate prefix match function instead of requiring an exact prefix match.

When this command is enabled, LDP performs the following procedures for all prefixes. When an LSR receives a FEC-label binding from an LDP neighbor for a specific FEC1 element, it installs 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
- the advertising LDP neighbor is the next-hop to reach the FEC prefix

When the FEC-label binding has been installed in the LDP FIB, LDP programs an NHLFE entry in the egress datapath to forward packets to FEC1. LDP also advertises a new FEC-label binding for FEC1 to all its LDP neighbors.

When a new prefix appears in the routing table, LDP inspects the LDP FIB to determine if this prefix is a closer 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 checks the LDP FIB for all FEC elements that matched this prefix to determine if another match exists in the routing table. If another match exists, it updates the NHLFE entry. If not, it sends a label withdraw message to its LDP neighbors to remove the binding.

If the next hop for a routing prefix changes, LDP updates the LDP FIB entry for the FEC elements that matched this prefix. It also updates the NHLFE entry for these FEC elements.

The **no** form of this command disables the use of the aggregate prefix match function and deletes the configuration. LDP then performs only exact prefix matching 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command specifies the policy name containing the prefixes to be excluded from the aggregate prefix match function. Against each excluded prefix, LDP performs an exact match of a specific FEC element prefix, instead of a longest prefix match of one or more LDP FEC element prefixes 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.

Parameters

policy-name

Specifies the import route policy name. Allowed values are any string up to 32 characters long composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

export

Syntax

export *policy-name* [*policy-name* … (up to 5 max)]

no export

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command specifies the export route policies that 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 are not exported from the routing table manager to LDP, and LDP-learned routes are exported only to LDP neighbors. The currenty implementation of the 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 overrides the previous command. A maximum of five policy names can be specified. Specified names must already be defined.

The **no** form of this command removes all policies from the configuration.

Default

no export

Parameters

policy-name

Specifies the export route policy name. Allowed values are any string up to 32 characters composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

fast-reroute

Syntax

fast-reroute

no fast-reroute

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables LDP Fast-Reroute (FRR). When enabled, LDP uses both the primary next hop and LFA next hop, when available, for resolving the next hop of an LDP FEC against the corresponding prefix in the routing table. This results in LDP programming a primary NHLFE and a backup NHLFE into the forwarding engine for each next hop of a FEC prefix for the purpose of forwarding packets over the LDP FEC.

The backup NHLFE is enabled for each affected FEC next hop when any of the following events occurs.

- An LDP interface goes operationally down or is administratively shut down. In this case, LDP sends a neighbor/next-hop down message to the IOM for each LDP peer it has adjacency with over this interface.

- An LDP session to a peer goes down because the Hello or keepalive timer has expired over a specific interface. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only.

- The TCP connection used by a link LDP session to a peer goes down, because, for example, next-hop tracking of the LDP transport address in RTM brings down the LDP session. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only.

- A BFD session, enabled on a T-LDP session to a peer, times out and causes the link LDP session to the same peer, which uses the same TCP connection as the T-LDP session, to also go down. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only.

- A BFD session enabled on the LDP interface to a directly connected peer times out and brings down the link LDP session to this peer. In this case, LDP sends a neighbor/next-hop down message to the IOM for this LDP peer only. BFD support on LDP interfaces is a recent feature that provides faster tracking of link LDP peers.

The **tunnel-down-damp-time** command or the **label-withdrawal-delay** command, when enabled, do not cause the corresponding timer to be activated for a FEC as long as a backup NHLFE is still available.

Because LDP can detect the loss of a neighbor/next-hop independently, it is possible that it will switch to the LFA next hop while IGP is still using the primary next hop. Also, when the interface for the previous primary next hop is restored, IGP may reconverge before LDP completes the FEC exchange with its neighbor over that interface. This may cause LDP to deprogram the LFA next hop from the FEC and blackhole traffic. To avoid this situation, IGP-LDP synchronization should be enabled on the LDP interface.

When the SPF computation determines there is more than one primary next hop for a prefix, it does not program an LFA next hop in RTM. The LDP FEC will resolve to the multiple primary next hops that provide the required protection.

The **no** form of this command disables LDP FRR.

Default

no fast-reroute

fec-originate

Syntax

fec-originate *ip-prefix/mask* [**advertised-label** *in-label*] [**swap-label** *out-label*] **interface** *interface-name*

fec-originate *ip-prefix/mask* [**advertised-label** *in-label*] **next-hop** *ip-address* [**swap-label** *out-label*]

fec-originate *ip-prefix/mask* [**advertised-label** *in-label*] **next-hop** *ip-address* [**swap-label** *out-label*] **interface** *interface-name*

fec-originate *ip-prefix/mask* [**advertised-label** *in-label*] **pop**

no fec-originate *ip-prefix/mask* **interface** *interface-name*

no fec-originate *ip-prefix/mask* **next-hop** *ip-address*

no fec-originate *ip-prefix/mask* **next-hop** *ip-address* **interface** *interface-name*

no fec-originate *ip-prefix/mask* **pop**

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command adds a FEC to the LDP prefix database with a specific label operation on the node.

Permitted operations are **swap** to originate a FEC for which the LSR is not egress or **pop** to originate a FEC for which the LSR is egress.

The **next-hop**, **advertised-label**, and **swap-label** keywords are optional. If **next-hop** is configured but no *out-label* is specified, a swap occurs with label 3, such as, pop and forward to the next hop. If the **next-hop** and **swap-label** are configured, a regular swap occurs. If no parameters are specified, a pop and route is performed.

Parameters

ip-prefix/mask

Specifies the information for the IP prefix and mask length.

Values	*ip-address/mask*	ipv4-prefix:	a.b.c.d
		ipv4-prefix-le:	0 to 32

next-hop

Keyword to specify the IP address of the next hop of the prefix.

advertised-label

Keyword to specify the label advertised to the upstream peer. If not configured, the label advertised should be from the label pool. If the configured static label is not available, the IP prefix is not advertised.

out-label

Specifies the number of labels to send to the peer associated with this FEC. If configured, the LSR should swap the label with the configured swap-label. If not configured, the default action is pop if the next-hop parameter is not defined.

Values   16 to 1048575

in-label

Specifies the number of labels to send to the peer associated with this FEC.

Values   32 to 1023

pop

Keyword to specify to pop the label and transmit without the label.

interface *interface-name*

Specifies the name of the interface that the label for the originated FEC is swapped to. For an unnumbered interface, this parameter is mandatory because there is no address for the next hop. For a numbered interface, it is optional.

graceful-restart

Syntax

[no] **graceful-restart**

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables graceful restart helper.

The **no** form of this command disables graceful restart.

Default

no graceful-restart

implicit-null-label

Syntax

[no] **implicit-null-label**

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables 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>graceful-restart

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the local maximum recovery time.

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

Default

120

Parameters

interval

Specifies the length of time, in seconds.

Values   15 to 1800

neighbor-liveness-time

Syntax

neighbor-liveness-time *interval*

no neighbor-liveness-time

Context

config>router>ldp>graceful-restart

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the neighbor liveness time.

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

Default

120

Parameters

interval

Specifies the length of time, in seconds.

Values   5 to 300

import

Syntax

import *policy-name* [*policy-name …* (up to 5 max)]

no import

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

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 overrides the previous command. A maximum of five policy names can be specified. The specified names must already be defined.

The **no** form of this command removes all policies from the configuration.

Default

no import

Parameters

policy-name

Specifies the import route policy name. Allowed values are any string up to 32 characters composed of printable, 7-bit ASCII characters. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

label-withdrawal-delay

Syntax

label-withdrawal-delay *seconds*

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the time interval, in seconds, that LDP will delay the withdrawal of the FEC-label binding it distributed to its neighbors when FEC is deactivated. When the timer expires, LDP then sends a label withdrawal for the FEC to all its neighbors. 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 the FEC-label binding it distributed to its neighbors when FEC is deactivated.

Values   3 to 120

keepalive

Syntax

keepalive *timeout factor*

no keepalive

Context

config>router>ldp>interface-parameters>interface>ipv4

config>router>ldp>interface-parameters>ipv4

config>router>ldp>targ-session>ipv4

config>router>ldp>targ-session>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the time, in seconds, that LDP waits before tearing down the session. The *factor* parameter is the keepalive interval.

If no LDP messages are exchanged for the configured amount of time, 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 the LDP session is being set up, the keepalive timeout is negotiated to the lower of the two peers. When a operational value is agreed upon, the keepalive factor derives the value of the keepalive interval. The session needs to be flapped for the new settings to work.

The **no** form of this command at the interface level sets the *timeout* and *factor* to the values defined under the **interface-parameters** level.

The **no** form of this command at the peer level sets the *timeout* and *factor* to the values defined under the **targeted-session** level.

Default

The default value is dependent upon the CLI context. Table 18: Keepalive timeout factor default values lists the **keepalive** *timeout factor* default values.

Table 18: Keepalive timeout factor default values

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

Specifies the time, in seconds, that LDP waits before tearing down the session.

Values 3 to 65535

factor

Specifies the number of keepalive messages, expressed as a decimal integer, that should be sent on an idle LDP session in the keepalive timeout interval.

Values 1 to 255

local-lsr-id

Syntax

local-lsr-id *interface-name*

no local-lsr-id

Context

config>router>ldp>targeted-session>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the use of the address of a specific interface as the LSR ID for the hello adjacency of a T-LDP session. The interface can be a regular interface or a loopback interface, including the system interface.

By default, a T-LDP session uses the system interface address as the LSR ID; however, the system interface must always be configured on the router or the LDP protocol will not come up on the node. There is no requirement to include the system interface in any routing protocol.

At initial configuration, the T-LDP session remains down while the specified interface is down. LDP does not try to bring it up using the system interface.

If the LSR ID is changed on the fly while the T-LDP session is up, LDP immediately tears down the session and attempts to establish one using the new LSR ID, regardless of the operational state of the new interface.

If the interface used as the LSR ID goes down, the T-LDP session also goes down.

The user-configured LSR ID is used exclusively for extended peer discovery to establish the T-LDP hello adjacency. It is also used as the transport address for the TCP session of the LDP session when it is bootstrapped by the T-LDP hello adjacency. The user-configured LSR ID is, however, not used in basic peer discovery to establish a link-level LDP hello adjacency.

The **no** form of this command reverts to the default behavior, in which case the system interface address is used as the LSR ID.

Default

no local-lsr-id

Parameters

interface-name

Specifies 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, and so on), the entire string must be enclosed within double quotes.

Values   1 to 32 characters

interface-parameters

Syntax

interface-parameters

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure LDP interfaces and parameters applied to LDP interfaces.

prefix-ipv4

Syntax

prefix-ipv4 {**enable** | **disable**}

Context

config>router>ldp>interface-params>interface>ipv4>fec-type-capability

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables and disables IPv4 prefix FEC capability on the interface.

Parameters

enable

Keyword to enable IPv4 FEC capability.

disable

Keyword to disable IPv4 FEC capability.

hello

Syntax

hello *timeout factor*

no hello

Context

config>router>ldp>interface-parameters>interface>ipv4

config>router>ldp>interface-parameters>ipv4

config>router>ldp>targ-session>ipv4

config>router>ldp>targ-session>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

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 hold-down time is negotiated to the lower of the two peers. After a operational value is agreed upon, the hello factor is used to derive the value of the hello interval. The session needs to be flapped for the new settings to operate.

The **no** form of this command at the targeted-session level sets the **hello** *timeout* and the **hello** *factor* to the default values.

The **no** form of this command at the peer level sets the **hello** *timeout* and the **hello** *factor* to the value defined under the targeted-session level.

Default

The default value is dependent upon the CLI context. The following table lists the **hello** *timeout factor* default values.

Table 19: Hello timeout factor default values

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

> Specifies the time interval, in seconds, that LDP waits before declaring a neighbor down.

> > **Values** 3 to 65535

factor

> Specifies the number of keepalive messages that should be sent on an idle LDP session in the hello timeout interval.

> > **Values** 1 to 255

hello-reduction

Syntax

hello-reduction {**enable** *factor* | **disable**}

no hello-reduction

Context

config>router>ldp>targ-session>ipv4

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the suppression of periodic targeted hello messages between LDP peers after the targeted LDP session is brought up.

When this feature is enabled, the target hello adjacency is brought up by advertising the hold-time value that the user configured in the **hello** *timeout* parameter for the targeted session. The LSR node starts advertising an exponentially increasing hold-time value in the hello message as soon as the targeted LDP session to the peer is up. Each new incremented hold-time value is sent in several hello messages equal to the value of the argument factor (the dampening factor) before the next exponential value is advertised. This functionality provides time for the two peers to settle on the new value. When the hold-time reaches the maximum value of 0xffff (binary 65535), the two peers send hello messages at a frequency of every [(65535-1)/local helloFactor] seconds for the lifetime of the targeted-LDP session; for example, if the local **hello** *factor* is three (3), hello messages are sent every 21844 seconds.

The LSR node continues to compute the frequency of sending the hello messages based on the minimum of its local hold-time value and the one advertised by its peer, as in RFC 5036. For the targeted LDP session to suppress the periodic hello messages, both peers must bring their advertised hold-time to the maximum value. If one of the LDP peers does not, the frequency of the hello messages sent by both peers continues to be governed by the smaller of the two hold-time values.

When the user enables the **hello-reduction** command on the LSR node while the targeted LDP session to the peer is operationally up, the change takes effect immediately. The LSR node starts advertising an exponentially increasing hold-time value in the hello message, starting with the currently configured hold-time value.

When the user disables the **hello-reduction** command while the targeted LDP session to the peer is operationally up, the change in the hold-time from 0xffff (binary 65535) to the user-configured value for this peer takea effect immediately. The local LSR immediately advertises the user-configured hold-time value and does not wait until the next scheduled time to send a hello to make sure the peer adjusts its local hold timeout value.

In general, any configuration change to the parameters of the T-LDP hello adjacency (modifying the hello adjacency **hello** *timeout* or *factor*, enabling or disabling **hello-reduction**, or modifying the **hello-reduction** *factor*) causes the LSR node to immediately trigger an updated hello message with the updated hold-time value without waiting for the next scheduled time to send a hello.

The **no** form of this command disables hello reduction.

Default

no hello-reduction

Parameters

disable

Keyword that disables hello reduction.

factor

Specifies the hello-reduction dampening factor.

Values 3 to 20

interface

Syntax

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

Context

config>router>ldp>if-params

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables LDP on the specified IP interface. The LDP interface must be disabled using the **shutdown** command before it can be deleted.

The **no** form of this command deletes the LDP interface and all configuration information associated with the LDP interface.

Parameters

ip-int-name

Specifies the name of an existing interface. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

bfd-enable

Syntax

bfd-enable

no bfd-enable

Context

config>router>ldp>interface-parameters>interface

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables tracking of the hello adjacency to an LDP peer using BFD.

When this command is enabled on an LDP interface, LDP registers with BFD and starts tracking the LSR ID of all peers it formed hello adjacencies with over that LDP interface. The LDP hello mechanism determines the remote address to be used for the BFD session. The parameters used for the BFD session, that is, transmit-interval, receive-interval, and multiplier, are those configured under the IP interface in the **config router interface bfd** command.

When multiple links exist to the same LDP peer, a hello adjacency is established over each link and a separate BFD session is enabled on each LDP interface. If a BFD session times out on a specific link, LDP immediately associates the LDP session with one of the remaining hello adjacencies and triggers the LDP FRR procedures. As soon as the last hello adjacency goes down because of BFD timing out, the LDP session goes down and the LDP FRR procedures are triggered.

> **Note:**
> For more information about the list of protocols that support BFD, see *7210 SAS-D, Dxp, K 2F1C2T, K 2F6C4T, K 3SFP+ 8C Router Configuration Guide*.

The **no** form of this command disables BFD on the LDP interface.

Default

no bfd-enable

ipv4

Syntax

ipv4

Context

config>router>ldp>interface-parameters>interface

config>router>ldp>interface-parameters

config>router>ldp>targeted-session

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure IPv4 LDP parameters for the interface.

transport-address

Syntax

transport-address {interface | system}

no transport-address

Context

config>router>ldp>interface-parameters>interface>ipv4

config>router>ldp>interface-parameters>ipv4

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the transport address used when setting up 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, users set up the LDP interface to the connection that can be set to the interface address or system address. However, there can be an issue of which address to use when there are parallel adjacencies. This address selection situation can also occur when there is a link and a targeted adjacency, because targeted adjacencies request the session to be set up only to the system IP address.

The **transport-address** value should not be **interface** if multiple interfaces exist between two LDP neighbors.

Depending on the first adjacency formed, the TCP endpoint is chosen. If one LDP interface is set up as **transport-address interface** and another as **transport-address system**, depending on which adjacency was set up first, the TCP endpoint addresses are determined. After that, because the hello contains the LSR ID, the LDP session can be checked to verify that it is set up and then the adjacency can be matched to the session.

For any specific ILDP interface, as the **local-lsr-id** parameters is changed to **interface**, the **transport-address** configuration loses effectiveness, because it is ignored and the ILDP session always uses the relevant interface IP address as the transport address even though **system** is chosen.

The **no** form of this command at the global level reverts the transport address to the default value.

The **no** form of this command at the interface level sets the transport address to the value defined under the global level.

Default

system

Parameters

interface

Keyword to specify 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, because only one LDP session is set up between two neighbors.

system

> Keyword to specify the system IP address is used to set up the LDP session between neighbors.

3.8.2.1.3 Session parameters commands

session-parameters

Syntax

session-parameters

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure peer-specific parameters.

peer

Syntax

[**no**] **peer** *ip-address*

Context

config>router>ldp>session-parameters

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures parameters for an LDP peer.

Parameters

ip-address

> Specifies the IP address of the LDP peer, in dotted-decimal notation.

export-addresses

Syntax

export-addresses *policy-name* [*policy-name* **...** (up to 5 max)]

no export-addresses

Context

config>router>ldp>session-params>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the export prefix policy to local addresses advertised to this peer.

Policies are configured in the **config>router>policy-options** context. A maximum of five policy names can be specified. The specified names must already be defined.

The **no** form of this command removes the policy from the configuration.

Default

no export-addresses

Parameters

policy-name

Specifies the export-prefix route policy name. Allowed values are any string up to 32 characters 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.

export-prefixes

Syntax

export-prefixes *policy-name* [*policy-name* **...** (up to 5 max)]

no export-prefixes

Context

config>router>ldp>session-params>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the export route policy used to determine which prefixes received from other LDP and T-LDP peers are redistributed to this LDP peer via the LDP/T-LDP session to this peer. A prefix that is filtered out (deny) is not exported. A prefix that is filtered in (accept) is exported.

If no export policy is specified, all FEC prefixes learned are exported to this LDP peer. This policy is applied in addition to the global LDP policy and targeted session policy.

Policies are configured in the **config>router>policy-options** context. A maximum of five policy names can be specified. The peer address must be the peer LSR ID address. The specified names must already be defined.

The **no** form of this command removes the policy from the configuration.

Default

no export-prefixes

Parameters

policy-name

Specifies the export-prefix route policy name. Allowed values are any string up to 32 characters 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.

fec-type-capability

Syntax

fec-type-capability

Context

config>router>ldp>session-params>peer

config>router>ldp>interface-params>interface>ipv4

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure FEC type capabilities for the session or interface.

prefix-ipv4

Syntax

prefix-ipv4 {**enable** | **disable**}

Context

config>router>ldp>session-params>peer>fec-type-capability

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables or disables IPv4 prefix FEC capability on the session or interface.

Default

prefix-ipv4 enable

Parameters

enable

Keyword to specify that IPv4 prefix FEC capability is enabled.

disable

Keyword to specify that IPv4 prefix FEC capability is disabled.

fec129-cisco-interop

Syntax

[**no**] **fec129-cisco-interop**

Context

config>router>ldp>session-params>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures whether LDP provides translation between non-compliant FEC 129 Cisco formats. Peer LDP sessions must be manually configured toward the non-compliant Cisco PEs.

When enabled, Cisco non-compliant format is used to send and interpret received label release messages. The FEC129 SAII and TAII fields are reversed.

The **no** form of this command disables use and support of Cisco non-compliant forms. The peer address must be the peer LSR ID address.

Default

no fec129-cisco-interop

import-prefixes

Syntax

import-prefixes *policy-name* [*policy-name*... (up to 5 max)]

no import-prefixes

Context

config>router>ldp>session-params>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the import FEC prefix policy to determine which prefixes received from this LDP peer are imported and installed by LDP on this node. If resolved, these FEC prefixes are then redistributed to other LDP and T-LDP peers. A FEC prefix that is filtered out (deny) is not imported. A FEC prefix that is filtered in (accept) is imported.

If no import policy is specified, the node imports all prefixes received from this LDP/T-LDP peer. This policy is applied in addition to the global LDP policy and targeted session policy. Policies are configured in the **config>router>policy-options** context. A maximum of five policy names can be specified. The peer address has to be the peer LSR ID address. The specified names must already be defined.

The **no** form of this command removes the policy from the configuration.

Default

no import-prefixes

Parameters

policy-name

Specifies the import-prefix route policy name. Allowed values are any string up to 32 characters 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.

3.8.2.1.4 Targeted session commands

targeted-session

Syntax

targeted-session

Context

config>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

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.

disable-targeted-session

Syntax

[no] **disable-targeted-session**

Context

config>router>ldp>targ-session

Platforms

Supported on all 7210 SAS platforms as described in this document

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 this 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures parameters for an LDP peer.

Parameters

ip-address

Specifies the IP address of the LDP peer in dotted-decimal notation.

tunneling

Syntax

[**no**] **tunneling**

Context

config>router>ldp>targ-session>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables LDP over tunnels.

The **no** form of this command disables tunneling.

Default

no tunneling

lsp

Syntax

[**no**] **lsp** *lsp-name*

Context

config>router>ldp>targ-session>tunneling

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures a specific LSP destined for this peer and to be used for tunneling of LDP FEC over RSVP. A maximum of four RSVP LSPs can be explicitly used for tunneling LDP FECs to the T-LDP peer.

It is not necessary to specify an RSVP LSP in this context unless there is a need to restrict the tunneling to selected LSPs. All RSVP LSPs with a "to" address matching that of the T-LDP peer are eligible by default. The user can also exclude specific LSP names by using the **ldp-over-rsvp exclude** command in the **config>router>mpls>lsp** context.

Default

no tunneling

3.8.2.2 Show commands

auth-keychain

Syntax

auth-keychain [*keychain*]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays LDP sessions using a particular authentication keychain.

Parameters

keychain

Specifies an existing keychain name.

Output

The following output is an example of LDP authentication keychain information, and Table 20: Output fields: LDP auth-keychain describes the output fields.

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#
```

Table 20: Output fields: LDP auth-keychain

Label	Description
Peer	The IP address of the peer

Label	Description
TTL Security	Indicates whether LDP peering session security is enabled
Min-TTL-Value	The minimum TTL value for an incoming packet
Authentication	Indicates whether authentication using MD5 message-based digest protocol is enabled
Auth key chain	Indicates the authentication keychain associated with the session, if applicable

bindings

Syntax

bindings active

bindings active prefixes [*family*] [{**summary** | **detail**}] [**egress-if** *port-id*]

bindings active prefixes [*family*] [{**summary** | **detail**}] [**egress-lsp** *tunnel-id*]

bindings active prefixes [**egress-nh** *ip-address*] [*family*] [{**summary** | **detail**}]

bindings prefix *ip-prefixlip-prefix-length* [{**summary** | **detail**}] [**egress-if** *port-id*]

bindings prefix *ip-prefixlip-prefix-length* [{**summary** | **detail**}] [**egress-lsp** *tunnel-id*]

bindings prefix *ip-prefixlip-prefix-length* [**egress-nh** *ip-address*] [{**summary** | **detail**}]

bindings fec-type {**prefixes**|**services**} [**session** *ip-addr* **4c5**]] [**summary**| **detail**]

bindings p2mp source *ip-address* **group** *mcast-address*

bindings [**fec-type** *fec-type* [**detail**]] [**session** *ip-addr*[:*label-space*]]

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*]]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays the contents of the label information base.

Parameters

family

Specifies the family type.

Values   ipv4

summary

Displays information in a summarized format.

detail

Displays detailed information.

session ip-addr

Displays configuration information about LDP sessions.

ip-prefix

Specifies information for the specified IP prefix and mask length. Host bits must be 0.

ip-prefix-length

Specifies the length of the IP prefix.

label-space

Specifies the label space identifier that the router is advertising on the interface.

Values   0 to 65535

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 to 32

ip-address

Specifies the egress IP address.

start-label

Specifies a label value to begin the display.

Values   16 to 1048575

end-label

Specifies a label value to end the display.

Values   17 to 1048575

vc-type

Specifies the VC type to display.

Values   ethernet, vlan, mirror

vc-id

Specifies the VC ID to display.

Values   1 to 4294967295

group multicast-address

Displays the P2MP group multicast address bindings.

Values   a.b.c.d

service-id

Specifies the service ID number to display.

Values   1 to 2147483647

Output

The following output is an example of LDP bindings information, and describes the output fields.

Sample output

```
A:7210SAS# show router ldp bindings

===============================================================================
LDP LSR ID: 2.2.2.2
===============================================================================
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
        BU - Alternate Next-hop for Fast Re-Route, TLV - (Type, Length: Value)
===============================================================================
LDP Prefix Bindings
===============================================================================
Prefix           IngLbl      EgrLbl     EgrIntf/       EgrNextHop
   Peer                                 LspId
-------------------------------------------------------------------------------
10.1.1.1/32          --       262143    1/1/3:12       10.11.12.1
   1.1.1.1
10.1.1.1/32      131069U      131069     --             --
   6.6.6.6
10.2.2.2/32      131071U        --       --             --
   1.1.1.1
10.2.2.2/32      131071U        --       --             --
   6.6.6.6
..........
10.6.6.6/32          --       131071    1/1/9:26       10.11.26.6
   6.6.6.6
-------------------------------------------------------------------------------
No. of Prefix Bindings: 10
===============================================================================


===============================================================================
LDP Generic P2MP Bindings
===============================================================================
P2MP-Id          RootAddr
Interface        Peer         IngLbl   EgrLbl EgrIntf/   EgrNextHop
                                              LspId
-------------------------------------------------------------------------------
8193             10.1.1.1
73732            1.1.1.1      131065U    --     --         --

8193             10.2.2.2
73728            1.1.1.1        --     262139 1/1/3:12   10.11.12.1

88194            10.6.6.6
73738            6.6.6.6      131054U    --     --         --
```

```
8195                10.6.6.6
73739               6.6.6.6         131053U     --      --         --

-------------------------------------------------------------------------------
No. of Generic P2MP Bindings: 13
===============================================================================


===============================================================================
LDP In-Band-SSM P2MP Bindings
===============================================================================
Source
Group
Interface         RootAddr
                  Peer            IngLbl    EgrLbl EgrIntf/    EgrNextHop
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================


===============================================================================
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:7210SAS#




A:7210SAS# show router ldp bindings p2mp-id 8193 root 2.2.2.2 detail


===============================================================================
LDP LSR ID: 2.2.2.2
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate Next-hop for Fast Re-Route
===============================================================================
LDP Generic P2MP Bindings
===============================================================================
-------------------------------------------------------------------------------
P2MP Type       : 1                   P2MP-Id             : 8193
                                      Root-Addr           : 10.2.2.2
-------------------------------------------------------------------------------
Ing Lbl         :   --                Peer                : 1.1.1.1
Egr Lbl         : 262139
Egr Int/LspId   : 1/1/3:12
EgrNextHop      : 10.11.12.1
Egr. Flags      : None                Ing. Flags          : None
Metric          : 1                   Mtu                 : 1560
-------------------------------------------------------------------------------
```

```
P2MP Type           : 1                    P2MP-Id            : 8193
                                           Root-Addr          : 2.2.2.2
-------------------------------------------------------------------------------
Ing Lbl             :    --                Peer               : 6.6.6.6
Egr Lbl             : 131059
Egr Int/LspId       : 1/1/9:26
EgrNextHop          : 10.11.26.6
Egr. Flags          : None                 Ing. Flags         : None
Metric              : 1                    Mtu                : 1560
===============================================================================
No. of Generic P2MP Bindings: 2
===============================================================================
A:7210SAS#
A:7210SAS# show router ldp bindings active fec-type p2mp

===============================================================================
LDP Generic P2MP Bindings (Active)
===============================================================================
P2MP-Id         RootAddr
Interface       Op            IngLbl    EgrLbl EgrIntf/        EgrNextHop
                                               LspId
-------------------------------------------------------------------------------
8193            10.1.1.1
73731           Pop           131064    --     --              --

8193            10.1.1.1
7
8195            10.6.6.6
73738           Pop           131058    --     --              --

-------------------------------------------------------------------------------
No. of Generic P2MP Active Bindings: 15
===============================================================================


===============================================================================
LDP In-Band-SSM P2MP Bindings (Active)
===============================================================================
Source
Group
Interface       RootAddr
                Op            IngLbl    EgrLbl EgrIntf/        EgrNextHop
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
No Matching Entries Found
===============================================================================
A:7210SAS#

A:7210SAS# show router ldp bindings fec-type p2mp detail

===============================================================================
LDP LSR ID: 2.2.2.2
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate Next-hop for Fast Re-Route
===============================================================================
LDP Generic P2MP Bindings
===============================================================================
-------------------------------------------------------------------------------
P2MP Type           : 1                    P2MP-Id            : 8193
                                           Root-Addr          : 1.1.1.1
-------------------------------------------------------------------------------
Ing Lbl             : 131053U              Peer               : 6.6.6.6
Egr Lbl             :    --
Egr Int/LspId       :    --
```

```
EgrNextHop          :   --
Egr. Flags          : None            Ing. Flags          : None
===============================================================================
No. of Generic P2MP Bindings: 13
===============================================================================


===============================================================================
LDP In-Band-SSM P2MP Bindings
===============================================================================
No Matching Entries Found
===============================================================================
A:7210SAS#

A:7210SAS# show router ldp bindings p2mp-id 8193 root 2.2.2.2 detail

===============================================================================
LDP LSR ID: 2.2.2.2
===============================================================================
Legend: U - Label In Use,  N - Label Not In Use, W - Label Withdrawn
        WP - Label Withdraw Pending, BU - Alternate Next-hop for Fast Re-Route
===============================================================================
LDP Generic P2MP Bindings
===============================================================================
-------------------------------------------------------------------------------
P2MP Type           : 1               P2MP-Id             : 8193
                                      Root-Addr           : 2.2.2.2
-------------------------------------------------------------------------------
Ing Lbl             :   --            Peer                : 1.1.1.1
Egr Lbl             : 262139
Egr Int/LspId       : 1/1/3:12
EgrNextHop          : 10.11.12.1
Egr. Flags          : None            Ing. Flags          : None
Metric              : 1               Mtu                 : 1560
-------------------------------------------------------------------------------
P2MP Type           : 1               P2MP-Id             : 8193
                                      Root-Addr           : 2.2.2.2
-------------------------------------------------------------------------------
Ing Lbl             :   --            Peer                : 6.6.6.6
Egr Lbl             : 131059
Egr Int/LspId       : 1/1/9:26
EgrNextHop          : 10.11.26.6
Egr. Flags          : None            Ing. Flags          : None
Metric              : 1               Mtu                 : 1560
===============================================================================
No. of Generic P2MP Bindings: 2
===============================================================================
A:7210SAS#
```

The following outputs pertain to unicast FEC resolved over an unnumbered interface.

```
A:7210SAS# # show router ldp bindings active
===============================================================================
Legend:  (S) - Static       (M) - Multi-homed Secondary Support
         (B) - BGP Next Hop (BU) - Alternate Next-hop for Fast Re-Route
===============================================================================
LDP Prefix Bindings (Active)
===============================================================================
Prefix               Op    IngLbl   EgrLbl   EgrIntf/LspId  EgrNextHop
-------------------------------------------------------------------------------
10.20.1.1/32         Push  --       262143   1/1/1          Unnumbered
10.20.1.1/32         Swap  262138   262143   1/1/1          Unnumbered
10.20.1.2/32         Push  --       262143   lag-1          Unnumbered
```

```
10.20.1.2/32              Swap 262139    262143    lag-1       Unnumbered
10.20.1.3/32              Pop  262143    --        --          --
10.20.1.4/32              Push --        262143    2/1/2       Unnumbered
10.20.1.4/32              Swap 262142    262143    2/1/2       Unnumbered
10.20.1.5/32              Push --        262143    2/1/1       Unnumbered
10.20.1.5/32              Swap 262141    262143    2/1/1       Unnumbered
10.20.1.6/32              Push --        262140    2/1/2       Unnumbered
10.20.1.6/32              Swap 262140    262140    2/1/2       Unnumbered
-------------------------------------------------------------------------------
No. of Prefix Active Bindings: 11
===============================================================================
A:7210SAS#
A:7210SAS# show router ldp bindings
===============================================================================
LDP LSR ID: 10.20.1.3
===============================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value)
===============================================================================
LDP Prefix Bindings
===============================================================================
Prefix            IngLbl      EgrLbl    EgrIntf/      EgrNextHop
   Peer                                 LspId
-------------------------------------------------------------------------------
10.20.1.1/32        --         262143    1/1/1        Unnumbered
   10.20.1.1
10.20.1.1/32      262138U      262142    --           --
   10.20.1.2
10.20.1.1/32      262138U      262138    --           --
   10.20.1.4
10.20.1.1/32      262138U      262138    --           --
   10.20.1.5
10.20.1.2/32      262139U      262142    --           --
   10.20.1.1
10.20.1.2/32        --         262143    lag-1        Unnumbered
   10.20.1.2
10.20.1.2/32      262139U      262139    --           --
   10.20.1.4
10.20.1.2/32      262139U      262139    --           --
   10.20.1.5
10.20.1.3/32      262143U       --       --           --
   10.20.1.1
10.20.1.3/32      262143U       --       --           --
   10.20.1.2
10.20.1.3/32      262143U       --       --           --
   10.20.1.4
10.20.1.3/32      262143U       --       --           --
   10.20.1.5
10.20.1.4/32      262142U      262141    --           --
   10.20.1.1
10.20.1.4/32      262142U      262141    --           --
   10.20.1.2
10.20.1.4/32        --         262143    2/1/2        Unnumbered
   10.20.1.4
10.20.1.4/32      262142U      262141    --           --
   10.20.1.5
10.20.1.5/32      262141U      262138    --           --
   10.20.1.1
10.20.1.5/32      262141U      262139    --           --
   10.20.1.2
```

```
10.20.1.5/32          262141U      262141       --              --
   10.20.1.4
10.20.1.5/32          --           262143       2/1/1           Unnumbered
   10.20.1.5
10.20.1.6/32          262140U      262140       --              --
   10.20.1.1
10.20.1.6/32          262140U      262138       --              --
   10.20.1.2
10.20.1.6/32          262140N      262140       2/1/2           Unnumbered
   10.20.1.4
10.20.1.6/32          262140U      262140       --              --
   10.20.1.5
-------------------------------------------------------------------------
No. of Prefix Bindings: 24
=========================================================================
A:7210SAS#


A:7210SAS# show router ldp bindings detail

=========================================================================
LDP LSR ID: 10.20.1.3
=========================================================================
Legend: U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down
        E - Epipe Service, V - VPLS Service, M - Mirror Service
        A - Apipe Service, F - Fpipe Service, I - IES Service, R - VPRN service
        P - Ipipe Service, WP - Label Withdraw Pending, C - Cpipe Service
        BU - Alternate For Fast Re-Route, TLV - (Type, Length: Value)
=========================================================================
LDP Prefix Bindings
=========================================================================
-------------------------------------------------------------------------
Prefix            : 10.20.1.1/32
-------------------------------------------------------------------------
Ing Lbl           :    --             Peer               : 10.20.1.1
Egr Lbl           : 262143
Egr Int/LspId     : 1/1/1
EgrNextHop        : Unnumbered
Egr. Flags        : None            Ing. Flags         : None
Egr If Name       : ip-10.10.2.3
Metric            : 1000            Mtu                : 1500
-------------------------------------------------------------------------
Prefix            : 10.20.1.1/32
-------------------------------------------------------------------------
Ing Lbl           : 262138U         Peer               : 10.20.1.2
Egr Lbl           : 262142
Egr Int/LspId     :    --
EgrNextHop        :    --
Egr. Flags        : None            Ing. Flags         : None
Egr If Name       : n/a
-------------------------------------------------------------------------
Prefix            : 10.20.1.1/32
-------------------------------------------------------------------------
Ing Lbl           : 262138U         Peer               : 10.20.1.4
Egr Lbl           : 262138
Egr Int/LspId     :    --
EgrNextHop        :    --
Egr. Flags        : None            Ing. Flags         : None
Egr If Name       : n/a
-------------------------------------------------------------------------
Prefix            : 10.20.1.1/32
-------------------------------------------------------------------------
Ing Lbl           : 262138U         Peer               : 10.20.1.5
```

```
Egr Lbl              : 262138
Egr Int/LspId        :   --
EgrNextHop           :   --
Egr. Flags           : None             Ing. Flags          : None
Egr If Name          : n/a
-------------------------------------------------------------------------------
Prefix               : 10.20.1.2/32
-------------------------------------------------------------------------------
Ing Lbl              : 262139U          Peer                : 10.20.1.1
Egr Lbl              : 262142
Egr Int/LspId        :   --
EgrNextHop           :   --
Egr. Flags           : None             Ing. Flags          : None
Egr If Name          : n/a
-------------------------------------------------------------------------------


A:7210SAS# show router ldp session local-addresses
===============================================================================
LDP Session Local-Addresses
===============================================================================
-------------------------------------------------------------------------------
Session with Peer 10.20.1.2:0, Local 10.20.1.3:0
-------------------------------------------------------------------------------
Sent Addresses: 10.1.1.1         10.10.12.3       10.10.22.3       10.20.1.3
                10.180.2.3       10.180.3.3       10.180.5.3       10.180.11.3
                10.181.2.3       10.181.3.3       10.181.5.3       10.181.11.3
                10.182.2.3       10.182.3.3       10.182.5.3       10.182.11.3

Recv Addresses: 10.2.2.2         10.10.12.2       10.20.1.2        10.180.1.2
                10.180.3.2       10.180.4.2       10.181.1.2       10.181.3.2
                10.181.4.2       10.182.1.2       10.182.3.2       10.182.4.2
-------------------------------------------------------------------------------
Session with Peer 10.20.1.4:0, Local 10.20.1.3:0
-------------------------------------------------------------------------------
Sent Addresses: 10.1.1.1         10.10.12.3       10.10.22.3       10.20.1.3
                10.180.2.3       10.180.3.3       10.180.5.3       10.180.11.3
                10.181.2.3       10.181.3.3       10.181.5.3       10.181.11.3
                10.182.2.3       10.182.3.3       10.182.5.3       10.182.11.3

Recv Addresses: 10.10.22.4       10.20.1.4        10.180.4.4       10.180.6.4
                10.180.9.4       10.180.11.4      10.181.4.4       10.181.6.4
                10.181.9.4       10.181.11.4      10.182.4.4       10.182.6.4
                10.182.9.4       10.182.11.4
-------------------------------------------------------------------------------
Session with Peer 10.20.1.5:0, Local 10.20.1.3:0
-------------------------------------------------------------------------------
Sent Addresses: 10.1.1.1         10.10.12.3       10.10.22.3       10.20.1.3
                10.180.2.3       10.180.3.3       10.180.5.3       10.180.11.3
                10.181.2.3       10.181.3.3       10.181.5.3       10.181.11.3
                10.182.2.3       10.182.3.3       10.182.5.3       10.182.11.3

Recv Addresses: 10.20.1.5        10.180.5.5       10.180.6.5       10.180.10.5
                10.181.5.5       10.181.6.5       10.181.10.5      10.182.5.5
                10.182.6.5       10.182.10.5
===============================================================================
A:7210SAS#
```

Table 21: Output fields: LDP bindings

Label	Description	
Legend	U: Label In Use	A: Apipe service
	N: Label Not In Use	F: Fpipe service
	W: Label Withdrawn	I: IES service
	S: Status Signaled Up	R: VPRN service
	D: Status Signaled Down	P: Ipipe service
	E: Epipe service	WP: Label Withdraw Pending
	V: VPLS service	C: Cpipe service
	M: Mirror service	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	
Op	Label Operation carried out (can be one of: pop, swap, or push)	
EgrNextHop	The next-hop gateway IP address	
EgrIntf/LspId	Displays the LSP Tunnel ID (not the LSP path ID)	
IngLbl	The ingress LDP label	
	U — Label in use	
	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	

discovery

Syntax

discovery [{**peer** [*ip-address*]} | {**interface** [*ip-int-name*]}] [**state** *state*] [**detail**] [**adjacency-type** *type*]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays the status of the interfaces participating in LDP discovery.

Parameters

peer *ip-address*

> Displays the IP address of the peer.

ip-int-name

> Specifies the name of an existing interface. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

state

> Displays the current operational state of the adjacency.
>
> > **Values**   established, trying, down

detail

> Displays detailed information.

adjacency-type *type*

> Displays the adjacency type.
>
> > **Values**   link, targeted

Output

The following output is an example of LDP discovery information, and Table 22: Output fields: LDP discovery describes the output fields.

Sample output

```
ALU-12# show router ldp discovery
===============================================================================
LDP Hello Adjacencies
===============================================================================
Interface Name Local Addr Peer Addr AdjType State
-------------------------------------------------------------------------------
N/A 10.10.10.103 10.10.10.93 Targ Trying
N/A 10.10.10.103 10.10.10.104 Targ Estab
to-104 10.0.0.103 224.0.0.2 Link Trying
-------------------------------------------------------------------------------
```

```
No. of Hello Adjacencies: 3
===============================================================================
ALU-12#
```

Table 22: Output fields: LDP discovery

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 — adjacency is established
	Trying — 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays configuration information about LDP interfaces.

Parameters

ip-int-name

Specifies the name of an existing interface. If the string contains special characters (#, $, spaces, and so on), the entire string must be enclosed within double quotes.

ip-address

Specifies the IP address of the LDP neighbor.

detail

Displays detailed information.

Output

The following output is an example of LDP interface information, and Table 23: Output fields: LDP interface describes the output fields.

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#
```

Table 23: Output fields: LDP interface

Label	Description
Interface	Specifies the interface associated with the LDP instance
Adm	Up — The LDP is administratively enabled Down — The LDP is administratively disabled
Opr	Up — The LDP is operationally enabled Down — The LDP is operationally disabled
Hello Factor	The value by which the hello timeout should be divided to give the hello-time 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 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 Disabled — No authentication is used
No. of Interface	The total number of LDP interfaces

parameters

Syntax

parameters

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays configuration information about LDP parameters.

Output

The following output is an example of LDP parameters information, and Table 24: Output fields: LDP parameters describes the output fields.

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#
```

Table 24: Output fields: LDP parameters

Label	Description
Keepalive Timeout	The factor used to derive the Keepalive interval

Label	Description
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 down
Hello Factor	The value by which the hello timeout should be divided to give the hello time between LDP hello messages. LDP uses hello messages to discover neighbors and detect loss of connectivity with its neighbors.
Auth	Enabled — Authentication using MD5 message based digest protocol is enabled 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 false — LDP actively tries to connect to its peers
Targeted-Sessions	true — Targeted sessions are enabled false — Targeted sessions are disabled

session

Syntax

session [*ip-addr*[*label-space*] **local-addresses** [**sent** | **recv**] **ip-addr** *ip-address*

session [*ip-addr*[*label-space*] [**session-type**] [**state** *state*] [**summary** | **detail**]

session [*ip-addr*[*label-space*] **local-addresses** [**sent**|**recv**] [**family**]

session [*ip-addr*[*label-space*] [**sent** | **recv**] **overload** [**fec-type** *fec-type*]

session [**sent**|**recv**] **overload** [**fec-type** *fec-type*] [**family**]

session [*ip-addr*[*label-space*] **statistics** [**packet-type**] [**session-type**]

session **statistics** [**packet-type**] [**session-type**] [**family**]

session [**session-type**] [**state** *state*] [**summary** | **detail**] [**family**]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays configuration information about LDP sessions.

Parameters

ip-address

Specifies the IP address of the LDP peer.

label-space

Specifies the label space identifier that the router is advertising on the interface.

Values   0 to 65535

detail

Displays detailed information.

statistics *packet-type*

Specifies the packet type.

Values   hello, keepalive, init, label, notification, address

session-type

Specifies to display the session type.

family

Displays IPv4 LDP session information.

Values   link, targeted, both

Output

The following output is an example of LDP session information, and Table 25: Output fields: LDP session describes the output fields.

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
-------------------------------------------------------------------------------
10.1.1.1:0         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
10.22.10.2:0       Link       Nonexistent  4         2          0d 00:00:16
10.22.11.2:0       Link       Nonexistent  4         4          0d 00:00:14
10.22.13.2:0       Link       Nonexistent  5         6          0d 00:00:20
10.66.33.1:0       Link       Nonexistent  6         7          0d 00:00:25
10.66.34.1:0       Link       Nonexistent  2         2          0d 00:00:05
10.66.35.1:0       Link       Nonexistent  4         4          0d 00:00:14
10.20.1.1:0        Targeted   Nonexistent  0         1          0d 00:00:04
10.20.1.3:0        Both       Established  94        97         0d 00:00:55
10.20.1.5:0        Both       Established  230866    286216     0d 12:48:27
10.20.1.110:0      Link       Nonexistent  2         2          0d 00:00:05
10.0.0.1:0         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#


*7210SAS# show router ldp session detail

===============================================================================
LDP Sessions (Detail)
===============================================================================
Legend:  DoD - Downstream on Demand (for address FEC's only)
         DU  - Downstream Unsolicited
===============================================================================
-------------------------------------------------------------------------------
Session with Peer 2.2.2.2:0, Local 1.1.1.1:0
-------------------------------------------------------------------------------
Adjacency Type     : Both          State                 : Established
Up Time            : 0d 00:07:48
Max PDU Length     : 4096          KA/Hold Time Remaining: 29
Link Adjacencies   : 1             Targeted Adjacencies  : 1
Local Address      : 1.1.1.1       Peer Address          : 2.2.2.2
Local TCP Port     : 646           Peer TCP Port         : 50980
Local KA Timeout   : 30            Peer KA Timeout       : 30
Mesg Sent          : 478           Mesg Recv             : 480
FECs Sent          : 182           FECs Recv             : 170
Addrs Sent         : 13            Addrs Recv            : 16
GR State           : Capable       Label Distribution    : DU
Nbr Liveness Time  : 0             Max Recovery Time     : 0
MP MBB             : Not Capable
Dynamic Capability : Not Capable
Advertise          : Address/Servi* BFD Operational Status: inService
-------------------------------------------------------------------------------
Session with Peer 3.3.3.3:0, Local 1.1.1.1:0
-------------------------------------------------------------------------------
Adjacency Type     : Both          State                 : Established
Up Time            : 0d 00:07:48
Max PDU Length     : 4096          KA/Hold Time Remaining: 29
Link Adjacencies   : 1             Targeted Adjacencies  : 1
Local Address      : 1.1.1.1       Peer Address          : 3.3.3.3
Local TCP Port     : 646           Peer TCP Port         : 49823
Local KA Timeout   : 30            Peer KA Timeout       : 30
Mesg Sent          : 502           Mesg Recv             : 418
FECs Sent          : 124           FECs Recv             : 124
Addrs Sent         : 13            Addrs Recv            : 5
GR State           : Capable       Label Distribution    : DU
Nbr Liveness Time  : 0             Max Recovery Time     : 0
MP MBB             : Not Capable
Dynamic Capability : Not Capable
Advertise          : Address/Servi* BFD Operational Status: inService
-------------------------------------------------------------------------------
Session with Peer 4.4.4.4:0, Local 1.1.1.1:0
-------------------------------------------------------------------------------
Adjacency Type     : Targeted      State                 : Established
Up Time            : 0d 00:07:47
Max PDU Length     : 4096          KA/Hold Time Remaining: 36
Link Adjacencies   : 0             Targeted Adjacencies  : 1
```

```
Local Address    : 1.1.1.1        Peer Address       : 4.4.4.4
Local TCP Port   : 646            Peer TCP Port      : 51307
Local KA Timeout : 40             Peer KA Timeout    : 40
Mesg Sent        : 122            Mesg Recv          : 124
FECs Sent        : 36             FECs Recv          : 36
Addrs Sent       : 13            Addrs Recv         : 3
GR State         : Capable        Label Distribution : DU
Nbr Liveness Time : 0            Max Recovery Time  : 0
MP MBB              : Not Capable
Dynamic Capability: Not Capable
Advertise        : Service        BFD Operational Status: inService
===============================================================================
* indicates that the corresponding row element may have been truncated.
```

Table 25: Output fields: LDP session

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
	Link — Specifies that this adjacency is a result of a link hello
	Targeted — Specifies that this adjacency is a result of a targeted hello
State	Established — The adjacency is established
	Trying — The adjacency is not yet established
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

session-parameters

Syntax

session-parameters [*family*]

session-parameters [*peer-ip-address*]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays LDP peer information.

Parameters

family

Specifies a peer family for which to display information.

Values   ipv4

ip-address

Specifies the IP address of a targeted LDP peer for which to display information.

ipv4-address — a.b.c.d

Output

The following output is an example of LDP session parameters, and Table 26: Output fields: Session parameters describes the output fields.

Sample output

```
===============================================================================
LDP IPv4 Session Parameters
===============================================================================
-------------------------------------------------------------------------------
Peer : 10.12.12.12
-------------------------------------------------------------------------------
DOD             : Disabled         Adv Adj Addr Only  : Disabled
FEC129 Cisco Inter*: Disabled
PE-ID MAC Flush In*: Disabled
Fec Limit       : 0                Fec Limit Threshold: 90
Fec Limit Log Only : Disabled
Import Policies   : None           Export Policies    : None
IPv4 Prefix Fec Cap: Enabled
P2MP Fec Cap      : Disabled
Address Export    : None
===============================================================================
No. of IPv4 Peers: 1
===============================================================================
* indicates that the corresponding row element may have been truncated.

===============================================================================
```

Table 26: Output fields: Session parameters

Label	Description
Peer	Displays the IP address of the peer
DOD	Indicates whether Downstream on Demand (DOD) label distribution is enabled
Adv Adj Addr Only	Indicates whether the LDP router advertises only the local IPv4 or IPv6 interfaces it uses to establish hello adjacencies with an LDP peer
FEC129 Cisco Interop	Indicates whether LDP will provide translation between non-compliant FEC 129 formats of Cisco enabled — Cisco non-compliant format is used to send and interpret received label release messages

Label	Description
	disabled — Cisco non-compliant format is not used or supported. The peer address must be the peer LSR-ID address
FEC Limit	Displays the limit of the number of FECs that an LSR accepts from a peer and adds to the LDP label database, if configured

statistics

Syntax

statistics

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays LDP statistics information.

status

Syntax

status

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays LDP status information.

Output

The following output is an example of LDP status information, and Table 27: Output fields: LDP status describes the fields.

Sample output

```
*A:Dut-A# show router ldp status
===============================================================================
LDP Status for IPv4 LSR ID 10.20.1.1:0
```

```
IPv6 LSR ID ::[0]
===========================================================================
Created at : 02/18/15 20:43:15
Last Change : 02/18/15 20:43:15
Admin State : Up
IPv4 Oper State : Up IPv6 Oper State : Down
IPv4 Up Time : 0d 01:33:06 IPv6 Down Time : 0d 01:33:06
IPv4 Oper Down Rea*: n/a IPv6 Oper Down Reason: systemIpDown
IPv4 Oper Down Eve*: 0 IPv6 Oper Down Events: 0
Tunn Down Damp Time: 3 sec
Label Withdraw Del*: 0 sec Implicit Null Label : Disabled
Short. TTL Local : Enabled Short. TTL Transit : Enabled
Import Policies : None Export Policies : None
Tunl Exp Policies : None Class-Forwarding : Enabled
FRR : Disabled Mcast Upstream FRR : Disabled
MP MBB Time : 3
Aggregate Prefix : False Agg Prefix Policies : None
---------------------------------------------------------------------------
Capabilities
---------------------------------------------------------------------------
Dynamic : Enabled P2MP : Enabled
IPv4 Prefix Fec : Enabled IPv6 Prefix Fec : Enabled
Service Fec128 : Enabled Service Fec129 : Enabled
MP MBB : Enabled Overload : Enabled
===========================================================================
* indicates that the corresponding row element may have been truncated.
```

Table 27: Output fields: LDP status

Label	Description
Admin State	Up — The LDP is administratively enabled
	Down — The LDP is administratively disabled
Oper State	Up — The LDP is operationally enabled
	Down — The LDP is operationally disabled
Created at	The date and time when the LDP instance was created
Up Time	The time, in hundredths of a second, 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 because 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

Label	Description
Inactive Interfaces	The number of inactive (operationally down) interfaces associated with the LDP instance
Active Peers	The number of active LDP peers
Inactive Peers	The number of inactive LDP peers
Addr FECs Sent	The number of labels that have been sent to the peer associated with this FEC
Addr FECs Recv	The number of labels that have been received from the peer associated with this FEC
Serv FECs Sent	The number of labels that have been sent to the peer associated with this FEC
Serv FECs Recv	The number of labels that have been received from the peer associated with this FEC
Attempted Sessions	The total number of attempted sessions for this LDP instance
No Hello Err	The total number of Session Rejected or No Hello Error notification messages sent or received by this LDP instance
Param Adv Err	The total number of Session Rejected or Parameters Advertisement Mode Error notification messages sent or received by this LDP instance
Max PDU Err	The total number of Session Rejected or Parameters Max PDU Length Error notification messages sent or received by this LDP instance
Label Range Err	The total number of Session Rejected or Parameters Label Range Error notification messages sent or received by this LDP instance
Bad LDP Id Err	The number of bad LDP identifier fatal errors detected for sessions associated with this LDP instance
Bad PDU Len Err	The number of bad PDU length fatal errors detected for sessions associated with this LDP instance
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

Label	Description
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

targ-peer

Syntax

targ-peer [*ip-address*] [**detail**]

targ-peer [**detail**] *family*

targ-peer resource-failures [*family*]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays targeted LDP peer information.

Parameters

detail

Displays detailed information.

family

Specifies a peer family for which to display information.

Values   ipv4

ip-address

Specifies the IP address of a targeted LDP peer for which to display information.

resource-failures

Displays resource failure information for targeted LDP peers.

Output

The following sample output shows targeted LDP peer information, and Table 28: Output fields: LDP targeted peer describes the output fields.

Sample output

```
===============================================================================
LDP IPv4 Targeted Peers
===============================================================================
Peer                                  Adm/   Hello Hold  KA   KA    Auto
                                      Opr    Fctr  Time  Fctr Time  Created
-------------------------------------------------------------------------------
1.1.1.1                               Up/Up  3     45    4    40    yes

2.2.2.2                               Up/Up  3     45    4    40    yes

3.3.3.3                               Up/Up  3     45    4    40    yes

5.5.5.5                               Up/Up  3     45    4    40    yes

6.6.6.6                               Up/Up  3     45    4    40    yes


-------------------------------------------------------------------------------
No. of IPv4 Targeted Peers: 5
===============================================================================


===============================================================================
```

Table 28: Output fields: LDP targeted peer

Label	Description
Peer	The IP address of the peer
Adm	Up — The LDP is administratively enabled Down — The LDP is administratively disabled
Opr	Up — The LDP is operationally enabled Down — The LDP is operationally disabled
Hello Fctr	The value by which the hello timeout should be divided to give the hello time, for example, the time interval (in s), 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 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 Fctr	The value by which the keepalive timeout is divided to calculate 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 Time	The time interval (in seconds) that LDP waits before tearing down a session. If no LDP messages are exchanged during this time interval, the LDP session is torn down. Generally, the value is configured to be 3 times

Label	Description
	the keepalive time (the time interval between successive LDP keepalive messages).
Auth	Enabled — Authentication using MD5 message-based digest protocol is enabled
	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.
	True — LDP responds only when it gets a connect request from a peer and will not attempt to actively connect to its neighbors
	False — LDP actively tries to connect to its peers
Auto Created	Specifies that 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

targ-peer-template

Syntax

targ-peer-template [*peer-template*]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays information about targeted LDP peer templates.

Parameters

peer-template

Specifies the name of a peer template, up to 32 characters.

targ-peer-template-map

Syntax

targ-peer-template-map [*template-name* [**peer**]]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays information about targeted LDP peer template mapping.

Parameters

template-name

Specifies the name of a template map, up to 32 characters.

peer

Displays peer information.

tcp-session-parameters

Syntax

tcp-session-parameters [**family**]

tcp-session-parameters [**keychain** *keychain*]

tcp-session-parameters [*transport-peer-ip-address*]

Context

show>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays information about the TCP transport session of an LDP peer.

Parameters

family

Specifies a peer family for which to display information.

Values   ipv4

keychain

Specifies the name of an auth-keychain, up to 32 characters.

transport-peer-ip-address

Specifies the IP address of a TCP transport peer for which to display information.

Values

ipv4-address — a.b.c.d

3.8.2.3 Clear commands

instance

Syntax

instance

Context

clear>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command resets the LDP instance.

interface

Syntax

interface [*ip-int-name*]

Context

clear>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command clears statistics for LDP interfaces.

Parameters

ip-int-name

Specifies 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command restarts or clears statistics for LDP targeted peers.

Parameters

ip-address

Specifies the IP address of a targeted peer.

statistics

Keyword that clears only the statistics for a targeted peer.

session

Syntax

session [*ip-addr*[**:***label-space*]] [**statistics**]

Context

clear>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command clears statistics for LDP sessions.

Parameters

label-space

Specifies the label space identifier that the router is advertising on the interface.

Values   0 to 65535

statistics

Keyword that clears only the statistics for a session.

statistics

Syntax

statistics

Context

clear>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command clears LDP instance statistics.

3.8.2.4 Debug commands

The following output is an example debug LDP configuration that is described 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

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures LDP debugging.

interface

Syntax

[**no**] **interface** *interface-name*

Context

debug>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs an LDP interface.

Parameters

interface-name

Specifies the name of an existing interface.

peer

Syntax

[**no**] **peer** *ip-address*

Context

debug>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command debugs an LDP peer.

Parameters

ip-address

Specifies the IP address of the LDP peer.

event

Syntax

[**no**] **event**

Context

debug>router>ldp>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures debugging for specific LDP events.

bindings

Syntax

[**no**] **bindings**

Context

debug>router>ldp>peer>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays debugging information about addresses and label bindings learned from LDP peers for LDP bindings.

The **no** form of this command disables the debugging output.

messages

Syntax

[**no**] **messages**

Context

debug>router>ldp>peer>event

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays specific information (for example, message type, source, and destination) about LDP messages sent to and received from LDP peers.

The **no** form of this command disables debugging output for LDP messages.

packet

Syntax

packet [**detail**]

no packet

Context

debug>router>ldp>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables debugging for specific LDP packets.

The **no** form of this command disables the debugging output.

Parameters

detail

Displays detailed information.

hello

Syntax

hello [**detail**]

no hello

Context

debug>router>ldp>peer>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables debugging for LDP hello packets.

The **no** form of this command disables the debugging output.

Parameters

detail

Displays detailed information.

init

Syntax

init [**detail**]

no init

Context

debug>router>ldp>peer>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables debugging for LDP Init packets.

The **no** form of this command disables the debugging output.

Parameters

detail

Displays detailed information.

keepalive

Syntax

[**no**] **keepalive**

Context

debug>router>ldp>peer>packet

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables debugging for LDP Keepalive packets.

The **no** form of this command disables the debugging output.

label

Syntax
label [**detail**]
no label

Context
debug>router>ldp>peer>packet

Platforms
Supported on all 7210 SAS platforms as described in this document

Description
This command enables debugging for LDP Label packets.

The **no** form of this command disables the debugging output.

Parameters
detail
      Displays detailed information.

3.8.2.5 Tools commands

peer

Syntax
peer *ip-address*

Context
tools>dump>router>ldp

Platforms
Supported on all 7210 SAS platforms as described in this document

Description
This command dumps information for an LDP peer.

instance

Syntax
instance

Context

tools>dump>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps information for the LDP instance.

interface

Syntax

interface *ip-int-name*

Context

tools>dump>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps information for an LDP interface.

Parameters

ip-int-name

Specifies the name of an existing router.

memory-usage

Syntax

memory-usage

Context

tools>dump>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps memory usage information for LDP.

peer

Syntax

peer *ip-address*

Context

tools>dump>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps information for an LDP peer.

session

Syntax

session *ip-addr*[*label-space*] [**connection** | **peer** | **adjacency**]

Context

tools>dump>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps information for an LDP session.

Parameters

ip-addr[*label-space*]

Dumps information for the specified IP address and label space identifier.

Values   ip-addr[label-spa*]: ipv4-address:label-space] label-space — 0 to
65535

connection

Filters output for connection information.

peer

Filters output for peering information.

adjacency

Filters output for adjacency information.

sockets

Syntax

sockets

Context

tools>dump>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps information for all LDP sockets.

timers

Syntax

timers [**session** *ip-addr*[*label-space*]]

Context

tools>dump>router>ldp

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps information for LDP timers.

static-route

Syntax

static-route ldp-sync-status

Context

tools>dump>router

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command dumps the sync status of LDP interfaces that static-route tracks.

Parameters

ldp-sync-status

Displays the sync status of LDP interfaces that static-route tracks.

ldp-sync-exit

Syntax

ldp-sync-exit

Context

tools>perform>router>isis

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command terminates LDP synchronization and restores the actual cost of an IS-IS interface.

run-manual-spf

Syntax

run-manual-spf

Context

tools>perform>router>isis

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command runs the Shortest Path First (SPF) algorithm.

ldp-sync-exit

Syntax

ldp-sync-exit

Context

tools>perform>router>ospf

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command terminates LDP synchronization and restores the actual cost of an OSPF interface.

refresh-lsas

Syntax

refresh-lsas [*lsa-type*] [*area-id*]

Context

tools>perform>router>ospf

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command refreshes LSAs for OSPF.

run-manual-spf

Syntax

run-manual-spf [**externals-only**]

Context

tools>perform>router>ospf

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command runs the Shorted Path First (SPF) algorithm.

Parameters

externals-only

Runs external only SPF.

4 PCEP

This chapter provides information about the Path Computation Element (PCE) Communication Protocol (PCEP).

4.1 Introduction to PCEP

> **Note:**
> The 7210 SAS operates as a PCE Client (PCC) only, supporting PCC capabilities for RSVP-TE LSPs. References to PCE router operation apply to the Network Services Platform (NSP) or to a virtualized Service Router (VSR) operating in the control and management domain of the NSP, and are included for informational purposes only.

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

The Nokia WAN SDN Controller is known as the Network Services Platform (NSP). The NSP is a set of applications built on a common framework that hosts and integrates them by providing common functions. The applications are developed in a Java environment.

The NSP provides two major functions:

- programmable multi-vendor service provisioning

- network resource control, including resource management at Layer 0 (optical path), Layer 1 (ODU path), Layer 2 (MPLS tunnel), and at the IP flow level

The network discovery and control function implements a common set of standards-based southbound interfaces to the network elements for both topology discovery and tunnel and flow programming. A virtual SR OS (vSROS) applies the southbound interfaces to the network elements and the adaptation layer to the applications. The southbound interfaces include IGP and the Network Functions Manager - Packet (NFM-P) for topology discovery, PCEP for handling path computation requests and LSP state updates with the network elements, and forwarding plane programming protocols such as Openflow, BGP flowspec, and I2RS.

The above NSP functions are provided in a number of modules that can be used together or separately as shown in the following figure.

Figure 16: NSP functional modules
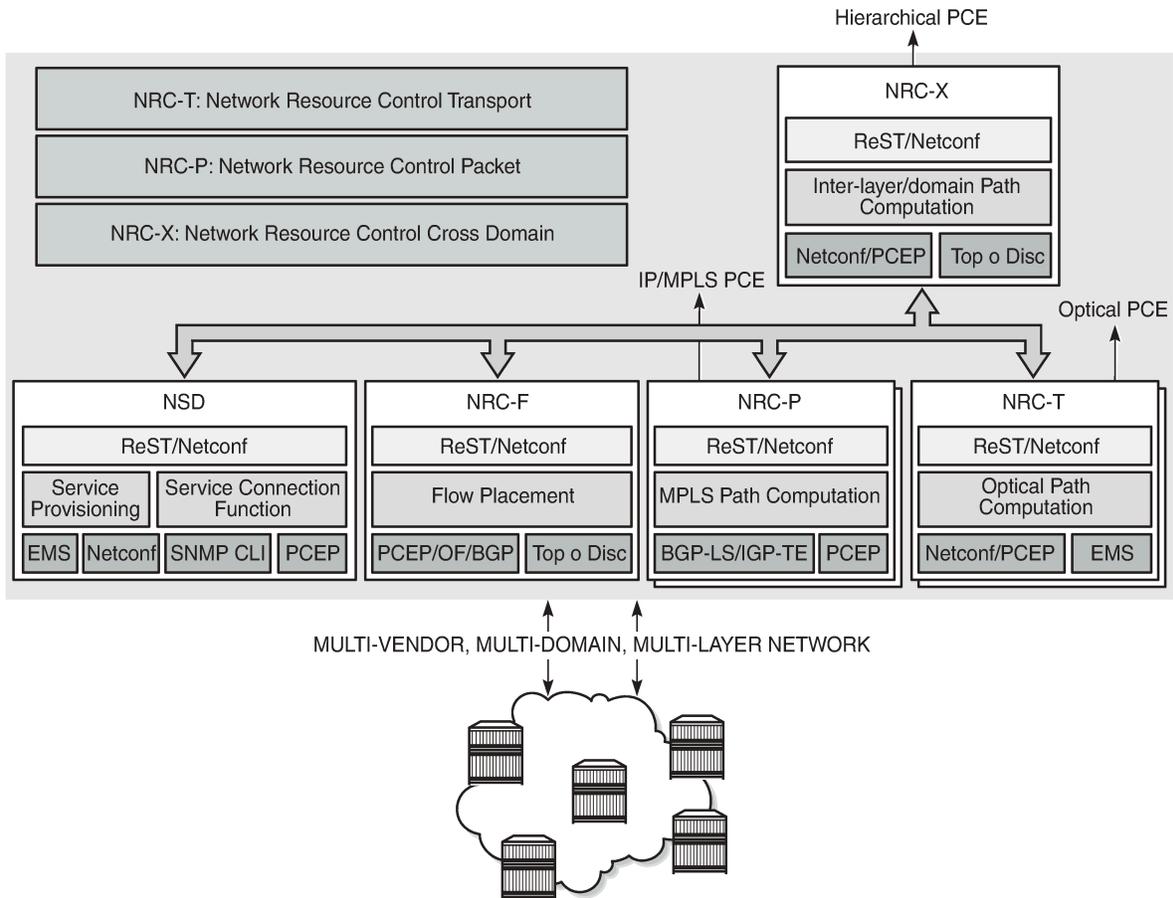
The two main components of the NSP are:

- **Network Services Director (NSD)**

  The NSD is a programmable and multi-vendor service provisioning tool that provides a single and simple API to the user and OSS. It implements a service model abstraction and adapts to each vendor-specific service model. It supports provisioning services such as E-Line, E-LAN, E-Tree, Layer 3 VPN, traffic steering, and service chaining.

- **Network Resource Controller (NRC)**

  The NRC implements separate modules for computing and managing optimal paths for optical tunnels (NRC-T) and MPLS tunnels (NRC-P), and for computing optimal routing and placement of IP flows (NRC-F). In addition, a resource controller for inter-layer IP and optical path computation and more complex inter-domain MPLS path computation is provided as part of the Network Resource Controller Cross Domain (NRC-X).

The Network Resource Controller - Packet (NRC-P) implements the stateful PCE for packet networks. The following figure shows the NRC-P architecture and its main components.

Figure 17: NRC-P architecture
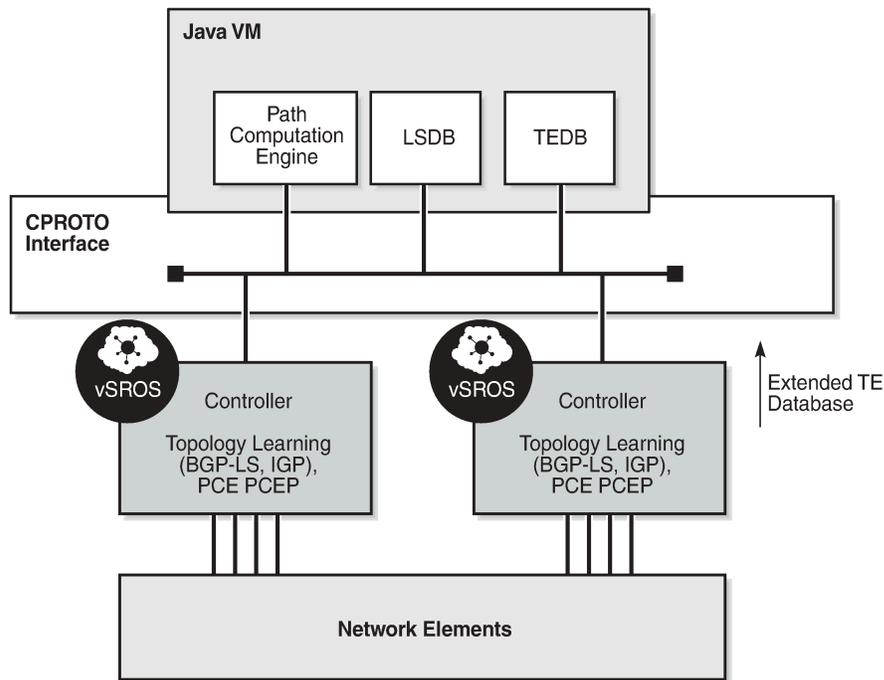
The NRC-P has the following architecture:

- a single Virtual Machine (VM) handling the Java implementation of an MPLS path computation engine, a TE graph database, and an LSP database

- a plug-in adapter with the Nokia CPROTO interface, providing reliable, TCP-based message delivery between vSROS and Java-VM. The plug-in adapter implements a compact encoding/decoding (codec) function for the message content using Google ProtoBuf. Google ProtoBuf also provides for automatic C++ (vSROS side) and Java (Java-VM side) code generation to process the exchanged message content.

- a single VM running a vSROS image that handles the functions of topology discovery of multiple IGP instances and areas via IGP and NFM-P. For larger network domains, one VM running the vSROS image can be dedicated to a specific function.

The PCE module uses PCEP to communicate with its PCCs, and communicates with other PCEs to coordinate inter-domain path computation. Each router acting as a PCC initiates a PCEP session to the PCE in its domain.

When the user enables PCE control for one or more RSVP-TE LSPs, the PCE owns the path updating and periodic reoptimization of the LSPs. In this case, the PCE acts in an active stateful role. The PCE can also act in a passive stateful role for other LSPs on the router by discovering the LSPs and taking into account their resource consumption when computing the path for the LSPs it has control ownership of.

The following is a high-level description of the PCE and PCC capabilities:

- base PCEP implementation, as defined in RFC 5440

- active and passive stateful PCE LSP update, as defined in *draft-ietf-pce-stateful-pce*

- delegation of LSP control to the PCE

- synchronization of the LSP database with network elements for PCE-controlled LSPs and network element-controlled LSPs
- support for PCC-initiated LSPs, as defined in *draft-ietf-pce-stateful-pce*
- support for LSP path diversity across different LERs using extensions to the PCE path profile, as defined in *draft-alvarez-pce-path-profiles*
- support for LSP path bidirectionality constraints using extensions to the PCE path profile, as defined in *draft-alvarez-pce-path-profiles*

4.2 Base implementation of PCE

The base implementation of the PCE uses the PCEP extensions defined in RFC 5440.

The main functions of PCEP are:

- PCEP session establishment, maintenance, and closing
- path computation requests using the PCReq message
- path computation replies using the PCRep message
- notification messages (PCNtf) by which the PCEP speaker can inform its peer about events, such as path request cancellation by the PCC or path computation cancellation by the PCE
- error messages (PCErr) by which the PCEP speaker can inform its peer about errors related to processing requests, message objects, or TLVs

The following table lists the base PCEP TLVs, objects, and messages.

Table 29: Base PCEP TLVs, objects, and messages

TLV, object, or message	Contained in object	Contained in message
OPEN Object	N/A	OPEN, PCErr
Request Parameter (RP) Object	N/A	PCReq, PCRep, PCErr, PCNtf
NO-PATH Object	N/A	PCRep
END-POINTS Object	N/A	PCReq
BANDWIDTH Object	N/A	PCReq, PCRep, PCRpt[9]
METRIC Object	N/A	PCReq, PCRep, PCRpt[9]
Explicit Route Object (ERO)	N/A	PCRep
Reported Route Object (RRO)	N/A	PCRpt[9]
LSPA Object	N/A	PCReq, PCRep, PCRpt[9]

---

[9] Nokia proprietary

TLV, object, or message	Contained in object	Contained in message
Include Route Object (IRO)	N/A	PCReq, PCRep
SVEC Object	N/A	PCReq
NOTIFICATION Object	N/A	PCNtf
PCEP-ERROR Object	N/A	PCErr
LOAD-BALANCING Object	N/A	PCReq
CLOSE Object	N/A	CLOSE

The behavior and limitations of the implementation of the objects in the preceding table are as follows:

- The PCE treats all supported objects received in a PCReq message as mandatory, regardless of whether the P-flag in the object's common header is set (mandatory object) or not (optional object).

- The PCC implementation always sets the B-flag (B=1) in the metric object containing the hop metric value, which means that a bound value must be included in PCReq message. The PCE returns the computed value in the PCRep message with flags set identically to the PCReq message.

- The PCC implementation always sets flags B=0 and C=1 in the metric object for the IGP or TE metric values in the PCReq message. This means that the request is to optimize (minimize) the metric without providing a bound value. The PCE returns the computed value in the PCRep message with flags set identically to the PCReq message.

- The IRO and LOAD-BALANCING objects are not part of the NSP PCE feature. If the PCE receives a PCReq message with one or more of these objects, it ignores them regardless of the setting of the P-flag, and processes the path computations normally.

- The LSPA, metric, and bandwidth objects are also included in the PCRpt message. The inclusion of these objects in the PCRpt message is proprietary to Nokia.

The following features are not supported on the 7210 SAS:

- PCE discovery using IS-IS, as defined in RFC 5089, and OSPF, as defined in RFC 5088, along with corresponding extensions for discovering stateful PCE, as defined in *draft-sivabalan-pce-disco-stateful*

- security of the PCEP session using MD5 or TLS between PCEP peers

- PCEP synchronization optimization as defined in *draft-ietf-pce-stateful-sync-optimizations*

- support of end-to-end secondary backup paths for an LSP. PCE standards do not currently support an LSP container with multiple paths, and the PCE treats each request as a path with a unique PLSP-ID. It is up to the router to tie the two paths together to create 1:1 protection and to request path or SRLG diversity among them when it makes the request to the PCE.

- jitter, latency, and packet loss metrics support as defined in RFC 7471 and *draft-ietf-isis-te-metric-extensions*, and their use in the PCE metric object as defined in *draft-ietf-pce-pcep-service-aware*

4.3 PCEP session establishment and maintenance

PCEP operates over TCP using destination TCP port 4189. The PCC always initiates the connection. When the user configures the PCEP local address and the peer address on the PCC, the PCC initiates a TCP connection to the PCE. When a connection is established, the PCC and PCE exchange OPEN messages, which initializes the PCEP session and exchanges the session parameters to be negotiated.

The PCC always tries to reach the remote PCE address in-band; the local address configured by the user is used for in-band sessions.

A keepalive mechanism is used as an acknowledgment of the acceptance of the session within the negotiated parameters. It is also used as a maintenance function to detect whether the PCEP peer is still alive.

The negotiated parameters include the **keepalive** timer and the **dead-timer**, and one or more PCEP capabilities such as support of stateful PCE and the LSP Path type.

The following figure shows the PCEP session initialization steps.

Figure 18: PCEP session initialization
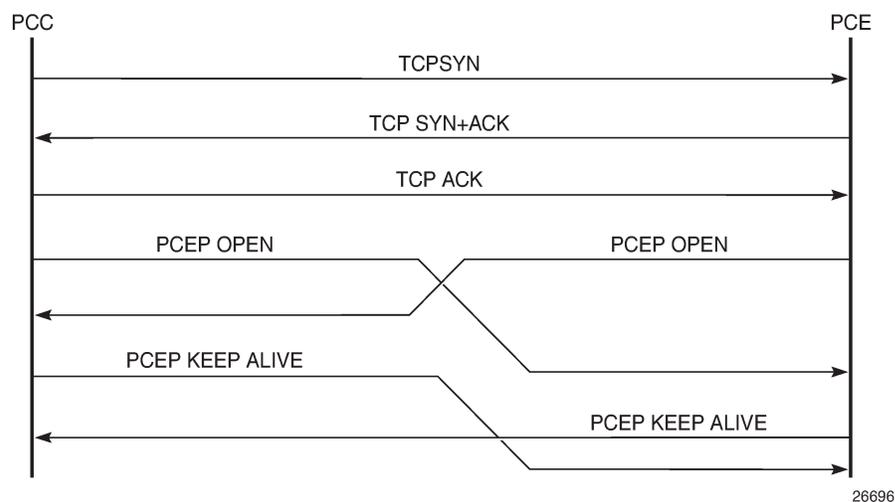
If the session to the PCE times out, the router acting as a PCC keeps the last successfully programmed path provided by the PCE until the session to the PCE is reestablished. Any subsequent change to the LSP state is synchronized at the time the session is reestablished.

When a PCEP session to a peer times out or closes, the rate at which the PCEP speaker attempts to reestablish the session is subject to an exponential back-off mechanism.

4.4 PCEP parameters

The following PCEP parameters are user-configurable on the PCC:

- **keepalive timer**

A PCEP speaker must send a keepalive message if no other PCEP message is sent to the peer at the expiry of this timer. This timer is restarted every time a PCEP message is sent or the keepalive message is sent.

The keepalive mechanism is asymmetric, which allows each peer to use a different keepalive timer value.

The range of this timer is 1 to 255 seconds and the default value is 30 seconds.

- **dead timer**

This timer tracks the amount of time a PCEP speaker waits after the receipt of the last PCEP message before declaring its peer down.

The dead timer mechanism is asymmetric, which allows each PCEP speaker to propose a different dead timer value to its peer to detect session timeouts.

The range of this timer is 1 to 255 seconds and the default value is 120 seconds.

- **maximum rate of unknown messages**

When the rate of received unrecognized or unknown messages reaches the configured limit, the PCEP speaker closes the session to the peer.

The range of this message rate is 1 to 255 messages per minute and the default value is 10 messages per minute.

- **session reestablishment and state timeout**

If the PCEP session to the PCE goes down, all delegated PCC-initiated LSPs have their state maintained in the PCC and are not timed out. The PCC continues to try reestablishing the PCEP session. When the PCEP session is reestablished, the LSP database is synchronized with the PCE database, and any LSP that went down since the last time the PCEP session was up has its path updated by the PCE.

4.4.1 PCC configuration

The following PCC parameters can be modified while the PCEP session is operational:

- **report-path-constraints**
- **unknown-message-rate**

The following PCC parameters cannot be modified while the PCEP session is operational:

- **local-address**
- **keepalive**
- **dead-timer**
- **peer** (regardless of **shutdown** state)

4.4.2 LSP initiation

An LSP that is configured on the router is referred to as a PCC-initiated LSP. An LSP that is not configured on the router, but is instead created by the PCE at the request of an application or a service instantiation, is referred to as a PCE-initiated LSP.

The 7210 SAS supports three modes of operation for PCC-initiated LSPs, which are configurable on a per-LSP basis:

- **PCC-initiated and PCC-controlled**

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

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

  – The LSP can contain strict or loose hops, or a combination of both.

  – CSPF is supported for RSVP-TE LSPs. Local path computation takes the form of hop-to-label translation for LSPs.

  – LSPs can be reported to synchronize the LSP database of a stateful PCE server using the **pce-report** option. In this case, the PCE acts in passive stateful mode for this LSP. The LSP path cannot be updated by the PCE. The control of the LSP is maintained by the PCC.

- **PCC-initiated and PCE-computed**

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

  A PCC-initiated and PCE-computed LSP has the following characteristics:

  – The **pce-computation** option must be enabled for the LSP so that the PCE can perform path computation at the request of the PCC only. The PCC retains control.

  – LSPs can be reported to synchronize the LSP database of a stateful PCE server using the **pce-report** option. In this case, the PCE acts in passive stateful mode for this LSP.

- **PCC-initiated and PCE-controlled**

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

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

  – The **pce-control** option must be enabled for the LSP so that the PCE can perform path updates following a network event without an explicit request from the PCC. The PCC delegates full control.

  – The **pce-report** option must be enabled for LSPs that cannot be delegated to the PCE. The PCE acts in active stateful mode for this LSP.

4.4.3 PCC-initiated and PCE-computed or PCE-controlled LSPs

The following is the procedure for configuring and programming a PCC-initiated LSP when control is delegated to the PCE:

1. The LSP configuration is created on the PE router via CLI or via the OSS/NSP NFM-P.

   The configuration dictates which PCE control mode is needed: active (**pce-control** and **pce-report** options enabled) or passive (**pce-computation** enabled and **pce-control** disabled).

2. PCC assigns a unique PLSP-ID to the LSP. The PLSP-ID uniquely identifies the LSP on a PCEP session and must remain constant during its lifetime. PCC on the router must keep track of the association of the PLSP-ID to the Tunnel-ID and Path-ID, and use the latter to communicate with MPLS about a specific path of the LSP. PCC also uses the SRP-ID to correlate PCRpt messages for each new path of the LSP.

3. The PE router does not validate the entered path. However, in the 7210 SAS, the PCE supports the computation of a path for an LSP with empty-hops in its path definition. While PCC will include the IRO objects in the PCReq message to PCE, the PCE will ignore them and compute the path with the other constraints except the IRO.

4. The PE router sends a PCReq message to the PCE to request a path for the LSP, and includes the LSP parameters in the METRIC object, the LSPA object, and the BANDWIDTH object. The PE router also includes the LSP object with the assigned PLSP-ID. At this point, the PCC does not delegate the control of the LSP to the PCE.

5. The PCE computes a new path, reserves the bandwidth, and returns the path in a PCRep message with the computed ERO in the ERO object. It also includes the LSP object with the unique PLSP-ID, the METRIC object with any computed metric value, and the BANDWIDTH object.

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

6. The PE router updates the CPM and the datapath with the new path.

   Up to this step, the PCC and PCE are using passive stateful PCE procedures. The next steps will synchronize the LSP database of the PCC and PCE for both PCE-computed and PCE-controlled LSPs. They will also initiate the active PCE stateful procedures for the PCE-controlled LSP only.

7. The PE router sends a PCRpt message to update the PCE with an Up state, and also sends the RRO as confirmation. It now includes the LSP object with the unique PLSP-ID. For a PCE-controlled LSP, the PE router also sets the delegation control flag to delegate control to the PCE. The state of the LSP is now synchronized between the router and the PCE.

8. Following a network event or a reoptimization, the PCE computes a new path for a PCE-controlled LSP and returns it in a PCUpd message with the new ERO. It will include the LSP object with the same unique PLSP-ID assigned by the PCC, as well as the Stateful Request Parameter (SRP) object with a unique SRP-ID-number to track error and state messages specific to this new path.

9. The PE router updates the CPM and the datapath with the new path.

10. The PE router sends a PCRpt message to inform the PCE that the older path is deleted. It includes the unique PLSP-ID value in the LSP object and the R (Remove) bit set.

11. The PE router sends a new PCRpt message to update PCE with an Up state, and also sends the RRO to confirm the new path. The state of the LSP is now synchronized between the router and the PCE.

12. If PCE owns the delegation of the LSP and is making a path update, MPLS will initiate the LSP and update the operational value of the changed parameters while the configured administrative values will not change. Both the administrative and operational values are shown in the details of the LSP path in MPLS.

13. If the user makes any configuration change to the PCE-computed or PCE-controlled LSP, MPLS requests that the PCC first revoke delegation in a PCRpt message (PCE-controlled only), and then MPLS and PCC follow the above steps to convey the changed constraint to PCE which will result in the programming of a new path into the datapath, the synchronization of the PCC and PCE LSP databases, and the return of delegation to PCE.

The preceding procedure is followed when the user performs a **no shutdown** command on a PCE-controlled or PCE-computed LSP. The starting point is an LSP which is administratively down with no active path. For an LSP with an active path, the following items may apply:

- If the user has enabled the **pce-computation** option on a PCC-controlled LSP with an active path, no action is performed until the next time the router needs a path for the LSP following a network event of a LSP parameter change. At that point, the prior procedure is followed.

- If the user has enabled the **pce-control** option on a PCC-controlled or PCE-computed LSP with an active path, the PCC will issue a PCRpt message to the PCE with an Up state, as well as the RRO of the active path. It will set the delegation control flag to delegate control to the PCE. The PCE will keep the active path of the LSP and make no updates to it until the next network event or reoptimization. At that point, the prior procedure is followed.

4.5 PCEP support for RSVP-TE LSPs

This section describes the support of PCC-initiated RSVP-TE LSPs. PCEP support of an RSVP-TE LSP is described in LSP initiation with the following differences:

- each primary and secondary path is assigned its own unique path LSP-ID (PLSP-ID)

- the PCC indicates to the PCE the state of each path (either up or down) and which path is currently active and carrying traffic (active state)

4.5.1 RSVP-TE LSP configuration for a PCC router

The following MPLS-level and LSP-level CLI commands are used to configure RSVP-TE LSPs in a router acting as a PCEP Client (PCC).

- **config>router>mpls>**

  pce-report rsvp-te {enable | disable}

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

  path-profile *profile-id* [**path-group** *group-id*]

  pce-computation

  pce-control

  pce-report {enable | disable | inherit}

The **cspf** option must be enabled on the LSP before the **pce-computation** or **pce-control** options can be enabled. An attempt to disable the **cspf** option on an RSVP-TE LSP that has the **pce-computation** or **pce-control** options enabled will be rejected.

If the LSP has disabled PCE reporting, either because of inheritance from the MPLS-level configuration or because of LSP-level configuration, enabling the **pce-control** option for the LSP has no effect. To help troubleshoot this situation, the output of the **show** commands for the LSP displays the operational values of both the **pce-report** and **pce-control** options.

> **Note:**
> The PCE function implemented in the NSP and referred to as the NRC-P, supports only Shared Explicit (SE) style bandwidth management for RSVP-TE LSPs. The PCEP does not support the ability of the PCC to convey this value to the PCE. Therefore, whether the LSP configuration

option **rsvp-resv-style** is set to **se** or **ff**, the PCE will always use the SE style in the CSPF computation of the path for a PCE-computed or PCE-controlled RSVP-TE LSP.

A manual bypass LSP does not support any of the PCE-related commands. Reporting a bypass LSP to the PCE is not required because the bypass LSP does not book bandwidth.

All other MPLS, LSP, and path-level commands are supported, with the exception of the following commands:

- **least-fill**
- **srlg** (on secondary standby path)

For more information about RSVP-TE PCC instantiation modes, see LSP initiation.

4.5.2 Behavior of the LSP path update

When the **pce-control** option is enabled, the PCC delegates control of the RSVP-TE LSP to the PCE.

The NRC-P sends a path update using the PCUpd message in the following cases:

- **a failure event that impacts a link or a node in the path of a PCE-controlled LSP**

  The operation is performed by the PCC as a Make-Before-Break (MBB) if the LSP remained in the up state because of protection provided by FRR or a secondary path. If the LSP went down, the update brings it into the up state. A PCRpt message is sent by the PCC for each change to the state of the LSP during this process. See Behavior of LSP MBB for more information.

- **a topology change that impacts a link in the path of a PCE-controlled LSP**

  This topology change can be a change to the IGP metric, the TE metric, admin-group, or SRLG membership of an interface. This update is performed as an MBB by the PCC.

- **the user has performed a manual resignal of a PCE-controlled RSVP-TE LSP path from the NRC-P**

  This update is performed as an MBB by the PCC.

- **the user has performed a Global Concurrent Optimization (GCO) on a set of PCE-controlled RSVP-TE LSPs from the NRC-P**

  This update is performed as an MBB by the PCC.

The procedures for the path update are described in LSP initiation. However, for an RSVP-TE LSP, the PCUpd message from the PCE contains the interface IP address or system IP address in the computed ERO. The PCC signals the path using the ERO returned by the PCE and, if successful, programs the datapath, then sends the PCRpt message with the resulting RRO and hop labels provided by RSVP-TE signaling.

If the signaling of the ERO fails, the ingress LER returns a PCErr message to the PCE with the LSP Error code field of the LSP-ERROR-CODE TLV set to a value of 8 (RSVP signaling error).

If the **no adaptive** option is set for the RSVP-TE LSP, the ingress LER cannot perform an MBB for the LSP. A PCUpd message received from the PCE is then failed by the ingress LER, which returns a PCErr message to the PCE with the LSP Error code field of the LSP-ERROR-CODE TLV set to a value of 8 (RSVP signaling error).

4.5.2.1 Path update with empty ERO

When the NRC-P reoptimizes the path of a PCE-controlled RSVP-TE LSP, it is possible that a path that satisfies the constraints of the LSP no longer exists. In this case, the NRC-P sends a PCUpd message with an empty ERO, which forces the PCC to bring down the path of the RSVP-TE LSP.

The NRC-P sends a PCUpd message with an empty ERO if any of the following cases are true:

- The requested bandwidth is the same as the current bandwidth, which avoids bringing down the path because of a resignal during an MBB transition.

- Local protection is not currently in use, which avoids bringing down a path that activated an FRR backup path. The LSP can remain on the FRR backup path until a new primary path can be found by the NRC-P.

- The links of the current path are all operationally up, which allows the NRC-P to ensure that the RSVP control plane will report the path down when a link is down and not prematurely bring the path down with an empty ERO.

4.5.3 Behavior of LSP MBB

In addition to the MBB support when the PCC receives a path update, as described in Behavior of the LSP path update, an RSVP-TE LSP supports the MBB procedure for any parameter configuration change, including the PCEP-related commands when they result in a change to the path of the LSP.

If the user adds or modifies the **path-profile** command for an RSVP-TE LSP, a configuration change MBB is only performed if the **pce-computation**, **pce-report**, or **pce-control** options are enabled on the LSP. Otherwise, no action occurs. When **pce-computation**, **pce-report**, or **pce-control** are enabled on the LSP, the path update MBB (**tools>perform>router>mpls>update-path**) fails, resulting in no operation.

MBB is also supported for the manual resignal MBB type.

If the LSP goes into an MBB state at the ingress LER, the behavior is dependent on the operating mode of the LSP.

4.5.3.1 PCC-controlled LSPs

All MBB types are supported for PCC-controlled LSPs. The LSP MBB actions for a PCC-controlled LSP (**pce-computation** and **pce-control** disabled) are as follows:

1. MPLS submits a path request, including the updated path constraints, to the local CSPF.

2. If the local CSPF returns a path, the PCC signals the LSP with the RSVP control plane and moves traffic to the new MBB path. If **pce-report** is enabled for this LSP, the PCC sends a PCRpt message with the delegation bit clear to retain control and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the new MBB path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear, which indicates the operational values of these parameters. Unless the user disables the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, and bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.

3. If the CSPF returns no path or the RSVP-TE signaling of the returned path fails, MPLS puts the LSP into retry mode and sends a request to the local CSPF every *retry-timer* seconds and up to the value of *retry-count*.

4. When **pce-report** is enabled for the LSP and the FRR global revertive MBB is triggered following a bypass LSP activation by a PLR in the network, the PCC issues an updated PCRpt message with the new RRO reflecting the PLR and RRO hops. The PCE releases the bandwidth on the links that are no longer used by the LSP path.

4.5.3.2 PCE-computed LSPs

All MBB types are supported for PCE-computed LSPs. The LSP MBB actions for a PCE-computed LSP (**pce-computation** enabled and **pce-control** disabled) are as follows:

1. The PCC issues a PCReq for the same PLSP-ID and includes the updated constraints in the metric, LSPA, and bandwidth objects.

   • If the PCE successfully finds a path, it replies with a PCRep message with the ERO.

   • If the PCE does not find a path, it replies with a PCRep message containing the No-Path object.

2. If the PCE returns a path, the PCC signals the LSP with the RSVP control plane and moves traffic to the new MBB path. If **pce-report** is enabled for this LSP, the PCC sends a PCRpt message with the delegation D-bit clear to retain control and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the new MBB path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear, which indicates the operational values of these parameters. Unless the user disables the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, and bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.

3. If the PCE returns no path or the RSVP-TE signaling of the returned path fails, MPLS puts the LSP into retry mode and sends a request to PCE every *retry-timer* seconds and up to the value of *retry-count*.

4. When the **pce-report** is enabled for the LSP and the FRR global revertive MBB is triggered following a bypass LSP activation by a PLR in the network, the PCC issues an updated PCRpt message with the new RRO reflecting the PLR and RRO hops. The PCE releases the bandwidth on the links that are no longer used by the LSP path.

5. If the user changes the RSVP-TE LSP configuration from **pce-computation** to **no pce-computation**, MBB procedures are not supported. In this case, the LSP path is torn down and is put into retry mode to compute a new path from the local CSPF on the router to signal the LSP.

4.5.3.3 PCE-controlled LSPs

The LSP MBB actions for a PCE-controlled LSP (**pce-control** enabled) are as follows:

> **Note:**
> Items 1 through 5 of the following procedure apply to the config change, and manual resignal MBB types. The delayed retry MBB type used with the SRLG on secondary standby LSP feature is not supported with a PCE-controlled LSP. See Behavior of secondary LSP paths for information about the SRLG on secondary standby LSP feature.

1. The PCC temporarily removes delegation by sending a PCRpt message for the corresponding path LSP-ID (PLSP-ID) with the delegation D-bit clear.

2. For an LSP with **pce-computation** disabled, MPLS submits a path request to the local CSPF, which includes the updated path constraints.

3. For an LSP with **pce-computation** enabled, the PCC issues a PCReq for the same PLSP-ID and includes the updated constraints in the metric, LSPA, or bandwidth objects:

   • If the PCE successfully finds a path, it replies with a PCRep message with the ERO.

   • If the PCE does not find a path, it replies with a PCRep message containing the No-Path object.

4. If the local CSPF or the PCE returns a path, the PCC performs the following actions:

   • The PCC signals the LSP with the RSVP control plane and moves traffic to the new MBB path. It then sends a PCRpt message with the delegation D-bit set to return delegation and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the new MBB path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear, which indicates the operational values of these parameters. Unless the user disabled the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, or bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.

   • The PCC sends a PathTear message to delete the state of the older path in the network. The PCC then sends a PCRpt message to the PCE with the older path LSP (PLSP-ID) and the remove R-bit set to also have the PCE remove the state of that LSP from its database.

5. If the local CSPF or the PCE returns no path or the RSVP-TE signaling of the returned path fails, the router makes no further requests. That is, there is no retry for the MBB:

   • The PCC sends a PCErr message to the PCE with the LSP Error code field of the LSP-ERROR-CODE TLV set to a value of 8 (RSVP signaling error) if the MBB failed because of a RSVP-TE signaling error.

   • The PCC sends a PCRpt message with the delegation D-bit set to return delegation and containing the RRO and LSP objects, with the LSP-IDENTIFIERS TLV containing the LSP-ID of the currently active path. The message includes the metric, LSPA, and bandwidth objects where the P-flag is clear to indicate the operational values of these parameters. Unless the user disabled the **report-path-constraints** option under the **pcc** context, the PCC also includes a second set of metric, LSPA, and bandwidth objects with the P-flag set to convey to the PCE the constraints of the path.

6. The ingress LER takes no action in the case of a network event triggered MBB, such as FRR global revertive or TE graceful shutdown:

   • The ingress PE keeps the information as required and sets the state of MBB to one of the FRR global revertive or TE graceful shutdown MBB values but does not perform the MBB action.

   • The NRC-P computes a new path for the global revertive MBB because of a failure event. This computation uses the PCUpd message to update the path using the MBB procedure described in Behavior of the LSP path update. The activation of a bypass LSP by a point of local repair (PLR) in the network causes the PCC to issue an updated PCRpt message with the new RRO reflecting the PLR and RRO hops. The PCE will release the bandwidth on the links that are no longer used by the LSP path.

   • The NRC-P computes a new path for the TE graceful shutdown MBB if the RSVP-TE is using the TE metric, because the TE metric of the link in TE graceful shutdown is set to infinity. This computation uses the PCUpd message to update the path using the MBB procedure described in Behavior of the LSP path update.

   • The NRC-P does not act on the TE graceful shutdown MBB if the RSVP-TE is using the IGP metric; however, the user can perform a manual resignal of the LSP path from the NRC-P to force a new path computation, which accounts for the newly available bandwidth on the link that caused the MBB event. This computation uses the PCUpd message to update the path using the MBB procedure described in Behavior of the LSP path update.

- The user can perform a manual resignal of the LSP path from the ingress LER, which forces an MBB for the path as per the remove-delegation/MBB/return-delegation procedures described in this section.

- If the user performs **no pce-control** while the LSP still has the state for any of the network event triggered MBBs, the MBB is performed immediately by the PCC as described in the procedures in PCE-computed LSPs for a PCE-computed LSP and as described in the procedures in PCC-controlled LSPs for a PCC-controlled LSP.

7. The timer-based manual resignal MBB behaves like the TE graceful shutdown MBB. The user can perform a manual resignal of the LSP path from the ingress LER or from the PCE.

8. The path update MBB (**tools>perform>router>mpls>update-path**) fails, which results in no operation. This is true in all cases when the RSVP-TE LSP enables the **pce-report** option.

4.5.4 Behavior of secondary LSP paths

Each of the primary, secondary standby, and secondary non-standby paths of the same LSP must use a separate path LSP-ID (PLSP-ID). The PCE function of the NSP, the NRC-P, checks the LSP-IDENTIFIERS TLV in the LSP object and can identify which PLSP-IDs are associated with the same LSP or the same RSVP-TE session. The parameters are the IPv4 Tunnel Sender Address, the Tunnel ID, the Extended Tunnel ID, and the IPv4 Tunnel Endpoint Address. This approach allows the use of all the PCEP procedures for all three types of LSP paths.

The PCC indicates to the PCE the following states for the path in the LSP object: down, up (signaled but not carrying traffic), or active (signaled and carrying traffic).

The PCE tracks active paths and displays them in the NSP GUI. It also provides only the tunnel ID of an active PLSP-ID to a destination prefix when a request is made by a service or a steering application.

The PCE recomputes the paths of all PLSP-IDs that are affected by a network event. The user can select each path separately on the NSP GUI and trigger a manual resignal of one or more paths of the RSVP-TE LSP.

> **Note:**
> Enabling the **srlg** option on a secondary standby path results in no operation. The NRC-P supports link and SRLG disjointedness using the PCE path profile. The user can apply the PCE path profile to the primary and secondary paths of the same LSP. See PCE path profile support for more information.

4.5.5 PCE path profile support

The PCE path profile ID and path group ID are configured at the LSP level (**config>router>mpls>lsp>path-profile**).

The NRC-P can enforce path disjointedness and bidirectionality among a pair of forward and a pair of reverse LSP paths. Both pairs of LSP paths must use a unique path group ID along with the same path profile ID.

If the user wants to apply path disjointedness and path bidirectionality constraints to RSVP-TE LSP paths, it is important to follow the following guidelines. The user can configure the following sets of LSP paths:

- a set consisting of a pair of forward RSVP-TE LSPs and a pair of reverse RSVP-TE LSPs, each with a single primary or secondary path. The pair of forward LSPs can originate and terminate on different

routers. The pair of reverse LSPs must mirror the forward pair. In this case, the path profile ID and the path group ID configured for each LSP must match. Because each LSP has a single path, the bidirectionality constraint applies automatically to the forward and reverse LSPs, which share the same originating node and the same terminating routers.

- a pair consisting of a forward RSVP-TE LSP and a reverse RSVP-TE LSP, each with a primary path and a single secondary path, or each with two secondary paths. Because the two paths of each LSP inherit the same LSP level path profile ID and path group ID configuration, the NRC-P path computation algorithm cannot guarantee that the primary paths in both directions meet the bidirectionality constraint. That is, it is possible that the primary path for the forward LSP shares the same links as the secondary path of the reverse LSP and the other way around.

4.6 LSP path diversity and bidirectionality constraints

The PCE path profile defined in *draft-alvarez-pce-path-profiles* is used to request path diversity or a disjoint for two or more LSPs originating on the same or different PE routers. It is also used to request that paths of two unidirectional LSPs between the same two routers use the same TE links. This is referred to as the bidirectionality constraint.

Path profiles are defined directly on the NRC-P Policy Manager with a number of LSP path constraints, which are metrics with upper bounds specified, and with an objective, which are metrics optimized with no bounds specified. The NRC-P Policy Manager allows the following PCE constraints to be configured within each PCE path profile:

- path diversity, node-disjoint, link-disjoint

- path bidirectionality, symmetric reverse route preferred, symmetric reverse route required

- maximum path IGP metric (cost)

- maximum path TE metric

- maximum hop count

The user can also specify the PCE objective used to optimize the path of the LSP in the PCE path profile, one of:

- IGP metric (cost)

- TE metric

- hops (span)

The CSPF algorithm will optimize the objective. If a constraint is provided for the same metric, the CSPF algorithm ensures that the selected path achieves a lower or equal value to the bound value specified in the constraint.

For hop-count metrics, if a constraint is sent in a metric object and is also specified in a PCE profile referenced by the LSP, the constraint in the metric object is used.

For IGP and TE metrics, if an objective is sent in a metric object and is also specified in a PCE profile referenced by the LSP, the objective in the path profile is used.

The constraints in the bandwidth object and the LSPA object, specifically the include and exclude admin-group constraints and setup and hold priorities, are not supported in the PCE profile.

To indicate the path diversity and bidirectionality constraints to the PCE, the user must configure the profile ID and path group ID of the PCE path to which the LSP belongs. The path group ID does not need to be

defined in the PCE as part of the path profile configuration and identifies implicitly the set of paths that must have the path diversity constraint applied.

The user can only associate a single path group ID with a specific PCE path profile ID for an LSP. However, the same path group ID can be associated with multiple PCE profile IDs for the same LSP.

The path profiles are inferred using the path ID in the path request by the PCC. When the PE router acting as a PCC wants to request path diversity from a set of other LSPs belonging to a path group ID value, it adds a new PATH-PROFILE object in the PCReq message. The object contains the path profile ID and the path group ID as an extended ID field. In other words, the diversity metric is carried in an opaque way from the PCC to the PCE.

The bidirectionality constraint operates the same way as the diversity constraint. The user can configure a PCE profile with both the path diversity and bidirectionality constraints. The PCE will check if there is an LSP in the reverse direction that belongs to the same path group ID as an originating LSP it is computing the path for, and will enforce the constraint.

To ensure that the PCE is aware of the path diversity and bidirectionality constraints for an LSP that is delegated but for which there is no prior state in the NRC-P LSP database, the PATH-PROFILE object is included in the PCRpt message with the P-flag set in the common header to indicate that the object must be processed. This is proprietary to Nokia.

The following table lists the new objects and TLVs introduced in the PCE path profile.

Table 30: PCEP path profile extension objects and TLVs

TLV, object, or message	Contained in object	Contained in message
PATH-PROFILE-CAPABILITY TLV	OPEN	OPEN
PATH-PROFILE Object	N/A	PCReq, PCRpt[10]

A PATH-PROFILE object can contain multiple TLVs containing each profile ID and extend ID, and should be processed properly. If multiple PATH-PROFILE objects are received, the first object is interpreted and the others are ignored. The PCC and the PCE support all PCEP capability TLVs defined in this document and will always advertise them. If the OPEN object received from a PCEP speaker does not contain one or more of the capabilities, the PCE or PCC will not use them during that PCEP session.

4.7 PCEP configuration command reference

4.7.1 Command hierarchies

- PCEP commands
- Show commands
- Tools commands

---

[10] Nokia proprietary

4.7.1.1 PCEP commands

```
config
    - router
        - [no] pcep
            - [no] pcc
                - dead-timer seconds
                - no dead-timer
                - keepalive seconds
                - no keepalive
                - local-address ip-address
                - no local-address
                - [no] peer ip-address
                    - [no] shutdown
                - [no] report-path-constraints
                - [no] shutdown
                - unknown-message-rate msg/min
                - no unknown-message-rate
```

4.7.1.2 Show commands

```
show
    - router
        - pcep
            - pcc
                - detail
                - lsp-db [lsp-type lsp_type] [delegated-pce ip-address]
                - lsp-db [lsp-type lsp_type] from ip-address [delegated-pce ip-address]
                - lsp-db [lsp-type lsp_type] lsp lsp-name [delegated-pce ip-address]
                - lsp-db [lsp-type lsp_type] to ip-address [tunnel-id [tunnel-id]]
                - lsp-db [lsp-type lsp_type] tunnel-id [tunnel-id]
                - path-request [lsp-type {rsvp-p2p}] [dest ip-address] [detail]
                - peer [ip-address] [detail]
                - status
```

4.7.1.3 Tools commands

```
tools
    - dump
        - router
            - pcep
                - pcc lsp [plsp-id plsp-id]
                - pcc lsp lsp-type lsp-type [tunnel-id tunnel-id]
```

4.7.2 Command descriptions

- PCEP commands
- Show commands
- Tools commands

4.7.2.1 PCEP commands

pcep

Syntax

[no] pcep

Context

config>router

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the Path Computation Element Communication Protocol (PCEP) and enters the context to configure PCEP parameters.

The **no** form of this command disables PCEP.

pcc

Syntax

[no] pcc

Context

config>router>pcep

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

Commands in this context configure PCC parameters.

The **no** form of this command disables PCC.

dead-timer

Syntax

dead-timer *seconds*

no dead-timer

Context

config>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the PCEP session **dead-timer** value, which is the amount of time a PCEP speaker waits after the receipt of the last PCEP message before declaring its peer down.

The dead-timer mechanism is asymmetric, which means that each PCEP speaker can propose a different dead-timer value to its peer to use to detect session timeout.

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

Default

120

Parameters

seconds

Specifies the dead timer value, in seconds.

Values 1 to 255

keepalive

Syntax

keepalive *seconds*

no keepalive

Context

config>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the PCEP session **keepalive** value. A PCEP speaker must send a keepalive message if no other PCEP message is sent to the peer at the expiry of this timer. This timer is restarted every time a PCEP message or keepalive message is sent.

The keepalive mechanism is asymmetric, which means that each peer can use a different keepalive timer value at its end.

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

Default

30

Parameters

seconds

Specifies the keepalive value, in seconds.

Values   1 to 255

local-address

Syntax

local-address *ip-address*

no local-address

Context

config>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the local address of the PCEP speaker.

The PCEP protocol operates over TCP using destination TCP port 4189. The PCE client (PCC) always initiates the connection. When the user configures the PCEP local address and the peer address on the PCC, the PCC initiates a TCP connection to the PCE. When the connection is established, the PCC and PCE exchange OPEN messages, which initializes the PCEP session and exchanges the session parameters to be negotiated.

The PCC checks if the remote PCE address is reachable in-band. Out-of-band sessions are not supported.

The **no** form of this command removes the configured local address of the PCEP speaker.

Parameters

ip-address

Specifies the IP address of the PCEP speaker to be used for in-band sessions.

peer

Syntax

[**no**] **peer** *ip-address*

Context

config>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the IP address of a peer PCEP speaker. The address is used as the destination address in the PCEP session messages to a PCEP peer.

The **no** form of this command removes the specified peer PCEP speaker.

Parameters

ip-address

Specifies the IP address of the PCEP peer to be used as the destination address in the PCEP session.

Values   a.b.c.d

report-path-constraints

Syntax

[no] **report-path-constraints**

Context

config>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command enables the inclusion of LSP path constraints in the PCE report messages sent from the PCC to a PCE.

For the PCE to know about the original constraints for an LSP that is delegated but for which there is no prior state in its LSP database (for example, if no PCReq message was sent for the same PLSP-ID), the following proprietary behavior applies:

- The PCC appends a duplicate of each of the LSPA, metric, and bandwidth objects in the PCRpt message. The only difference between two objects of the same type is that the P-flag is set in the common header of the duplicate object to indicate that it is a mandatory object for processing by the PCE.

- The value of the metric or bandwidth in the duplicate object contains the original constraint value, while the first object contains the operational value. This is applicable to hop metrics in the metric and bandwidth objects only. The 7210 SAS PCC does not support configuring a boundary on the path computation IGP or TE metrics.

- The path computation on the PCE must use the first set of objects when updating a path if the PCRpt message contained a single set. If the PCRpt message contained a duplicate set, PCE path computation must use the constraints in the duplicate set.

The **no** form of this command disables the preceding behavior in case of interoperability issues with third-party PCE implementations.

Default

report-path-constraints

shutdown

Syntax

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

Context

config>router>pcep>pcc

config>router>pcep>pcc>peer

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command administratively disables the PCC process.

The following PCC parameters can be modified without shutting down the PCEP session:

- **report-path-constraints**
- **unknown-message-rate**

The following PCC parameters can only be modified when the PCEP session is shut down:

- **local-address**
- **keepalive**
- **dead-timer**
- **peer**

The **no** form of this command administratively enables the PCC process.

Default

shutdown

unknown-message-rate

Syntax

unknown-message-rate *msg/min*

no unknown-message-rate

Context

config>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command configures the maximum rate of unknown messages that can be received during a PCEP session.

When the rate of received unrecognized or unknown messages reaches the configured limit, the PCEP speaker closes the session to the peer.

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

Default

10

Parameters

msg/min

Specifies the rate of unknown messages, in messages per minute.

Values   1 to 255

4.7.2.2 Show commands

Note:
The following command outputs are examples only; actual displays may differ depending on supported functionality and user configuration.

detail

Syntax

detail

Context

show>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays PCEP PCC detailed information.

Output

The following output is an example of PCEP PCC detailed information, and Table 31: Output fields: PCEP PCC describes the output fields.

Sample output

```
*A:ZBG>show>router>pcep# pcc detail
===============================================================================
Path Computation Element Protocol (PCEP) Path Computation Client (PCC) Info
===============================================================================
Admin Status         : Down           Oper Status        : Down
Unknown Msg Limit     : 10 msg/min
Keepalive Interval    : 50 seconds     DeadTimer Interval  : 150 seconds
Capabilities List     : stateful-delegate stateful-pce rsvp-path
Address              : 10.10.10.10
Report Path Constraints: True
Open Wait Timer       : 60 seconds     Keep Wait Timer     : 60 seconds
Sync Timer            : 60 seconds     Request Timer       : 120 seconds
Connection Timer      : 60 seconds     Allow Negotiations  : False
Max Sessions          : 1              Max Unknown Req     : 1000
===============================================================================
*A:ZBG>show>router>pcep#
```

Table 31: Output fields: PCEP PCC

Label	Description
Admin Status	The administrative status of the PCC
Oper Status	The operational status of the PCC
Unknown Msg Limit	The maximum rate of unknown messages that can be received on a PCEP session
Keepalive Interval	The specified keepalive interval for the PCEP session
DeadTimer Interval	The specified dead time interval for the PCEP session
Capabilities List	The capabilities list for the PCEP session
Address	The local IP address of the PCEP speaker
Report Path Constraints	Indicates whether to include LSP path constraints in the PCE report messages sent from the PCC to a PCE
Open Wait Timer	The value of the open wait timer for the PCEP session
Keep Wait Timer	The value of the keep wait timer for the PCEP session
Sync Timer	The value of the synchronization timer for the PCEP session
Request Timer	The value of the request timer for the PCEP session
Connection Timer	The value of the keep wait timer for the PCEP session

Label	Description
Allow Negotiations	Indicates where negotiations between PCEP PCC and PCE are allowed
Max Sessions	The maximum number of PCEP sessions on the router
Max Unknown Req	The maximum number of unknown requests for PCEP sessions on the router

lsp-db

Syntax

lsp-db [**lsp-type** *lsp_type*] [**delegated-pce** *ip-address*]

lsp-db [**lsp-type** *lsp_type*] **from** *ip-address* [**delegated-pce** *ip-address*]

lsp-db [**lsp-type** *lsp_type*] **lsp** *lsp-name* [**delegated-pce** *ip-address*]

lsp-db [**lsp-type** *lsp_type*] **to** *ip-address* [**tunnel-id** [*tunnel-id*]]

lsp-db [**lsp-type** *lsp_type*] **tunnel-id** [*tunnel-id*]

Context

show>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays PCEP PCC LSP information.

Parameters

lsp_type

Specifies the type of LSP to display. The only available option is RSVP-TE point-to-point LSPs (rsvp-p2p).

tunnel-id

Specifies a tunnel ID.

Values   1 to 65535

ip-address

Specifies an IPv4 address.

Values   a.b.c.d

Output

The following output is an example of PCEP PCC LSP information, and Table 32: Output fields: PCEP PCC LSP describes the output fields.

Sample output

```
*A:ZBG# show router pcep pcc lsp-db
===============================================================================
PCEP Path Computation Client (PCC) LSP Update Info
===============================================================================
PCEP-specific LSP ID: 1
LSP ID             : 21504          LSP Type            : rsvp-p2p
Tunnel ID          : 1              Extended Tunnel Id  : 10.20.1.3
LSP Name           : test_lsp::fully_loose
Source Address     : 10.20.1.3      Destination Address : 10.20.1.1
LSP Delegated      : True           Delegate PCE Address: 10.120.210.36
Oper Status        : active
-------------------------------------------------------------------------
PCEP-specific LSP ID: 2
LSP ID             : 21510          LSP Type            : rsvp-p2p
Tunnel ID          : 1              Extended Tunnel Id  : 10.20.1.3
LSP Name           : test_lsp::stdby_fully_loose_2
Source Address     : 10.20.1.3      Destination Address : 10.20.1.1
LSP Delegated      : True           Delegate PCE Address: 10.120.210.36
Oper Status        : up
===============================================================================
*A:ZBG#
```

Table 32: Output fields: PCEP PCC LSP

Label	Description
PCEP-specific LSP ID	The PCEP-specific LSP identifier
LSP ID	The LSP identifier
Tunnel ID	The tunnel identifier for the LSP
LSP Name	The configured LSP name
Source Address	The source IP address of the LSP
LSP Delegated	The delegation status of the LSP
Oper Status	The operational status of the LSP
LSP Type	The type of the LSP
Extended Tunnel Id	The expanded tunnel identifier for the LSP
Destination Address	The destination IP address of the LSP
Delegate PCE Address	The IP address of the delegate PCE router

path-request

Syntax

path-request [**lsp-type** {**rsvp-p2p**}] [**dest** *ip-address*] [**detail**]

Context

show>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays PCEP PCC path request information.

Parameters

lsp-type

Specifies the type of LSP to display. The only available option is RSVP-TE point-to-point LSPs.

ip-address

Specifies the destination IPv4 address to display.

Values   a.b.c.d

detail

Displays detailed path request information.

Output

The following output is an example of PCEP PCC path request information, and Table 33: Output fields: PCEP PCC path request describes the output fields.

Sample output

```
*A:ZBG# show router pcep pcc path-request
===============================================================================
PCEP Path Computation Client (PCC) Path Computation Request (PCReq) Info
===============================================================================
Request ID        : 4              Message State     : sent-for-compute
Tunnel ID         : 2              Extended Tunnel Id : 10.20.1.3
LSP ID            : 62468          LSP Type          : rsvp-p2p
LSP Name          : test_lsp::fully_loose
Source Address    : 10.20.1.3      Destination Address: 10.20.1.1
SVEC Id           : 4              LSP Bandwidth     : 0
===============================================================================
*A:ZBG#
```

Table 33: Output fields: PCEP PCC path request

Label	Description
Request ID	The PCEP PCC path request identifier
Tunnel ID	The tunnel identifier for the LSP
LSP ID	The LSP identifier
LSP Name	The configured LSP name
Source Address	The source IP address of the LSP
SVEC Id	The synchronization vector identifier
Message State	The current state of the request
Extended Tunnel Id	The expanded tunnel identifier for the LSP
LSP Type	The type of the LSP
Destination Address	The destination IP address of the LSP
LSP Bandwidth	The bandwidth of the LSP

peer

Syntax

peer [*ip-address*] [**detail**]

Context

show>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays PCEP PCC peer information.

Parameters

ip-address

Specifies a peer IPv4 address to display.

Values   a.b.c.d

detail

Displays detailed peer information.

Output

The following output is an example of a PCEP PCC peer information, and Table 34: Output fields: PCEP PCC peer describes the output fields.

Sample output

```
*A:ZBG>show>router>pcep>pcc# peer detail
===============================================================================
PCEP Path Computation Client (PCC) Peer Info
===============================================================================
IP Address           : 10.10.10.11
Admin Status         : Down           Oper Status          : Down
Peer Capabilities    : (Not Specified)
Speaker ID           : (Undefined)
Sync State           : not-initialized Peer Overloaded     : False
Session Establish Time: 0d 00:00:00
Oper Keepalive       : N/A            Oper DeadTimer       : N/A
Session Setup Count  : 0              Session Setup Fail Count: 0
-------------------------------------------------------------------------------
Statistics Information
-------------------------------------------------------------------------------
                           Sent                 Received
-------------------------------------------------------------------------------
PC Request Message         0                    0
PC Reply Message           0                    0
PC Error Message           0                    0
PC Notification Message    0                    0
PC Keepalive Message       0                    0
PC Update Message          0                    0
PC Report Message          0                    0
Path Report                0                    0
Path Request               0                    0
-------------------------------------------------------------------------------
===============================================================================
*A:ZBG>show>router>pcep>pcc#
```

Table 34: Output fields: PCEP PCC peer

Label	Description
IP Address	The IP address of the PCC peer
Admin Status	The administrative status of the PCC peer
Oper Status	The operational status of the PCC peer
Peer Capabilities	The PCEP capabilities of the PCC peer
Speaker ID	The IP address of the PCC peer speaker
Sync State	The synchronization state of the
Peer Overloaded	Indicates whether the PCC peer is overloaded
Session Establish Time	The length of time since the PCEP session was established
Oper Keepalive	The operational value for the PCC peer keepalive timer

Label	Description
Oper DeadTimer	The operational value for the PCC peer dead timer
Session Setup Count	The number of times that the PCEP session has been set up
Session Setup Fail Count	The number of times that the PCEP session failed to be set up
Statistics Information	
PC Request Message	The number of path computation (PC) request messages sent the PCC peer and received from the PCC peer
PC Reply Message	The number of PC reply messages sent to the PCC peer and received from the PCC peer
PC Error Message	The number of PC error messages sent to the PCC peer and received from the PCC peer
PC Notification Message	The number of PC notification messages sent to the PCC peer and received from the PCC peer
PC Keepalive Message	The number of PC keepalive messages sent to the PCC peer and received from the PCC peer
PC Update Message	The number of PC update messages sent to the PCC peer and received from the PCC peer
PC Report Message	The number of PC report messages sent to the PCC peer and received from the PCC peer
Path Report	The number of path reports sent to the PCC peer and received from the PCC peer
Path Request	The path requests sent to the PCC peer and received from the PCC peer

status

Syntax

status

Context

show>router>pcep>pcc

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays PCEP PCC status information.

Output

The following output is an example of PCEP PCC status information, and Table 35: Output fields: PCEP PCC status describes the output fields.

Sample output

```
*A:ZBG>show>router>pcep>pcc# status
===============================================================================
Path Computation Element Protocol (PCEP) Path Computation Client (PCC) Info
===============================================================================
Admin Status         : Down            Oper Status        : Down
Unknown Msg Limit    : 10 msg/min
Keepalive Interval   : 50 seconds      DeadTimer Interval  : 150 seconds
Capabilities List    : stateful-delegate stateful-pce rsvp-path
Address              : 10.10.10.10
Report Path Constraints: True
-------------------------------------------------------------------------------
PCEP Path Computation Client (PCC) Peer Info
-------------------------------------------------------------------------------
Peer                    Admin State/Oper State Oper Keepalive/Oper DeadTimer
-------------------------------------------------------------------------------
10.10.10.11             Down/Down              Not-Applicable/Not-Applicable
-------------------------------------------------------------------------------
===============================================================================
*A:ZBG>show>router>pcep>pcc#
```

Table 35: Output fields: PCEP PCC status

Label	Description
Admin Status	The administrative status of the PCC
Oper Status	The operational status of the PCC
Unknown Msg Limit	The maximum rate of unknown messages that can be received on a PCEP session
Keepalive Interval	The specified keepalive interval for the PCEP session
DeadTimer Interval	The specified dead time interval for the PCEP session
Capabilities List	The capabilities list for the PCEP session
Address	The local IP address of the PCEP speaker
Report Path Constraints	Indicates whether to include LSP path constraints in the PCE report messages sent from the PCC to a PCE
PCEP Path Computation Client (PCC) peer info	
Peer	The IP address of the PCC peer
Admin State/Oper State	The administrative and operational states of the PCC peer

Label	Description
Oper Keepalive/Oper Dead Timer	The operational keepalive and dead timer intervals of the PCC peer

4.7.2.3 Tools commands

pcc

Syntax

pcc lsp [**plsp-id** *plsp-id*]

pcc lsp lsp-type *lsp-type* [**tunnel-id** *tunnel-id*]

Context

tools>dump>router>pcep

Platforms

Supported on all 7210 SAS platforms as described in this document

Description

This command displays PCEP PCC LSP information.

Parameters

lsp

Keyword used to display LSP information.

plsp-id

Specifies the ID of a PCC LSP. Only information for the PCC LSP with the specified ID is displayed.

Values 1 to 1048575

lsp-type

Specifies an LSP type. Only information for LSPs matching the specified type is displayed.

Values rsvp-p2p

tunnel-id

Specifies a tunnel ID. Only information for the tunnel with the specified ID is displayed.

Values 1 to 65535

5 Standards and protocol support

> **Note:**
> The information provided in this chapter is subject to change without notice and may not apply to all platforms.
>
> Nokia assumes no responsibility for inaccuracies.

The following conventions are used in this section:

- T(A,N) indicates 7210 SAS-T in both Access-uplink mode and Network mode. Similarly T(N) means 7210 SAS-T in network mode only.

- K5 indicates 7210 SAS-K 2F2T1C.

- K12 indicates 7210 SAS-K 2F4T6C.

- K30 indicates 7210 SAS-K 3SFP+ 8C.

- Sx/S-1/10GE indicates all variants of 7210 SAS-Sx 1/10GE and 7210 SAS-S 1/10GE platforms.

- Sx/S-1/10GE-VC indicates 7210 SAS-Sx 1/10GE and 7210 SAS-S 1/10GE platforms in standalone-VC mode.

- Sx-10/100GE indicates only the variants of 7210 SAS-Sx 10/100GE. Sx-10/100GE QSFP28 indicates the 7210 SAS-Sx 10/100GE 64 SFP+ 4QSFP28 variant.

- R6 indicates 7210 SAS-R6.

- R12 indicates 7210 SAS-R12.

- D indicates 7210 SAS-D and 7210 SAS-D ETR. If a line item applies only to 7210 SAS-D ETR, then it is indicated as D-ETR.

- Dxp indicates 7210 SAS-Dxp 12p (2SFP+ 4F6T), 7210 SAS-Dxp 12p ETR (2SFP+ 4F6T), 7210 SAS-Dxp 16p (2SFP+ 4F10T), and 7210 SAS-Dxp 24p (2SFP+ 6F16T). If a line item applies only to a particular variant, the variant name is called out explicitly against that item.

- This standards list is not applicable to platforms in the satellite mode of operation, as most of the features are supported on 7x50 SR platforms. For this reason, the host platforms standards compliance must be consulted for the satellite mode of operation.

5.1 BGP

draft-ietf-idr-add-paths-04, Advertisement of Multiple Paths in BGP is supported on T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

draft-ietf-sidr-origin-validation-signaling-04, BGP Prefix Origin Validation State Extended Community is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1772, Application of the Border Gateway Protocol in the Internet is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1997, BGP Communities Attribute is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2385, Protection of BGP Sessions via the TCP MD5 Signature Option is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2439, BGP Route Flap Damping is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2545, Use of BGP-4 Multiprotocol Extensions for IPv6 Inter-Domain Routing is supported on K12, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2858, Multiprotocol Extensions for BGP-4 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2918, Route Refresh Capability for BGP-4 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3107, Carrying Label Information in BGP-4 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3392, Capabilities Advertisement with BGP-4 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4271, A Border Gateway Protocol 4 (BGP-4) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4360, BGP Extended Communities Attribute is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4364, BGP/MPLS IP Virtual Private Networks (VPNs) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 4456, BGP Route Reflection: An Alternative to Full Mesh Internal BGP (IBGP) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> Only R6 and R12 supports RR server functionality. Rest of the platforms support only client function.

RFC 4659, BGP-MPLS IP Virtual Private Network (VPN) Extension for IPv6 VPN is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 4684, Constrained Route Distribution for Border Gateway Protocol/MultiProtocol Label Switching (BGP/MPLS) Internet Protocol (IP) Virtual Private Networks (VPNs) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4724, Graceful Restart Mechanism for BGP (Helper Mode) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4760, Multiprotocol Extensions for BGP-4 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4798, Connecting IPv6 Islands over IPv4 MPLS Using IPv6 Provider Edge Routers (6PE) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 4893, BGP Support for Four-octet AS Number Space is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5004, Avoid BGP Best Path Transitions from One External to Another is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5291, Outbound Route Filtering Capability for BGP-4 is supported on K12, K30, T(N), X, Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5668, 4-Octet AS Specific BGP Extended Community is supported on K12, K30, T(N), Mxp, Sx/ S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6811, Prefix Origin Validation is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/ S-1/10GE-VC, R6, and R12

5.2 Ethernet

IEEE 802.1AB, Station and Media Access Control Connectivity Discovery is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

TIA-1057, LLDP for Media endpoint devices is supported on Dxp, Sx/S-1/10GE, and Sx/S-1/10GE-VC

IEEE 802.1ad, Provider Bridges is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1ag, Connectivity Fault Management is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/ S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1ah, Provider Backbone Bridges is supported on T(N)

IEEE 802.1ax, Link Aggregation is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1D, MAC Bridges is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1p, Traffic Class Expediting is supported on D, E, Dxp, K5, K12, K30, T(A,N), X, Mxp, Sx/ S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1Q, Virtual LANs is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1s, Multiple Spanning Trees is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1w, Rapid Reconfiguration of Spanning Tree is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.1X, Port Based Network Access Control is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/ S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.3ab, 1000BASE-T is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.3ac, VLAN Tag is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.3ad, Link Aggregation is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.3ae, 10 Gb/s Ethernet is supported on Dxp, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/ S-1/10GE-VC, R6, and R12

IEEE 802.3ah, Ethernet in the First Mile is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.3ba, 40 Gb/s and 100 Gb/s Ethernet is supported on R6, R12, and Sx-10/100GE

IEEE 802.3i, Ethernet is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/ S-1/10GE-VC, R6, and R12

IEEE 802.3u, Fast Ethernet is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.3z, Gigabit Ethernet is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE 802.3af, Power Over Ethernet (PoE) is supported on Dxp, T-ETR, Mxp-ETR, and Sx/S-1/10GE

> **Note:**
> Sx/S-1/10GE only on PoE variant and Sx-1/10GE fiber variant with two fixed copper ports. Only on Dxp-16p and Dxp-24p.

IEEE 802.3at, Power Over Ethernet (PoE+) is supported on Dxp, T-ETR, Mxp-ETR, and Sx/S-1/10GE

> **Note:**
> Sx/S-1/10GE only on PoE variant and Sx-1/10GE fiber variant with two fixed copper ports. Only on Dxp-16p and Dxp-24p.

IEEE 802.3bt, Power Over Ethernet (PoE++/HPoE) is supported on Dxp

> **Note:**
> Only on Dxp-16p and Dxp-24p.

ITU-T G.8032, Ethernet Ring Protection Switching is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

ITU-T Y.1731, OAM functions and mechanisms for Ethernet based networks is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

5.3 EVPN

draft-snr-bess-evpn-proxy-arp-nd-00, Proxy-ARP/ND function in EVPN networks is supported on K12, K30, Mxp, Sx/S-1/10GE, R6, and R12

> **Note:**
> Sx/S-/10GE standalone mode only.

RFC 7432, BGP MPLS-Based Ethernet VPN is supported on K12, K30, Mxp, Sx/S-1/10GE, R6, and R12

> **Note:**
> Sx/S-/10GE standalone mode only.

5.4 Fast Reroute

draft-ietf-rtgwg-lfa-manageability-08, Operational management of Loop Free Alternates is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5286, Basic Specification for IP Fast Reroute: Loop-Free Alternates is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 7490, Remote Loop-Free Alternate (LFA) Fast Reroute (FRR) is supported on K12, K30, Mxp, Sx/S-1/10GE,R6, and R12

Note:
With Segment Routing.

5.5 Internet Protocol (IP) — General

draft-grant-tacacs-02, The TACACS+ Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-vrrp-unified-spec-02, Virtual Router Redundancy Protocol Version 3 for IPv4 and IPv6 is supported on Mxp

RFC 768, User Datagram Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 793, Transmission Control Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 854, TELNET Protocol Specifications is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 951, Bootstrap Protocol (BOOTP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1034, Domain Names - Concepts and Facilities is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1035, Domain Names - Implementation and Specification is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1350, The TFTP Protocol (revision 2) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1534, Interoperation between DHCP and BOOTP is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1542, Clarifications and Extensions for the Bootstrap Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2131, Dynamic Host Configuration Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2347, TFTP Option Extension is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2348, TFTP Blocksize Option is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2349, TFTP Timeout Interval and Transfer Size Options is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2428, FTP Extensions for IPv6 and NATs is supported on D, Dxp, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2865, Remote Authentication Dial In User Service (RADIUS) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2866, RADIUS Accounting is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3046, DHCP Relay Agent Information Option (Option 82) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3596, DNS Extensions to Support IP version 6 is supported on D, Dxp, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3768, Virtual Router Redundancy Protocol (VRRP) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4250, The Secure Shell (SSH) Protocol Assigned Numbers is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4251, The Secure Shell (SSH) Protocol Architecture is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4252, The Secure Shell (SSH) Authentication Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> All 7210 platforms support password and publickey based user authentication. 7210 SAS-D supports only password based authentication.

RFC 4253, The Secure Shell (SSH) Transport Layer Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4254, The Secure Shell (SSH) Connection Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4632, Classless Inter-domain Routing (CIDR): The Internet Address Assignment and Aggregation Plan is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5880, Bidirectional Forwarding Detection (BFD) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> IPv4 only on all platforms listed. IPv4 and IPv6 only on Mxp.

RFC 5881, Bidirectional Forwarding Detection (BFD) IPv4 and IPv6 (Single Hop) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> IPv4 only on all platforms listed. IPv4 and IPv6 only on Mxp.

RFC 5883, Bidirectional Forwarding Detection (BFD) for Multihop Paths is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> IPv4 only on all platforms listed. IPv4 and IPv6 only on Mxp.

RFC 6528, Defending against Sequence Number Attacks is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 7130, Bidirectional Forwarding Detection (BFD) on Link Aggregation Group (LAG) Interfaces is supported on T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

5.6 IP — Multicast

RFC 1112, Host Extensions for IP Multicasting is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> IGMP v1, v2, v3 are supported.

RFC 2236, Internet Group Management Protocol, Version 2 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3306, Unicast-Prefix-based IPv6 Multicast Addresses is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3376, Internet Group Management Protocol, Version 3 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3446, Anycast Rendevous Point (RP) mechanism using Protocol Independent Multicast (PIM) and Multicast Source Discovery Protocol (MSDP) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> MSDP supported only on Sx/S-1/10GE standalone.

RFC 3618, Multicast Source Discovery Protocol (MSDP) is supported on Sx/S-1/10GE

> **Note:**
> Only in standalone mode.

RFC 4601, Protocol Independent Multicast - Sparse Mode (PIM-SM): Protocol Specification (Revised) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4604, Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> MLD not supported.

RFC 4607, Source-Specific Multicast for IP is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4608, Source-Specific Protocol Independent Multicast in 232/8 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4610, Anycast-RP Using Protocol Independent Multicast (PIM) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5059, Bootstrap Router (BSR) Mechanism for Protocol Independent Multicast (PIM) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5384, The Protocol Independent Multicast (PIM) Join Attribute Format is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6513, Multicast in MPLS/BGP IP VPNs is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

Note:
Only IPv4.

RFC 6514, BGP Encodings and Procedures for Multicast in MPLS/IP VPNs is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

Note:
Only IPv4.

RFC 6515, IPv4 and IPv6 Infrastructure Addresses in BGP Updates for Multicast VPNs is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

Note:
Only IPv4.

RFC 6625, Wildcards in Multicast VPN Auto-Discover Routes is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

Note:
Only IPv4.

RFC 6826, Multipoint LDP In-Band Signaling for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Path is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

Note:
Only IPv4.

RFC 7246, Multipoint Label Distribution Protocol In-Band Signaling in a Virtual Routing and Forwarding (VRF) Table Context is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

Note:
Only IPv4.

RFC 7385, IANA Registry for P-Multicast Service Interface (PMSI) Tunnel Type Code Points is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

Note:
Only IPv4.

5.7 IP — Version 4

RFC 791, Internet Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 792, Internet Control Message Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 826, An Ethernet Address Resolution Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1519, Classless Inter-Domain Routing (CIDR): an Address Assignment and Aggregation Strategy is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1812, Requirements for IPv4 Routers is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1981, Path MTU Discovery for IP version 6 is supported on K12, K30, T(N), X, Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2401, Security Architecture for Internet Protocol is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> Supported only for OSPFv3 authentication. Not supported for services.

RFC 2460, Internet Protocol, Version 6 (IPv6) Specification is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

5.8 IP — Version 6

RFC 2464, Transmission of IPv6 Packets over Ethernet Networks is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 3021, Using 31-Bit Prefixes on IPv4 Point-to-Point Links is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3122, Extensions to IPv6 Neighbor Discovery for Inverse Discovery Specification is supported on K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3587, IPv6 Global Unicast Address Format is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 4007, IPv6 Scoped Address Architecture is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 4193, Unique Local IPv6 Unicast Addresses is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 4291, Internet Protocol Version 6 (IPv6) Addressing Architecture is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 4443, Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 4861, Neighbor Discovery for IP version 6 (IPv6) is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 4862, IPv6 Stateless Address Autoconfiguration (Router Only) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5095, Deprecation of Type 0 Routing Headers in IPv6 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5952, A Recommendation for IPv6 Address Text Representation is supported on D, Dxp, K12, K30, T(A, N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> D, Dxp, and T(A) for management only.

RFC 6106, IPv6 Router Advertisement Options for DNS Configuration is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6164, Using 127-Bit IPv6 Prefixes on Inter-Router Links is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

5.9 IPsec

RFC 2401, Security Architecture for the Internet Protocol is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> Only for use with OSPFv3 authentication. Not supported for services.

RFC 2406, IP Encapsulating Security Payload (ESP) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> Only for use with OSPFv3 authentication. Not supported for services.

5.10 IS-IS

draft-ietf-isis-mi-02, IS-IS Multi-Instance is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-isis-segment-routing-extensions-04, IS-IS Extensions for Segment Routing is supported on K12, K30, Mxp, Sx/S-1/10GE, R6, and R12

draft-kaplan-isis-ext-eth-02, Extended Ethernet Frame Size Support is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

ISO/IEC 10589:2002, Second Edition, Nov. 2002, Intermediate system to Intermediate system intra-domain routeing information exchange protocol for use in conjunction with the protocol for providing the connectionless-mode Network Service (ISO 8473) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1195, Use of OSI IS-IS for Routing in TCP/IP and Dual Environments is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3359, Reserved Type, Length and Value (TLV) Codepoints in Intermediate System to Intermediate System is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3719, Recommendations for Interoperable Networks using Intermediate System to Intermediate System (IS-IS) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3787, Recommendations for Interoperable IP Networks using Intermediate System to Intermediate System (IS-IS) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4971, Intermediate System to Intermediate System (IS-IS) Extensions for Advertising Router Information is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5120, M-ISIS: Multi Topology (MT) Routing in IS-IS is supported on K12, T(N), X, Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 5130, A Policy Control Mechanism in IS-IS Using Administrative Tags is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5301, Dynamic Hostname Exchange Mechanism for IS-IS is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5302, Domain-wide Prefix Distribution with Two-Level IS-IS is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5303, Three-Way Handshake for IS-IS Point-to-Point Adjacencies is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5304, IS-IS Cryptographic Authentication is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5305, IS-IS Extensions for Traffic Engineering TE is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5306, Restart Signaling for IS-IS (Helper Mode) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5308, Routing IPv6 with IS-IS is supported on K12, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 5309, Point-to-Point Operation over LAN in Link State Routing Protocols is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5310, IS-IS Generic Cryptographic Authentication is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6232, Purge Originator Identification TLV for IS-IS is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6233, IS-IS Registry Extension for Purges is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-isis-mi-02, IS-IS Multi-Instance is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> K12, K30 support only a single instance and can operate in multi-instance deployment as it supports the processing of TLVs for multi-instance support.

draft-ietf-isis-segment-routing-extensions-04, IS-IS Extensions for Segment Routing is supported on K12, K30, Mxp, Sx/S-1/10GE, R6, and R12

5.11 Management

draft-ieft-snmpv3-update-mib-05, Management Information Base (MIB) for the Simple Network Management Protocol (SNMP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-idr-bgp4-mib-05, Definitions of Managed Objects for the Fourth Version of Border Gateway Protocol (BGP-4) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-isis-wg-mib-06, Management Information Base for Intermediate System to Intermediate System (IS-IS) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-mboned-msdp-mib-01, Multicast Source Discovery protocol MIB is supported on Sx/S-1/10GE

> **Note:**
> Only in standalone mode.

draft-ietf-mpls-ldp-mib-07, Definitions of Managed Objects for the Multiprotocol Label Switching, Label Distribution Protocol (LDP) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-mpls-lsr-mib-06, Multiprotocol Label Switching (MPLS) Label Switching Router (LSR) Management Information Base Using SMIv2 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-mpls-te-mib-04, Multiprotocol Label Switching (MPLS) Traffic Engineering Management Information Base is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-ospf-mib-update-08, OSPF Version 2 Management Information Base is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

ianaaddressfamilynumbers-mib, IANA-ADDRESS-FAMILY-NUMBERS-MIB is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

ianaiftype-mib, IANAifType-MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

ianaiprouteprotocol-mib, IANA-RTPROTO-MIB is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE8021-CFM-MIB, IEEE P802.1ag(TM) CFM MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE8021-PAE-MIB, IEEE 802.1X MIB is supported on D, Dxp, K5, K12, K30, T(A,N), X, Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

IEEE8023-LAG-MIB, IEEE 802.3ad MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

LLDP-MIB, IEEE P802.1AB(TM) LLDP MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1157, A Simple Network Management Protocol (SNMP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1215, A Convention for Defining Traps for use with the SNMP is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 1724, RIP Version 2 MIB Extension is supported on Mxp

RFC 2021, Remote Network Monitoring Management Information Base Version 2 using SMIv2 is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2138, Remote Authentication Dial In User Service (RADIUS) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2206, RSVP Management Information Base using SMIv2 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2213, Integrated Services Management Information Base using SMIv2 is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2571, An Architecture for Describing SNMP Management Frameworks is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2572, Message Processing and Dispatching for the Simple Network Management Protocol (SNMP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2573, SNMP Applications is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2575, View-based Access Control Model (VACM) for the Simple Network Management Protocol (SNMP) is supported on D, E, Dxp, K5, K12, K30, T(A,N), X, Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2578, Structure of Management Information Version 2 (SMIv2) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2579, Textual Conventions for SMIv2 is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2787, Definitions of Managed Objects for the Virtual Router Redundancy Protocol is supported on K12, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2819, Remote Network Monitoring Management Information Base is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2856, Textual Conventions for Additional High Capacity Data Types is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2863, The Interfaces Group MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2864, The Inverted Stack Table Extension to the Interfaces Group MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2933, Internet Group Management Protocol MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3014, Notification Log MIB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3164, The BSD syslog Protocol is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3165, Definitions of Managed Objects for the Delegation of Management Scripts is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3231, Definitions of Managed Objects for Scheduling Management Operations is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3273, Remote Network Monitoring Management Information Base for High Capacity Networks is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3414, User-based Security Model (USM) for version 3 of the Simple Network Management Protocol (SNMPv3) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3416. Version 2 of the Protocol Operations for the Simple Network Management Protocol (SNMP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3417, Transport Mappings for the Simple Network Management Protocol (SNMP) (SNMP over UDP over IPv4) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3419, Textual Conventions for Transport Addresses is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3584, Coexistence between Version 1, Version 2, and Version 3 of the Internet-standard Network Management Framework is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3593, Textual Conventions for MIB Modules Using Performance History Based on 15 Minute Intervals is supported on Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3635, Definitions of Managed Objects for the Ethernet-like Interface Types is supported on D, E, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3826, The Advanced Encryption Standard (AES) Cipher Algorithm in the SNMP User-based Security Model is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3877, Alarm Management Information Base (MIB) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4001, Textual Conventions for Internet Network Addresses is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4022, Management Information Base for the Transmission Control Protocol (TCP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4113, Management Information Base for the User Datagram Protocol (UDP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4220, Traffic Engineering Link Management Information Base is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4292, IP Forwarding Table MIB is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4293, Management Information Base for the Internet Protocol (IP) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6241, Network Configuration Protocol (NETCONF) is supported on K5, K12, T(N), Mxp, Sx/S-1/10GE, R6, and R12

RFC 6242, Using the NETCONF Protocol over Secure Shell (SSH) is supported on K5, K12, T(N), Mxp, Sx/S-1/10GE, R6, and R12

5.12 MPLS — General

RFC 3031, Multiprotocol Label Switching Architecture is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3032, MPLS Label Stack Encoding is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3443, Time To Live (TTL) Processing in Multi-Protocol Label Switching (MPLS) Networks is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4182, Removing a Restriction on the use of MPLS Explicit NULL is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5332, MPLS Multicast Encapsulations is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

5.13 MPLS — GMPLS

draft-ietf-ccamp-rsvp-te-srlg-collect-04, RSVP-TE Extensions for Collecting SRLG Information is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

5.14 MPLS — LDP

draft-ietf-mpls-ldp-ipv6-15, Updates to LDP for IPv6 is supported on Mxp

draft-pdutta-mpls-ldp-adj-capability-00, LDP Adjacency Capabilities is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-pdutta-mpls-ldp-v2-00, LDP Version 2 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-pdutta-mpls-tldp-hello-reduce-04, Targeted LDP Hello Reduction is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3037, LDP Applicability is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3478, Graceful Restart Mechanism for Label Distribution Protocol (Helper Mode) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5036, LDP Specification is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5283, LDP Extension for Inter-Area Label Switched Paths (LSPs) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5443, LDP IGP Synchronization is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5561, LDP Capabilities is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6388, Label Distribution Protocol Extensions for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Paths is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> P2MP LSPs only.

5.15 MPLS — MPLS-TP

RFC 5586, MPLS Generic Associated Channel is supported on T(N), R6, and R12

RFC 5921, A Framework for MPLS in Transport Networks is supported on T(N), R6, and R12

RFC 5960, MPLS Transport Profile Data Plane Architecture is supported on T(N), R6, and R12

RFC 6370, MPLS Transport Profile (MPLS-TP) Identifiers is supported on T(N), R6, and R12

RFC 6378, MPLS Transport Profile (MPLS-TP) Linear Protection is supported on T(N), R6, and R12

RFC 6426, MPLS On-Demand Connectivity and Route Tracing is supported on T(N), R6, and R12

RFC 6428, Proactive Connectivity Verification, Continuity Check and Remote Defect indication for MPLS Transport Profile is supported on T(N), R6, and R12

RFC 6478, Pseudowire Status for Static Pseudowires is supported on T(N), R6, and R12

RFC 7213, MPLS Transport Profile (MPLS-TP) Next-Hop Ethernet Addressing is supported on T(N), R6, and R12

5.16 MPLS — OAM

RFC 6424, Mechanism for Performing Label Switched Path Ping (LSP Ping) over MPLS Tunnels is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6425, Detecting Data Plane Failures in Point-to-Multipoint Multiprotocol Label Switching (MPLS) - Extensions to LSP Ping is supported on T(N), Mxp, R6, and R12

5.17 MPLS — RSVP-TE

RFC 2702, Requirements for Traffic Engineering over MPLS is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2747, RSVP Cryptographic Authentication is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2961, RSVP Refresh Overhead Reduction Extensions is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3097, RSVP Cryptographic Authentication -- Updated Message Type Value is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3209, RSVP-TE: Extensions to RSVP for LSP Tunnels is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3477, Signalling Unnumbered Links in Resource ReSerVation Protocol - Traffic Engineering (RSVP-TE) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4090, Fast Reroute Extensions to RSVP-TE for LSP Tunnels is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4561, Definition of a Record Route Object (RRO) Node-Id Sub-Object is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4875, Extensions to Resource Reservation Protocol - Traffic Engineering (RSVP-TE) for Point-to-Multipoint TE Label Switched Paths (LSPs) is supported on T(N), Mxp, Sx/S-1/10GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4950, ICMP Extensions for Multiprotocol Label Switching is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5817, Graceful Shutdown in MPLS and Generalized MPLS Traffic Engineering Networks is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

5.18 OSPF

draft-ietf-ospf-prefix-link-attr-06, OSPFv2 Prefix/Link Attribute Advertisement is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-ospf-segment-routing-extensions-04, OSPF Extensions for Segment Routing is supported on K12, K30, Mxp, Sx/S-1/10GE, R6, and R12

RFC 1765, OSPF Database Overflow is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2328, OSPF Version 2 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3101, The OSPF Not-So-Stubby Area (NSSA) Option is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3509, Alternative Implementations of OSPF Area Border Routers is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3623, Graceful OSPF Restart Graceful OSPF Restart (Helper Mode) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3630, Traffic Engineering (TE) Extensions to OSPF Version 2 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4222, Prioritized Treatment of Specific OSPF Version 2 Packets and Congestion Avoidance is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4552, Authentication/Confidentiality for OSPFv3 is supported on K12, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 4576, Using a Link State Advertisement (LSA) Options Bit to Prevent Looping in BGP/MPLS IP Virtual Private Networks (VPNs) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 4577, OSPF as the Provider/Customer Edge Protocol for BGP/MPLS IP Virtual Private Networks (VPNs) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 4970, Extensions to OSPF for Advertising Optional Router Capabilities is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5185, OSPF Multi-Area Adjacency is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5187, OSPFv3 Graceful Restart (Helper Mode) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

RFC 5243, OSPF Database Exchange Summary List Optimization is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5250, The OSPF Opaque LSA Option is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5309, Point-to-Point Operation over LAN in Link State Routing Protocols is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5340, OSPF for IPv6 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5838, Support of Address Families in OSPFv3 is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6987, OSPF Stub Router Advertisement is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

draft-ietf-ospf-prefix-link-attr-06, OSPFv2 Prefix/Link Attribute Advertisement is supported on K12, K30, Mxp, Sx/S-1/10GE, R6, and R12

draft-ietf-ospf-segment-routing-extensions-04, OSPF Extensions for Segment Routing is supported on K12, K30, Mxp, Sx/S-1/10GE, R6, and R12

5.19 Pseudowire

draft-ietf-l2vpn-vpws-iw-oam-04, OAM Procedures for VPWS Interworking is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3916, Requirements for Pseudo- Wire Emulation Edge-to-Edge (PWE3) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3985, Pseudo Wire Emulation Edge-to-Edge (PWE3) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4385, Pseudo Wire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4446, IANA Allocations for Pseudowire Edge to Edge Emulation (PWE3) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4447, Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 4448, Encapsulation Methods for Transport of Ethernet over MPLS Networks is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5659, An Architecture for Multi-Segment Pseudowire Emulation Edge-to-Edge is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6073, Segmented Pseudowire is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6310, Pseudowire (PW) Operations, Administration, and Maintenance (OAM) Message Mapping is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6391, Flow-Aware Transport of Pseudowires over an MPLS Packet Switched Network is supported on K12, K30, Mxp, R6, and R12

RFC 6718, Pseudowire Redundancy is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6870, Pseudowire Preferential Forwarding Status bit is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 7023, MPLS and Ethernet Operations, Administration, and Maintenance (OAM) Interworking is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 7267, Dynamic Placement of Multi-Segment Pseudowires is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

5.20 Quality of Service

RFC 2430, A Provider Architecture for Differentiated Services and Traffic Engineering (PASTE) is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2474, Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 2598, An Expedited Forwarding PHB is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3140, Per Hop Behavior Identification Codes is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 3260, New Terminology and Clarifications for Diffserv is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

5.21 RIP

RFC 1058, Routing Information Protocol is supported on Mxp

RFC 2082, RIP-2 MD5 Authentication is supported on Mxp

RFC 2453, RIP Version 2 is supported on Mxp

5.22 Timing

GR-1244-CORE, Clocks for the Synchronized Network: Common Generic Criteria, Issue 3, May 2005 is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR, Dxp-16p, and Dxp-24p.

GR-253-CORE, SONET Transport Systems: Common Generic Criteria. Issue 3, September 2000 is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR, Dxp-16p, and Dxp-24p.

IEEE 1588-2008, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR. Dxp-ETR and Sx-10/100GE does not support IEEE default profile.

ITU-T G.781, Synchronization layer functions, issued 09/2008 is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR, Dxp-16p, and Dxp-24p.

ITU-T G.813, Timing characteristics of SDH equipment slave clocks (SEC), issued 03/2003 is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR, Dxp-16p, and Dxp-24p.

ITU-T G.8261, Timing and synchronization aspects in packet networks, issued 04/2008 is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR, Dxp-16p, and Dxp-24p.

ITU-T G.8262, Timing characteristics of synchronous Ethernet equipment slave clock (EEC), issued 08/2007 is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR, Dxp-16p, and Dxp-24p.

ITU-T G.8264, Distribution of timing information through packet networks, issued 10/2008 is supported on D-ETR, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on Dxp-12p ETR, Dxp-16p, and Dxp-24p.

ITU-T G.8265.1, Precision time protocol telecom profile for frequency synchronization, issued 10/2010 is supported on D-ETR, K5, K12, K30, T(A,N), Mxp, Sx-1/10GE, R6, and R12

ITU-T G.8275.1, Precision time protocol telecom profile for phase/time synchronization with full timing support from the network, issued 07/2014 is supported on Dxp, K12, K30, T(A,N), Mxp, Sx-1/10GE, Sx-10/100GE, R6, and R12

> **Note:**
> Only on 7210 SAS-Sx 10/100GE QSFP28 variant and Dxp-12p ETR.

IEC/IEEE 61850-9-3-2016, Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation is supported on Dxp-16p and Dxp-24p

IEEE C37.238-2017 - IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications is supported on Dxp-16p and Dxp-24p

RFC 5905, Network Time Protocol Version 4: Protocol and Algorithms Specification is supported on D, Dxp, K5, K12, K30, T(A,N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

5.23 VPLS

RFC 4761, Virtual Private LAN Service (VPLS) Using BGP for Auto-Discovery and Signaling is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

> **Note:**
> On 7210 platforms, only BGP-AD is suported with TLDP signalling for PW. No BGP signalling is supported for PW establishment.

RFC 4762, Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 5501, Requirements for Multicast Support in Virtual Private LAN Services is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

RFC 6074, Provisioning, Auto-Discovery, and Signaling in Layer 2 Virtual Private Networks (L2VPNs) is supported on K12, K30, T(N), Mxp, Sx/S-1/10GE, Sx-10/100GE, Sx/S-1/10GE-VC, R6, and R12

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