



## **MPLS High Availability Configuration Guide, Cisco IOS XE Release 2**

### **Americas Headquarters**

Cisco Systems, Inc.  
170 West Tasman Drive  
San Jose, CA 95134-1706  
USA  
<http://www.cisco.com>  
Tel: 408 526-4000  
800 553-NETS (6387)  
Fax: 408 527-0883

THE SPECIFICATIONS AND INFORMATION REGARDING THE PRODUCTS IN THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE. ALL STATEMENTS, INFORMATION, AND RECOMMENDATIONS IN THIS MANUAL ARE BELIEVED TO BE ACCURATE BUT ARE PRESENTED WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. USERS MUST TAKE FULL RESPONSIBILITY FOR THEIR APPLICATION OF ANY PRODUCTS.

THE SOFTWARE LICENSE AND LIMITED WARRANTY FOR THE ACCOMPANYING PRODUCT ARE SET FORTH IN THE INFORMATION PACKET THAT SHIPPED WITH THE PRODUCT AND ARE INCORPORATED HEREIN BY THIS REFERENCE. IF YOU ARE UNABLE TO LOCATE THE SOFTWARE LICENSE OR LIMITED WARRANTY, CONTACT YOUR CISCO REPRESENTATIVE FOR A COPY.

The Cisco implementation of TCP header compression is an adaptation of a program developed by the University of California, Berkeley (UCB) as part of UCB's public domain version of the UNIX operating system. All rights reserved. Copyright © 1981, Regents of the University of California.

NOTWITHSTANDING ANY OTHER WARRANTY HEREIN, ALL DOCUMENT FILES AND SOFTWARE OF THESE SUPPLIERS ARE PROVIDED "AS IS" WITH ALL FAULTS. CISCO AND THE ABOVE-NAMED SUPPLIERS DISCLAIM ALL WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THOSE OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT OR ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.

IN NO EVENT SHALL CISCO OR ITS SUPPLIERS BE LIABLE FOR ANY INDIRECT, SPECIAL, CONSEQUENTIAL, OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, LOST PROFITS OR LOSS OR DAMAGE TO DATA ARISING OUT OF THE USE OR INABILITY TO USE THIS MANUAL, EVEN IF CISCO OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.

© 2011 Cisco Systems, Inc. All rights reserved.



## **CONTENTS**

### **MPLS LDP Graceful Restart 1**

Finding Feature Information 1

Prerequisites for MPLS LDP Graceful Restart 1

Restrictions for MPLS LDP Graceful Restart 2

Information About MPLS LDP Graceful Restart 2

How MPLS LDP Graceful Restart Works 2

How a Route Processor Advertises That It Supports MPLS LDP Graceful Restart 3

What Happens If a Route Processor Does Not Have MPLS LDP Graceful Restart 3

How to Configure MPLS LDP Graceful Restart 3

Configuring MPLS LDP Graceful Restart 3

Verifying the MPLS LDP Graceful Restart Configuration 5

Configuration Examples for MPLS LDP Graceful Restart 6

Configuring MPLS LDP Graceful Restart Example 6

Additional References 9

Feature Information for MPLS LDP Graceful Restart 10

### **NSF SSO--MPLS LDP and LDP Graceful Restart 13**

Finding Feature Information 13

Prerequisites for NSF SSO--MPLS LDP and LDP Graceful Restart 14

Restrictions for NSF SSO--MPLS LDP and LDP Graceful Restart 14

Information About NSF SSO--MPLS LDP and LDP Graceful Restart 14

How NSF SSO--MPLS LDP and LDP Graceful Restart Works 14

What Happens During an LDP Restart and an LDP Session Reset 15

How a Route Processor Advertises That It Supports NSF SSO--MPLS LDP and LDP Graceful Restart 16

What Happens if a Route Processor Does Not Have LDP Graceful Restart 16

Checkpointing for NSF SSO--MPLS LDP and LDP Graceful Restart 16

Troubleshooting Tips 17

How to Configure and Use NSF SSO--MPLS LDP and LDP Graceful Restart 17

Configuring MPLS LDP Graceful Restart 17

- Verifying the MPLS LDP Graceful Restart Configuration 19
- Configuration Examples for NSF SSO--MPLS LDP and LDP Graceful Restart 20
  - Configuring NSF SSO--MPLS LDP and LDP Graceful Restart Example 20
- Additional References 23
- Feature Information for NSF SSO--MPLS LDP and LDP Graceful Restart 24
- ISSU MPLS Clients 27**
  - Finding Feature Information 27
  - Prerequisites for ISSU MPLS Clients 27
  - Information About ISSU MPLS Clients 28
    - ISSU-Capable Protocols and Applications Clients 28
    - ISSU-Capable MPLS Feature Sets 29
  - How to Verify that an MPLS Client Can Support an In Service Software Upgrade 29
    - Verifying the ISSU Process for an MPLS Client 30
  - Configuration Examples for ISSU MPLS Clients 31
    - Verifying the ISSU Process for an MPLS LDP Client Example 32
    - Verifying the ISSU Process for an MPLS VPN Client Example 33
    - Verifying the ISSU Process for an MPLS VRF (Table ID) Client Example 34
    - Verifying the ISSU Process for an MPLS LSD Label Manager HA Client Example 35
    - Verifying the ISSU Process for an MPLS MFI Pull Client Example 35
    - Verifying the ISSU Process for an MPLS MFI Push Client Example 36
    - Verifying the ISSU Process for an MPLS LSPV Push Client Example 37
    - Verifying the ISSU Process for an MPLS TE Client Example 38
  - Additional References 38
  - Feature Information for ISSU MPLS Clients 40
  - Glossary 41
- MPLS Traffic Engineering--RSVP Graceful Restart 43**
  - Finding Feature Information 43
  - Prerequisites for MPLS TE--RSVP Graceful Restart 43
  - Restrictions for MPLS TE--RSVP Graceful Restart 44
  - Information About MPLS TE--RSVP Graceful Restart 44
    - Graceful Restart 44
    - Graceful Restart Benefits 46
  - How to Configure MPLS TE--RSVP Graceful Restart 46
    - Enabling Graceful Restart 46
    - Setting a DSCP Value on a Router for MPLS TE Graceful Restart 47

Setting a Hello Refresh Interval for MPLS TE Graceful Restart	48
Setting a Missed Refresh Limit for MPLS TE Graceful Restart	49
Verifying Graceful Restart Configuration	50
Configuration Examples for MPLS TE--RSVP Graceful Restart	51
Example MPLS TE--RSVP Graceful Restart	51
Additional References	51
Feature Information for MPLS Traffic Engineering--RSVP Graceful Restart	53
Glossary	54
<b>NSF SSO--MPLS TE and RSVP Graceful Restart</b>	<b>57</b>
Finding Feature Information	57
Prerequisites for NSF SSO--MPLS TE and RSVP Graceful Restart	57
Restrictions for NSF SSO--MPLS TE and RSVP Graceful Restart	58
Information About NSF SSO--MPLS TE and RSVP Graceful Restart	58
Overview of MPLS TE and RSVP Graceful Restart	58
Benefits of MPLS TE and RSVP Graceful Restart	60
How to Configure NSF SSO--MPLS TE and RSVP Graceful Restart	60
Enabling RSVP Graceful Restart Globally	60
Enabling RSVP Graceful Restart on an Interface	61
Setting a DSCP Value for RSVP Graceful Restart	63
Setting a Value to Control the Refresh Interval for RSVP Hello Messages	63
Setting a Value to Control the Missed Refresh Limit for RSVP Graceful Restart Hello Acknowledgements	64
Verifying the RSVP Graceful Restart Configuration	65
Configuration Examples for NSF SSO--MPLS TE and RSVP Graceful Restart	66
Example Configuring NSF SSO--MPLS TE and RSVP Graceful Restart	66
Example Verifying the NSF SSO--MPLS TE and RSVP Graceful Restart Configuration	67
Additional References	67
Feature Information for NSF SSO--MPLS TE and RSVP Graceful Restart	68
Glossary	70
<b>AToM Graceful Restart</b>	<b>73</b>
Finding Feature Information	73
Prerequisites for AToM Graceful Restart	73
Restrictions for AToM Graceful Restart	74
Information About AToM Graceful Restart	74
How AToM Graceful Restart Works	74

- How to Configure AToM Graceful Restart **74**
  - Configuring AToM Graceful Restart **74**
- Configuration Examples for AToM Graceful Restart **75**
  - Configuring AToM Graceful Restart Example **75**
  - AToM Graceful Restart--Recovering from an LDP Session Disruption Examples **76**
- Additional References **77**
- Feature Information for AToM Graceful Restart **79**



# MPLS LDP Graceful Restart

---

When a router is configured with Multiprotocol Label Switching (MPLS) Label Distribution Protocol (LDP) Graceful Restart (GR), it assists a neighboring router that has MPLS LDP Stateful Switchover/ Nonstop Forwarding (SSO/NSF) Support and Graceful Restart to recover gracefully from an interruption in service. MPLS LDP GR functions strictly in helper mode, which means it can only help other routers that are enabled with MPLS SSO/NSF and GR to recover. If the router with LDP GR fails, its peer routers cannot help the router recover.

For brevity, the following are used in this document:

- MPLS LDP SSO/NSF Support and Graceful Restart is called LDP SSO/NSF.
- The MPLS LDP GR feature described in this document refers to helper mode.

When you enable MPLS LDP GR on a router that peers with an MPLS LDP SSO/NSF-enabled router, the SSO/NSF-enabled router can maintain its forwarding state when the LDP session between them is interrupted. While the SSO/NSF-enabled router recovers, the peer router forwards packets using stale information. This enables the SSO/NSF-enabled router to become operational more quickly.

- [Finding Feature Information, page 1](#)
- [Prerequisites for MPLS LDP Graceful Restart, page 1](#)
- [Restrictions for MPLS LDP Graceful Restart, page 2](#)
- [Information About MPLS LDP Graceful Restart, page 2](#)
- [How to Configure MPLS LDP Graceful Restart, page 3](#)
- [Configuration Examples for MPLS LDP Graceful Restart, page 6](#)
- [Additional References, page 9](#)
- [Feature Information for MPLS LDP Graceful Restart, page 10](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for MPLS LDP Graceful Restart

You must enable MPLS LDP GR on all route processors for an LDP session to be preserved during an interruption in service.

## Restrictions for MPLS LDP Graceful Restart

- MPLS LDP GR is supported in strict helper mode.
- MPLS LDP GR cannot be configured on label-controlled ATM (LC-ATM) interfaces.

## Information About MPLS LDP Graceful Restart

- [How MPLS LDP Graceful Restart Works, page 2](#)
- [How a Route Processor Advertises That It Supports MPLS LDP Graceful Restart, page 3](#)
- [What Happens If a Route Processor Does Not Have MPLS LDP Graceful Restart, page 3](#)

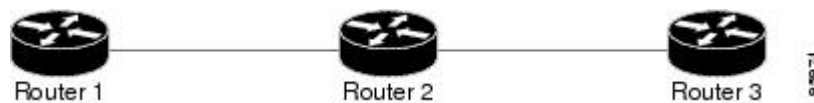
## How MPLS LDP Graceful Restart Works

MPLS LDP GR works in strict helper mode, which means it helps a neighboring route processor that has MPLS LDP SSO/NSF to recover from disruption in service without losing its MPLS forwarding state. The disruption in service could be the result of a TCP or UDP event or the stateful switchover of a route processor. When the neighboring router establishes a new session, the LDP bindings and MPLS forwarding states are recovered.

In the topology shown in the figure below, the following elements have been configured:

- LDP sessions are established between Router 1 and Router 2, as well as between Router 2 and Router 3.
- Router 2 has been configured with MPLS LDP SSO/NSF. Routers 1 and 3 have been configured with MPLS LDP GR.
- A label switched path (LSP) has been established between Router 1 and Router 3.

**Figure 1** Example of a Network Using LDP Graceful Restart



The following process shows how Routers 1 and 3, which have been configured with MPLS LDP GR, help Router 2, which has been configured with LDP SSO/NSF, recover from a disruption in service:

- 1 Router 1 notices an interruption in service with Router 2. (Router 3 also performs the same actions in this process.)
- 2 Router 1 marks all the label bindings from Router 2 as stale, but it continues to use the bindings for MPLS forwarding.

Router 1 reestablishes an LDP session with Router 2, but keeps its stale label bindings. If you issue a **showmplsldpneighbor** command with the **graceful-restart** keyword, the command output displays the recovering LDP sessions.

- 1 Both routers readvertise their label binding information. If Router 1 relearns a label from Router 2 after the session has been established, the stale flags are removed. The **showmplsforwarding-table** command



displays the information in the MPLS forwarding table, including the local label, outgoing label or VC, prefix, label-switched bytes, outgoing interface, and next hop.

You can set various graceful restart timers. See the following commands for more information:

- `mpls ldp graceful-restart timers neighbor-liveness`
- `mpls ldp graceful-restart timers max-recovery`

## How a Route Processor Advertises That It Supports MPLS LDP Graceful Restart

A Route Processor (RP) that is configured to perform MPLS LDP GR includes the Fault Tolerant (FT) Type Length Value (TLV) in the LDP initialization message. The RP sends the LDP initialization message to a neighbor to establish an LDP session.

The FT session TLV includes the following information:

- The Learn from Network (L) flag is set to 1, which indicates that the route processor is configured to perform MPLS LDP GR.
- The Reconnect Timeout field shows the time (in milliseconds) that the neighbor should wait for a reconnection if the LDP session is lost. In this release, the timer is set to 0, which indicates that if the local router fails, its peers should not wait for it to recover. The timer setting indicates that the local router is working in helper mode.
- The Recovery Time field shows the time (in milliseconds) that the neighbor should retain the MPLS forwarding state during a recovery. If a neighbor did not preserve the MPLS forwarding state before the restart of the control plane, the neighbor sets the recovery time to 0.

## What Happens If a Route Processor Does Not Have MPLS LDP Graceful Restart

If two route processors establish an LDP session and one route processor is not configured for MPLS LDP GR, the two route processors create a normal LDP session but do not have the ability to perform MPLS LDP GR. Both route processors must be configured for MPLS LDP GR.

## How to Configure MPLS LDP Graceful Restart

- [Configuring MPLS LDP Graceful Restart, page 3](#)
- [Verifying the MPLS LDP Graceful Restart Configuration, page 5](#)

## Configuring MPLS LDP Graceful Restart

To configure MPLS LDP Graceful Restart, perform the following task.

You must enable MPLS LDP GR on all route processors for an LDP session to be preserved during an interruption in service.

MPLS LDP GR is enabled globally. When you enable MPLS LDP GR, it has no effect on existing LDP sessions. New LDP sessions that are established can perform MPLS LDP GR.

**Note**

You can also issue the **mpls label protocol ldp** command in global configuration mode, which enables LDP on all interfaces configured for MPLS.

**SUMMARY STEPS**

1. **enable**
2. **configure terminal**
3. **ip cef distributed**
4. **mpls ldp graceful-restart**
5. **interface** *type slot / subslot / port* [*. subinterface-number*]
6. **mpls ip**
7. **mpls label protocol ldp**
8. **exit**
9. **exit**

**DETAILED STEPS**

Command or Action	Purpose
<b>Step 1</b> <b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3</b> <b>ip cef distributed</b>  <b>Example:</b> Router(config)# ip cef distributed	Enables distributed Cisco Express Forwarding.
<b>Step 4</b> <b>mpls ldp graceful-restart</b>  <b>Example:</b> Router(config)# mpls ldp graceful-restart	Enables the router to protect the LDP bindings and MPLS forwarding state during a disruption in service.

Command or Action	Purpose
<b>Step 5</b> <code>interface type slot / subslot / port [. subinterface-number]</code>  <b>Example:</b> <pre>Router(config)# interface pos 0/3/0</pre>	Specifies an interface and enters interface configuration mode.
<b>Step 6</b> <code>mpls ip</code>  <b>Example:</b> <pre>Router(config-if)# mpls ip</pre>	Configures MPLS hop-by-hop forwarding for an interface.
<b>Step 7</b> <code>mpls label protocol ldp</code>  <b>Example:</b> <pre>Router(config-if)# mpls label protocol ldp</pre>	Configures the use of LDP for an interface.
<b>Step 8</b> <code>exit</code>  <b>Example:</b> <pre>Router(config-if)# exit</pre>	Exits interface configuration mode and returns to global configuration mode.
<b>Step 9</b> <code>exit</code>  <b>Example:</b> <pre>Router(config)# exit</pre>	Exits global configuration mode and returns to privileged EXEC mode.

## Verifying the MPLS LDP Graceful Restart Configuration

To verify that MPLS LDP Graceful Restart is configured correctly, perform the following task.

### SUMMARY STEPS

1. `enable`
2. `show mpls ldp neighbor graceful restart`
3. `show mpls ldp graceful-restart`
4. `exit`

### DETAILED STEPS

- 
- Step 1** `enable`  
Use this command to enable privileged EXEC mode. Enter your password if prompted. For example:

**Example:**

```
Router>? enable
Router#
```

**Step 2** **show mpls ldp neighbor graceful restart**

Use this command to display graceful restart information for LDP sessions. For example:

**Example:**

```
Router# show mpls ldp neighbor graceful restart
Peer LDP Ident: 10.20.20.20:0; Local LDP Ident 10.17.17.17:0
  TCP connection: 10.20.20.20.16510 - 10.17.17.17.646
  State: Oper; Msgs sent/rcvd: 8/18; Downstream
  Up time: 00:04:39
  Graceful Restart enabled; Peer reconnect time (msecs): 120000
Peer LDP Ident: 10.19.19.19:0; Local LDP Ident 10.17.17.17:0
  TCP connection: 10.19.19.19.11007 - 10.17.17.17.646
  State: Oper; Msgs sent/rcvd: 8/38; Downstream
  Up time: 00:04:30
  Graceful Restart enabled; Peer reconnect time (msecs): 120000
```

**Step 3** **show mpls ldp graceful-restart**

Use this command to display graceful restart sessions and session parameters. For example:

**Example:**

```
Router# show mpls ldp graceful-restart
LDP Graceful Restart is enabled
Neighbor Liveness Timer: 5 seconds
Max Recovery Time: 200 seconds
Down Neighbor Database (0 records):
Graceful Restart-enabled Sessions:
VRF default:
  Peer LDP Ident: 10.18.18.18:0, State: estab
  Peer LDP Ident: 10.17.17.17:0, State: estab
```

**Step 4** **exit**

Use this command to exit to user EXEC mode. For example:

**Example:**

```
Router# exit
Router>
```

## Configuration Examples for MPLS LDP Graceful Restart

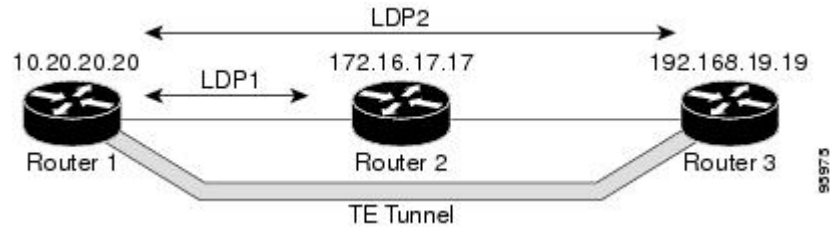
- [Configuring MPLS LDP Graceful Restart Example, page 6](#)

### Configuring MPLS LDP Graceful Restart Example

The figure below shows a configuration where MPLS LDP GR is enabled on Router 1 and MPLS LDP SSO/NSF is enabled on Routers 2 and 3. In this configuration example, Router 1 creates an LDP session

with Router 2. Router 1 also creates a targeted session with Router 3 through a traffic engineering tunnel using Router 2.

**Figure 2 MPLS LDP Graceful Restart Configuration Example**



**Router 1 configured with LDP GR:**

```

!
ip subnet-zero
ip cef
mpls label range 16 10000 static 10001 1048575
mpls label protocol ldp
mpls ldp logging neighbor-changes
mpls ldp graceful-restart
mpls traffic-eng tunnels
no mpls traffic-eng auto-bw timers frequency 0
mpls ldp router-id Loopback0 force
!
interface Loopback0
 ip address 20.20.20.20 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Tunnel1
 ip unnumbered Loopback0
 no ip directed-broadcast
 mpls label protocol ldp
 mpls ip
 tunnel destination 19.19.19.19
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 500
 tunnel mpls traffic-eng path-option 1 dynamic
!
interface ATM5/1/0
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM5/1/0.5 point-to-point
 ip address 10.12.0.2 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 pvc 6/100
 encapsulation aal5snap
 mpls label protocol ldp
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 1000
!
router ospf 100
 log-adjacency-changes
 redistribute connected
 network 10.12.0.0 0.255.255.255 area 100
 network 10.20.20.20 0.0.0.0 area 100

```

```
mpls traffic-eng router-id Loopback0
mpls traffic-eng area 100
```

### Router 2 configured with LDP SSO/NSF:

```
!
redundancy
  mode sso
!
ip cef
no ip domain-lookup
mpls label range 17 10000 static 10001 1048575
mpls label protocol ldp
mpls ldp logging neighbor-changes
mpls ldp graceful-restart
mpls traffic-eng tunnels
no mpls traffic-eng auto-bw timers frequency 0
no mpls advertise-labels
mpls ldp router-id Loopback0 force
!
interface Loopback0
 ip address 10.17.17.17 255.255.255.255
 no ip directed-broadcast
!
interface ATM4/0/0
 no ip address
 no ip directed-broadcast
 no ip mroute-cache
 atm clock INTERNAL
 atm sonet stm-1
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM4/0/0.5 point-to-point
 ip address 10.12.0.1 255.0.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 pvc 6/100
  encapsulation aal5snap
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ip
 ip rsvp bandwidth 1000
!
interface POS5/1/0
 ip address 10.11.0.1 255.0.0.0
 no ip directed-broadcast
 encapsulation ppp
 mpls label protocol ldp
 mpls traffic-eng tunnels
 mpls ip
 no peer neighbor-route
 clock source internal
 ip rsvp bandwidth 1000
!
router ospf 100
 log-adjacency-changes
 redistribute connected
 nsf enforce global
 network 10.11.0.0 0.255.255.255 area 100
 network 10.12.0.0 0.255.255.255 area 100
 network 10.17.17.17 0.0.0.0 area 100
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 100
!
ip classless
```

### Router 3 configured with LDP SSO/NSF:

```
!
```

```

redundancy
  mode sso
!
ip subnet-zero
ip cef
!
no ip finger
no ip domain-lookup
mpls label protocol ldp
mpls ldp neighbor 10.11.11.11 targeted ldp
mpls ldp logging neighbor-changes
mpls ldp graceful-restart
mpls traffic-eng tunnels
no mpls traffic-eng auto-bw timers frequency 0
mpls ldp discovery directed-hello interval 12
mpls ldp discovery directed-hello holdtime 130
mpls ldp discovery directed-hello accept
mpls ldp router-id Loopback0 force
!
interface Loopback0
  ip address 10.19.19.19 255.255.255.255
  no ip directed-broadcast
!
interface POS1/0
  ip address 10.11.0.2 255.0.0.0
  no ip directed-broadcast
  encapsulation ppp
  mpls label protocol ldp
  mpls traffic-eng tunnels
  mpls ip
  no peer neighbor-route
  clock source internal
  ip rsvp bandwidth 1000
!
router ospf 100
  log-adjacency-changes
  redistribute connected
  nsf enforce global
  network 10.11.0.0 0.255.255.255 area 100
  network 10.19.19.19 0.0.0.0 area 100
  mpls traffic-eng router-id Loopback0
  mpls traffic-eng area 100
!
ip classless

```

## Additional References

The following sections provide references related to MPLS LDP GR.

### Related Documents

Related Topic	Document Title
MPLS Label Distribution Protocol	MPLS Label Distribution Protocol (LDP)
LDP commands	<i>Cisco IOS Multiprotocol Label Switching Command Reference</i>

**Standards**

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

**MIBs**

MIBs	MIBs Link
<i>MPLS Label Distribution Protocol MIB Version 8 Upgrade</i>	To locate and download MIBs for selected platforms, Cisco IOS XE software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

RFCs	Title
RFC 3036	<i>LDP Specification</i>
RFC 3478	<i>Graceful Restart Mechanism for Label Distribution</i>

**Technical Assistance**

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a>

## Feature Information for MPLS LDP Graceful Restart

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.



Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 1** Feature Information for MPLS LDP Graceful Restart

Feature Name	Releases	Feature Information
MPLS LDP Graceful Restart	Cisco IOS XE Release 2.1	<p>When a router is configured with Multiprotocol Label Switching (MPLS) Label Distribution Protocol (LDP) Graceful Restart (GR), it assists a neighboring router that has MPLS LDP Stateful Switchover/Nonstop Forwarding (SSO/NSF) Support and Graceful Restart to recover gracefully from an interruption in service. MPLS LDP GR functions strictly in helper mode, which means it can only help other routers that are enabled with MPLS SSO/NSF and GR to recover. If the router with LDP GR fails, its peer routers cannot help the router recover.</p> <p>In Cisco IOS XE Release 2.1, this feature was introduced on the Cisco ASR 1000 Series Aggregation Services Routers.</p> <p>The following commands were introduced or modified:</p> <p><b>debugmplsldpgraceful-restart,</b>  <b>mplsldpgraceful-restart,</b>  <b>mplsldpgraceful-restarttimersmax-recovery,</b>  <b>mplsldpgraceful-restarttimersneighbor-liveness,</b>  <b>showmplsipbinding,</b>  <b>showmplsldpbindings,</b>  <b>showmplsldpgraceful-restart,</b>  <b>showmplsldpneighbor.</b></p>

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams,

and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.



# NSF SSO--MPLS LDP and LDP Graceful Restart

Cisco Nonstop Forwarding (NSF) with Stateful Switchover (SSO) provides continuous packet forwarding, even during a network processor hardware or software failure. In a redundant system, the secondary processor recovers control plane service during a critical failure in the primary processor. SSO synchronizes the network state information between the primary and the secondary processor.

Multiprotocol Label Switching (MPLS) Label Distribution Protocol (LDP) uses SSO, NSF, and graceful restart to allow a Route Processor (RP) to recover from disruption in control plane service (specifically, the LDP component) without losing its MPLS forwarding state. LDP NSF works with LDP sessions between directly connected peers and with peers that are not directly connected (targeted sessions).



## Note

---

In this document, the NSF/SSO--MPLS LDP and LDP Graceful Restart feature is called LDP NSF for brevity.

---

- [Finding Feature Information, page 13](#)
- [Prerequisites for NSF SSO--MPLS LDP and LDP Graceful Restart, page 14](#)
- [Restrictions for NSF SSO--MPLS LDP and LDP Graceful Restart, page 14](#)
- [Information About NSF SSO--MPLS LDP and LDP Graceful Restart, page 14](#)
- [How to Configure and Use NSF SSO--MPLS LDP and LDP Graceful Restart, page 17](#)
- [Configuration Examples for NSF SSO--MPLS LDP and LDP Graceful Restart, page 20](#)
- [Additional References, page 23](#)
- [Feature Information for NSF SSO--MPLS LDP and LDP Graceful Restart, page 24](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for NSF SSO--MPLS LDP and LDP Graceful Restart

MPLS high availability (HA) requires that neighbor networking devices be NSF-aware.

To perform LDP NSF, RPs must be configured for SSO. See the "Stateful Switchover" feature module for more information:

You must enable nonstop forwarding on the routing protocols running between the provider (P) routers, provider edge (PE) routers, and customer edge (CE) routers. The routing protocols are:

- Border Gateway Protocol (BGP)
- Open Shortest Path First (OSPF)
- Intermediate System-to-Intermediate System (IS-IS)

See the Cisco Nonstop Forwarding feature module for more information.

## Restrictions for NSF SSO--MPLS LDP and LDP Graceful Restart

LDP NSF has the following restriction:

- LDP NSF cannot be configured on label-controlled ATM (LC-ATM) interfaces.

## Information About NSF SSO--MPLS LDP and LDP Graceful Restart

- [How NSF SSO--MPLS LDP and LDP Graceful Restart Works, page 14](#)
- [What Happens During an LDP Restart and an LDP Session Reset, page 15](#)
- [How a Route Processor Advertises That It Supports NSF SSO--MPLS LDP and LDP Graceful Restart, page 16](#)
- [What Happens if a Route Processor Does Not Have LDP Graceful Restart, page 16](#)
- [Checkpointing for NSF SSO--MPLS LDP and LDP Graceful Restart, page 16](#)

## How NSF SSO--MPLS LDP and LDP Graceful Restart Works

LDP NSF allows an RP to recover from disruption in service without losing its MPLS forwarding state. LDP NSF works under the following circumstances:

- LDP restart--An LDP Restart occurs after an SSO event interrupts LDP communication with all LDP neighbors. If the RPs are configured with LDP NSF, the backup RP retains the MPLS forwarding state and reestablishes communication with the LDP neighbors. Then the RP ensures that the MPLS forwarding state is recovered.
- LDP session reset--An LDP session reset occurs after an individual LDP session has been interrupted, but the interruption is not due to an SSO event. The LDP session might have been interrupted due to a TCP or UDP communication problem. If the RP is configured with MPLS LDP NSF support and

graceful restart, the RP associates a new session with the previously interrupted session. The LDP bindings and MPLS forwarding states are recovered when the new session is established.

If an SSO event occurs on an LSR, that LSR performs an LDP restart. The adjacent LSRs perform an LDP session reset.

See the following section for more information about LDP restart and reset.

## What Happens During an LDP Restart and an LDP Session Reset

In the topology shown in the figure below, the following elements have been configured:

- LDP sessions are established between Router 1 and Router 2, as well as between Router 2 and Router 3.
- A label switched path (LSP) has been established between Router 1 and Router 3.
- The routers have been configured with LDP NSF.

**Figure 3** Example of a Network Using LDP Graceful Restart



The following process shows how LDP recovers when one of the routers fails:

- 1 When an RP fails on Router 2, communications between the routers is interrupted.
- 2 Router 1 and Router 3 mark all the label bindings from Router 2 as stale, but they continue to use the bindings for MPLS forwarding.
- 3 Router 1 and Router 3 attempt to reestablish an LDP session with Router 2.
- 4 Router 2 restarts and marks all of its forwarding entries as stale. If you enter a **showmplsldpgraceful-restart** command, the command output includes the following line:

```
LDP is restarting gracefully.
```

- 1 Router 1 and Router 3 reestablish LDP sessions with Router 2, but they keep their stale label bindings. If you enter a **showmplsldpneighbor** command with the **graceful-restart** keyword, the command output displays the recovering LDP sessions.
- 2 All three routers readvertise their label binding information. If a label has been relearned after the session has been established, the stale flags are removed. The **showmplsforwarding-table** command displays the information in the MPLS forwarding table, including the local label, outgoing label or VC, prefix, label-switched bytes, outgoing interface, and next hop.

You can set various timers to limit how long the routers wait for an LDP session to be reestablished before restarting the router. See the following commands for more information:

- **mpls ldp graceful-restart timers forwarding-holding**
- **mpls ldp graceful-restart timers max-recovery**
- **mpls ldp graceful-restart timers neighbor-liveness**

## How a Route Processor Advertises That It Supports NSF SSO--MPLS LDP and LDP Graceful Restart

An RP that is configured to perform LDP NSF includes the Fault Tolerant (FT) Type Length Value (TLV) in the LDP initialization message. The RP sends the LDP initialization message to a neighbor to establish an LDP session.

The FT session TLV includes the following information:

- The Learn from Network (L) flag is set to 1, which indicates that the RP is configured to perform LDP Graceful Restart.
- The Reconnect Timeout field shows the time (in milliseconds) that the neighbor should wait for a reconnection if the LDP session is lost. This field is set to 120 seconds and cannot be configured.
- The Recovery Time field shows the time (in milliseconds) that the neighbor should retain the MPLS forwarding state during a recovery. If a neighbor did not preserve the MPLS forwarding state before the restart of the control plane, the neighbor sets the recovery time to 0.

## What Happens if a Route Processor Does Not Have LDP Graceful Restart

If an RP is not configured for MPLS LDP Graceful Restart and it attempts to establish an LDP session with an RP that is configured with LDP Graceful Restart, the following events occur:

- 1 The RP that is configured with MPLS LDP Graceful Restart sends an initialization message that includes the FT session TLV value to the RP that is not configured with MPLS LDP Graceful Restart.
- 2 The RP that is not configured for MPLS LDP Graceful Restart receives the LDP initialization message and discards the FT session TLV.
- 3 The two RPs create a normal LDP session but do not have the ability to perform MPLS LDP Graceful Restart.

You must enable all RPs with MPLS LDP Graceful Restart for an LDP session to be preserved during an interruption in service.

## Checkpointing for NSF SSO--MPLS LDP and LDP Graceful Restart

Checkpointing is a function that copies state information from the active RP to the backup RP, thereby ensuring that the backup RP has the latest information. If the active RP fails, the backup RP can take over.

For the LDP NSF feature, the checkpointing function copies the active RP's LDP local label bindings to the backup RP. The active RP sends updates to the backup RP when local label bindings are modified as a result of routing changes.



### Note

Local label bindings that are allocated by BGP and null local label bindings are not included in the checkpointing operation.

The checkpointing function is enabled by default.

To display checkpointing data, issue the **show mpls ldp graceful-restart** command on the active RP.

To check that the active and backup RPs have identical copies of the local label bindings, you can issue the **show mpls ldp bindings** command with the **detail** keyword on the active and backup RPs. This command displays the local label bindings that have been saved. The active RP and the backup RP should have the same local label bindings.

- [Troubleshooting Tips, page 17](#)

## Troubleshooting Tips

You can use the `debug mpls ldp graceful-restart` command to enable the display of MPLS LDP checkpoint events and errors.

# How to Configure and Use NSF SSO--MPLS LDP and LDP Graceful Restart

- [Configuring MPLS LDP Graceful Restart, page 17](#)
- [Verifying the MPLS LDP Graceful Restart Configuration, page 19](#)

## Configuring MPLS LDP Graceful Restart

To configure MPLS LDP Graceful Restart, perform the following task. MPLS LDP Graceful Restart (GR) is enabled globally. When you enable LDP GR, it has no effect on existing LDP sessions. LDP GR is enabled for new sessions that are established after the feature has been globally enabled.

- RPs must be configured for SSO. See the Stateful Switchover feature module for more information:
- You must enable Nonstop Forwarding on the routing protocols running between the P, PE, routers, and CE routers. See the Cisco Nonstop Forwarding feature module for more information.

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ip cef [distributed]`
4. `mpls ldp graceful-restart`
5. `interface type slot / subslot / port [, subinterface-number]`
6. `mpls ip`
7. `mpls label protocol ldp`
8. `exit`
9. `exit`

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b> <code>Router&gt; enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

Command or Action	Purpose
<p><b>Step 2</b> <code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <code>ip cef [distributed]</code></p> <p><b>Example:</b></p> <pre>Router(config)# ip cef distributed</pre>	<p>Enables distributed Cisco Express Forwarding.</p>
<p><b>Step 4</b> <code>mpls ldp graceful-restart</code></p> <p><b>Example:</b></p> <pre>Router (config)# mpls ldp graceful-restart</pre>	<p>Enables the router to protect the LDP bindings and MPLS forwarding state during a disruption in service.</p>
<p><b>Step 5</b> <code>interface type slot / subslot / port [, subinterface-number]</code></p> <p><b>Example:</b></p> <pre>Router(config)# interface pos 0/3/0</pre>	<p>Specifies an interface and enters interface configuration mode.</p>
<p><b>Step 6</b> <code>mpls ip</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# mpls ip</pre>	<p>Configures MPLS hop-by-hop forwarding for an interface.</p>
<p><b>Step 7</b> <code>mpls label protocol ldp</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# mpls label protocol ldp</pre>	<p>Configures the use of LDP for an interface. You must use LDP. You can also issue the <b>mpls label protocol ldp</b> command in global configuration mode, which enables LDP on all interfaces configured for MPLS.</p>
<p><b>Step 8</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# exit</pre>	<p>Exits interface configuration mode and returns to global configuration mode.</p>



Command or Action	Purpose
<b>Step 9</b> <code>exit</code>  <b>Example:</b>  <code>Router(config)# exit</code>	Exits global configuration mode and returns to privileged EXEC mode.

## Verifying the MPLS LDP Graceful Restart Configuration

Use the following procedure to verify that MPLS LDP Graceful Restart has been configured correctly.

### SUMMARY STEPS

1. `enable`
2. `show mpls ldp graceful-restart`
3. `show mpls ldp neighbor graceful restart`
4. `show mpls ldp checkpoint`
5. `exit`

### DETAILED STEPS

**Step 1** `enable`  
Use this command to enable privileged EXEC mode. Enter your password if prompted. For example:

**Example:**

```
Router> enable
Router#
```

**Step 2** `show mpls ldp graceful-restart`  
The command output displays Graceful Restart sessions and session parameters:

**Example:**

```
Router# show mpls ldp graceful-restart
LDP Graceful Restart is enabled
Neighbor Liveness Timer: 5 seconds
Max Recovery Time: 200 seconds
Down Neighbor Database (0 records):
Graceful Restart-enabled Sessions:
VRF default:
  Peer LDP Ident: 10.18.18.18:0, State: estab
  Peer LDP Ident: 10.17.17.17:0, State: estab
```

**Step 3** `show mpls ldp neighbor graceful restart`  
The command output displays the Graceful Restart information for LDP sessions:

**Example:**

```
Router# show mpls ldp neighbor graceful-restart
```

```
Peer LDP Ident: 10.20.20.20:0; Local LDP Ident 10.17.17.17:0
TCP connection: 10.20.20.20.16510 - 10.17.17.17.646
State: Oper; Msgs sent/rcvd: 8/18; Downstream
Up time: 00:04:39
Graceful Restart enabled; Peer reconnect time (msecs): 120000
Peer LDP Ident: 10.19.19.19:0; Local LDP Ident 10.17.17.17:0
TCP connection: 10.19.19.19.11007 - 10.17.17.17.646
State: Oper; Msgs sent/rcvd: 8/38; Downstream
Up time: 00:04:30
Graceful Restart enabled; Peer reconnect time (msecs): 120000
```

**Step 4** `show mpls ldp checkpoint`

The command output displays the summary of the checkpoint information:

**Example:**

```
Router# show mpls ldp checkpoint
Checkpoint status: dynamic-sync
Checkpoint resend timer: not running
5 local bindings in add-skipped
9 local bindings in added
1 of 15+ local bindings in none
```

**Step 5** `exit`

Use this command to return to user EXEC mode. For example:

**Example:**

```
Router# exit
Router>
```

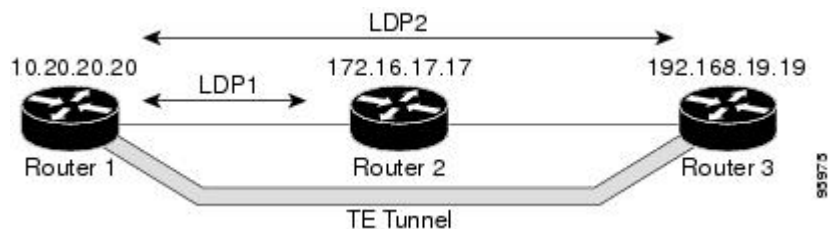
## Configuration Examples for NSF SSO--MPLS LDP and LDP Graceful Restart

- [Configuring NSF SSO--MPLS LDP and LDP Graceful Restart Example, page 20](#)

### Configuring NSF SSO--MPLS LDP and LDP Graceful Restart Example

The following configuration example shows the LDP NSF feature configured on three routers. (See the figure below.) In this configuration example, Router 1 creates an LDP session with Router 2. Router 1 also creates a targeted session with Router 3 through a TE tunnel using Router 2.

**Figure 4** *MPLS LDP: NSF/SSO Support and Graceful Restart Configuration Example*



**Router 1**

```

redundancy
mode sso
ip subnet-zero
ip cef distributed
mpls label range 16 10000 static 10001 1048575
mpls label protocol ldp
mpls ldp logging neighbor-changes
mpls ldp graceful-restart
mpls traffic-eng tunnels
no mpls traffic-eng auto-bw timers frequency 0
mpls ldp router-id Loopback0 force
!
interface Loopback0
 ip address 172.20.20.20 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Tunnell
 ip unnumbered Loopback0
 no ip directed-broadcast
 mpls label protocol ldp
 mpls ip
 tunnel destination 10.19.19.19
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng priority 7 7
 tunnel mpls traffic-eng bandwidth 500
 tunnel mpls traffic-eng path-option 1 dynamic
!
interface ATM0/1/0
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM0/1/0.5 point-to-point
 ip address 172.17.0.2 255.255.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 pvc 6/100
 encapsulation aal5snap
 mpls label protocol ldp
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 1000
!
router ospf 100
 log-adjacency-changes
 redistribute connected
 nsf enforce global
 network 172.17.0.0 0.255.255.255 area 100
 network 172.20.20.20 0.0.0.0 area 100
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 100

```

**Router 2**

```

redundancy
mode sso
!
ip cef distributed
no ip domain-lookup
mpls label range 17 10000 static 10001 1048575
mpls label protocol ldp
mpls ldp logging neighbor-changes
mpls ldp graceful-restart
mpls traffic-eng tunnels
no mpls traffic-eng auto-bw timers frequency 0

```

```

no mpls advertise-labels
mpls ldp router-id Loopback0 force
!
interface Loopback0
 ip address 172.18.17.17 255.255.255.255
 no ip directed-broadcast
!
interface ATM0/3/0
 no ip address
 no ip directed-broadcast
 no ip mroute-cache
 atm clock INTERNAL
 atm sonet stm-1
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
!
interface ATM0/3/0.5 point-to-point
 ip address 172.17.0.1 255.255.0.0
 no ip directed-broadcast
 no atm enable-ilmi-trap
 pvc 6/100
  encapsulation aal5snap
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ip
 ip rsvp bandwidth 1000
!
interface POS0/1/0
 ip address 10.0.0.1 255.0.0.0
 no ip directed-broadcast
 encapsulation ppp
 mpls label protocol ldp
 mpls traffic-eng tunnels
 mpls ip
 no peer neighbor-route
 clock source internal
 ip rsvp bandwidth 1000
!
router ospf 100
 log-adjacency-changes
  nsf enforce global
 redistribute connected
 network 10.0.0.0 0.255.255.255 area 100
 network 172.17.0.0 0.255.255.255 area 100
 network 172.18.17.17 0.0.0.0 area 100
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 100
!
ip classless

```

### Router 3

```

redundancy
mode sso
!
ip subnet-zero
ip cef distributed
!
no ip finger
no ip domain-lookup
mpls label protocol ldp
mpls ldp neighbor 10.11.11.11 targeted ldp
mpls ldp logging neighbor-changes
mpls ldp graceful-restart
mpls traffic-eng tunnels
no mpls traffic-eng auto-bw timers frequency 0
mpls ldp discovery directed-hello interval 12
mpls ldp discovery directed-hello holdtime 130
mpls ldp discovery directed-hello accept
mpls ldp router-id Loopback0 force
!
interface Loopback0

```

```

ip address 172.19.19.19 255.255.255.255
no ip directed-broadcast
!
interface POS1/1/0
ip address 10.0.0.2 255.0.0.0
no ip directed-broadcast
encapsulation ppp
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ip
no peer neighbor-route
clock source internal
ip rsvp bandwidth 1000
!
router ospf 100
log-adjacency-changes
  nsf enforce global
redistribute connected
network 10.0.0.0 0.255.255.255 area 100
network 172.19.19.19 0.0.0.0 area 100
mpls traffic-eng router-id Loopback0
mpls traffic-eng area 100
!
ip classless

```

## Additional References

The following sections provide references related to the NSF/SSO--MPLS LDP and LDP Graceful Restart feature.

### Related Documents

Related Topic	Document Title
Stateful switchover	Stateful Switchover
MPLS Label Distribution Protocol	MPLS Label Distribution Protocol (LDP)
MPLS LDP commands	<i>Cisco IOS Multiprotocol Label Switching Command Reference</i>
Cisco nonstop forwarding	Cisco Nonstop Forwarding
High availability commands	<i>Cisco IOS High Availability Command Reference</i>

### Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

**MIBs**

<b>MIB</b>	<b>MIBs Link</b>
MPLS Label Distribution Protocol MIB Version 8 Upgrade	To locate and download MIBs for selected platforms, Cisco IOS XE software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

<b>RFC</b>	<b>Title</b>
RFC 3036	<i>LDP Specification</i>
RFC 3478	<i>Graceful Restart Mechanism for Label Distribution</i>

**Technical Assistance**

<b>Description</b>	<b>Link</b>
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a>

## Feature Information for NSF SSO--MPLS LDP and LDP Graceful Restart

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 2**      **Feature Information for NSF/SSO--MPLS LDP and LDP Graceful Restart**

Feature Name	Releases	Feature Information
NSF/SSO--MPLS LDP and MPLS LDP Graceful Restart	Cisco IOS XE Release 2.1	<p data-bbox="1154 348 1516 758">Cisco Nonstop Forwarding (NSF) with Stateful Switchover (SSO) provides continuous packet forwarding, even during a network processor hardware or software failure. In a redundant system, the secondary processor recovers control plane service during a critical failure in the primary processor. SSO synchronizes the network state information between the primary and the secondary processor.</p> <p data-bbox="1154 774 1516 1213">Multiprotocol Label Switching (MPLS) Label Distribution Protocol (LDP) uses SSO, NSF, and graceful restart to allow a Route Processor (RP) to recover from disruption in control plane service (specifically, the LDP component) without losing its MPLS forwarding state. LDP NSF works with LDP sessions between directly connected peers and with peers that are not directly connected (targeted sessions).</p> <p data-bbox="1154 1230 1516 1352">In Cisco IOS XE Release 2.1, this feature was introduced on Cisco ASR 1000 Series Aggregation Services Routers.</p> <p data-bbox="1154 1369 1516 1818">The following commands were introduced or modified: <b>debug mpls ldp graceful-restart</b>, <b>mpls label protocol (global configuration)</b>, <b>mpls ldp graceful-restart</b>, <b>mpls ldp graceful-restart timers forwarding-holding</b>, <b>mpls ldp graceful-restart timers max-recovery</b>, <b>mpls ldp graceful-restart timers neighbor-liveness</b>, <b>show mpls ip binding</b>, <b>show mpls ldp bindings</b>, <b>show mpls ldp checkpoint</b>, <b>show mpls</b></p>

Feature Name	Releases	Feature Information
		<b>ldp graceful-restart, show mpls ldp neighbor.</b>

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.





## ISSU MPLS Clients

---

MPLS applications can be upgraded using the In Service Software Upgrade (ISSU) process. Thus, MPLS applications are considered ISSU's MPLS clients. The ISSU process allows Cisco IOS XE software to be updated or otherwise modified while packet forwarding continues.

- [Finding Feature Information, page 27](#)
- [Prerequisites for ISSU MPLS Clients, page 27](#)
- [Information About ISSU MPLS Clients, page 28](#)
- [How to Verify that an MPLS Client Can Support an In Service Software Upgrade, page 29](#)
- [Configuration Examples for ISSU MPLS Clients, page 31](#)
- [Additional References, page 38](#)
- [Feature Information for ISSU MPLS Clients, page 40](#)
- [Glossary, page 41](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for ISSU MPLS Clients

Before you perform an upgrade, you need to verify that the clients you are concerned about are compatible with the intended switchover. Use the commands listed in the [Verifying the ISSU Process for an MPLS Client, page 30](#) to determine compatibility.

The success performance of some clients in the upgraded network will depend upon their compatibility with other clients as described in the table below.

**Table 3**      **MPLS Client Interdependencies**

<b>This client . . .</b>	<b>...can only work when this client is shown to be compatible</b>
MPLS VPN	LSD Label Manager High Availability
LDP	LSD Label Manager High Availability
VRF (“Table ID”)	LSD Label Manager High Availability
LSD Label Manager High Availability	Base clients: Checkpointing and Redundancy Facility
MFI Pull	XDR
MFI Push	XDR
LSPV Push within OAM	XDR
TE	Base clients: <ul style="list-style-type: none"> <li>• Checkpointing and Redundancy Facility</li> <li>• MPLS TE High Availability</li> </ul>

## Information About ISSU MPLS Clients

Before examining ISSU coordination of MPLS clients, you should understand the following concepts:

This section provides information about upgrading MPLS-related applications through ISSU. Those MPLS applications are considered ISSU’s MPLS “clients.”

For more information on the ISSU procedure, see Cisco IOS XE In Service Software Upgrade Process document and see the [Cisco ASR 1000 Series Aggregation Services Routers Software Configuration Guide](#).

- [ISSU-Capable Protocols and Applications Clients, page 28](#)
- [ISSU-Capable MPLS Feature Sets, page 29](#)

## ISSU-Capable Protocols and Applications Clients

Protocols and applications that can be upgraded through the ISSU process are considered clients of ISSU. These include at least the following:

- Address Resolution Protocol (ARP)
- Asynchronous Transfer Mode (ATM)
- Cisco Express Forwarding
- Dynamic Host Configuration Protocol (DHCP)
- EtherChannel--port aggregation protocol (PagP) and Link Aggregation Control Protocol (LACP)
- Frame Relay (FR)
- Gateway Load Balancing Protocol (GLBP)
- High-Level Data Link Control (HDLC)

- Hot Standby Router Protocol (HSRP)
- IEEE 802.1x and 802.3af
- Internet Group Management Protocol (IGMP) snooping
- IP host
- Intermediate System-to-Intermediate System (IS-IS)
- Multiprotocol Label Switching (MPLS)
- PPP and Multilink PPP
- Port security
- Quality of service (QoS)
- Remote File System (RFS) versioning
- Simple Network Management Protocol (SNMP)
- Spanning Tree Protocol (STP)

**Note**

---

For a complete list of ISSU- compliant protocols and applications that are supported for the Cisco ASR Series Routers for your release, see the Release Notes for Cisco ASR Series Aggregation Services Routers .

---

## ISSU-Capable MPLS Feature Sets

Within the MPLS technology, ISSU supports the following feature sets as clients:

- Label Distribution Protocol (LDP)
- MPLS Virtual Private Network (MPLS VPN)
- VPN routing and forwarding (VRF), also called the “Table ID” client
- Label Switching Database Label Manager for high availability, usually called “LSD Label Manager for HA”
- MPLS Forwarding Infrastructure Pull, called “MFI Pull”
- MPLS Forwarding Infrastructure Push, called “MFI Push”
- Label Switched Path Verification Push within Operation, Administration, and Management (OAM), called “LSPV Push”
- TE

## How to Verify that an MPLS Client Can Support an In Service Software Upgrade

**Note**

---

For the complete task sequence that accomplishes ISSU see the [Cisco ASR 1000 Series Aggregation Services Routers Software Configuration Guide](#) .

---

- [Verifying the ISSU Process for an MPLS Client, page 30](#)

## Verifying the ISSU Process for an MPLS Client

Perform this task to verify that a particular MPLS client can be upgraded successfully during a particular ISSU session. The commands in this task also can be used to display other details about the ISSU MPLS clients, and should be entered in the order described.

Ensure that you have successfully loaded new Cisco IOS XE software onto the standby processor as described in the [Cisco ASR 1000 Series Aggregation Services Routers Software Configuration Guide](#).

### SUMMARY STEPS

1. **enable**
2. **show issu clients**
3. **show issu sessions** *clientID*
4. **show issu negotiated version** *sessionID*
5. **show issu negotiated capability** *sessionID*
6. **show issu message types** *clientID*

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <b>show issu clients</b>  <b>Example:</b> Router# show issu clients	Lists network applications and protocols currently supported by ISSU. <ul style="list-style-type: none"> <li>• You can use this command to discover the client ID that you will need to enter in Steps 3 and 6.</li> </ul>
<b>Step 3</b> <b>show issu sessions</b> <i>clientID</i>  <b>Example:</b> Router# show issu sessions 2002	Displays detailed information about a particular ISSU client that includes whether a particular client is compatible with the intended upgrade. <ul style="list-style-type: none"> <li>• You can use this command to discover the session ID that you will need to enter in Steps 4 and 5.</li> </ul>
<b>Step 4</b> <b>show issu negotiated version</b> <i>sessionID</i>  <b>Example:</b> Router# show issu negotiated version 33	Displays details of the session's negotiated message version.

Command or Action	Purpose
<p><b>Step 5</b> <code>show issu negotiated capability sessionID</code></p> <p><b>Example:</b></p> <pre>Router# show issu negotiated capability 33</pre>	Displays results of a negotiation about the client application's capabilities.
<p><b>Step 6</b> <code>show issu message types clientID</code></p> <p><b>Example:</b></p> <pre>Router# show issu message types 2002</pre>	Displays the message formats ("types") and versions supported by the specified client.

## Configuration Examples for ISSU MPLS Clients

To examine any ISSU client, you must specify its unique client ID when entering the `show issu sessions` command. If you do not already know that client ID, enter the `show issu clients` command in user EXEC or privileged EXEC mode. Each ISSU client on the network will then be listed, with its client ID and client name on the same line, as shown in the following example:

```
Router# show issu clients
Client_ID = 2, Client_Name = ISSU Proto client, Entity_Count = 1
Client_ID = 3, Client_Name = ISSU RF, Entity_Count = 1
Client_ID = 4, Client_Name = ISSU CF client, Entity_Count = 1
Client_ID = 5, Client_Name = ISSU Network RF client, Entity_Count = 1
Client_ID = 7, Client_Name = ISSU CONFIG SYNC, Entity_Count = 1
Client_ID = 8, Client_Name = ISSU ifIndex sync, Entity_Count = 1
Client_ID = 9, Client_Name = ISSU IPC client, Entity_Count = 1
Client_ID = 10, Client_Name = ISSU IPC Server client, Entity_Count = 1
Client_ID = 11, Client_Name = ISSU Red Mode Client, Entity_Count = 1
Client_ID = 12, Client_Name = ISSU EHSA services client, Entity_Count = 1
Client_ID = 100, Client_Name = ISSU rfs client, Entity_Count = 1
Client_ID = 110, Client_Name = ISSU ifs client, Entity_Count = 1
Client_ID = 1001, Client_Name = OC3POS-6, Entity_Count = 4
Client_ID = 1002, Client_Name = C10K ATM, Entity_Count = 1
Client_ID = 1003, Client_Name = C10K CHSTM1, Entity_Count = 1
Client_ID = 1004, Client_Name = C10K CT3, Entity_Count = 1
Client_ID = 1005, Client_Name = C10K GE, Entity_Count = 1
Client_ID = 1006, Client_Name = C10K ET, Entity_Count = 1
Client_ID = 1007, Client_Name = C10K CHE1T1, Entity_Count = 1
Client_ID = 1009, Client_Name = C10K MFE, Entity_Count = 1
Client_ID = 1010, Client_Name = C10K APS, Entity_Count = 1
Client_ID = 1013, Client_Name = C10K CARD OIR, Entity_Count = 1
Client_ID = 2002, Client_Name = CEF Push ISSU client, Entity_Count = 1
Client_ID = 2003, Client_Name = ISSU XDR client, Entity_Count = 1
Client_ID = 2004, Client_Name = ISSU SNMP client, Entity_Count = 1
Client_ID = 2005, Client_Name = ISSU HDLC Client, Entity_Count = 1
Client_ID = 2006, Client_Name = ISSU QoS client, Entity_Count = 1
Client_ID = 2007, Client_Name = ISSU LSD Label Mgr HA Client, Entity_Count = 1
Client_ID = 2008, Client_Name = ISSU Tableid Client, Entity_Count = 1
Client_ID = 2009, Client_Name = ISSU MPLS VPN Client, Entity_Count = 1
Client_ID = 2010, Client_Name = ARP HA, Entity_Count = 1
Client_ID = 2011, Client_Name = ISSU LDP Client, Entity_Count = 1
Client_ID = 2012, Client_Name = ISSU HSRP Client, Entity_Count = 1
Client_ID = 2013, Client_Name = ISSU ATM Client, Entity_Count = 1
Client_ID = 2014, Client_Name = ISSU FR Client, Entity_Count = 1
Client_ID = 2015, Client_Name = ISSU REDSSOC client, Entity_Count = 1
```

```

Client_ID = 2019, Client_Name = ISSU TCP client, Entity_Count = 1
Client_ID = 2020, Client_Name = ISSU BGP client, Entity_Count = 1
Client_ID = 2021, Client_Name = XDR Int Priority ISSU client, Entity_Count = 1
Client_ID = 2022, Client_Name = XDR Proc Priority ISSU client, Entity_Count = 1
Client_ID = 2023, Client_Name = FIB HWIDB ISSU client, Entity_Count = 1
Client_ID = 2024, Client_Name = FIB IDB ISSU client, Entity_Count = 1
Client_ID = 2025, Client_Name = FIB HW subblock ISSU client, Entity_Count = 1
Client_ID = 2026, Client_Name = FIB SW subblock ISSU client, Entity_Count = 1
Client_ID = 2027, Client_Name = Adjacency ISSU client, Entity_Count = 1
Client_ID = 2028, Client_Name = FIB IPV4 ISSU client, Entity_Count = 1
Client_ID = 2030, Client_Name = MFI Pull ISSU client, Entity_Count = 1
Client_ID = 2031, Client_Name = MFI Push ISSU client, Entity_Count = 1
Client_ID = 2051, Client_Name = ISSU CCM Client, Entity_Count = 1
Client_ID = 2052, Client_Name = ISSU PPP SIP CCM Client, Entity_Count = 1
Client_ID = 2053, Client_Name = ISSU MPLS TE Client, Entity_Count = 1
Client_ID = 2054, Client_Name = ISSU process client, Entity_Count = 1
Client_ID = 2089, Client_Name = MPLS LSPV Push client, Entity_Count = 1
.
.
.

```

Base Clients:

```

Client_Name = ISSU Proto client
Client_Name = ISSU RF
Client_Name = ISSU CF client
Client_Name = ISSU Network RF client
Client_Name = ISSU CONFIG SYNC
Client_Name = ISSU ifIndex sync
Client_Name = ISSU IPC client
Client_Name = ISSU IPC Server client
Client_Name = ISSU Red Mode Client
Client_Name = ISSU EHSA services client
Client_Name = ISSU rfs client
Client_Name = ISSU ifs client
Client_Name = ISSU EM client
Client_Name = ISSU Platform Medialayer Client
Client_Name = ISSU FM Client
Client_Name = ISSU TCAM Manager Client
Client_Name = ISSU L2 Cmn Client
Client_Name = ISSU L3 Manager HA Client
Client_Name = ISSU L3 Manager Client
Client_Name = ISSU CFIB BASE Client
Client_Name = ISSU PF CONFIG SYNC Client
Client_Name = ISSU MLS CEF Client
Client_Name = ISSU Cat6k Logger Client

```

- [Verifying the ISSU Process for an MPLS LDP Client Example, page 32](#)
- [Verifying the ISSU Process for an MPLS VPN Client Example, page 33](#)
- [Verifying the ISSU Process for an MPLS VRF \(Table ID\) Client Example, page 34](#)
- [Verifying the ISSU Process for an MPLS LSD Label Manager HA Client Example, page 35](#)
- [Verifying the ISSU Process for an MPLS MFI Pull Client Example, page 35](#)
- [Verifying the ISSU Process for an MPLS MFI Push Client Example, page 36](#)
- [Verifying the ISSU Process for an MPLS LSPV Push Client Example, page 37](#)
- [Verifying the ISSU Process for an MPLS TE Client Example, page 38](#)

## Verifying the ISSU Process for an MPLS LDP Client Example

This example shows how to verify the ISSU process for an LDP client.

The first command shows you whether the LDP client's old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```

Router# show issu sessions 2011
-----
Client_ID = 2011, Entity_ID = 1 :
*** Session_ID = 46, Session_Name = LDP Session :

```

```

Peer   Peer   Negotiate   Negotiated   Cap   Msg   Session
UniqueID Sid   Role       Result      GroupID GroupID Signature
  4     34   PRIMARY    COMPATIBLE  1     1     0
                    (no policy)
Negotiation Session Info for This Message Session:
  Nego_Session_ID = 46
  Nego_Session_Name = LDP Session
  Transport_Mtu = 3948

```

Now you can take the session ID displayed in the previous command's output and enter it into the next command, to see the negotiated message version:

```

Router# show issu negotiated version 46
Session_ID = 46 :
  Message_Type = 1, Negotiated_Version = 2, Message_MTU = 20
  Message_Type = 2, Negotiated_Version = 2, Message_MTU = 20
  Message_Type = 3, Negotiated_Version = 2, Message_MTU = 4

```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```

Router# show issu negotiated capability 46
Session_ID = 46 :
  Negotiated_Cap_Entry = 1

```

Finally, to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```

Router# show issu message types 2011
-----
Client_ID = 2011, Entity_ID = 1 :
  Message_Type = 1, Version_Range = 2 ~ 2
    Message_Ver = 2, Message_Mtu = 20
  Message_Type = 2, Version_Range = 2 ~ 2
    Message_Ver = 2, Message_Mtu = 20
  Message_Type = 3, Version_Range = 2 ~ 2
    Message_Ver = 2, Message_Mtu = 4

```

## Verifying the ISSU Process for an MPLS VPN Client Example

This example shows how to verify the ISSU process for an MPLS VPN client.

The first command shows you whether the VPN client's old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```

Router# show issu sessions 2009
-----
Client_ID = 2009, Entity_ID = 1 :
*** Session_ID = 39, Session_Name = MPLS VPN ISSU Session :
Peer   Peer   Negotiate   Negotiated   Cap   Msg   Session
UniqueID Sid   Role       Result      GroupID GroupID Signature
  3     33   PASSIVE    COMPATIBLE  1     1     0
                    (no policy)
Negotiation Session Info for This Message Session:
  Nego_Session_ID = 39
  Nego_Session_Name = MPLS VPN ISSU Session
  Transport_Mtu = 3980

```

Now you can take the session ID displayed in the previous command's output and enter it into the next command, in order to see the negotiated message version:

```

Router# show issu negotiated version 39
Session_ID = 39 :
  Message_Type = 1, Negotiated_Version = 1, Message_MTU = 32

```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```
Router# show issu negotiated capability 39
Session_ID = 39 :
Negotiated_Cap_Entry = 1
```

Finally, to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```
Router# show issu message types 2009
-----
Client_ID = 2009, Entity_ID = 1 :
  Message_Type = 1, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 32
```

## Verifying the ISSU Process for an MPLS VRF (Table ID) Client Example

This example shows how to verify the ISSU process for an MPLS VRF (“Table ID”) client.

The first command shows you whether the VRF client’s old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```
Router# show issu sessions 2008
-----
Client_ID = 2008, Entity_ID = 1 :
*** Session_ID = 19, Session_Name = TABLEID ISSU CF :
  Peer Peer Negotiate Negotiated Cap Msg Session
  UniqueID Sid Role Result GroupID GroupID Signature
  4 13 PRIMARY COMPATIBLE 1 1 0
      (no policy)
Negotiation Session Info for This Message Session:
  Nego_Session_ID = 19
  Nego_Session_Name = TABLEID ISSU CF
  Transport_Mtu = 3948
```

Now you can take the session ID displayed in the previous command’s output and enter it into the next command, in order to see the negotiated message version:

```
Router# show issu negotiated version 19
Session_ID = 19 :
  Message_Type = 1, Negotiated_Version = 1, Message_MTU = 44
  Message_Type = 2, Negotiated_Version = 1, Message_MTU = 4
```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```
Router# show issu negotiated capability 19
Session_ID = 19 :
Negotiated_Cap_Entry = 1
```

Finally, to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```
Router# show issu message types 2008
-----
Client_ID = 2008, Entity_ID = 1 :
  Message_Type = 1, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 44
  Message_Type = 2, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 4
```



## Verifying the ISSU Process for an MPLS LSD Label Manager HA Client Example

This example shows how to verify the ISSU process for an MPLS LSD Label Manager HA client.

The first command shows you whether the LSD client's old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```
Router# show issu sessions 2007
-----
Client_ID = 2007, Entity_ID = 1 :
*** Session_ID = 40, Session_Name = lsd_ha :
  Peer Peer Negotiate Negotiated Cap      Msg      Session
  UniqueID Sid  Role      Result  GroupID GroupID Signature
   4      30  PRIMARY  COMPATIBLE  1      1      0
                        (policy)
  Negotiation Session Info for This Message Session:
    Nego_Session_ID = 40
    Nego_Session_Name = lsd_ha
    Transport_Mtu = 3948
    Compat_Result: raw_result = COMPATIBLE, policy_result = COMPATIBLE
```

Now you can take the session ID displayed in the previous command's output and enter it into the next command, in order to see the negotiated message version:

```
Router# show issu negotiated version 40
Session_ID = 40 :
  Message_Type = 1, Negotiated_Version = 2, Message_MTU = 8
```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```
Router# show issu negotiated capability 40
-----
Client_ID = 2007, Entity_ID = 1, Session_ID = 40 :
  Negotiated_Cap_Entry = 1
```

Finally, to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```
Router# show issu message types 2007
-----
Client_ID = 2007, Entity_ID = 1 :
  Message_Type = 1, Version_Range = 1 ~ 2
    Message_Ver = 1, Message_Mtu = 12
    Message_Ver = 2, Message_Mtu = 8
```

## Verifying the ISSU Process for an MPLS MFI Pull Client Example

This example shows how to verify the ISSU process for an MPLS MFI Pull client.

The first command shows you whether the MFI Pull client's old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```
Router# show issu sessions 2030
-----
Client_ID = 2030, Entity_ID = 1 :
*** Session_ID = 131073, Session_Name = MFI Pull      (6):
  Peer Peer Negotiate Negotiated Cap      Msg      Session
  UniqueID Sid  Role      Result  GroupID GroupID Signature
   7      35  PRIMARY  COMPATIBLE  1      1      0
```

```

                                (no policy)
Negotiation Session Info for This Message Session:
  Nego_Session_ID = 131073
  Nego_Session_Name = MFI Pull                                (6)
  Transport_Mtu = 4056

```

Now you can take the session ID displayed in the previous command's output and enter it into the next command, in order to see the negotiated message version:

```

Router# show issu negotiated version 131073
  Session_ID = 131073:
  Message_Type = 1006, Negotiated_Version = 1, Message_MTU = 4
  Message_Type = 3003, Negotiated_Version = 1, Message_MTU = 12

```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```

Router# show issu negotiated capability 131073
  Session_ID = 131073 :
  Negotiated_Cap_Entry = 1

```

Finally to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```

Router# show issu message types 2030
-----
Client_ID = 2030, Entity_ID = 1 :
Message_Type = 1006, Version_Range = 1 ~ 1
  Message_Ver = 1, Message_Mtu = 4
Message_Type = 2004, Version_Range = 1 ~ 1
  Message_Ver = 1, Message_Mtu = 12

```

## Verifying the ISSU Process for an MPLS MFI Push Client Example

This example shows how to verify the ISSU process for an MPLS MFI Push client.

The first command shows you whether the MFI Push client's old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```

Router# show issu sessions 2031
-----
Client_ID = 2031, Entity_ID = 1 :
*** Session_ID = 196646, Session_Name = MFI Push            (6):
  Peer Peer Negotiate Negotiated Cap Msg Session
UniqueID Sid Role Result GroupID GroupID Signature
  7 36 PRIMARY COMPATIBLE 1 1 0
                                (no policy)
Negotiation Session Info for This Message Session:
  Nego_Session_ID = 196646
  Nego_Session_Name = MFI Push                                (6)
  Transport_Mtu = 4056

```

Now you can take the session ID displayed in the previous command's output and enter it into the next command, in order to see the negotiated message version:

```

Router# show issu negotiated version 196646
Session_ID = 196646:
  Message_Type = 101, Negotiated_Version = 1, Message_MTU = 17
  Message_Type = 105, Negotiated_Version = 1, Message_MTU = 31

```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```

Router# show issu negotiated capability 196646
Session_ID = 196646 :
  Negotiated_Cap_Entry = 1

```

Finally to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```
Router# show issu message types 2031
-----
Client_ID = 2031, Entity_ID = 1 :
  Message_Type = 5002, Version_Range = 1 ~ 2
    Message_Ver = 1, Message_Mtu = 10
  Message_Type = 5018, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 39
```

## Verifying the ISSU Process for an MPLS LSPV Push Client Example

This example shows how to verify the ISSU process for an MPLS LSPV Push client.

The first command shows you whether the LSPV Push client's old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```
Router# show issu sessions 2089
-----
Client_ID = 2089, Entity_ID = 1 :
*** Session_ID = 45, Session_Name = MPLS LSPV Push (6 ) :
  Peer Peer Negotiate Negotiated Cap Msg Session
  UniqueID Sid Role Result GroupID GroupID Signature
    7 36 PRIMARY COMPATIBLE 1 1 0
      (no policy)
  Negotiation Session Info for This Message Session:
    Nego_Session_ID = 45
    Nego_Session_Name = MPLS LSPV Push (6 )
    Transport_Mtu = 1438
```

Now you can take the session ID displayed in the previous command's output and enter it into the next command, in order to see the negotiated message version:

```
Router# show issu negotiated version 45
Session_ID = 45:
  Message_Type = 0, Negotiated_Version = 1, Message_MTU = 74
  Message_Type = 1, Negotiated_Version = 1, Message_MTU = 120
  Message_Type = 2, Negotiated_Version = 1, Message_MTU = 120
  Message_Type = 3, Negotiated_Version = 1, Message_MTU = 5122
  Message_Type = 4, Negotiated_Version = 1, Message_MTU = 6
```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```
Router# show issu negotiated capability 45
Session_ID = 45:
Cap_Type = 0 Cap_Result = 1 No cap value assigned
```

Finally to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```
Router# show issu message types 2089
-----
Client_ID = 2089, Entity_ID = 1 :
  Message_Type = 0, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 74
  Message_Type = 1, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 120
  Message_Type = 2, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 120
  Message_Type = 3, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 5122
  Message_Type = 4, Version_Range = 1 ~ 1
    Message_Ver = 1, Message_Mtu = 6
```

## Verifying the ISSU Process for an MPLS TE Client Example

This example shows how to verify the ISSU process for an MPLS TE client.

The first command shows you whether the TE client's old and new software versions are compatible, and therefore are able to make use of the ISSU opportunity:

```
Router# show issu sessions 2053
-----
Client_ID = 2053, Entity_ID = 1 :
*** Session_ID = 84, Session_Name = RSVP HA Session :
  Peer Peer Negotiate Negotiated Cap      Msg      Session
UniqueID Sid  Role      Result  GroupID GroupID Signature
  22    94  PRIMARY  COMPATIBLE  1        1        0
                               (no policy)
Negotiation Session Info for This Message Session:
  Nego_Session_ID = 84
  Nego_Session_Name = RSVP HA Session
  Transport_Mtu = 1392
```

Now you can take the session ID displayed in the previous command's output and enter it into the next command, in order to see the negotiated message version:

```
Router# show issu negotiated version 84
Session_ID = 84 :
  Message_Type = 1, Negotiated_Version = 2, Message_MTU = 1024
```

Next you can enter the same session ID into the following command to display the capability negotiation result:

```
Router# show issu negotiated capability 84
Session_ID = 84 :
  Cap_Type = 0, Cap_Result = 1 No cap value assigned
```

Finally to see which message types and versions are supported by this particular client, you enter the client ID into the following command:

```
Router# show issu message types 2053
-----
Client_ID = 2053, Entity_ID = 1 :
  Message_Type = 1, Version_Range = 1 ~ 2
    Message_Ver = 1, Message_Mtu = 1024
    Message_Ver = 2, Message_Mtu = 1024
```

## Additional References

The following sections provide references related to the ISSU MPLS Clients feature.

### Related Documents

Related Topic	Document Title
ISSU process	<ul style="list-style-type: none"> <li>Cisco IOS XE In Service Software Upgrade Process</li> <li><a href="#">Cisco ASR 1000 Series Aggregation Services Routers Software Configuration Guide</a></li> </ul>

Related Topic	Document Title
<i>High availability commands</i>	<i>Cisco IOS High Availability Command Reference</i>

### Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature	--

### MIBs

MIB	MIBs Link
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature	To locate and download MIBs for selected platforms, Cisco IOS XE software releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature	--

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a>

## Feature Information for ISSU MPLS Clients

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 4**      **Feature Information for ISSU MPLS Clients**

Feature Name	Releases	Feature Information
ISSU MPLS--LDP	Cisco IOS XE Release 2.1	<p>This feature allows In Service Software Upgrade (ISSU) support for the Label Distribution Protocol (LDP) and Multiprotocol Label Switching (MPLS) Forwarding.</p> <p>MPLS applications can be upgraded using the In Service Software Upgrade (ISSU) process. Thus, MPLS applications are considered ISSU's MPLS clients. The ISSU process allows Cisco IOS XE software to be updated or otherwise modified while packet forwarding continues.</p> <p>In Cisco IOS XE Release 2.1, this feature was introduced on Cisco ASR 1000 Series Aggregation Services Routers.</p> <p>The following commands were introduced or modified: <b>show issu clients</b>, <b>show issu entities</b>, <b>show issu message types</b>, <b>show issu negotiated</b>, <b>show issu outage</b>, <b>show issu sessions</b>.</p>

Feature Name	Releases	Feature Information
ISSU--MPLS VPN (Support for IPv4 VPNs)	Cisco IOS XE Release 2.1	<p>This feature supports In Service Software Upgrade (ISSU) for Multiprotocol Label Switching (MPLS) Virtual Private networks (VPNs) for IPv4 address families only.</p> <p>In Cisco IOS XE Release 2.1, this feature was introduced on Cisco ASR 1000 Series Aggregation Services Routers.</p> <p>No commands were introduced or modified for this feature.</p>
ISSU--MPLS TE	Cisco IOS XE Release 2.3	<p>This feature allows upgrade or downgrade of compatible Cisco IOS XE software images on the back up Route Processor (RP) while the device is operational and passing traffic on Multiprotocol Label Switching (MPLS) traffic engineering (TE) tunnels.</p> <p>In Cisco IOS XE Release 2.3, this feature was introduced on Cisco ASR 1000 Series Aggregation Services Routers.</p> <p>No commands were introduced or modified for this feature.</p>

## Glossary

- IS--intermediate system.
- ISSU--In Service Software Upgrade.
- LACP--Link Aggregation Control Protocol.
- LDP--Label Distribution Protocol.
- MFI--Multiprotocol Label Switching Forwarding Infrastructure.
- MPLS--Multiprotocol Label Switching.
- OAM--Operation, Administration, and Management.
- PagP--port aggregation Protocol.
- PPP--Point to Point protocol.
- RP--Route Processor.
- RSVP GR--Resource Reservation Protocol graceful restart.

TE--traffic engineering.

VPN--Virtual Private Network.

VRF--virtual routing and forwarding.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.





# MPLS Traffic Engineering--RSVP Graceful Restart

---

The MPLS Traffic Engineering--RSVP Graceful Restart feature allows a neighboring Route Processor (RP) to recover from disruption in control plane service (specifically, the Label Distribution Protocol [LDP] component) without losing its Multiprotocol Label Switching (MPLS) forwarding state.

- [Finding Feature Information, page 43](#)
- [Prerequisites for MPLS TE--RSVP Graceful Restart, page 43](#)
- [Restrictions for MPLS TE--RSVP Graceful Restart, page 44](#)
- [Information About MPLS TE--RSVP Graceful Restart, page 44](#)
- [How to Configure MPLS TE--RSVP Graceful Restart, page 46](#)
- [Configuration Examples for MPLS TE--RSVP Graceful Restart, page 51](#)
- [Additional References, page 51](#)
- [Feature Information for MPLS Traffic Engineering--RSVP Graceful Restart, page 53](#)
- [Glossary, page 54](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for MPLS TE--RSVP Graceful Restart

Perform the following tasks on routers before configuring the MPLS Traffic Engineering--RSVP Graceful Restart feature:

- Configure the Resource Reservation Protocol (RSVP).
- Enable MPLS.
- Configure traffic engineering (TE).
- Enable graceful restart.

If you have many tunnels/LSPs (100 or more) or if you have a large-scale network, the following configuration is recommended:

```
ip rsvp signalling refresh reduction
ip rsvp signalling rate-limit period 50 burst 16 maxsize 3000 limit 37
ip rsvp signalling patherr state-removal
ip rsvp signalling initial-retransmit-delay 15000
```

Additional info about these RSVP commands can be found in the *Cisco IOS Quality of Service Command Reference*.

## Restrictions for MPLS TE--RSVP Graceful Restart

- Graceful restart supports node failure only.
- Graceful restart does not support restart or recovery on Cisco nodes, but helps in recovering a neighbor that is restart capable. Cisco routers advertise a restart time of 5 milliseconds (ms) and a recovery time of 0 in hello messages.
- Unnumbered interfaces are not supported.

## Information About MPLS TE--RSVP Graceful Restart

- [Graceful Restart](#), page 44
- [Graceful Restart Benefits](#), page 46

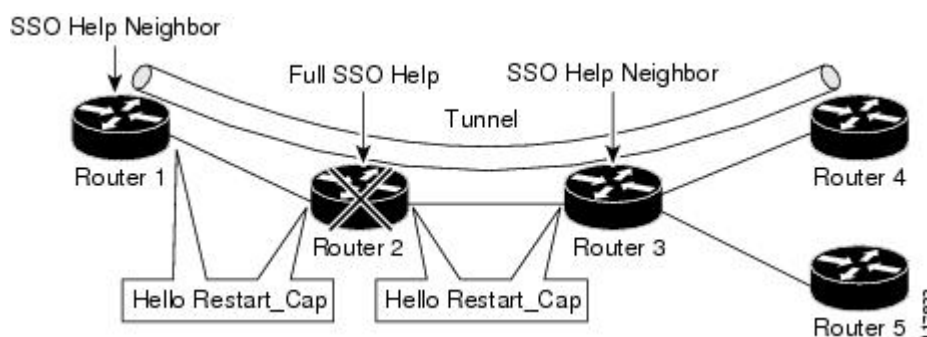
## Graceful Restart

Graceful restart allows RSVP TE enabled nodes to start gracefully following a node failure in the network such that the RSVP state after the failure is restored as quickly as possible. The node failure may be completely transparent to other nodes in the network as far as the RSVP state is concerned.

Graceful restart preserves the label values and forwarding information and works with third-party or Cisco routers seamlessly.

Graceful restart depends on RSVP hello messages that include Hello Request or Hello Acknowledgment (ACK) objects between two neighbors.

The figure below shows the graceful restart extension to these messages that an object called `Restart_Cap`, which tells neighbors that a node, may be capable of restarting if a failure occurs. The time-to-live (TTL) in these messages is set to 255 so that adjacencies can be maintained through alternate paths even if the link between two neighbors goes down.



The Restart\_Cap object has two values--the restart time, which is the sender's time to restart the RSVP\_TE component and exchange hello messages after a failure; and the recovery time, which is the desired time that the sender wants the receiver to synchronize the RSVP and MPLS databases.

In the figure above, graceful restart is enabled on Router 1, Router 2, Router 3, and Router 4. For simplicity, assume that all routers are restart capable. A TE label switched path (LSP) is signaled from Router 1 to Router 4.

Router 2 and Router 3 exchange periodic graceful restart hello messages every 10,000 ms (10 seconds), and so do Router 2 and Router 1 and Router 3 and Router 4. Assume that Router 2 advertises its restart time as 60,000 ms (60 seconds) and its recovery time as 60,000 ms (60 seconds) as shown in the following example:

```
23:33:36: Outgoing Hello:
23:33:36:   version:1 flags:0000 cksum:883C ttl:255 reserved:0 length:32
23:33:36:   HELLO                               type HELLO REQUEST length 12:
23:33:36:   Src_Instance: 0x6EDA8BD7, Dst_Instance: 0x00000000
23:33:36:   RESTART_CAP                             type 1 length 12:
23:33:36:   Restart_Time: 0x0000EA60
, Recovery_Time: 0x0000EA60
```

**Note**

The restart and recovery time are shown in **bold** in the last entry.

Router 3 records this into its database. Also, both neighbors maintain the neighbor status as UP. However, Router 3's control plane fails at some point (for example, a Primary Route Processor failure). As a result, RSVP and TE lose their signaling information and states although data packets continue to be forwarded by the line cards.

When four ACK messages are missed from Router 2 (40 seconds), Router 3 declares communication with Router 2 lost "indicated by LOST" and starts the restart time to wait for the duration advertised in Router 2's restart time previously and recorded (60 seconds). Router 1 and Router 2 suppress all RSVP messages to Router 3 except hellos. Router 3 keeps sending the RSVP Path and Resv refresh messages to Router 4 and Router 5 so that they do not expire the state for the LSP; however, Router 3 suppresses these messages for Router 2.

**Note**

A node restarts if it misses four ACKs or its hello src\_instance (last source instance sent to its neighbor) changes so that its restart time = 0.

Before the restart time expires, Router 2 restarts and loads its configuration and graceful restart makes the configuration of router 2 send the hello messages with a new source instance to all the data links attached. However, because Router 2 has lost the neighbor states, it does not know what destination instance it should use in those messages; therefore, all destination instances are set to 0.

When Router 3 sees the hello from Router 2, Router 3 stops the restart time for Router 2 and sends an ACK message back. When Router 3 sees a new source instance value in Router 2's hello message, Router 3 knows that Router 2 had a control plane failure. Router 2 gets Router 3's source instance value and uses it as the destination instance going forward.

Router 3 also checks the recovery time value in the hello message from Router 2. If the recovery time is 0, Router 3 knows that Router 2 was not able to preserve its forwarding information and Router 3 deletes all RSVP state that it had with Router 2.

If the recovery time is greater than 0, Router 1 sends Router 2 Path messages for each LSP that it had previously sent through Router 2. If these messages were previously refreshed in summary messages, they

are sent individually during the recovery time. Each of these Path messages includes a Recovery\_Label object containing the label value received from Router 2 before the failure.

When Router 3 receives a Path message from Router 2, Router 3 sends a Resv message upstream. However, Router 3 suppresses the Resv message until it receives a Path message.

## Graceful Restart Benefits

- Graceful restart allows a node to recover state information from its neighbor when there is an RP failure or the device has undergone a stateful switchover (SSO).
- Graceful restart allows session information recovery with minimal disruption to the network.
- A node can perform a graceful restart to help a neighbor recover its state by keeping the label bindings and state information to provide a quick recovery of the failed node and not affect the traffic that is currently forwarded.

## How to Configure MPLS TE--RSVP Graceful Restart

- [Enabling Graceful Restart, page 46](#)
- [Setting a DSCP Value on a Router for MPLS TE Graceful Restart, page 47](#)
- [Setting a Hello Refresh Interval for MPLS TE Graceful Restart, page 48](#)
- [Setting a Missed Refresh Limit for MPLS TE Graceful Restart, page 49](#)
- [Verifying Graceful Restart Configuration, page 50](#)

## Enabling Graceful Restart

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ip RSVP signalling hello graceful-restart mode help-neighbor`
4. `exit`

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b>  Router> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

Command or Action	Purpose
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b> <code>ip rsvp signalling hello graceful-restart mode help-neighbor</code>  <b>Example:</b> <pre>Router(config)# ip rsvp signalling hello graceful- restart mode help-neighbor</pre>	Sets the number of DSCP hello messages on a neighboring router with restart capability.
<b>Step 4</b> <code>exit</code>  <b>Example:</b> <pre>Router(config)# exit</pre>	Exits to privileged EXEC mode.

**Note**

If you have many tunnels/LSPs (100 or more) or if you have a large-scale network, the following configuration is recommended:

```
ip rsvp signalling refresh reduction
ip rsvp signalling rate-limit period 50 burst 16 maxsize 3000 limit 37
ip rsvp signalling patherr state-removal
ip rsvp signalling initial-retransmit-delay 15000
```

Additional info about these RSVP commands can be found in the Cisco IOS Quality of Service Command Reference.

## Setting a DSCP Value on a Router for MPLS TE Graceful Restart

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `ip rsvp signalling hello graceful-restart dscp num`
4. `exit`

## DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b> <code>ip rsvp signalling hello graceful-restart dscp num</code>  <b>Example:</b> <pre>Router(config)# ip rsvp signalling hello graceful-restart dscp 30</pre>	Sets the number of DSCP hello messages on a graceful restart-enabled router.
<b>Step 4</b> <code>exit</code>  <b>Example:</b> <pre>Router(config)# exit</pre>	Exits to privileged EXEC mode.

## Setting a Hello Refresh Interval for MPLS TE Graceful Restart

## SUMMARY STEPS

- `enable`
- `configure terminal`
- `ip rsvp signalling hello graceful-restart refresh interval interval-value`
- `exit`

## DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>

Command or Action	Purpose
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b> <code>ip rsvp signalling hello graceful-restart refresh interval interval-value</code>  <b>Example:</b> <pre>Router(config)# ip rsvp signalling hello graceful-restart refresh interval 5000</pre>	Sets a hello refresh interval on a router with graceful restart enabled.
<b>Step 4</b> <code>exit</code>  <b>Example:</b> <pre>Router(config)# end</pre>	Exits to privileged EXEC mode.

## Setting a Missed Refresh Limit for MPLS TE Graceful Restart

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ip rsvp signalling hello graceful-restart refresh misses msg-count`
4. `exit`

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.

Command or Action	Purpose
<b>Step 3</b> <code>ip rsvp signalling hello graceful-restart refresh misses <i>msg-count</i></code>  <b>Example:</b>  <pre>Router(config)# ip rsvp signalling hello graceful-restart refresh misses 5</pre>	Sets a refresh limit on a router with graceful restart enabled.
<b>Step 4</b> <code>exit</code>  <b>Example:</b>  <pre>Router(config)# end</pre>	Exits to privileged EXEC mode.

## Verifying Graceful Restart Configuration

### SUMMARY STEPS

1. `enable`
2. `show ip rsvp hello graceful-restart`
3. `exit`

### DETAILED STEPS

**Step 1** `enable`  
Use this command to enable privileged EXEC mode. Enter your password if prompted. For example:

**Example:**

```
Router> enable
Router#
```

**Step 2** `show ip rsvp hello graceful-restart`  
Use this command to display information about the status of graceful restart and related parameters. For example:

**Example:**

```
Router# show ip rsvp hello graceful-restart
Graceful Restart:Enabled (help-neighbor only)
Refresh interval:10000 msec
Refresh misses:4
DSCP:0x30
Advertised restart time:0 secs
Advertised recovery time:0 secs
Maximum wait for recovery:3600000 secs
```

**Step 3** `exit`  
Use this command to exit to user EXEC mode. For example:



**Example:**

```
Router# exit
Router>
```

## Configuration Examples for MPLS TE--RSVP Graceful Restart

- [Example MPLS TE--RSVP Graceful Restart, page 51](#)

### Example MPLS TE--RSVP Graceful Restart

In the following example, graceful restart is enabled, and related parameters, including a DSCP value, a refresh interval, and a missed refresh limit are set:

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# ip rsvp signalling hello graceful-restart mode help-neighbor
Router(config)# ip rsvp signalling hello graceful-restart dscp 30
Router(config)# ip rsvp signalling hello graceful-restart refresh interval 10000
Router(config)# ip rsvp signalling hello graceful-restart refresh misses 4
Router(config)# end
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
RSVP commands: complete command syntax, command mode, defaults, usage guidelines, and examples	<i>Cisco IOS Quality of Service Solutions Command Reference</i>
Quality of service (QoS) features including signaling, classification, and congestion management	<i>Cisco IOS XE Quality of Service Solutions Configuration Guide, Release 2</i>
Stateful switchover	Stateful Switchover
MPLS Label Distribution Protocol	MPLS Label Distribution Protocol (LDP)
Cisco nonstop forwarding	Cisco Nonstop Forwarding
Information on stateful switchover, Cisco nonstop forwarding, graceful restart	MPLS LDP: SSO/NSF Support and Graceful Restart

Related Topic	Document Title
Hellos for state timeout	MPLS TE--RSVP Hello State Timer

### Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

### MIBs

MIBs	MIBs Link
No new or modified MIBS are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

### RFCs

RFCs	Title
RFC 3209	RSVP-TE: Extensions to RSVP for LSP Tunnels
RFC 3473	<i>Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions</i>
RFC 3478	Graceful Restart Mechanism for Label Distribution

### Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for MPLS Traffic Engineering--RSVP Graceful Restart

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 5** Feature Information for MPLS Traffic Engineering--RSVP Graceful Restart

Feature Name	Releases	Feature Information
MPLS Traffic Engineering--RSVP Graceful Restart	Cisco IOS XE Release 2.3	<p>The MPLS TE--RSVP Graceful Restart feature allows a neighboring Route Processor (RP) to recover from disruption in control plane service (specifically, the Label Distribution Protocol (LDP) component) without losing its MPLS forwarding state.</p> <p>In Cisco IOS XE Release 2.3, this feature was introduced on the Cisco ASR 1000 Series Aggregation Services Routers.</p> <p>The following commands were introduced or modified: <b>ip rsvp signalling hello graceful-restart dscp</b>, <b>ip rsvp signalling hello graceful-restart mode help-neighbor</b>, <b>ip rsvp signalling hello graceful-restart refresh interval</b>, <b>ip rsvp signalling hello graceful-restart refresh misses</b>, <b>show ip rsvp counters</b>, <b>show ip rsvp counters state teardown</b>, <b>show ip rsvp hello</b>, <b>show ip rsvp hello client lsp detail</b>, <b>show ip rsvp hello client lsp summary</b>, <b>show ip rsvp hello client neighbor detail</b>, <b>show ip rsvp hello client neighbor summary</b>, <b>show ip rsvp hello graceful-restart</b>, <b>show ip rsvp hello instance detail</b>, <b>show ip rsvp hello instance summary</b>.</p>

## Glossary

**autonomous system** --A collection of networks that share the same routing protocol and that are under the same system administration.

**ASBR** --**Autonomous System Boundary Router**. A router that connects and exchanges information between two or more autonomous systems.

**backup tunnel** --A Multiprotocol Label Switching (MPLS) traffic engineering (TE) tunnel used to protect other (primary) tunnels' traffic when a link or node failure occurs.

**DSCP** --differentiated services code point. Six bits in the IP header, as defined by the Internet Engineering Task Force (IETF). These bits determine the class of service provided to the IP packet.

**Fast Reroute** --A mechanism for protecting Multiprotocol Label Switching (MPLS) traffic engineering (TE) label switched paths (LSPs) from link and node failure by locally repairing the LSPs at the point of failure, allowing data to continue to flow on them while their headend routers attempt to establish end-to-end LSPs to replace them. Fast Reroute (FRR) locally repairs the protected LSPs by rerouting them over backup tunnels that bypass failed links or nodes.

**graceful restart** --A process for helping a neighboring Route Processor (RP) restart after a node failure has occurred.

**headend** --The router that originates and maintains a given label switched path (LSP). This is the first router in the LSP's path.

**IGP** --Interior Gateway Protocol. Internet protocol used to exchange routing information within an autonomous system. Examples of common Internet IGPs include Interior Gateway Routing Protocol (IGRP), Open Shortest Path First (OSPF), and Routing Information Protocol (RIP).

**instance** --A mechanism that implements the Resource Reservation Protocol. (RSVP) hello extensions for a given router interface address and remote IP address. Active hello instances periodically send Hello Request messages, expecting Hello ACK messages in response. If the expected ACK message is not received, the active hello instance declares that the neighbor (remote IP address) is unreachable (that is, it is lost). This can cause label switched paths (LSPs) crossing this neighbor to be fast rerouted.

**label** --A short, fixed-length data identifier that tells switching nodes how to forward data (packets or cells).

**LDP** --Label Distribution Protocol. The protocol that supports Multiprotocol Label Switching (MPLS) hop-by-hop forwarding by distributing bindings between labels and network prefixes.

**LSP** --label switched path. A configured connection between two routers, in which Multiprotocol Label Switching (MPLS) is used to carry packets. A path created by the concatenation of one or more label switched hops, allowing a packet to be forwarded by swapping labels from an MPLS node to another MPLS node.

**merge point** --The tail of the backup tunnel.

**MPLS** --Multiprotocol Label Switching. A method for forwarding packets (frames) through a network. MPLS enables routers at the edge of a network to apply labels to packets (frames). ATM switches or existing routers in the network core can switch packets according to the labels.

**PLR** --point of local repair. The headend of the backup tunnel.

**RSVP** --Resource Reservation Protocol. A protocol that supports the reservation of resources across an IP network. Applications running on IP end systems can use RSVP to indicate to other nodes the nature (bandwidth, jitter, maximum burst, and so on) of the packet streams they want to receive.

**state** --Information that a router must maintain about each label switched path (LSP). The information is used for rerouting tunnels.

**tailend** --The router upon which an label switched path (LSP) is terminated. This is the last router in the LSP's path.

**TE** --traffic engineering. The techniques and processes used to cause routed traffic to travel through the network on a path other than the one that would have been chosen if standard routing methods had been used.

**topology** --The physical arrangement of network nodes and media within an enterprise networking structure.

**tunnel** --Secure communications path between two peers, such as two routers.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.



# NSF SSO--MPLS TE and RSVP Graceful Restart

The NSF/SSO--MPLS TE and RSVP Graceful Restart feature allows a Route Processor (RP) to recover from disruption in control plane service without losing its Multiprotocol Label Switching (MPLS) forwarding state.

Cisco nonstop forwarding (NSF) with stateful switchover (SSO) provides continuous packet forwarding, even during a network processor hardware or software failure. In a redundant system, the secondary processor recovers control plane service during a critical failure in the primary processor. SSO synchronizes the network state information between the primary and the secondary processor.

- [Finding Feature Information, page 57](#)
- [Prerequisites for NSF SSO--MPLS TE and RSVP Graceful Restart, page 57](#)
- [Restrictions for NSF SSO--MPLS TE and RSVP Graceful Restart, page 58](#)
- [Information About NSF SSO--MPLS TE and RSVP Graceful Restart, page 58](#)
- [How to Configure NSF SSO--MPLS TE and RSVP Graceful Restart, page 60](#)
- [Configuration Examples for NSF SSO--MPLS TE and RSVP Graceful Restart, page 66](#)
- [Additional References, page 67](#)
- [Feature Information for NSF SSO--MPLS TE and RSVP Graceful Restart, page 68](#)
- [Glossary, page 70](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for NSF SSO--MPLS TE and RSVP Graceful Restart

- Configure Resource Reservation Protocol (RSVP) graceful restart in full mode.
- Configure RSVP graceful restart on all interfaces of the neighbor that you want to be restart-capable.
- Configure the redundancy mode as SSO. See the Stateful Switchover feature module for more information.

- Enable NSF on the routing protocols running among the provider routers (P), provider edge (PE) routers, and customer edge (CE) routers. The routing protocols are as follows:
  - Border Gateway Protocol (BGP)
  - Open Shortest Path First (OSPF)
  - Intermediate System-to-Intermediate System (IS-IS)

See the Cisco Nonstop Forwarding feature module for more information.

- Enable MPLS.
- Configure traffic engineering (TE).

## Restrictions for NSF SSO--MPLS TE and RSVP Graceful Restart

- RSVP graceful restart supports node failure only.
- Unnumbered interfaces are not supported.
- You cannot enable RSVP fast reroute (FRR) hello messages and RSVP graceful restart on the same router.
- You cannot enable primary one-hop autotunnels, backup autotunnels, or autotunnel mesh groups on a router that is also configured with SSO and Route Processor Redundancy Plus (RPR+). This restriction does not prevent an MPLS TE tunnel that is automatically configured by TE autotunnel from being successfully recovered if any midpoint router along the label-switched path (LSP) of the router experiences an SSO.
- MPLS TE LSPs that are fast reroutable cannot be successfully recovered if the LSPs are FRR active and the Point of Local Repair (PLR) router experiences an SSO.
- When you configure RSVP graceful restart, you must use the neighbor's interface IP address.

## Information About NSF SSO--MPLS TE and RSVP Graceful Restart

- [Overview of MPLS TE and RSVP Graceful Restart, page 58](#)
- [Benefits of MPLS TE and RSVP Graceful Restart, page 60](#)

## Overview of MPLS TE and RSVP Graceful Restart

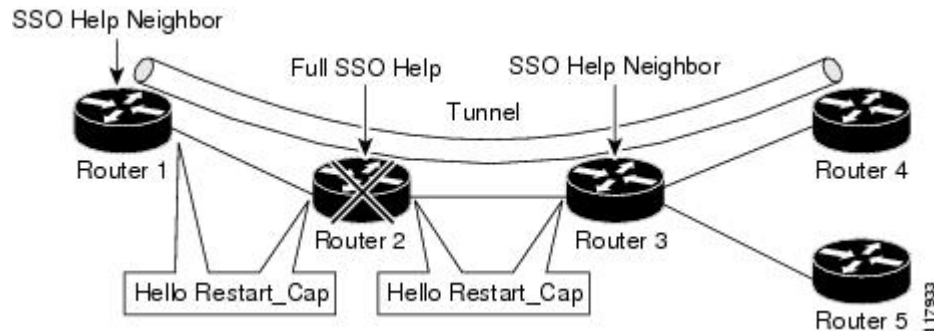
RSVP graceful restart allows RSVP TE-enabled nodes to recover gracefully following a node failure in the network such that the RSVP state after the failure is restored as quickly as possible. The node failure may be completely transparent to other nodes in the network.

RSVP graceful restart preserves the label values and forwarding information and works with third-party or Cisco routers seamlessly.

RSVP graceful restart depends on RSVP hello messages to detect that a neighbor went down. Hello messages include Hello Request or Hello Acknowledgment (ACK) objects between two neighbors.



As shown in the figure below, the RSVP graceful restart extension to these messages adds an object called Hello Restart\_Cap, which tells neighbors that a node may be capable of recovering if a failure occurs.



The Hello Restart\_Cap object has two values: the restart time, which is the sender's time to restart the RSVP\_TE component and exchange hello messages after a failure; and the recovery time, which is the desired time that the sender wants the receiver to synchronize the RSVP and MPLS databases.

In the figure above, RSVP graceful restart help neighbor support is enabled on Routers 1 and 3 so that they can help a neighbor recover after a failure, but they cannot perform self recovery. Router 2 has full SSO help support enabled, meaning it can perform self recovery after a failure or help its neighbor to recover. Router 2 has two RPs, one that is active and one that is standby (backup). A TE LSP is signaled from Router 1 to Router 4.

Router 2 performs checkpointing; that is, it copies state information from the active RP to the standby RP, thereby ensuring that the standby RP has the latest information. If an active RP fails, the standby RP can take over.

Routers 2 and 3 exchange periodic graceful restart hello messages every 10,000 milliseconds (ms) (10 seconds), and so do Routers 2 and 1 and Routers 3 and 4. Assume that Router 2 advertises its restart time = 60,000 ms (60 seconds) and its recovery time = 60,000 ms (60 seconds) as shown in the following example:

```
23:33:36: Outgoing Hello:
23:33:36:   version:1 flags:0000 cksum:883C ttl:255 reserved:0 length:32
23:33:36:   HELLO                               type HELLO REQUEST length 12:
23:33:36:   Src_Instance: 0x6EDA8BD7, Dst_Instance: 0x00000000
23:33:36:   RESTART_CAP                             type 1 length 12:
23:33:36:   Restart_Time: 0x0000EA60, Recovery_Time: 0x0000EA60
```

Router 3 records this into its database. Also, both neighbors maintain the neighbor status as UP. However, Router 3's control plane fails at some point (for example, a primary RP failure). As a result, RSVP and TE lose their signaling information and states although data packets continue to be forwarded by the line cards.

When Router 3 declares communication with Router 2 lost, Router 3 starts the restart time to wait for the duration advertised in Router 2's restart time previously recorded (60 seconds). Routers 1 and 2 suppress all RSVP messages to Router 3 except hellos. Router 3 keeps sending the RSVP PATH and RESV refresh messages to Routers 4 and 5 so that they do not expire the state for the LSP; however, Routers 1 and 3 suppress these messages for Router 2.

When Routers 1 and 3 receive the hello message from Router 2, Routers 1 and 3 check the recovery time value in the message. If the recovery time is 0, Router 3 knows that Router 2 was not able to preserve its forwarding information, and Routers 1 and 3 delete all RSVP state that they had with Router 2.

If the recovery time is greater than 0, Router 1 sends Router 2 PATH messages for each LSP that it had previously sent through Router 2. If these messages were previously refreshed in summary messages, they

are sent individually during the recovery time. Each of these PATH messages includes a Recovery\_Label object containing the label value received from Router 2 before the failure.

When Router 3 receives a PATH message from Router 2, Router 3 sends a RESV message upstream. However, Router 3 suppresses the RESV message until it receives a PATH message. When Router 2 receives the RESV message, it installs the RSVP state and reprograms the forwarding entry for the LSP.

## Benefits of MPLS TE and RSVP Graceful Restart

### State Information Recovery

RSVP graceful restart allows a node to perform self recovery or to help its neighbor recover state information when there is an RP failure or the device has undergone an SSO.

### Session Information Recovery

RSVP graceful restart allows session information recovery with minimal disruption to the network.

### Increased Availability of Network Services

A node can perform a graceful restart to help itself or a neighbor recover its state by keeping the label bindings and state information, thereby providing a faster recovery of the failed node and not affecting currently forwarded traffic.

## How to Configure NSF SSO--MPLS TE and RSVP Graceful Restart

- [Enabling RSVP Graceful Restart Globally, page 60](#)
- [Enabling RSVP Graceful Restart on an Interface, page 61](#)
- [Setting a DSCP Value for RSVP Graceful Restart, page 63](#)
- [Setting a Value to Control the Refresh Interval for RSVP Hello Messages, page 63](#)
- [Setting a Value to Control the Missed Refresh Limit for RSVP Graceful Restart Hello Acknowledgements, page 64](#)
- [Verifying the RSVP Graceful Restart Configuration, page 65](#)

## Enabling RSVP Graceful Restart Globally

### SUMMARY STEPS

1. enable
2. configure terminal
3. ip rsvp signalling hello graceful-restart mode (help-neighbor| full)
4. exit

## DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> <code>enable</code></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> <code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <code>ip rsvp signalling hello graceful-restart mode (help-neighbor  full)</code></p> <p><b>Example:</b></p> <pre>Router(config)# ip rsvp signalling hello graceful-restart mode full</pre>	<p>Enables RSVP TE graceful restart capability on an RP.</p> <ul style="list-style-type: none"> <li>Enter the <b>help-neighbor</b> keyword to enable a neighboring router to restart after a failure.</li> <li>Enter the <b>full</b> keyword to enable a router to perform self recovery or to help a neighbor recover after a failure.</li> </ul>
<p><b>Step 4</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config)# exit</pre>	<p>(Optional) Returns to privileged EXEC mode.</p>

## Enabling RSVP Graceful Restart on an Interface

You must repeat this procedure for each of the neighbor router's interfaces.

### SUMMARY STEPS

- `enable`
- `configure terminal`
- `interface type slot / subslot / port [ . subinterface-number]`
- Repeat Step 3 as needed to configure additional interfaces.
- `ip rsvp signalling hello graceful-restart neighbor ip-address`
- Repeat Step 5 as needed to configure additional IP addresses on a neighbor router's interfaces.
- `exit`
- `exit`

## DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> <code>enable</code></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> <code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <code>interface type slot / subslot / port [. subinterface-number]</code></p> <p><b>Example:</b></p> <pre>Router(config)# interface POS 1/0/0</pre>	<p>Configures the interface type and number and enters interface configuration mode.</p>
<p><b>Step 4</b> Repeat Step 3 as needed to configure additional interfaces.</p>	<p>(Optional) Configures additional interfaces.</p>
<p><b>Step 5</b> <code>ip rsvp signalling hello graceful-restart neighbor ip-address</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# ip rsvp signalling hello graceful-restart neighbor 10.0.0.0</pre>	<p>Enables support for RSVP graceful restart on routers helping their neighbors recover TE tunnels following SSO.</p> <p><b>Note</b> The IP address must be that of the neighbor's interface.</p>
<p><b>Step 6</b> Repeat Step 5 as needed to configure additional IP addresses on a neighbor router's interfaces.</p>	<p>(Optional) Configures additional IP addresses on a neighbor router's interfaces.</p>
<p><b>Step 7</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# exit</pre>	<p>Exits interface configuration mode and returns to global configuration mode.</p>
<p><b>Step 8</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config)# exit</pre>	<p>(Optional) Exits global configuration mode and returns to privileged EXEC mode.</p>

## Setting a DSCP Value for RSVP Graceful Restart

### SUMMARY STEPS

1. enable
2. configure terminal
3. ip rsvp signalling hello graceful-restart dscp num
4. exit

### DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> enable</p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> configure terminal</p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> ip rsvp signalling hello graceful-restart dscp num</p> <p><b>Example:</b></p> <pre>Router(config)# ip rsvp signalling hello graceful-restart dscp 30</pre>	<p>Sets a DSCP value on a router with RSVP graceful restart enabled.</p>
<p><b>Step 4</b> exit</p> <p><b>Example:</b></p> <pre>Router(config)# exit</pre>	<p>(Optional) Returns to privileged EXEC mode.</p>

## Setting a Value to Control the Refresh Interval for RSVP Hello Messages

### SUMMARY STEPS

1. enable
2. configure terminal
3. ip rsvp signalling hello graceful-restart refresh interval *interval-value*
4. exit

## DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> <code>enable</code></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> <code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <code>ip rsvp signalling hello graceful-restart refresh interval interval-value</code></p> <p><b>Example:</b></p> <pre>Router(config)# ip rsvp signalling hello graceful-restart refresh interval 5000</pre>	<p>Sets the value to control the request interval in graceful restart hello messages. This interval represents the frequency at which RSVP hello messages are sent to a neighbor; for example, one hello message is sent per each interval.</p> <p><b>Note</b> If you change the default value for this command and you also changed the RSVP refresh interval using the <b>ip rsvp signalling refresh interval</b> command, ensure that the value for the <b>ip rsvp signalling hello graceful-restart refresh interval</b> command is less than the value for the <b>ip rsvp signalling hello refresh interval</b> command. Otherwise, some or all of the label-switched paths (LSPs) may not be recovered after an SSO has occurred.</p>
<p><b>Step 4</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config)# exit</pre>	<p>(Optional) Returns to privileged EXEC mode.</p>

## Setting a Value to Control the Missed Refresh Limit for RSVP Graceful Restart Hello Acknowledgements

## SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `ip rsvp signalling hello graceful-restart refresh misses msg-count`
4. `exit`

## DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> <code>enable</code></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> <code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <code>ip rsvp signalling hello graceful-restart refresh misses <i>msg-count</i></code></p> <p><b>Example:</b></p> <pre>Router(config)# ip rsvp signalling hello graceful-restart refresh misses 5</pre>	<p>Specifies how many sequential RSVP TE graceful restart hello acknowledgments (ACKs) a node can miss before the node considers communication with its neighbor lost.</p> <p><b>Note</b> If you change the default value for this command and you are also using the <code>ip rsvp signalling hello refresh misses</code> command, ensure that the value for the <code>ip rsvp signalling hello graceful-restart refresh misses</code> command is less than the value for the <code>ip rsvp signalling hello refresh misses</code> command. Otherwise, some or all of the LSPs may not be recovered after an SSO has occurred.</p>
<p><b>Step 4</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config)# exit</pre>	<p>(Optional) Returns to privileged EXEC mode.</p>

## Verifying the RSVP Graceful Restart Configuration

## SUMMARY STEPS

- enable
- show ip rsvp hello graceful-restart
- exit

## DETAILED STEPS

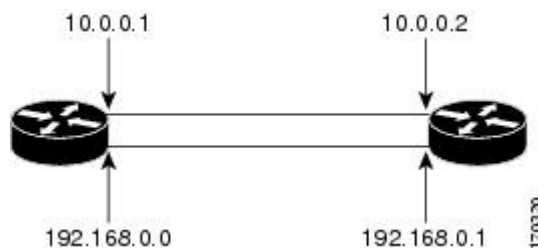
Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b> <pre>Router&gt; enable</pre>	(Optional) Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b> <code>show ip rsvp hello graceful-restart</code>  <b>Example:</b> <pre>Router# show ip rsvp hello graceful-restart</pre>	Displays information about the status of RSVP graceful restart and related parameters.
<b>Step 3</b> <code>exit</code>  <b>Example:</b> <pre>Router# exit</pre>	(Optional) Returns to user EXEC mode.

## Configuration Examples for NSF SSO--MPLS TE and RSVP Graceful Restart

- [Example Configuring NSF SSO--MPLS TE and RSVP Graceful Restart, page 66](#)
- [Example Verifying the NSF SSO--MPLS TE and RSVP Graceful Restart Configuration, page 67](#)

### Example Configuring NSF SSO--MPLS TE and RSVP Graceful Restart

In the following example, RSVP graceful restart is enabled globally and on a neighbor router's interfaces as shown in the figure below. Related parameters, including a DSCP value, a refresh interval, and a missed refresh limit are set.



```
enable
configure terminal
ip rsvp signalling hello graceful-restart mode full
```



```

interface POS 1/0/0
 ip rsvp signalling hello graceful-restart neighbor 10.0.0.1
 ip rsvp signalling hello graceful-restart neighbor 10.0.0.2
 exit
 ip rsvp signalling hello graceful-restart dscp 30
 ip rsvp signalling hello graceful-restart refresh interval 50000
 ip rsvp signalling hello graceful-restart refresh misses 5
 exit

```

## Example Verifying the NSF SSO--MPLS TE and RSVP Graceful Restart Configuration

```

Router# show ip rsvp hello graceful-restart
Graceful Restart: Enabled (full mode)
 Refresh interval: 10000 msec
 Refresh misses: 4
 DSCP:0x30
 Advertised restart time: 30000 msec
 Advertised recovery time: 120000 msec
 Maximum wait for recovery: 3600000 msec

```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
RSVP commands: complete command syntax, command mode, defaults, usage guidelines, and examples	<i>Cisco IOS Quality of Service Solutions Command Reference</i>
Quality of service (QoS) classification	Classification Overview
Stateful switchover	Stateful Switchover
Cisco nonstop forwarding	Information about Cisco Nonstop Forwarding
RSVP hello state timer	MPLS Traffic Engineering: RSVP Hello State Timer

### Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

**MIBs**

<b>MIBs</b>	<b>MIBs Link</b>
No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

<b>RFCs</b>	<b>Title</b>
RFC 3209	<i>RSVP-TE: Extensions to RSVP for LSP Tunnels</i>
RFC 3473	<i>Generalized Multi-Protocol Label Switching (GMPLS) Signaling Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions</i>
RFC 4558	<i>Node-ID Based Resource Reservation Protocol (RSVP) Hello: A Clarification Statement</i>

**Technical Assistance**

<b>Description</b>	<b>Link</b>
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for NSF SSO--MPLS TE and RSVP Graceful Restart

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 6**      **Feature Information for NSF/SSO--MPLS TE and RSVP Graceful Restart**

Feature Name	Releases	Feature Information
NSF/SSO--MPLS TE and RSVP Graceful Restart	Cisco IOS XE Release 3.1S Cisco IOS XE Release 3.5S	<p>The NSF/SSO--MPLS TE and RSVP Graceful Restart feature allows a Route Processor (RP) to recover from disruption in control plane service without losing its Multiprotocol Label Switching (MPLS) forwarding state.</p> <p>Cisco nonstop forwarding (NSF) with stateful switchover (SSO) provides continuous packet forwarding, even during a network processor hardware or software failure. In a redundant system, the secondary processor recovers control plane service during a critical failure in the primary processor. SSO synchronizes the network state information between the primary and the secondary processor.</p> <p>In Cisco IOS XE Release 3.1S, this feature was implemented on the Cisco ASR 1000 Series Aggregation Services Routers.</p>

Feature Name	Releases	Feature Information
		<p>The following commands were introduced or modified: <b>clear ip rsvp high-availability counters</b>, <b>debug ip rsvp high-availability</b>, <b>debug ip rsvp sso</b>, <b>debug mpls traffic-eng ha sso</b>, <b>ip rsvp signalling hello graceful-restart dscp</b>, <b>ip rsvp signalling hello graceful-restart mode</b>, <b>ip rsvp signalling hello graceful-restart mode help-neighbor</b>, <b>ip rsvp signalling hello graceful-restart neighbor</b>, <b>ip rsvp signalling hello graceful-restart refresh interval</b>, <b>ip rsvp signalling hello graceful-restart refresh misses</b>, <b>show ip rsvp counters</b>, <b>show ip rsvp counters state teardown</b>, <b>show ip rsvp hello</b>, <b>show ip rsvp hello client lsp detail</b>, <b>show ip rsvp hello client lsp summary</b>, <b>show ip rsvp hello client neighbor detail</b>, <b>show ip rsvp hello client neighbor summary</b>, <b>show ip rsvp hello graceful-restart</b>, <b>show ip rsvp hello instance detail</b>, <b>show ip rsvp hello instance summary</b>, <b>show ip rsvp high-availability counters</b>, <b>show ip rsvp high-availability database</b>, <b>show ip rsvp high-availability summary</b>.</p>
MPLS TE--RSVP Graceful Restart 12.0S--12.2S Interop	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, this feature was implemented on the Cisco ASR 1000 Series Aggregation Services Routers.
MPLS TE— Autotunnel/ Automesh SSO Coexistence	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, this feature was implemented on the Cisco ASR 1000 Series Aggregation Services Routers.

## Glossary

**DSCP** --differentiated services code point. Six bits in the IP header, as defined by the Internet Engineering Task Force (IETF). These bits determine the class of service provided to the IP packet.

**Fast Reroute** --A mechanism for protecting Multiprotocol Label Switching (MPLS) traffic engineering (TE) label switched paths (LSPs) from link and node failure by locally repairing the LSPs at the point of

failure, allowing data to continue to flow on them while their headend routers attempt to establish end-to-end LSPs to replace them. Fast reroute (FRR) locally repairs the protected LSPs by rerouting them over backup tunnels that bypass failed links or nodes.

**graceful restart** --A process for helping a Route Processor (RP) restart after a node failure has occurred.

**headend** --The router that originates and maintains a given label switched path (LSP). This is the first router in the LSP's path.

**hello instance** --A mechanism that implements the Resource Reservation Protocol (RSVP) hello extensions for a given router interface address and remote IP address. Active hello instances periodically send hello request messages, expecting Hello ACK messages in response. If the expected ACK message is not received, the active hello instance declares that the neighbor (remote IP address) is unreachable (that is, it is lost). This can cause LSPs crossing this neighbor to be fast rerouted.

**IGP** --Interior Gateway Protocol. Internet protocol used to exchange routing information within an autonomous system. Examples of common Internet IGPs include Interior Gateway Routing Protocol (IGRP), Open Shortest Path First (OSPF), and Routing Information Protocol (RIP).

**ISSU** --In Service Software Upgrade. Software upgrade without service interruption.

**label** --A short, fixed-length data identifier that tells switching nodes how to forward data (packets or cells).

**LSP** --label switched path. A configured connection between two routers, in which Multiprotocol Label Switching (MPLS) is used to carry packets.

**MPLS** --Multiprotocol Label Switching. A method for forwarding packets (frames) through a network. MPLS enables routers at the edge of a network to apply labels to packets (frames). ATM switches or existing routers in the network core can switch packets according to the labels.

**RSVP** --Resource Reservation Protocol. A protocol that supports the reservation of resources across an IP network. Applications running on IP end systems can use RSVP to indicate to other nodes the nature (bandwidth, jitter, maximum burst, and so on) of the packet streams they want to receive.

**state** --Information that a router must maintain about each label switched path (LSP). The information is used for rerouting tunnels.

**tailend** --The router upon which a label switched path (LSP) is terminated. This is the last router in the LSP's path.

**TE** --traffic engineering. The techniques and processes used to cause routed traffic to travel through the network on a path other than the one that would have been chosen if standard routing methods had been used.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.





## AToM Graceful Restart

---

The AToM Graceful Restart feature assists neighboring routers that have nonstop forwarding (NSF), stateful switchover (SSO) and graceful restart (GR) for Any Transport over MPLS (AToM) to recover gracefully from an interruption in service. AToM GR functions strictly in helper mode, which means it helps other routers that are enabled with the NSF/SSO: Any Transport over MPLS and AToM Graceful Restart feature to recover. If the router with AToM GR fails, its peers cannot help it recover. AToM GR is based on the MPLS Label Distribution Protocol (LDP) Graceful Restart feature.

Keep the following points in mind when reading this document:

- The AToM GR feature described in this document refers to helper mode.
- For brevity, the NSF/SSO: Any Transport over MPLS and AToM Graceful Restart feature is called AToM SSO/NSF in this document.
- [Finding Feature Information, page 73](#)
- [Prerequisites for AToM Graceful Restart, page 73](#)
- [Restrictions for AToM Graceful Restart, page 74](#)
- [Information About AToM Graceful Restart, page 74](#)
- [How to Configure AToM Graceful Restart, page 74](#)
- [Configuration Examples for AToM Graceful Restart, page 75](#)
- [Additional References, page 77](#)
- [Feature Information for AToM Graceful Restart, page 79](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

## Prerequisites for AToM Graceful Restart

AToM must be configured. For information about setting up or configuring AToM, see the Any Transport over MPLS document.

## Restrictions for AToM Graceful Restart

- AToM GR is supported in strict helper mode.
- MPLS LDP GR cannot be configured on label-controlled ATM (LC-ATM) interfaces.

## Information About AToM Graceful Restart

- [How AToM Graceful Restart Works, page 74](#)

## How AToM Graceful Restart Works

AToM GR works in strict helper mode, which means it helps a neighboring Route Processor (RP) that has AToM NSF/SSO to recover from a disruption in service without losing its MPLS forwarding state. The disruption in service could result from a TCP or User Datagram Protocol (UDP) event or the stateful switchover of a route processor. AToM GR is based on the MPLS LDP Graceful Restart feature, which preserves forwarding information for AToM circuits during an LDP session interruption. When the neighboring router establishes a new session, the LDP bindings and MPLS forwarding state are recovered. For more information related to how the LDP Graceful Restart feature works, see the MPLS LDP Graceful Restart feature module.

## How to Configure AToM Graceful Restart

- [Configuring AToM Graceful Restart, page 74](#)

## Configuring AToM Graceful Restart

To configure AToM Graceful Restart, perform the following task.

There is no AToM-specific configuration for AToM GR. You enable LDP GR to assist a neighboring router configured with AToM NSF/SSO to maintain its forwarding state while the LDP session is disrupted. See the LDP Graceful Restart document for information about how LDP GR works and how you can customize it for your network.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef distributed**
4. **mpls ldp graceful-restart**
5. **exit**



## DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
<b>Step 2</b> <b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3</b> <b>ip cef distributed</b>  <b>Example:</b> Router(config)# ip cef distributed	Enables distributed Cisco Express Forwarding.
<b>Step 4</b> <b>mpls ldp graceful-restart</b>  <b>Example:</b> Router(config)# mpls ldp graceful-restart	Enables the router to protect the LDP bindings and MPLS forwarding state during a disruption in service. <ul style="list-style-type: none"> <li>AToM GR is enabled globally. When you enable AToM GR, it has no effect on existing LDP sessions. New LDP sessions that are established can perform AToM GR.</li> </ul>
<b>Step 5</b> <b>exit</b>  <b>Example:</b> Router(config)# exit	Exits to privileged EXEC mode.

## Configuration Examples for AToM Graceful Restart

- [Configuring AToM Graceful Restart Example, page 75](#)
- [AToM Graceful Restart--Recovering from an LDP Session Disruption Examples, page 76](#)

### Configuring AToM Graceful Restart Example

The following example shows a Fast Ethernet VLAN over MPLS configuration. PE1 is configured with AToM Graceful Restart. PE2 is configured with AToM NSF/SSO. The commands for configuring AToM GR and NSF/SSO are shown in bold.

**PE1 with AToM GR**

```

ip cef distributed
!
mpls label protocol ldp
mpls ldp graceful-restart
mpls ldp router-id Loopback0
!
pseudowire-class atom
encapsulation mpls
!
interface Loopback0
 ip address 10.1.1.2 255.255.255.255
!
interface FastEthernet2/1/1
 no ip address
!
interface FastEthernet2/1/1.2
 description "xconnect to PE2"
 encapsulation dot1Q 2 native
 xconnect 10.2.2.2 1002 pw-class mpls
!
! IGP for MPLS
router ospf 10
log-adjacency-changes
auto-cost reference-bandwidth 1000
network 10.1.1.2 10.0.0.0 area 0
network 10.1.1.0 10.0.0.255 area 0
    
```

**PE2 with AToM NSF/SSO**

```

redundancy
  mode sso
ip cef distributed
!
mpls label protocol ldp
mpls ldp graceful-restart
mpls ldp router-id Loopback0
!
pseudowire-class atom
encapsulation mpls
!
interface Loopback0
 ip address 10.2.2.2 255.255.255.255
!
interface FastEthernet0/3/2
 no ip address
!
interface FastEthernet0/3/2.2
 description "xconnect to PE1"
 encapsulation dot1Q 2
 xconnect 10.1.1.2 1002 pw-class mpls
!
! IGP for MPLS
router ospf 10
log-adjacency-changes
nsf cisco enforce global
auto-cost reference-bandwidth 1000
network 10.2.2.2 10.0.0.0 area 0
network 10.1.1.0 10.0.0.255 area 0
    
```

## AToM Graceful Restart--Recovering from an LDP Session Disruption Examples

The following examples show the output of the **show mpls l2transport vc** command during normal operation and when an LDP session is recovering from a disruption.

The following example shows the status of the VC on PE1 with AToM GR during normal operation:

```

Router# show mpls l2transport vc
Local intf    Local circuit  Dest address  VC ID    Status
-----
Fa2/1/1.2    Eth VLAN 2    10.2.2.2     1002    UP
    
```

The following example shows the status of the VC on PE1 with AToM GR while the VC is recovering from an LDP session disruption. The forwarding state for the circuit remains as it was before the disruption.

```

Router# show mpls l2transport vc
Local intf    Local circuit  Dest address  VC ID    Status
-----
Fa2/1/1.2    Eth VLAN 2    10.2.2.2     1002    RECOVERING
    
```

The following example shows the status of the VC on PE1 with AToM GR after the LDP session disruption was cleared. The AToM label bindings were advertised within the allotted time and the status returned to UP.

```

Router# show mpls l2transport vc
Local intf    Local circuit  Dest address  VC ID    Status
-----
Fa2/1/1.2    Eth VLAN 2    10.2.2.2     1002    UP
    
```

The following example shows the detailed status of the VC on PE1 with AToM GR during normal operation:

```
Router# show mpls l2transport vc detail
Local interface: Fa2/1/1.2 up, line protocol up, Eth VLAN 2 up
  Destination address: 10.2.2.2, VC ID: 1002, VC status: up
  Preferred path: not configured
  Default path: active
  Tunnel label: imp-null, next hop point2point
  Output interface: Se2/0/2, imposed label stack {16}
  Create time: 1d00h, last status change time: 1d00h
  Signaling protocol: LDP, peer 10.2.2.2:0 up
  MPLS VC labels: local 21, remote 16
  Group ID: local 0, remote 0
  MTU: local 1500, remote 1500
  Remote interface description: "xconnect to PE2"
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 3466, send 12286
    byte totals:   receive 4322368, send 5040220
    packet drops:  receive 0, send 0
```

The following example shows the detailed status of the VC on PE1 with AToM GR while the VC is recovering.

```
Router# show mpls l2transport vc detail
Local interface: Fa2/1/1.2 up, line protocol up, Eth VLAN 2 up
  Destination address: 10.2.2.2, VC ID: 1002, VC status: recovering
  Preferred path: not configured
  Default path: active
  Tunnel label: imp-null, next hop point2point
  Output interface: Se2/0/2, imposed label stack {16}
  Create time: 1d00h, last status change time: 00:00:03
  Signaling protocol: LDP, peer 10.2.2.2:0 down
  MPLS VC labels: local 21, remote 16
  Group ID: local 0, remote 0
  MTU: local 1500, remote 1500
  Remote interface description: "xconnect to PE2"
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 20040, send 28879
    byte totals:   receive 25073016, send 25992388
    packet drops:  receive 0, send 0
```

## Additional References

The following sections provide references related to the AToM GR feature.

### Related Documents

Related Topic	Document Title
MPLS LDP graceful restart	MPLS LDP Graceful Restart
Configuring AToM	Any Transport over MPLS
Nonstop forwarding and stateful switchover for AToM	NSF/SSO--Any Transport over MPLS and AToM Graceful Restart
MPLS AToM and LDP commands	<i>Cisco IOS Multiprotocol Label Switching Command Reference</i>

Related Topic	Document Title
High availability commands	<i>Cisco IOS High Availability Command Reference</i>

### Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

### MIBs

MIBs	MIBs Link
<i>MPLS Label Distribution Protocol MIB Version 8 Upgrade</i>	To locate and download MIBs for selected platforms, Cisco IOS XE software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mib">http://www.cisco.com/go/mib</a>

### RFCs

RFCs	Title
RFC 3036	<i>LDP Specification</i>
RFC 3478	<i>Graceful Restart Mechanism for Label Distribution</i>

### Technical Assistance

Description	Link
<p>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies.</p> <p>To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds.</p> <p>Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</p>	<a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a>

## Feature Information for AToM Graceful Restart

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to [www.cisco.com/go/cfn](http://www.cisco.com/go/cfn). An account on Cisco.com is not required.

**Table 7** Feature Information for AToM Graceful Restart

Feature Name	Releases	Feature Information
AToM Graceful Restart	Cisco IOS XE Release 2.3	<p>The AToM Graceful Restart feature assists neighboring routers that have nonstop forwarding (NSF), stateful switchover (SSO) and graceful restart (GR) for Any Transport over MPLS (AToM) to recover gracefully from an interruption in service. AToM GR functions strictly in helper mode, which means it helps other routers that are enabled with the NSF/SSO: Any Transport over MPLS and AToM Graceful Restart feature to recover. If the router with AToM GR fails, its peers cannot help it recover. AToM GR is based on the MPLS Label Distribution Protocol (LDP) Graceful Restart feature.</p> <p>In Cisco IOS Release XE 2.3, this feature was implemented on the Cisco ASR 1000 Series Aggregation Services Routers.</p> <p>This feature uses no new or modified commands</p>

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams,

and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.