Implementing MPLS OAM

This module describes Multiprotocol Label Switching (MPLS) P2MP Ping and Traceroute features. These features provide a means to check connectivity, isolate failure point, thus providing the MPLS Operations, Administration, and Maintenance (OAM) solution.

For detailed information about MPLS commands and examples, seeCisco ASR 9000 Series Aggregation Services Router MPLS Command Reference.

Feature History for Implementing MPLS OAM

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<th>Release</th>
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<tr>
<td>Release 4.1.0</td>
<td>This feature was introduced.</td>
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Prerequisites for MPLS LSP Ping and Traceroute for P2MP

Before you use the MPLS LSP Ping and Traceroute for P2MP feature, you should have the support for following:

- Cisco IOS XR software Release 4.1.0 or a later release
- Configure Resource Reservation Protocol (RSVP) features on the headend, midpoint, and tailend routers in the MPLS network
- Configure traffic engineering features on the headend, midpoint, and tailend routers in the MPLS network
- Enable MPLS OAM using the mpls oam command on all routers in the MPLS network
MPLS Network Management with MPLS LSP Ping and MPLS LSP Traceroute

To manage an MPLS network, you must have the ability to monitor LSPs and quickly isolate MPLS forwarding problems. You need ways to characterize the liveliness of an LSP and reliably detect when an LSP fails to deliver user traffic.

You can use MPLS LSP ping to verify the LSP that is used to transport packets. You can use MPLS LSP traceroute to trace LSPs that are used to carry packets destined for P2MP LSP.

An MPLS echo request is sent through an LSP to validate it. A TTL expiration or LSP breakage causes the transit router to process the echo request before it gets to the intended destination. The router returns an MPLS echo reply that contains an explanatory reply code to the originator of the echo request.

The successful echo request is processed at the egress of the LSP. The echo reply is sent through an IP path, an MPLS path, or a combination of both, back to the originator of the echo request.

Roles of Various Routers

A P2MP TE network contains the following elements:

- **Headend Router**
  The headend router, also called the source or ingress router, is responsible for initiating the signaling messages that set up the P2MP TE LSP. The headend router can also be a branch point, which means the router performs packet replication and the sub-LSPs split into different directions.

- **Midpoint Router**
  The midpoint router is where the sub-LSP signaling is processed. The midpoint router can be a branch point.

- **Tailend Router**
  The tailend router, also called the destination, egress, or leaf-node router, is where sub-LSP signaling ends. The router which is one of potentially many destinations of the P2MP TE LSP.

- **Bud Router**
  A bud router is a midpoint and tailend router at the same time. An LSR that is an egress LSR, but also has one or more directly connected downstream LSRs.

- **Branch Router**
  A branch router is either a midpoint or tailend router at any given time.

- **Transit Router**
  A transit router is an LSR that is not an egress router, but also has one or more directly connected downstream routers.

- **A P2MP tunnel consists of one or more sub-LSPs. All sub-LSPs belonging to the same P2MP tunnel employ the same constraints, protection policies, and so on, which are configured at the headend router.**
P2MP TE tunnels build on the features that exist in basic point-to-point TE tunnels. The P2MP TE tunnels have the following characteristics:

- There is one source (headend) but more than one destination (tailend).
- They are unidirectional.
- They are explicitly routed.
- Multiple sub-LSPs connect the headend router to various tailend routers.

### P2MP Ping

The P2MP ping feature is used to check the connectivity between Ingress LSR and egress LSR, along a P2MP LSP. The Ingress LSR sends the P2MP echo request message along the specified P2MP LSP. All egress LSRs which receive the P2MP echo request message from the ingress LSR must send a P2MP echo reply message to the ingress LSR, according to the reply mode specified in the P2MP echo request message.

MPLS LSP ping uses MPLS echo request and reply packets to validate an LSP. You can use MPLS LSP ping to validate RSVP P2MP IPv4 FECs by using appropriate keywords and arguments with the `ping mpls` command.
The MPLS echo request packet is sent to a target router through the use of the appropriate label stack associated with the LSP to be validated. Use of the label stack causes the packet to be forwarded over the LSP itself.

The destination IP address of the MPLS echo request packet is different from the address used to select the label stack. The destination IP address is defined as a 127.x.y.z/8 address. The 127.x.y.z/8 address prevents the IP packet from being IP switched to its destination, if the LSP is broken.

An MPLS echo reply is sent in response to an MPLS echo request. The reply is sent as an IP packet and it is forwarded using IP, MPLS, or a combination of both types of switching. The source address of the MPLS echo reply packet is an address obtained from the router generating the echo reply. The destination address is the source address of the router that originated the MPLS echo request packet.

The MPLS echo reply destination port is set to the echo request source port.

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**Note**

Only P2MP TE LSP IPv4 is supported. If the Responder Identifier TLV is missing, the echo request requests information from all responder-ids.

**Jitter**

Jitter is used to reduce the load on the LSR where the ping is performed. By adding a jitter, the replying routers will space their reply time based on a random number between 0 and the jitter value, Jitter TLV, specified in the packet.

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**P2MP Traceroute**

The P2MP traceroute feature is used to isolate the failure point of a P2MP LSP. It is used for hop-by-hop fault localization and path tracing. The traceroute feature relies on the expiration of the TTL of the packet that carries the echo request. When the P2MP echo request message hits a transit node, it checks the TTL and if it is expired, the packet is punted to the control plane, else the message is forwarded or replicated. If punted to the control plane, a reply message is build based on the contents of the request message.

Traceroute can be applied to all nodes in the P2MP tree. However, you can select a specific traceroute target through the P2MP Responder Identifier TLV. An entry in this TLV represents an responder-id or a transit node. This is only the case for P2MP TE LSPs.

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**Note**

Only P2MP TE LSP IPv4 is supported. If the Responder Identifier TLV is missing, the echo request requests information from all responder-ids.

**Jitter**

Jitter is used to reduce the load on the LSR where the traceroute is performed. By adding a jitter, the replying routers will space their reply time based on a random number between 0 and the jitter value, Jitter TLV, specified in the packet.

For more information about ping and traceroute commands, see *MPLS OAM commands* chapter in the *Cisco ASR 9000 Series Aggregation Services Router MPLS Command Reference*.

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**Configure the Ping and Traceroute: Example**

This section contains examples of the ping and traceroute commands, based on this topology.
This example shows multiple destinations set on the assigned LSP path.

```
RP/0/RSP0/CPU0# show run int tunnel-mte 10
interface tunnel-mte10
   ipv4 unnumbered Loopback0
   destination 11.0.0.1
      path-option 1 dynamic
   destination 12.0.0.1
      path-option 1 dynamic
   destination 13.0.0.1
      path-option 1 dynamic
```

This example shows an extract of the ping command.

```
# ping mpls traffic-eng tunnel-mte 10
Sending 1, 100-byte MPLS Echos to tunnel-mte10,
   timeout is 2.2 seconds, send interval is 0 msec, jitter value is 200 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
   'L' - labeled output interface, 'B' - unlabeled output interface,
   'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
   'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
   'P' - no rx intf label prot, 'p' - premature termination of LSP,
   'R' - transit router, 'I' - unknown upstream index,
   'X' - unknown return code, 'x' - return code 0, 'd' - DDMAP

Type escape sequence to abort.

Request #1
! reply addr 192.168.222.2
! reply addr 192.168.140.2
! reply addr 192.168.170.1
Success rate is 100 percent (3 received replies/3 expected replies),
   round-trip min/avg/max = 154/232/302 ms
```

This example shows an extract of the ping command with the jitter option.

```
RP/0/RSP0/CPU0# ping mpls traffic-eng tunnel-mte 10 jitter 300
Sending 1, 100-byte MPLS Echos to tunnel-mte10,
   timeout is 2.3 seconds, send interval is 0 msec, jitter value is 300 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
   'L' - labeled output interface, 'B' - unlabeled output interface,
   'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
   'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
   'P' - no rx intf label prot, 'p' - premature termination of LSP,
   'R' - transit router, 'I' - unknown upstream index,
   'X' - unknown return code, 'x' - return code 0, 'd' - DDMAP
```
Type escape sequence to abort.

Request #1
! reply addr 192.168.222.2
! reply addr 192.168.140.2
! reply addr 192.168.170.1
Success rate is 100 percent (3 received replies/3 expected replies),
round-trip min/avg/max = 148/191/256 ms

This example shows an extract of the ping command with the ddmap option.

RP/0/RSP0/CPU0:router# ping mpls traffic-eng tunnel-mte 10 ddmap
Sending 1, 100-byte MPLS Echos to tunnel-mte10,
timeout is 2.2 seconds, send interval is 0 msec, jitter value is 200 msec:
Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
'L' - labeled output interface, 'U' - unlabeled output interface,
'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
'P' - no rx intf label prot, 'p' - premature termination of LSP,
'R' - transit router, 'I' - unknown upstream index,
'X' - unknown return code, 'x' - return code 0, 'd' - DDMA

Type escape sequence to abort.

Request #1
! reply addr 192.168.222.2
! reply addr 192.168.140.2
! reply addr 192.168.170.1
Success rate is 100 percent (3 received replies/3 expected replies),
round-trip min/avg/max = 105/178/237 ms

RP/0/RSP0/CPU0:router# show mpls traffic-eng tunnels p2mp 10
Mon Apr 12 12:13:55.075 EST
Signalling Summary:
- LSP Tunnels Process: running
- RSVP Process: running
- Forwarding: enabled
- Periodic reoptimization: every 3600 seconds, next in 654 seconds
- Periodic FRR Promotion: every 300 seconds, next in 70 seconds
- Auto-bw enabled tunnels: 0 (disabled)

Name: tunnel-mte10
Status: Admin: up Oper: up (Up for 12w4d)
Config Parameters:
- Bandwidth: 0 kbps (CT0) Priority: 7 7 Affinity: 0x0/0xffffffff
- Metric Type: TE (default)
- Fast Reroute: Not Enabled, Protection Desired: None
- Record Route: Not Enabled
- Destination summary: (3 up, 0 down, 0 disabled) Affinity: 0x0/0xffffffff
- Auto-bw: disabled
- Destination: 11.0.0.1
  State: Up for 12w4d
  Path options: path-option 1 dynamic [active]
- Destination: 12.0.0.1
  State: Up for 12w4d
  Path options: path-option 1 dynamic [active]
- Destination: 13.0.0.1
  State: Up for 12w4d
  Path options: path-option 1 dynamic [active]
History:
Reopt. LSP:
Last Failure:
LSP not signalled, identical to the [CURRENT] LSP
Date/Time: Thu Jan 14 02:49:22 EST 2010 [12w4d ago]

Current LSP:
  lsp-id: 10002 p2mp-id: 10 tun-id: 10 src: 10.0.0.1 extid: 10.0.0.1
  LSP up for: 12w4d
  Reroute Pending: No
  Inuse Bandwidth: 0 kbps (CT0)
  Number of S2Ls: 3 connected, 0 signaling proceeding, 0 down

S2L Sub LSP: Destination 11.0.0.1 Signaling Status: connected
  S2L up for: 12w4d
  Sub Group ID: 1 Sub Group Originator ID: 10.0.0.1
  Path option path-option 1 dynamic (path weight 1)
  Path info (OSPF 1 area 0)
    192.168.222.2
    11.0.0.1

S2L Sub LSP: Destination 12.0.0.1 Signaling Status: connected
  S2L up for: 12w4d
  Sub Group ID: 2 Sub Group Originator ID: 10.0.0.1
  Path option path-option 1 dynamic (path weight 2)
  Path info (OSPF 1 area 0)
    192.168.222.2
    192.168.140.3
    192.168.140.2
    12.0.0.1

S2L Sub LSP: Destination 13.0.0.1 Signaling Status: connected
  S2L up for: 12w4d
  Sub Group ID: 3 Sub Group Originator ID: 10.0.0.1
  Path option path-option 1 dynamic (path weight 2)
  Path info (OSPF 1 area 0)
    192.168.222.2
    192.168.170.3
    192.168.170.1
    13.0.0.1

Reoptimized LSP (Install Timer Remaining 0 Seconds):
  None
Cleaned LSP (Cleanup Timer Remaining 0 Seconds):
  None
Displayed 1 (of 16) heads, 0 (of 0) midpoints, 0 (of 0) tails
Displayed 1 up, 0 down, 0 recovering, 0 recovered heads

RP/0/RSP0/CPU0# router# ping mpls traffic-eng tunnel-mte 10 lsp id 10002
Mon Apr 12 12:14:04.532 EST
Sending 1, 100-byte MPLS Echos to tunnel-mte10,
timeout is 2.2 seconds, send interval is 0 msec, jitter value is 200 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
'L' - labeled output interface, 'B' - unlabeled output interface,
'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
'R' - no rx intf label prot, 'p' - premature termination of LSP,
'R' - transit router, 'I' - unknown upstream index,
'X' - unknown return code, 'x' - return code 0, 'd' - DDMAP

Type escape sequence to abort.

Request #1
  ! reply addr 192.168.222.2
  ! reply addr 192.168.170.1
  ! reply addr 192.168.140.2

Success rate is 100 percent (3 received replies/3 expected replies),
round-trip min/avg/max = 128/153/167 ms
This example shows an extract of the ping command with the responder-id of R3.

```
RP/0/RSP0/CPU0:router# ping mpls traffic-eng tunnel-mte 10 responder-id 13.0.0.1
Mon Apr 12 12:15:34.205 EST
Sending 1, 100-byte MPLS Echos to tunnel-mte10,
    timeout is 2.2 seconds, send interval is 0 msec, jitter value is 200 msec:
Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
    'L' - labeled output interface, 'U' - unlabeled output interface,
    'D' - DS Map mismatch, 'F' - no FEC mapping, 'E' - FEC mismatch,
    'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
    'P' - no rx intf label prot, 'p' - premature termination of LSP,
    'R' - transit router, 'I' - unknown upstream index,
    'X' - unknown return code, 'x' - return code 0, 'd' - DDMAP
Type escape sequence to abort.
Request #1
! reply addr 192.168.170.1
Success rate is 100 percent (1 received reply/1 expected reply),
    round-trip min/avg/max = 179/179/179 ms
```

This example shows an extract of the traceroute command with the ttl option.

```
RP/0/RSP0/CPU0:router# traceroute mpls traffic-eng tunnel-mte 10 ttl 4
Mon Apr 12 12:16:50.095 EST
Tracing MPLS MTE Label Switched Path on tunnel-mte10, timeout is 2.2 seconds
Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
    'L' - labeled output interface, 'U' - unlabeled output interface,
    'D' - DS Map mismatch, 'F' - no FEC mapping, 'E' - FEC mismatch,
    'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
    'P' - no rx intf label prot, 'p' - premature termination of LSP,
    'R' - transit router, 'I' - unknown upstream index,
    'X' - unknown return code, 'x' - return code 0, 'd' - DDMAP
Type escape sequence to abort.
! 1 192.168.222.2 186 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
! 2 192.168.222.2 115 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
! 3 192.168.222.2 108 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
! 4 192.168.170.1 198 ms [Estimated Role: Egress]
! 4 192.168.222.2 206 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
```

This example shows an extract of the traceroute command with the responder-id option.

```
RP/0/RSP0/CPU0:router# traceroute mpls traffic-eng tunnel-mte 10 responder-id 13.0.0.1
Mon Apr 12 12:18:01.994 EST
Tracing MPLS MTE Label Switched Path on tunnel-mte10, timeout is 2.2 seconds
```

This example shows an extract of the ping command with the responder-id of R3.

```
RP/0/RSP0/CPU0:router# ping mpls traffic-eng tunnel-mte 10 responder-id 13.0.0.1
Mon Apr 12 12:15:34.205 EST
Sending 1, 100-byte MPLS Echos to tunnel-mte10,
    timeout is 2.2 seconds, send interval is 0 msec, jitter value is 200 msec:
Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
    'L' - labeled output interface, 'U' - unlabeled output interface,
    'D' - DS Map mismatch, 'F' - no FEC mapping, 'E' - FEC mismatch,
    'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
    'P' - no rx intf label prot, 'p' - premature termination of LSP,
    'R' - transit router, 'I' - unknown upstream index,
    'X' - unknown return code, 'x' - return code 0, 'd' - DDMAP
Type escape sequence to abort.
Request #1
! reply addr 192.168.170.1
Success rate is 100 percent (1 received reply/1 expected reply),
    round-trip min/avg/max = 179/179/179 ms
```

This example shows an extract of the traceroute command with the ttl option.

```
RP/0/RSP0/CPU0:router# traceroute mpls traffic-eng tunnel-mte 10 ttl 4
Mon Apr 12 12:16:50.095 EST
Tracing MPLS MTE Label Switched Path on tunnel-mte10, timeout is 2.2 seconds
Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
    'L' - labeled output interface, 'U' - unlabeled output interface,
    'D' - DS Map mismatch, 'F' - no FEC mapping, 'E' - FEC mismatch,
    'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
    'P' - no rx intf label prot, 'p' - premature termination of LSP,
    'R' - transit router, 'I' - unknown upstream index,
    'X' - unknown return code, 'x' - return code 0, 'd' - DDMAP
Type escape sequence to abort.
! 1 192.168.222.2 186 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
! 2 192.168.222.2 115 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
! 3 192.168.222.2 108 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
! 4 192.168.170.1 198 ms [Estimated Role: Egress]
! 4 192.168.222.2 206 ms [Estimated Role: Bud]
    [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
```

This example shows an extract of the traceroute command with the responder-id option.

```
RP/0/RSP0/CPU0:router# traceroute mpls traffic-eng tunnel-mte 10 responder-id 13.0.0.1
Mon Apr 12 12:18:01.994 EST
Tracing MPLS MTE Label Switched Path on tunnel-mte10, timeout is 2.2 seconds
```
This example shows an extract of the traceroute command with the jitter option.

```plaintext
RP/0/RSP0/CPU0:router# traceroute mpls traffic-eng tunnel-mte 10 responder-id 13.0.0.1 ttl 4 jitter 500
Mon Apr 12 12:19:00.292 EST
Tracing MPLS MTE Label Switched Path on tunnel-mte10, timeout is 2.5 seconds
```

Type escape sequence to abort.

```
d 1 192.168.222.2 238 ms [Estimated Role: Branch]
  [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
d 2 192.168.222.2 188 ms [Estimated Role: Branch]
  [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
  ! 2 192.168.170.1 244 ms [Estimated Role: Egress]
d 3 192.168.222.2 141 ms [Estimated Role: Branch]
  [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
  ! 3 192.168.170.1 204 ms [Estimated Role: Egress]
d 4 192.168.222.2 110 ms [Estimated Role: Branch]
  [L] DDMAP 0: 192.168.140.2 192.168.140.2 MRU 1500 [Labels: 16001 Exp: 0]
  ! 4 192.168.170.1 114 ms [Estimated Role: Egress]
```

This example shows an extract of the traceroute command with the jitter option.
Configure the Ping and Traceroute: Example